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DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate: National Water Resource Planning

ALBANY COAST SITUATION ASSESSMENT STUDY

Main Report: Volume 1

Final

December 2004

Prepared by :

UWP Consulting (Pty) Ltd

PO Box 9311
CENTURION
0046

TEL: (012) 664-9232

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
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Submitted on behalf of UWP Consulting (Pty) Ltd by:

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HV DOUDENSKI
Project Leader

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate: National Water Resource Planning

Approved for Department of Water Affairs and Forestry by:

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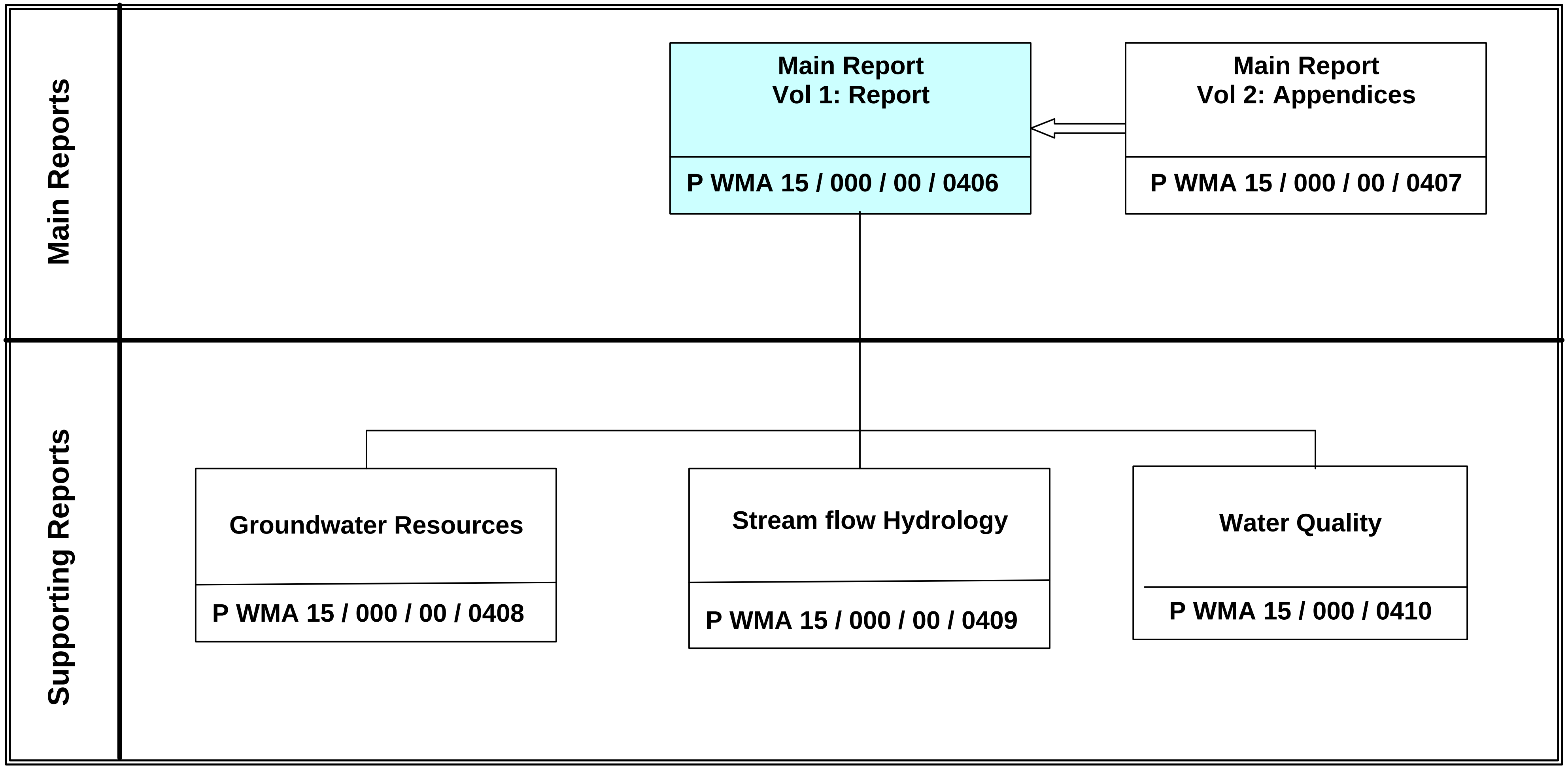
FA STOFFBERG	**JA VAN ROOYEN**
Chief Engineer: National Water Resource Planning	Director: National Water Resource Planning

ALBANY COAST SITUATION ASSESSMENT STUDY

Structure of Reports



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Cacadu District Municipality

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DWAF: Eastern Cape Region

DWAF: Hydrology

DWAF: National Water Resource Planning

DWAF: Water Resource Planning Systems

DWAF: Water Quality Management

Ndlambe Local Municipality

P & S Consulting Engineers

WSM Leshika Civil Engineers, Hydrologists & Project Managers

ALBANY COAST SITUATION ASSESSMENT STUDY

MAIN REPORT

EXECUTIVE SUMMARY

1. INTRODUCTION

In October 2003, at the request of the Easter Cape Regional Office, the Directorate: Water Resource Planning of the Department of Water Affairs and Forestry (DWAF) commissioned the Albany Coast Situation Assessment Study.

The study was triggered by the fact that a number of towns situated within the coastal belt of drainage region P (Port Alfred, Bathurst, Kleinemonde, Kenton on Sea, Boesmansriviermond, Boknes, Cannon Rocks and Alexandria) experience serious periodic water supply problems, mainly because of inadequate sources, poor water quality and insufficient capacity of their bulk supply infrastructure. The aim of the study was to investigate the water resources situation in the entire region and in particular the water supply problems of the afore-mentioned towns, as well as to consider possible solutions that may present themselves for ready implementation. The study therefore comprised two main components, both undertaken at reconnaissance level of detail - water resources situation assessment study for drainage region P and a development options study for the augmentation of the water supply to the affected towns.

The set of study reports includes this Main Report, as well as the following supporting reports: Main Report Volume 2: Appendices, Stream Flow Hydrology, Water Quality and Groundwater Resources.

2. BASE INFORMATION

The study area (about 5 300 km^2), known as the Albany Coast, covers drainage region P, which is located along the coast, midway between Port Elizabeth and East London and extends about 70 km inland. The area falls under the jurisdiction of the Cacadu District Municipality and includes a number of formal urban towns, the biggest being Grahamstown and Port Alfred.

The topography around the coast is mainly flat, while it becomes steep and mountainous towards Grahamstown to the north. The area is drained by three main rivers – the Kowie, the Kariega and the Lower Bushmans, which are perennial and flow in the south-easterly direction from the mountainous inland towards the Indian Ocean. The area is divided into 4 tertiary and 16 quaternary catchments **(Figure 3.2)**.

The runoff in the study area is regulated by about 50 small and medium sized dams used predominantly for water supply to the local population and for irrigation. The main dams are the New Year's Dam, the Settlers Dam and the Sarel Hayward Dam. The mean annual precipitation (MAP) for the quaternary catchments within the study area varies between 386 mm and 715 mm. The mean annual evaporation (S-pan equivalent) varies between 1450 and 1650 mm.

According to the latest Census 2001 results, the present (base year 2001) population size in the study area is about 139 000 people, of which 119 000 live in urban areas and about 20 000 in rural areas. It is projected that by year 2025 the total population will grow to about 170 000, resulting in an average growth rate of about 0.8% per annum. The relatively high growth is associated with the increase of the urban population mainly in the costal towns and in Grahamstown.

The predominant type of land-use within drainage region P is for grazing (4 400 km²). The area covered by nature reserves (including the indigenous forests) is 278 km². About 380 km² of land is used for dry land agriculture, while only about 7 km² of land is irrigated. Afforestation covers about 6 km² and urban areas are about 25 km². A significant portion of the land is infested by invasive alien plants – 230 km² (4% of total). The most severe infestation occurs along the coastal strip at Boesmansriviermond and Kenton on Sea.

The number of equivalent large stock units in the study area is estimated at about 90 000.

3. WATER REQUIREMENTS

The water requirements for study area were estimated per quaternary catchment for each of the following user sectors: urban domestic and industrial, rural domestic, stock watering, irrigation, afforestation, invasive alien plants and ecological. The current and projected use of groundwater sources, the inter-basin transfers, as well as the return flows from the urban areas were also taken into consideration. This was done in order to estimate the consumptive water requirements imposed on the surface water resources. The results of the estimates for the water requirements per user sector in the study area are shown in **Table E3** on the following page.

The urban water requirements were estimated on the basis of the methodology developed for the National Demographic Study (NDS) (Schlemmer *et al*, 2001) taking into account the direct and indirect water use. The population in each urban centre was divided into the seven categories of water use on the basis of the relevant data from Census 2001, as well as based on site information obtained during the course of this study. The unit water use per category as recommended by the NDS was applied in order to determine the direct water requirements. In addition, an allowance has been made for bulk conveyance and distribution losses.

The reduction of runoff owing to infestation with invasive alien plants has been modelled using the SHELL model. The estimates for the ecological Reserve were produced on the basis of the desktop methodology applying the Hughes model. The ecological management classes, used as an input to the model, have been assessed by a team of environmental specialists during a workshop in August 1999. The ecological Reserve requirements in the study area vary between 11% and 18% of the mean annual runoff, but these are not included in the table everleaf as they are specific for each development site.

The groundwater usage has been estimated and projected in broad terms. The existing records of current usage from groundwater have been taken into account, while the projected future groundwater usage was based on a regional scale desktop study, which assessed the potential for development of the groundwater resources in the area. Owing to the lack of accurate data, it has been assumed that 40% of the total urban water usage in towns with water-borne sewer systems will return to the surface water system.

The inter-basin transfer scheme from the Lower Fish River Government Water Scheme to Grahamstown has an installed capacity 3.65 million m³/a. The actual volume transferred in 2001 was 2.3 million m³, but it has been assumed that the full capacity of the system will be reached by about 2016.

Table E3: Consumptive Water Requirements per User Sector

User Sector	Water Requirements ($10^6 m^3/a$)			
	2001	**2005**	**2015**	**2025**
Urban domestic and industrial	7.88	9.95	12.35	13.89
Rural domestic	0.40	0.42	0.42	0.39
Stock watering	1.67	1.67	1.67	1.67
Irrigation	12.78	12.78	12.78	12.78
Afforestation	0.16	0.16	0.16	0.16
Invasive alien plants	16.81	16.81	16.81	16.81
Total consumptive requirements	**39.70**	**41.79**	**44.19**	**45.69**
Return Flows	-2.35	-2.69	-3.08	-3.20
Inter-basin transfer	-2.31	-2.80	-3.45	-3.65
Groundwater supply	-1.97	-2.60	-2.73	-3.11
Total inflows	-6.63	-8.09	-9.26	-9.96
Total use from surface water	**33.07**	**33.70**	**34.93**	**35.73**

4. WATER RESOURCES

The stream flow analysis of the surface water resources for drainage region P has been undertaken per quaternary catchment on the basis of WR90. The total natural MAR for the study area is estimated at 173 million m³/a and the present day MAR at 132 million m³/a.

The Water Resources Yield Model (WRYM) was used to determine the yield at the outlets of the quaternary catchments and at three dam sites. The model was configured for two scenarios - with and without provision for the release of the Ecological Reserve Requirements (ERR). All quaternary catchments in the study area are generally in balance (no surplus yield available), except for P40C which has a surplus yield of 4.0 million m³/a.

The surface water quality in the middle and lower reaches of region is generally poor owing to the geology of the catchment, which is of a marine origin. Both the Bushmans and the Kariega Rivers are classified as "completely unacceptable" in terms of water quality according to the Mineralogical Classification of DWAF. The maximum total dissolved salts (TDS) in these rivers are often greater than 3 400 parts per million (ppm). The water quality of the Kowie River is classified as "poor" with maximum levels of TDS in the region of 1 800 to 3 400 ppm.

The groundwater resources of drainage region P are currently not being utilised to their full potential, with present groundwater use in the order of 2.0 million m^3/a. Although many of the towns within the study area already rely on groundwater as the primary water source, more groundwater sources can be harvested in a sustainable manner to augment the water supply to certain areas. In general, the groundwater harvest potential for the area is positive (41 million m^3/a), but the actual utilisable resources are subject to economic, water quality and environmental constrains. It is estimated that additional groundwater sources with acceptable water quality (Class 0 and I) with a yield of about 2.6 million m^3/a can be utilised in a sustainable manner.

A number of sites within the fractured Witpoort aquifer are considered to have relatively high groundwater potential. Exploration drilling undertaken during the course of the study has confirmed the potential for the development of these sites. Drilling depths vary between 100 m to 180 m with success rates of between 30% and 60% and an average yield of about 4 l/s.

Another source with high potential yields is the Intergranular Coastal Aquifers. Boreholes drilled in those areas are expected to yield in the order of 3 to 5 l/s of Class I and Class II water. Some of the sources from the dune aquifer system, like Kwaaihoek and Sunshine Coast well fields, fall within the jurisdiction of the Sanparks and approval from the Department of Environmental Affairs and Tourism (DEAT) is required before any implementation processes for the development of these sources can commence.

This marine-originated geology causes salinization or mineralisation of groundwater, which results in poor quality water. Generally the quality of groundwater varies between a Class I and II. Over-pumping of coastal aquifers results in saline intrusions that cause the water quality to deteriorate. This is currently the phenomenon during peak seasons when water demands are higher than during normal periods.

5. DEVELOPMENT OPTIONS

This part of the report deals with the identification, sizing, costing and evaluation of the development options required to augment the sources of water supply in certain towns within the study area, which experience serious water supply problems.

5.1 POPULATION NUMBERS IN THE AFFECTED TOWNS

The present and projected population numbers in the affected towns were estimated in accordance with the methodology described in detail in **Section 3.1** in this report. The results are shown in the **Table E5.1**. As seen from the table the projected population growth rates vary substantially – from 0.5% per annum in the case of Alexandria to 5% per annum in the case of Boknes and Cannon Rocks. The estimated additional seasonal population is also shown.

Table E5.1: Projected population numbers for selected urban centres

Quat.	Town	Population numbers				
		2001	2005	2015	2025	Seasonal
P10G	Kenton on Sea/ Bushmans	9 480	12 745	13 734	14 539	15 000
P20A	Alexandria	7 715	8 371	9 178	8 720	-
	Boknes / Cannon Rocks	931	1 422	2 573	2 949	2 500
P40C	Port Alfred	20 965	27 526	35 376	40 542	15 000
	Bathurst	5 549	6 497	6 445	6 227	-
P40D	Kleinemonde	1 450	1 833	2 156	2 471	2 000

5.2 PROJECTED WATER REQUIREMENTS FOR THE AFFECTED TOWNS

The projected water requirements were estimated in accordance with the methodology developed for the NDS. The methodology is described in detail in **Section 4.1** of the main body of the report**.** The results are shown in **Table E5.2**. The table also shows the yield of the existing water sources of supply in each town, as well as the deficit or surplus in water availability in relation to the water requirements in 2005.

Table E5.2: Projected water requirements, capacity of existing source and deficit

Town	Total gross water requirements				Yield of source	Growth in use	Deficit (-) Surplus (+)
	10^6 m^3/a				10^6 m^3/a	%	%
	2001	2005	2015	2025	2005	2005 to 2025	in 2005
Kenton on Sea/ Bushmans	0.66	0.91	1.21	1.49	0.52	64%	-75%
Alexandria	0.52	0.62	0.79	0.76	0.65	23%	+5%
Cannon/Boknes	0.18	0.25	0.46	0.53	0.24	109%	-5%
Port Alfred	1.27	2.16	3.04	3.90	1.73	81%	-25%
Bathurst	0.26	0.34	0.39	0.41	0.30	23%	-12%
Kleinemonde	0.05	0.08	0.12	0.16	0.15	88%	+44%

For the period 2005 to 2025 the water requirements are expected to grow from as little as 23% in Alexandria and Bathurst, to 88% in Port Alfred, and 109% in Cannon Rocks and Boknes.

The deficit in the capacity of the existing water source, compared to the water requirements in 2005 is the greatest for Kenton on Sea/Boesmansriviermond (-75%) followed by Port Alfred (-25%). This indicates that the water supply situation in these towns is the most critical.

5.3 OUTLINE OF PLANNING CONSIDERATIONS

5.3.1 Reasons for water supply problems

Most of the affected towns currently experience severe water supply problems, which are related to one or more of the following reasons:

- **Poor water quality**. All towns except Alexandria are supplied with water with salinity levels exceeding those recommended for long-term use (TDS should be lower than 1 000 mg/l). During normal periods the TDS for the water supplied to these towns exceeds 1 400 mg/l, but during certain periods could reach levels as high as 3 000 mg/l. This is associated with the specific geological conditions in the lower part of the drainage region, where these towns are located.

- **Inadequate capacity of the existing water sources**. The water resources with acceptable water quality in the drainage region are very scarce. As seen from **Table E 5.2** the water sources for some of the affected towns have inadequate capacity to meet the present water requirements and urgent augmentation is required. The existing water sources are insufficient to meet the 2025 requirements for all towns.

- **Inadequate capacity of the bulk supply infrastructure**. Some of the affected towns located in the coastal area are holiday destinations. The summer peak factors (SPF) in these towns vary in the range of 1.5 to 1.8 of the annual average daily demands (AADD), while the extreme peaks can reach as high as 3 times the AADD. In some cases the bulk supply infrastructure (water treatment plants, storage reservoirs, bulk supply conveyance system) have inadequate capacity to provide for the peak requirements.

5.3.2 Possible sources of supply

Owing to the high seasonal variability of flows, the available run-of-river yields are insufficient to supply the demands in the study area at the required assurance level of 98%. Therefore, run-of-river schemes are considered not feasible and do not form part of the proposed development options.

The surface water quality is poor in the middle to lower reaches (a belt within about 40 to 50 km from the coast line) of the study area. Conveying water from surface sources located beyond the problematic areas is expected to be costly.

Areas with high potential for groundwater development were identified during the course of this study. Exploration drilling was also done. In general, the yields per borehole are expected to be low (not exceeding 4 l/s), and the water quality in the lower reaches of the study area is expected to be poor (possibly Class II and higher). However, potential sites with superior water quality have been identified mostly in the coastal aquifer.

The expected yield of acceptable quality groundwater appears to be sufficient to supply the towns of Alexandria, Cannon Rocks/Boknes and partially Kenton on Sea. However, some of the identified sources are located within the environmentally sensitive coastal dunes. Any exploration of these resources will be subject to acceptable environmental impact management measures.

Desalination of seawater through the process of reverse osmosis is currently used as one of the sources of supply to Kenton on Sea and Boesmansriviermond. Subject to the acceptability of the high operation and maintenance costs, this technology is suitable for the study area as it produces water of a superior quality.

5.3.3 Water usage and conservation

No sufficient data was available to assess the current losses in the distribution networks of the affected towns. The water requirement projections were based on the assumption that the best water conservation and demand management practices will be maintained.

At present, the water is generally being used wisely. Owing to the poor water quality supplied to the affected towns, most of the households have rainwater harvesting facilities. The upmarket houses and some of the public buildings are equipped with dual internal plumbing systems, which distribute the harvested rainwater for domestic use. In these cases the municipal supply is used predominantly for gardening. The usage of bottled water for cooking and drinking purposes is a common practice for those who can afford it. The effect of the utilisation of rainwater has not been considered as this source of supply generally has low assurance.

5.4 IDENTIFICATION OF DEVELOPMENT OPTIONS

An investigation of the water supply infrastructure for each of the affected towns has been carried out during the study. A detailed description of the existing infrastructure and its capacity is available in **Section 5** of the main body of the report.

Based on the specific circumstances in and around each town (water supply situation, capacity of infrastructure, available water sources, water quality, etc.) various development options for the augmentation of the water sources and the bulk water supply infrastructure have been identified and evaluated. Options range from individual groundwater supply schemes, regional surface water schemes supplying a number of towns in the area, to conjunctive use schemes and sea or brackish water desalination schemes. Details are available in **Section 8.4** of the main body of the report. The layouts of the proposed development options are illustrated in **Figure 13.1** and **Diagrams S1 to S7**. Diagrams showing the possible timing of implementation of the various components of each scheme are shown in **Figure 13.2**. The milestone parameters for the infrastructure components for each option are summarised in **Table 8.4** (page 74) of the main body of the report.

The economic evaluation was done on the basis of the unit reference value (URV) of water supplied, calculated on the basis of the models developed for the VAPS study. The economic parameters for the development options are summarised in the **Table E5.4**.

Table E5.4: Economic parameters for the development options

Option No.	Development Option	Tot Capital Cost (R mil)	Tot Annual O&M (R mil)	Residual Value (R mil)	Max Energy (R mil)	URV of Water, 6 % discount (R/m³)
1	Alexandria – GW	R 10.609	R 0.151	R 3.674	R 0.056	R 15.22
2	Cannon Rocks – GW	R 5.619	R 0.104	R 1.746	R 0.043	R 5.02
3	Kenton on Sea – GW	R 28.114	R 0.425	R 10.008	R 0.483	R 10.08
4a	Kenton on Sea – RO1	R 34.646	R 0.771	R 14.750	R 0.937	R 13.56
4b	Kenton on Sea – RO2	R 28.767	R 0.606	R 9.709	R 0.739	R 11.33
5	Kenton on Sea – SW	R 41.335	R 0.499	R 14.681	R 0.716	R 10.21
6	Port Alfred – GM 1	R 130.907	R 1.538	R 48.291	R 1.539	R 10.68
7	Port Alfred – GM 2	R 98.241	R 1.196	R 36.947	R 1.212	R 9.97
8a	Port Alfred – SH	R 55.184	R 0.622	R 24.331	R 0.496	R 5.70
8b	Port Alfred – SH & RO	R 73.535	R 1.148	R 31.617	R 1.290	R 8.27
9	Port Alfred – SD	R 100.456	R 1.292	R 38.524	R 1.282	R 10.91
10	Port Alfred – RO	R 84.108	R 2.030	R 31.744	R 2.447	R 10.85

It should be noted that the figures regarding the URV in the above table are very rough and are provided only for comparison purposes. Owing to the reconnaissance nature of this study, the phased implementation of the components associated with the development options has not been taken into account when running the economics models. This may have resulted in certain inaccuracy of the calculated URV's.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 DEVELOPMENT OPTIONS

6.1.1 Introduction

The water supply situation in most of the affected towns is not ideal and steps for the augmentation of the water sources need to be taken. However, the situation in Kenton on Sea/Boesmansriviermond, Cannon Rocks/Boknes and Port Alfred is critical and emergency measures for augmentation of the water sources for these towns are urgently required.

Where possible, this study has identified solutions to the water supply problems that present themselves for immediate implementation. In other cases, more detailed investigations have been recommended to be undertaken before final decisions on the best solutions can be made. A summary of the cost estimates for the proposed augmentation schemes is given in **Section 8.6** and more detail is available in **Appendix 10**. A detailed description of the components of the proposed schemes is given in **Section 8.4** and a summary in **Table 8.4.**

The specific recommendations for each town are offered in the next paragraphs. The responsibility for further actions is indicated in brackets and in bold print after each recommended action. Where the Ndlambe Local Municipality (NLM) has been identified as the responsible institution, they will most likely have to rely on Municipal Infrastructure Grant (MIG) funding. The NLM should draw up an implementation strategy, based on the recommendations in this report. Provision of direct financial assistance from DWAF for implementation of infrastructure is unlikely. However, when the implementation strategy is completed, NLM can approach DWAF for further advice and assistance. Where possible, it terms of current legislation, DWAF will do its best to assist.

When estimating the water requirements it has been assumed that the best water demand management measures would be implemented. In all towns, projects are recommended to assess the levels of existing losses in the bulk supply and reticulation systems, to propose measures for the reduction of those losses and to undertake the necessary remedial work. This will ensure that the limited resources are utilized in the most efficient manner. **(NLM, but DWAF can provide assistance in terms of advice).**

The NLM should not allow substantial housing developments in the most affected towns before solutions to the severe water supply problems are identified and implemented.

6.1.2 Alexandria

- The existing water source (Fishkraal coastal aquifer) has sufficient yield to meet the projected water requirements until 2007. Thereafter the source needs to be augmented.
- The water quality of the source is of acceptable standard.
- The additional water source from the Fishkraal coastal aquifer, identified during the course of this study, has sufficient capacity to meet the water requirements until 2025 and beyond. The development of this source can commence as soon as a record of decision from the Department of Environmental Affairs and Tourism (DEAT) is received. **(NLM, funding from MIG, but DWAF can assist with advice).**
- The NLM should follow up with the DEAT with regards to the outcome of the application for approval of the further exploration of the Fishkraal costal aquifer submitted earlier.
- If the Fishkraal coastal aquifer development is acceptable from an environmental point of view, the source should be developed and the phasing of the upgrading of the bulk supply system should be optimized. The total capital cost for this development is estimated at R10.6 million at April 2004 price levels **(NLM, but DWAF can assist with advice).**
- The existing bulk supply system is undersized and needs to be upgraded urgently. However, a decision on the likely additional water source needs to be made before the upgrading of this system. **(NLM, funding from the MIG as budgeted for in the Water Services Development Plan (WSDP)).**
- If the Fishkraal coastal aquifer development is not acceptable, the existing bulk supply system should be upgraded to the capacity of the source. This will ensure adequate water supply until 2007. Further groundwater investigations should be undertaken at the same time in order to identify alternative groundwater sources. Investigations

should include studies and exploration drilling. **(NLM to appoint a specialised consultant, but DWAF can assist with advice).**

- It should be noted that at a capital cost exceeding R10 million the proposed scheme based on the Fishkraal coastal aquifer is already relatively expensive. Owing to the shortage of water sources with acceptable water quality standards in the area, the alternatives to that scheme, which include the utilization of inland surface water, or groundwater, are expected to be prohibitively expensive.

6.1.3 Cannon Rocks/Boknes

- Although the existing Cannon Rocks water source (boreholes) is theoretically adequate to meet the projected water requirements of Cannon Rocks and Boknes until 2005, the water is of poor quality and the pattern of demand makes supply during the peak holiday season very expensive and unreliable. The water source needs to be augmented urgently.
- Additional storage capacity will be required within the bulk supply system to meet the growing peak requirements **(NLM).**
- The coastal aquifer at the Apies River has sufficient supplementary yield of acceptable quality to meet the projected future requirements at least until 2025. Subject to the approval of the EIA report, this source should be developed at an estimated cost of R5,6 million. (**NLM, but DWAF can be approached for advice).**
- The NLM should follow up with the DEAT with regards to the application for the development of the Apies River coastal aquifer submitted earlier.
- If the Apies River development is not acceptable, further investigations should be undertaken in order to identify alternative groundwater sources. Investigations should include studies and exploration drilling **(NLM to appoint a specialised consultant, but DWAF can be approached for advice)**.
- As it is unlikely that groundwater with acceptable quality standards will be identified in this coastal area, the use of brackish groundwater in combination with reverse osmosis desalination facilities could be considered as an alternative to the proposed Apies River coastal aquifer development. (**NLM to appoint a specialised consultant, but DWAF can be approached for advice).**

6.1.4 Kenton on Sea and Boesmansriviermond

- The existing water sources (Diaz Cross aquifer and a sea water desalination plant) are unable to meet the present water requirements even during low consumption periods. The system is severely stressed during peak periods. Water restrictions and even water outages are common. Urgent measures for the augmentation of the water source need to be taken.
- The water of the coastal aquifer sources (Diaz Cross and Kwaaihoek) is saline, but when mixed with desalinated water, the product is of an acceptable quality.
- The coastal aquifer at Kwaaihoek with a yield of 0.11 million m^3/a can be developed reasonably quickly as the existing bulk supply system from Diaz Cross has sufficient capacity to convey the additional flows. The development of this source at an

estimated cost of R800 000 will bring some relief to the water supply situation, but the total yield of all sources will still be insufficient to meet the present water requirements.

- The Albany Coast Water Board (ACWB) on behalf of NLM should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of this source for approval by DEAT.

- If approval is granted, the source should be developed urgently as a fast track project (**ACWB and NLM, but DWAF will support with advice).**

- Concurrently with the above, the ACWB should follow up with the DEAT on the application submitted earlier regarding the proposed upgrading of the RO plant.

- If the upgrading is approved, the proposed upgrading of the RO plant should be implemented urgently as a fast track project at an estimated cost of R6.0 million. This will increase the combined capacity of the water sources by 0.3 million m^3/a. The combined available yield will then be sufficient until 2006. (**ACWB and NLM, funding from the MIG as budgeted for in the WSDP).**

- The ACWB should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of the proposed Merville and Bushfontein groundwater sources and the associated bulk supply conveyance systems**.**

- Concurrently, a geohydrological consultant should be appointed to evaluate the potential for development of the rest of the Witpoort formation to the south east of Merville. The study should include exploration drilling and testing. **(ACWB and NLM, but DWAF can be approached for advice).**

- Once the extent of the possible future development of the overall Witpoort formation is established and DEAT approval is received, the Merville groundwater source (yield 0.29 million m^3/a) should be developed and the bulk conveyance system between Merville and Kenton on Sea should be optimised and constructed as a fast track project. The capital cost of this development is estimated at R12 million. If this source is developed the total combined yield of all sources will be sufficient until about 2010. (**ACWB and NLM, funding from the MIG).**

- The development of the Bushfontein groundwater source (yield 0.29 million m^3/a) and/or other groundwater sources, which may be identified within the Witpoort aquifer, together with the associated conveyance system should follow when required for further augmentation of the source. The incremental cost for the development of the Bushfontein source is estimated at R9 million. If this source is developed the total combined yield of all sources will be sufficient until about 2015. (**ACWB and NLM, possible funding from the MIG, DWAF can assist with advice).**

- At that later stage, the water supply situation will have to be reviewed through additional studies, which need to identify the best further development options to follow. **(NLM, but DWAF can be approached to provide assistance in terms of management and funding for the study)**. At least the following options should be considered:

    - Construction of an additional RO plant sourced by sea water, or brackish water, including a possibility to recharge the coastal aquifer with effluent (subject to confirmation of the availability of a brackish water source with the required capacity, acceptable environmental impact, and if the water quality problems associated with the creation of a closed loop can be resolved).

- o Development of a regional surface water scheme, which would include the supply to Port Alfred. Such a regional scheme is discussed in the following section.

6.1.5 Port Alfred and Regional Schemes

- At present the existing water sources (Sarel Hayward Dam and boreholes) are sufficient. However, substantial proposed new housing developments will most likely necessitate the urgent upgrading of the source before 2006.
- The water quality of the existing sources is below the acceptable standard.
- The internal reticulation system and balancing storage reservoirs do not have sufficient capacity to meet the peak seasonal requirements and urgent upgrading is required **(NLM, MIG funding).**
- Additional groundwater sources with anticipated acceptable water quality and a total yield of 0.64 million m^3/a have been identified to the west of the town in the areas of Glendower and Sunshine Coast. With the development of these sources the water requirements will be met until about 2007, which will provide much needed relief to the present water supply situation and will allow time for further investigations to identify the best augmentation option to follow.
- The NLM should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of this source for approval by DEAT.
- If approval is granted, the source and the associated conveyance system should be developed urgently as a fast track project at an estimated cost of R 8,0 million **(NLM, but DWAF can assist with advice).**
- A more detailed study should urgently be commissioned in order to assess the feasibility of a possible regional scheme (inter-basin transfer, or joint inter-municipal water supply scheme) to supply Port Alfred and to other towns in the area. Such scheme should be implemented before 2008 at an estimated cost varying between R47 million and R92 million depending on the option selected. **The study can possibly be funded and managed by the DWAF, but the NLM should formally request the Regional Office of the Department for assistance).**

The study should include the following components and activities:

Engineering aspects:

- o Overall study management and co-ordination of the multidisciplinary team
- o Review of water requirements and water resources
- o Review and identification of competitive options. Consider supply from: groundwater, raising of the Sarel Hayward Dam, Glen Melville Dam, Settlers Dam, desalination of sea or brackish water, etc.
- o Site investigations and surveys: geotechnical, land surveys, etc as required

- Engineering sizing and costing based on preliminary designs and site specific information
- Economic models and evaluation
- Implementation strategy, including programmes and funding sources

Hydrogeological aspects:

- Undertake further hydro-census and field investigations into the potential for development of groundwater sources for the supply of Port Alfred, Bathurst, Kleinemonde and Kenton on Sea.
- Undertake exploration drilling and testing in order to determine the parameters of each identified source

Ecological aspects:

- Undertake site surveys and acquire necessary field information
- Determine the Ecological Reserve at specific surface water development sites
- Produce EIA and scoping reports for approval by the DEAT for the selected development options
- Public participation and shareholder involvement

It is anticipated that such study can be completed in 18 months at an estimated cost of about R3,0 million.

- A decision on the implementation of further augmentation options should be taken on completion of the afore-mentioned study. **A number of institutions should be party to such a decision, e.g. DWAF, Cacadu DM, NLM, Makana DM, DEAT, etc.**

6.1.6 Bathurst

- The existing water source (Golden Ridge Dam) has sufficient yield to meet the present water requirements until about 2006. However, if the old town is provided with water services, the water source will have to be upgraded. Also an Ecological Reserve determination should be carried out to verify the yield of the Golden Ridge Dam. This should be included in the scope of services for the study referred to in the previous section.
- The water quality of the existing sources is below the acceptable standard.
- The capacity of the existing water treatment works is insufficient and needs to be upgraded urgently as a fast track project **(NLM, MIG funding).**
- The augmentation of the existing water source can be done through one of two options:
    - Supply from a possible regional scheme, which is developed to supply Port Alfred, if the bulk supply system runs near Bathurst. Clarity on this longer term option will be available on completion of the study referred to in the previous section.
    - If augmentation is urgent, local groundwater sources should be sited and developed **(NLM, but DWAF can assist with advice)**.

6.1.7 Kleinemonde / Seafield

- The existing water sources (Mount Wellington Dam and boreholes) have sufficient capacity to meet the present water requirements during normal periods, but not during peak season. Normal requirements can be supplied until about 2015.
- The water quality of the existing sources is below the acceptable standard.
- The capacity of the existing water treatment works is insufficient and needs to be upgraded urgently as a fast track project **(NLM, MIG funding).**
- The capacity of the existing storage reservoirs should be increased in order to provide for peak requirements **(NLM, MIG funding).**
- The NLM should appoint a consultant to verify the yield of the Mount Wellington Dam **(NLM, DWAF can be approached for technical assistance).**
- The augmentation of the available water source could be done through the development of additional groundwater sources. The NLM should appoint a specialised consultant to identify potential drilling sites. **(NLM, but DWAF can assist with advice).**

6.2 IMPLEMENTATION STRATEGY

- NLM is the institution responsible for the implementation of the actions recommended in this report.
- NLM should draw up an implementation strategy for the actions recommended in this report, taking into account the water supply situation in each town, the availability of funds and resources within the municipality and the timing for implementation.
- NLM can appoint a consultant, familiar with the water infrastructure and the water resources in the area, to assists with the compilation of such strategy.
- In the implementation strategy, NLM should make provision for water demand and water loss management project in the affected towns.
- On the basis of the implementation strategy, NLM should seek assistance and support (financial, advisory, etc.) form the Cacadu District Municipality and other institutions and authorities. DWAF should also be approached to discuss the details of the advisory assistance that can be provided.
- NLM should not allow new substantial developments before solutions to the severe water supply problems can be found and implemented.

DEPARTMENT OF WATER AFFAIRS & FORESTRY

DIRECTORATE: NATIONAL WATER RESOURCE PLANNING

ALBANY COAST SITUATION ASSESSMENT STUDY

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LIST OF ACRONYMS

10^6 m^3/a	million cubic metre per year
AADD	average annual daily demand
AEMC	attainable ecological management class
BH	borehole
BPT	break pressure tank
CLRM	clean water raising main
CSIR	Council for Scientific and Industrial Research
CWGM	clean water gravity main
CWPS	clean water pump station
DEAT	Department of Environmental Affairs and Tourism
DEMC	default ecological management class
DESC	default ecological sensitivity class
DM	District Municipality
DSL	dead storage level
DWAF	Department of Water Affairs and Forestry
EIA	Environmental impact assessment
EISC	ecological importance sensitivity class
ELSU	equivalent large stock units
ERR	ecological reserve requirements
GAADD	gross average annual daily demand
GW	groundwater
hr	hour
IAP	invasive alien plants
m^3/d	cubic metre per day
m^3/h	cubic metre per hour
km	kilometre
l/c/d	litre per capita per day
l/day	litre per day
LFw	water treatment loss
LFr	conveyance loss
LM	Local municipality
l/s	litre per second
MAE	mean annual evaporation
mamsl	metres above mean sea level

MAP	mean annual precipitation
MAR	mean annual runoff
mg/l	milligram per litre
MIG	Municipal Infrastructure Grant
m^3/a	cubic metre per year
m^3/d	cubic metre per day
m^3/h	cubic metre per hour
ND	nominal diameter
NDS	National Demographic Study / Schlemmer *et al*, 2001
NGL	natural ground level
No	number
PE	polyethylene
PESC	present ecological status class
ppm	parts per million
Res	reservoir
RO	reverse osmosis
RWGM	raw water gravity main
RWPS	raw water pump station
RWRM	raw water raising main
SDDpl	summer daily demand (for bulk pipelines and pump
SDDpu	summer daily demand (for boreholes and BH pump
SDDww	summer daily demand (for water treatment works)
SPF	summer peak factor
TDS	total dissolved salts
WR90	Surface Water Resources of South Africa, Water Research Commission, 1990
WRYM	Water Resources Yield Model
WTW	water treatment works

1. INTRODUCTION

In October 2003 the Directorate: National Water Resource Planning of the Department of Water Affairs and Forestry (DWAF) commissioned a study titled: "Albany Coast Situation Assessment". UWP Consulting was appointed as the lead consultant, in association with DMM Development Consultants (DMM) and Water System Management (WSM).

The study area, known as the Albany Coast, covers about 5 300 km^2 of land and is situated within the drainage region P. It is located between the catchments of the Great Fish River, the Sundays River and the Indian Ocean, in the south-western part of the Eastern Cape. The study area falls under the jurisdiction of the Cacadu District Municipality and includes portions of four Local Municipalities – Ndlambe, Sunday's River Valley, Blue Crane and Makana (see **Figure 1.1**)

A number of coastal and inland towns situated within the coastal belt of the study area experience serious periodic water supply problems, mainly because of inadequate sources, poor water quality and insufficient capacity of their bulk supply infrastructure. These towns are Port Alfred, Bathurst, Kleinemonde, Kenton on Sea, Boesmansriviermond, Boknes, Cannon Rocks and Alexandria, all situated within the Ndlambe Local Municipality.

The purpose of the study is to investigate at a reconnaissance level the water supply problems of the area, with a specific reference to the afore-mentioned towns, through a broad review of existing information, and to consider possible solutions that may present themselves for ready implementation.

Although the primary focus of the study would be to resolve the water supply problems for the specified towns (urban sector), when investigating the availability of water resources, due consideration has been given to meeting the legitimate water requirements of all other users in the catchment, including rural domestic, agricultural, afforestation, ecological Reserve, etc. For this reason, a water balance for the entire catchment has been compiled.

The study therefore comprises two main components, both undertaken at reconnaissance level of detail:

- Water resources situation assessment for the entire drainage region P
- Development options study for the augmentation of the water supply to the coastal towns

The Terms of Reference for the study is attached in **Appendix 2**. The set of study reports include this main report, as well as three supporting reports namely the Surface Water Resources, Groundwater Resources and Water Quality supporting reports.

This report is structured in the following manner.

An overview of the physical characteristics of the study area is covered in **Section 2** of the report. This includes location boundaries, topography, rivers, drainage regions, climate, geology and soils, natural vegetation cover, ecological sensitivity, and cultural or historical heritage sites.

Section 3 covers the demography and development status and includes current and future land-use, industrial, general and water related development.

Section 4 provides an estimate of the present and future water requirements for all user sectors in the study area, projected until the year 2025.

The water supply situation at each of the affected towns is described in **Section 5**.

Section 6 provides an overview of the existing major water related infrastructure.

An overview of the available water resources (surface and groundwater) is offered in **Section 7**.

A number of development options are presented in **Section 8** including the factors that could affect the feasibility thereof.

Section 9 includes the conclusions and recommendations of this study.

2. BASE INFORMATION

2.1 OVERVIEW OF THE STUDY AREA

The Albany Coast (study area) is located along the coast of the Eastern Cape Province, midway between Port Elizabeth and East London, extends about 70 km inland and covers an area of about 5 300 km^2. From a hydrological perspective the area covers primary drainage region P, which is sub-divided into 4 tertiary and 16 quaternary catchments. Refer to **Figure 1.1** for the locality and overview of the study area.

The area falls under the jurisdiction of the Cacadu District Municipality and includes portions of four Local Municipalities – Blue Crane in the north-west, Makana in the north, Sunday's River Valley in the south-west and Ndlambe in the south-east.

The study area includes a number of formal urban towns, but has no metropolitan centres. The biggest towns are Grahamstown and Port Alfred. Most of the rural population is scattered and consists of farm labour living on private farmland. The following smaller towns are included in the area: Riebeeck East, Bathurst, Kenton on Sea, Boesmansriviermond, Alexandria, Alicedale, Paterson, Boknes, Cannon Rocks and Kleinemonde. Port Elizabeth, part of the Nelson Mandela Metropolitan Municipality, is the nearest metropolitan area and is situated approximately 100 km south-west of Grahamstown.

The study area includes 120 km of coastline with six of the urban towns situated along the coast. The region can be accessed from King William's Town on the N2 south, or from Port Elizabeth on the N2 north. Alternative smaller routes are the R67 south from Fort Beaufort and the R72 west from East London.

2.2 TOPOGRAPHY RIVERS AND DRAINAGE REGIONS

The ground elevation within the study area rises from the coastline to a maximum of 935 m above mean sea level (amsl) in the north-western corner near Riebeeck East (**Figure 2.1**). The topography around the coast is mainly flat, while it becomes steep and mountainous towards Grahamstown, Alicedale and Riebeeck East. North of Alicedale, around Riebeeck East, lays the Swartwaters Mountain with elevations between 700 m and 1000 m amsl. The area is deeply incised by the river valleys.

The study area is situated between the catchments of the Great Fish River, the Sundays River, and the Indian Ocean. The area is drained by three main rivers – the Kowie (P40), the Kariega (P30) and the Lower Bushmans (P10) **(Figure 3.1)**. All three rivers are perennial and flow in the south-easterly direction from the mountainous inland towards the Indian Ocean. A number of smaller coastal rivers are located in quaternary catchments P20A, P20B and P40D. The area is divided into 4 tertiary and 16 quaternary catchments **(Figure 3.2)**.

Water quality of these rivers is generally poor owing to the geology of the catchments. Highly saline base flow causes high levels of total dissolved salts (TDS) with both the Bushmans and Kariega Rivers classified as "Completely Unacceptable Water Quality" according to the Mineralogical Classification by the DWAF. The TDS of the Bushmans and Kariega Rivers is greater than 3 400 parts per million (ppm), while the water quality of the Kowie River is classified as "Poor" with TDS in the region of 1 801 – 3 400 ppm.

Figure 3.1 illustrates the river catchments within the study area. **Table 2.2.1** offers a summary of the characteristics of the main rivers.

Table 2.2.1: Characteristics of the main rivers within the study area

River	Quaternary Catchment	Catchment Area (km^2)	Virgin MAR ($10^6 m^3/a$)
Bushmans River	P10A to G	2 757	57.94
Kariega River	P30A to C	647	20.25
Kowie River	P40A to C	918	35.93
Coastal Rivers	P20A & B, P40D	1 000	58.93
TOTAL		**5 322**	**173.05**

The runoff is regulated by a number of small and medium sized dams used predominantly for water supply to the local population and for irrigation. The following main dams are located in the study area.

Dam	Quaternary Catchments	Wall Height (m)	Max Capacity (x 10^3 m^3)	Use
New Year's	P10B	22	4 700	Domestic Supply
Howiesonspoort	P30B	24	883	Domestic Supply & Irrigation
Settlers	P30B	21	5 620	Domestic Supply & Irrigation
Golden Ridge	P40B	13	400	Domestic Supply
Sarel Hayward	P40C	40	2 522	Domestic Supply
Mansfield	P40C	14	165	Domestic Supply
Mount Wellington	P40D	10	250	Farm dam

In addition, 48 registered dams have been built in the area. More information about these dams is provided in **Section 6** and in **Appendix 5**. The position of these dams is shown on **Figure 3.2**.

2.3 CLIMATE, RAINFALL AND EVAPORATION

The climate along the coast is warm to hot throughout the year, with humidity levels rising from December to March. The inland climate is more temperate with warm summers and cool winters. Frost occurs in the inland areas in winter, typically over the period from mid-May to late August. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. Coastal winds are common throughout the year with sea temperatures moderate.

The annual precipitation for the entire region is moderate, while higher annual rainfall values are associated with the coastline. Peak rainfall months are December and January. Annual rainfall values decrease gradually toward the interior. The study area falls within three rainfall zones, P1A, P1B and P4A, as defined by WR90. The mean annual precipitation (MAP) for the quaternary catchments within the study area varies between 386 mm and 715 mm as illustrated in **Figure 4.1** and **Table 2.3.1**. The greatest portion of the study area has a MAP of 400 mm to 500 mm, while the lowest MAP occurs towards the north-west interior – 300 mm to 400 mm. The relative humidity is higher in summer than in winter, generally highest in February and lowest in July. During summer periods the daily mean relative humidity is in the order of 80% and during the winter months the daily mean relative humidity is in the order of 70%.

The mean annual evaporation (MAE) for the region (S-pan equivalent) varies between 1450 and 1650 mm. The entire drainage region falls under evaporation zone 26A. **Figure 4.2** illustrates the mean annual evaporation for the study area and **Table 2.3.1** offers a summary of the mean annual evaporation per quaternary catchment.

Table 2.3.1: Mean Annual Precipitation and Evaporation (S-pan)

Quaternary catchment	Area (km^2)	Rainfall Zone	MAP (mm)	MAE (mm)
P10A	126	P1A	600	1 550
P10B	508		531	1 550
P10C	281		386	1 650
P10D	564		432	1 600
P10E	466	P1B	493	1 550
P10F	469		557	1 550
P10G	343		550	1 500
P20A	422		715	1 500
P20B	332		635	1 550
P30A	176	P4A	623	1 550
P30B	403		559	1 500
P30C	68		536	1 500
P40A	312		635	1 500
P40B	264		570	1 500
P40C	342		616	1 450
P40D	246		666	1 450

2.4 GEOLOGY AND SOILS

Figure 5.1 illustrates the geological zones for the study area, i.e. three different types. Compact, dominantly argillaceous strata (Cape Supergroup) covers the greatest portion of the northern, central, eastern and southern parts of the drainage region P. Part of the P10C quaternary catchment consists of mainly compact tillite, shale and sandstone from the Dwyka formation and Ecca Group. The coastal stretch west of Port Alfred and the south-western portion up to Paterson are underlain predominantly by compact sedimentary strata.

The study area consists of mainly one type of soil, viz. clay loam (illustrated in **Figure 6.1**). This clay loam varies in relief and forms two different categories: flat and undulating. The northern portion consists of moderate to deep clay loam with a flat relief and stretches as far south as Paterson. The area further south of Paterson consists of moderate to deep clay loam with an undulating relief type of soil.

2.5 NATURAL VEGETATION COVER

The major types of vegetation in the study area are Coastal Tropical Forest, False Karoo, False Schlerophyllous Bush, and Karoo and Karroid Types as shown on **Figure 7.1**.

Coastal Tropical Forest

Coastal Tropical Forest type of vegetation is widely spread throughout the study area and crops up as far north as Paterson. This veld type is typically confined to the coastal area or immediate vicinity, and includes areas of forest, thornveld and bushveld. There is considerable turnover in species composition between forest patches and therefore different forest patches typically comprise different species compositions. Rainfall is typically higher than that for Temperate and Transitional Forest and Scrub. Coastal Tropical Forest occurs at any altitude from sea level to 450 m amsl. This veld type exhibits a long history of anthropogenic effects, especially grazing by livestock.

False Karoo Types

This is a less dominant veld type within this study area, occurring towards the northern and north-western parts, excluding the area surrounding Riebeeck East. Similar to Karoo and Karroid veld type, the False Karoo veld type is typified by low vegetation, but in contrast contains more grassy elements. The areas occupied by this veld type are typically very arid and in parts may receive less than 100 mm of rainfall per annum. This veld type generally occurs below 1200 m amsl.

False Sclerophyllous Bush Types

This veld type occurs in certain areas towards the central and northern parts of the study area. It forms a band about 5 km wide and stretches from Alicedale towards the east of Grahamstown, as well as the area surrounding Riebeeck East. False Schlerophyllous Bush is typically indistinguishable from true Fynbos. It is usually dominated by Asterocous elements (daisies). As for Sclerophyllous Bush, the areas occupied by the False Sclerophyllous Bush veld type are typically fairly mosaic, receiving in excess of 500 mm of rainfall per annum.

Karoo and Karroid Types

This veld type occurs in patches widely spread over the entire study area, except along the coast and the far northern areas. The flora is characteristically low, typically less than 1 m in height, and includes scrubs, bushes, dwarf trees and a few grasses. Rainfall within this vegetation type typically ranges between 150 mm and 500 mm per annum, but reaches a maximum of up to 900 mm per annum in some of the river valleys. Karoo and Karroid Types occur at any altitude from sea level to 1700 m amsl.

2.6 ECOLOGICAL SENSITIVITY, RIVER CLASSIFICATION & NATURE RESERVES

Ecological Sensitivity

The conservation of living resources is essential for sustaining development by maintaining the essential ecological process and life support systems, preserving genetic diversity and ensuring that utilisation of species and ecosystems is sustainable. However, for conservation to succeed it should be underpinned by two basis principles, namely the need to plan resource management (including exploration) on the basis of an accurate inventory and the need to implement proactive protective measures to ensure that resources do not become exhausted. Accordingly, a vital component of ensuring sustainable conservation practices is the identification of conservation worthy habitats or sensitive ecosystems.

In terms of section 2(1) of the Environment Conservation Act (No. 73 of 1989), South Africa's schedule of protected areas was published in the Government Gazette 15726 in May 1994 (Notice 449 of 1994). This classification identifies the following sensitive or protected areas: Scientific and Wilderness Areas, National Parks and Equivalent Reserves, National Monuments and areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes, based on their location and the functions they fulfil.

South Africa has also recognised the importance of its wetlands as sensitive ecosystems that require conservation, and accordingly has become a signatory to the international Conservation on Wetlands of International Importance especially as Waterfowl Habitat or RAMSAR Convention. In terms of this convention signatories undertake to include wetland conservation considerations in their national land-use planning, and as far as possible to ensure the wise use of wetlands within their territory.

It would be prudent to give some consideration to the definition of aquatic ecosystems, especially with respect to the National Water Act (No. 36 of 1998). In general terms, an ecosystem may be defined as a community of organisms and their physical environment interacting as an ecological unit. Hence, aquatic ecosystems encompass the aquatic community and water resources necessary to sustain its ecological integrity. Within the National Water Act, the water resource requirements of aquatic ecosystems are recognised and protected by the introduction of the concept of an ecological reserve viz. the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both the quantity and quality of the resource. Accordingly, development must take cognisance not only of the sensitivity of the receiving ecosystem but also of the resource requirements or ecological reserve of the aquatic communities it supports.

2.6.1 River Classifications

The water resources of South Africa are protected in terms of the National Water Act (No. 36 of 1998). The protection of the river system can be achieved by maintaining riverine flows, which are not lower than the Ecological Reserve.

In order to determine the Ecological Reserve, the river reaches have to be classified in terms of their future attainable ecological management class (AEMC). The classification of the river reaches has been done at the bottom of each quaternary catchment in the study area as part of the Water Resources Situation Assessment of the Fish to Tsitsikamma Water Management Area carried out by Ninham Shand in 2002.

The classification has been undertaken on the basis of the methodology described by Kleynhans in 1999 in a report titled "Procedure for the determination of the ecological reserve for the purpose of the National Water Balance Model for South African Rivers, DWAF".

During a number of workshops in 2000 the main stems of the rivers within the quaternary catchments have been classified in the following management classes:

- **Ecological Importance and Sensitivity Class (EISC):** The ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and broader scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its resilience or capacity to recover from a disturbance that has occurred. This class can range as follows: very high, high, moderate or low margined.
- **Present Ecological Status Class (PESC):** This classification indicates the degree to which present conditions of an area have been modified from natural (undeveloped) conditions. Factors that are considered in the classification include the extent of flow modification, inundation, water quality, stream-bed condition, riparian condition and proportion of exotic biota. Values range from Class A (largely natural) to Class F (critically modified).
- **Default Ecological Management Class (DEMC):** A class indicating the ecological importance and sensitivity of an area, as it is likely to have been under natural (undeveloped) conditions, and the risk of disturbance that should be tolerated. Values range from class A (highly sensitive, no risk allowed) to Class D (resilient systems, large risk allowed).
- **Attainable Ecological Management Class (AEMC):** A class indicating the potential to improve the ecological conditions and can be determined by comparing the difference between the present ecological status class and the default ecological status. Values range from class A (unmodified natural) to Class F (critically modified).
- **Default Ecological Sensitivity Class (DESC):** The DEMC relates to a default ecological status class that is assigned to a resource (i.e. river or river reach) depending on the level of ecological importance and sensitivity.

On the basis of similarity of environmental characteristics the quaternary catchments in drainage region P were sub divided into 3 groups.

Group 1	P10A, P10B, P10C, P10D, P30A, P40A
Group 2	P10E, P10F, P10G, P20A, P20B
Group 3	P30B, P40B, P40C, P40D

The ecological management classes determined during the workshops were as shown in the table below.

Table 2.6.1.1: Ecological Management Classification

Quaternary	EISC	DEMC	PESC	AEMC
Group 1	High	Class B	Class C	Class C
Group 2	Moderate	Class C	Class D	Class D
Group 3	High	Class B	Class C	Class C

The water resources situation assessment has been performed at the quaternary catchments scale of resolution. However, the delineation of these quaternary catchments was not based on ecological principles. In order to provide some ecological basis for the estimates of water requirements to maintain a particular class of river it was decided to base estimates of water requirements on an index of the ecological importance and sensitivity class (EISC) of the rivers in the quaternary catchments of concern. The ecological importance and sensitivity class of the rivers was used to derive the default ecological management class (DEMC), which relates to a default ecological status class (DESC). The default ecological status class and the present ecological status class (PESC) have been used to arrive at a suggested future ecological management class (AEMC) to be considered for the water resources. The default ecological status class would normally be assigned to a water resource on the basis of ecological sensitivity and importance. This methodology is based on the assumption that the ecological importance and sensitivity of a river would generally be closely associated with its default ecological management class and that its current ecological status and potential to recover from past ecological damage will determine the possibility of restoring it to a particular ecological management class.

2.6.2 Sensitivity of Aquatic Ecosystems

Sensitive Aquatic ecosystems refer to those ecosystems that are sensitive with respect to possible changes in water quantity and quality. The river reaches in the P10A-D, P30A, P30B and P40A-D quaternary catchments have a default ecological management class (DEMC) of Class A or B and occur in the conservation areas. Any future human manipulation of these reaches would require very strong motivation. The remaining river reaches in the study area have become modified to various degrees and are classified with an ecological importance and sensitivity class (EISC) of “moderate” to “low”. The present ecological status classes (PESC) are derived from the EISCs and DEMCs and are used to determine the ecological flow requirements of the river reaches.

2.6.3 Other Protected Areas

The study area contains protected areas that may be impacted directly or indirectly upon by development activities associated with water resources. These protected areas include National Heritage Sites, Scientific and Wilderness Areas, National Parks and Equivalent Reserves, National Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes. All water resource development and utilisation should take cognisance of these sites and it is the developer's responsibility to identify the exact proximity of activities to any of these sites, and to ensure that activities do not threaten the integrity of these sites. This consideration is particularly pertinent where water resource development activities impact on the supply of water resources to these areas and hence their long-term ecological sustainability.

Table 2.6.3.1 shows the protected areas within the drainage region P.

Table 2.6.3.1: Protected Natural Areas and National Heritage Sites

Quaternary	Area Name	Category
P10E	Tootabi	National Parks and Equivalent Reserves
P20A	Woody Cape Nature Reserve	Habitat and Wildlife Management Area
P20B	Woody Cape West Nature Reserve	Habitat and Wildlife Management Area
P30A	Thomas Baines Nature Reserve	Habitat and Wildlife Management Area
P40A	Beggar's Bush	National Parks and Equivalent Reserves
P40B	Waters Meeting II Nature Reserve	Habitat and Wildlife Management Area
P40C	Barville Park	South African Natural Heritage Site
P40C	Elmhurst	South African Natural Heritage Site
P40C	Glendower	South African Natural Heritage Site
P40C	Kasouga Farm	South African Natural Heritage Site
P40C	Sunshine Coast Nature Reserve -West	Habitat and Wildlife Management Area
P40C	Waters Meeting I Nature Reserve	Habitat and Wildlife Management Area
P40D	Sunshine Coast Nature Reserve -East	Habitat and Wildlife Management Area

Figure 9.1 illustrates the location and boundary of each of the abovementioned areas.

2.7 CULTURAL AND HISTORICAL HERITAGE SITES

Development of water supplies and services can have a negative impact on the archaeological and cultural heritage by way of development of dams, pipelines, canals, water services infrastructure and enterprises following on the provisions of water.

The National Monuments Act (No. 28 of 1969) provides for the protection and conservation of cultural resources including all archaeological sites. In addition, the Environment Conservation Act (No. 73 of 1989) provides for the integration of cultural resources into environmental management processes.

Any given development may have an impact on archaeological or cultural heritage sites. It is essential therefore that the potential impact of any water supply and services related development should be assessed at the earliest possible phase of project planning.

Permission for the development to proceed is granted by the National Monuments Council once it is satisfied that steps have been taken to safeguard archaeological or cultural heritage sites, or that they have been adequately recorded and/or sampled.

The purpose of this section is to highlight the need to take cognisance of any cultural or historical sites that may be present within the study area and accordingly could influence the further development and utilisation of water resources within this area. Cultural and historical sites can be broadly defined as natural or manmade areas that are associated with human activity and history, and which carry social, cultural, religious, spiritual or historic significance. Furthermore, sites of palaeontological significance contain fossilised human or animal remains. The National Heritage Resources Act (No. 25 of 1999) provides automatic protection for palaeontological, archaeological and historical sites and materials older than 60 years, and a permit is required before any alterations can be made to such artefacts.

No general listing of the sites of palaeontological, archaeological and historical significance within the study area is available.

3. DEVELOPMENT STATUS

3.1 DEMOGRAPHY

3.1.1 Base year population numbers

The results from the most recent Census 2001 were published in January 2004. These results compare favourably with other available population data from the following studies: National Demographic Study (Schlemmer *et al*, 2001), Water Services Development Plans, Water Resources Situation Assessment: Fish to Tsitsikamma WMA (Ninham Shand, 2002). After consideration of the other available data sets, it was decided that the data from Census 2001, where available, should be used as an estimate of the base year population numbers for this study.

The present (base year 2001) population size within the study area is estimated at about 139 000 people. About 119 000 live in urban areas, and about 20 000 in rural areas. The distribution of the base year population per quaternary catchment is shown in **Table 3.1.1A**. More detailed information is available in **Appendix 3**.

Table 3.1.1A: Population size per quaternary catchment in 2001

Quaternary	Town	Population in 2001		
		Urban	Rural	Total
P10A		0	363	363
P10B	Riebeeck East	689	1 452	2 141
P10C		0	310	310
P10D	Alicedale *	5 950	977	6 927
P10E	Paterson	4 404	1 328	5 732
P10F		0	1 344	1 344
P10G	Kenton on Sea, Bushmans, Marselle	9 480	2 488	11 968
P20A	Alexandria, Cannon Rocks, Boknes	8 646	3 242	11 888
P20B		0	894	894
P30A		0	484	484
P30B		0	1 575	1 575
P30C		0	328	328
P40A	Grahamstown	61 759	997	62 756
P40B		0	1 228	1 228
P40C	Port Alfred, Bathurst	26 514	1 511	28 025
P40D	Kleinemonde *	1 450	1 117	2 567
TOTAL FOR STUDY AREA		**118 892**	**19 638**	**138 530**

* Census 2001 does not provide an estimate for the population in the town of Alicedale. The estimate for the population in the town of Kleinemonde is unrealistically low. The data from the national demographic study was therefore used to patch the Census data in these instances.

The rural population, consisting mainly of farm labourers was estimated *pro rata* to the enumerator area falling within the relevant quaternary catchment boundaries.

The estimated population numbers per urban centre are shown in the table below.

Table 3.1.1B: Population numbers in urban centres in 2001

Quaternary	Town	Urban Population
P10B	Riebeeck East	689
P10D	Alicedale	5 950
P10E	Paterson	4 404
P10G	Kenton on Sea/Ekuphuleni	4 781
	Marselle/Boesmansriviermond	4 699
P20A	Alexandria	7 715
	Boknes	466
	Cannon Rocks	465
P40A	Grahamstown	61 759
P40C	Port Alfred	20 965
	Bathurst	5 549
P40D	Kleinemonde	1 450
TOTAL URBAN POPULATION		**118 892**

3.1.2 Population growth rates

A national demographic study (Schlemmer *et al*, 2001) to develop water-use projections to the year 2025 was commissioned by the Department of Water Affairs and Forestry in order to support the development of the National Water Resources Strategy. This study included the development of a baseline 1995 population estimate, which was reconciled with the data from Census 1996. The study also included the development of population growth projections until year 2025, which where specific for each enumerator area.

Owing to the absence of more accurate information, the recommended population growth rates by the national demographic study were used in this study. In general, it is expected that until year 2025 the urban population in the coastal belt of the study area will grow at rates varying between 2.3% and 1.3% per annum. The population in the interior urban centres is expected to grow initially at rates around 0.5% per annum, but later during the period, to decline at rates of around –0.5% per annum. Rural population is expected to initially grow marginally at rates of about 0.3% per annum, but to decline at rates exceeding –0.8% per annum towards the end of the projection period. The projected population growth rates used for the purposes of this study are shown in **Appendix 3.3**.

As shown in the table below, certain significant housing developments are being planned and implemented in the coastal towns. It was considered that the additional population associated with these developments is not provided for in the standardised population growth rates. Therefore, provision for additional population numbers for the relevant towns has been made.

Overall, it is expected that the total population in the study area will grow from about 139 000 in 2001 to about 170 000 in 2025, resulting in an average growth rate of about 0.8% per annum.

Table 3.1.2: Planned housing developments

Town	Planned housing development, No of units		
	2001	**2005**	**2015**
Kenton on Sea/Ekuphuleni	100	400	
Marselle/Bushmans River		100	500
Alexandria		150	350
Boknes/Cannon Rocks	170	130	400
Port Alfred		3 000	2 000
Bathurst		400	

3.1.3 Projected population numbers

The projected population numbers per quaternary catchment of the study area are shown in the table below. More detail is available in **Appendix 3.3**.

Table 3.1.3: Projected population numbers per quaternary

Quaternary Sub-catchment	**Projected population numbers**			
	2001	**2005**	**2015**	**2025**
P10A	363	368	358	321
P10B	2 141	2 177	2 118	1 935
P10C	310	313	284	251
P10D	6 927	7 062	6 893	6 498
P10E	5 732	5 840	5 665	5 345
P10F	1 344	1 364	1 324	1 187
P10G	11 968	15 270	16 127	16 737
P20A	11 888	13 084	14 870	14 533
P20B	894	907	860	790
P30A	484	491	477	428
P30B	1 575	1 599	1 515	1 391
P30C	328	333	315	290
P40A	62 756	65 382	67 370	67 471
P40B	1 228	1 246	1 181	1 085
P40C	28 025	35 556	43 275	48 104
P40D	2 567	2 967	3 230	3 458
Urban	**118 592**	**134 029**	**146 855**	**152 499**
Rural	**19 638**	**19 930**	**19 006**	**17 324**
TOTAL	**138 530**	**153 959**	**165 861**	**169 882**

In 2001 a total number of about 139 000 people lived in the study area. About 119 000 (86%) resided in urban centres, while the remaining about 20 000 (14%) people lived in rural areas.

In 2025 the total population in the study area is expected to grow to about 170 000 people, which constitutes and average annual growth of about 0.8% per annum. The relatively high growth is associated with the increase of the urban population mainly in the costal towns and in Grahamstown. In 2025 the urban population is expected to be in the order of 152 000 people (90%) and the rural about 17 000 people (10%).

3.2 SOCIO-ECONOMIC DEVELOPMENT STATUS

3.2.1 Population Density

The highest population density occurs in the Makana Local Municipality, 34 people per km², with Grahamstown, Riebeeck East and Alicedale as the major urban areas within the Municipality. Ndlambe Local Municipality has the second highest population density with 32 people per km², the major urban areas are Port Alfred, Alexandria, Bathurst and Kenton on Sea. Blue Crane Municipality has the lowest population density with 0.6 persons per km². There are no urban areas within this district.

3.2.2 Age Distribution

57% of the total population falls between the age of 19 and 65 years, while 36% are younger than 19 years. The remaining 7% of the population are above the age of 65 years.

3.2.3 Education

61% of the total population are educated at a level of school certification of Grade 1 to 12, while 21% have no education at all. 3% have a certificate or diploma obtained from a grade-12 certification, while 2% are qualified with a degree. The remaining 13% do not apply; they are people not being able to be educated for some or other reason.

3.2.4 Income

More than half the population of the workforce (58%) have no form of financial income, while 39.4% earn a monthly income of less than R6 400. This is an indication of the poor socio-economic status of the permanent residents in the study area. This does not include the holidaymakers that only visit during peak seasons. Only 2.2% currently earn between R6 400 and R25 600 per month.

3.2.5 Employment Status

Only 34% of the population is permanently employed, this excludes the scholars/students that form 18% and pensioners that form 7%. Therefore the total percentage of the population that contributes to the GGP is only 34%, while the remaining 66% are scholars, pensioners or unemployed people.

3.2.6 Employment Sector

The total labour force contributing to the GGP can be divided into the following sectors:

- Agricultural: 13.8%
- Mining: 0.25%
- Manufacturing: 5.2%
- Municipal Services: 0.43%
- Construction: 6.84%
- Trade: 12.8%
- Transport: 2.1%
- Finance: 5.3%
- Government: 26.3%
- Other: 26.98

3.3 LAND-USE

3.3.1 Introduction

The land-use data shown in this section has been obtained from the Fish to Tsitsikamma Water Management Area Situation Assessment Study (DWAF, 2002). The information has been derived from the CSIR, 1999 land-use coverage, obtained by analysing satellite images. The table below summarises the land-use information per type of use and per quaternary catchment as at 1995.

Table 3.3.1: Summary land-use data (1995) (km²)

Quaternary Catchment	Total Area	Area Under Invasive Alien Plants	Area Under Afforestation	Nature Reserves & Natural Forests	Irrigation [(1)] (maximum)	Urban [(3)] Areas	Other [(2)]
P10A	126	5.27	2.14	0.00	0.44	0.00	118.37
P10B	508	4.51	0.00	0.00	1.65	0.72	501.94
P10C	281	0.00	0.00	0.00	0.94	0.00	280.53
P10D	564	0.26	0.00	0.00	1.87	0.30	562.50
P10E	466	0.78	0.00	3.29	1.53	0.44	460.72
P10F	469	11.20	0.00	0.00	1.53	0.00	457.03
P10G	343	0.41	0.00	0.00	1.09	0.35	341.69
P20A	422	51.10	0.00	156.45	0.00	1.44	213.01
P20B	332	57.19	0.00	45.20	0.00	0.00	229.61
P30A	176	22.12	3.40	9.46	1.05	0.00	140.49
P30B	403	5.49	0.00	0.00	2.37	0.00	396.32
P30C	68	0.38	0.00	0.00	0.40	0.08	67.34
P40A	312	40.11	0.75	0.00	0.12	11.86	259.22
P40B	264	5.62	0.00	0.00	0.06	0.26	258.09
P40C	342	10.98	0.00	63.80	0.12	7.71	259.45
P40D	246	13.51	0.00	0.00	0.06	1.30	231.16
TOTAL	**5 322**	**228.93**	**6.29**	**278.20**	**13.23**	**24.46**	**4 777.47**

Notes:

(1) The average area of land being irrigated during years with average rainfall is 6.65 km², while the maximum can be 13.2 km² when sufficient water is available.

(2) "Other" includes: rough grazing, dry land agriculture and water bodies. We were unable to obtain data to differentiate between these per quaternary catchment. However, for the entire drainage region P the area used for dry land agriculture is estimated to be 384 km², and the total area occupied by water bodies – about 8 km². The total area used for rough grazing is therefore estimated at 4 385 km².

(3) Urban areas derived from 1:50 000 maps, excluding small holdings and rural villages.

The predominant type of land-use within drainage region P in 1995 has been for rough grazing, about 4 400 km² (82%).

About 384 km² (7%) has been used for dry land agriculture. The area covered by nature reserves (including the indigenous forests) is 278 km² (5%). A significant portion of the land in drainage region P is infested by invasive alien plants – 229 km² (4.3%).

Figure 9.1 indicates the different coverage of land-use i.e. dry land agriculture, grassland, indigenous forests, afforestation, natural veld, nature reserves, water bodies and built-up areas.

3.3.2 Irrigated Areas

The maximum area covered under irrigation within the drainage region P is about 13.2 km² and is subdivided per quaternary catchment in **Table 3.3.1.** Land is irrigated from farm dams and run-of-river flow when sufficient water is available. The areas irrigated vary from year to year, depending on availability of water, with the average being about 6.6 km², distributed as shown in **Table 3.3.1**.

3.3.3 Dry land Agriculture

The area used for dry land agriculture is estimated at 384 km² or about 7% of the total catchment. Pineapples are grown on a large scale without irrigation along the coast (P20A, P20B, P30C, P40C and P40D). Chicory is also grown as a dry land crop along the coast, mainly in the P20A and P20B quaternary catchments as follows.

3.3.4 Afforestation

The main tree species grown is pine. The total area covered by commercial timber plantations is estimated at 6.29 km², extending over three quaternary catchments as follows:

- P10A with 2.14 km²
- P30A with 3.40 km²
- P40A with 0.75 km²

3.3.5 Invasive Alien Plants

The widespread infestation by invasive alien plants (IAP) and all its related problems are increasingly acknowledged throughout South Africa. This infestation, if not controlled, can result in the loss of much, or possibly even all, of the available water in certain catchment areas. The acacias, pines, eucalyptus, prosopis species and melia azedarachs are among the top ten IAP, which account for about 40% of the water use.

The estimated total area under IAP in the study area is about 229 km². This value is for condensed areas, which are equivalent areas that IAP would occupy if it were condensed to provide a completely closed canopy cover. The most severe infestation occurs along the coastal strip at Boesmansriviermond and Kenton on Sea.

3.3.6 Livestock

Equivalent Large Stock Units (ELSU) are used to measure the water requirements of livestock. Each ELSU is assumed to represent a water requirement of 45 l/day. For example, one ELSU is equivalent to 0.85 head of cattle, or 1 horse or donkey, or 6.5 sheep or goats, or 4 pigs. **Table 3.3.6A** shows the distribution of livestock located in the study area and the total number of ELSU. **Table 3.3.6B** specifies the conversion of mature livestock and game population to ELSU.

The numbers for livestock are approximate because the information was obtained from the 1994 livestock census that gives information in terms of magisterial districts and not hydrological catchments. These numbers have been converted to hydrological catchments by assuming the distribution of livestock to be proportional to land area. No information on numbers of game or ostriches could be obtained.

Table 3.3.6A: Livestock (No of heads)

Drainage Region	Cattle	Horses and Donkeys	Sheep	Goats	Pigs	ELSU
P	72 441	591	14 713	8 750	720	89 757

Table 3.3.6B: Livestock (No of heads)

Quaternary Catchments	ELSU	Quaternary Catchments	ELSU	Quaternary Catchments	ELSU
P10A	849	P10G	8 851	P40A	3 211
P10B	3 436	P20A	12 476	P40B	6 994
P10C	822	P20B	9 812	P40C	9 469
P10D	2 535	P30A	1 188	P40D	6 797
P10E	9 982	P30B	4 082		
P10F	7 392	P30C	1 861	**TOTAL**	**89 757**

Table 3.3.6C: Conversion of Mature Livestock and Game Populations to ELSU

Species	Number per ELSU
Cattle	0.85
Sheep	6.5
Goats	5.8
Horses	1
Donkeys / Mules	1.1
Pigs	4
Game:	
Black Wildebeest	3.3
Blesbuck	5.1
Blou Wildebeest	2.4
Buffalo	1
Eland	1
Elephant	0.3
Gemsbok	2.2
Giraffe	0.7

Species	Number per ELSU
Hippopotamus	0.4
Impala	7
Kudu	2.2
Nyala	3.3
Ostrich	2.7
Red Hartbeest	2.8
Roan Antelope	2
Sable Antelope	2
Southern Reedbuck	7.7
Springbok	10.3
Tsessebe	2.8
Warthog	5
Waerbuck	2.4
Rhinoceros	0.4
Zebra	1.6

3.3.7 Urban Areas

Table 3.3.1 illustrates the urban areas for each quaternary catchment. Data on urban areas was obtained from 1:50 000 maps and exclude the smallholdings and rural villages.

3.3.8 Nature Reserves and Indigenous Forests

Information on nature reserves and indigenous forests was obtained from both the WR90 dataset, and the CSIR Land-use Coverage, 1999. **Table 3.3.1** summarises the area occupied by nature reserves and natural forest per quaternary catchment. The indigenous forests in drainage region P fall within nature reserves and are therefore not shown separately.

4. WATER REQUIREMENTS

This section outlines the methodology for estimating and projecting the water requirements per quaternary catchment within the study area, for the following consumer sectors:

- Urban and rural
- Stock watering
- Irrigation
- Afforestation
- Invasive alien plants
- Ecological

The current and projected use of groundwater resources, the inter-basin transfers, as well as the return flows from the urban areas were also taken into consideration. This was done in order to estimate the consumptive water requirements imposed on the surface water resources generated from drainage region P.

4.1 URBAN AND RURAL WATER REQUIREMENTS

4.1.1 Introduction

The distribution of urban and rural domestic water requirements is shown in **Tables 4.1.2A** and **4.1.3B**. The requirements shown include distribution and conveyance losses.

The total combined domestic requirement at 2001 levels of development was estimated to be 8.28 million m^3/a, of which approximately 7.88 million m^3/a was required by towns and only about 0.4 million m^3/a by consumers in the rural areas. Until year 2025 the urban requirements are expected to grow substantially to about 13.89 million m^3/a, while the rural requirements are expected to remain constant.

4.1.2 Urban requirements

The methodology and the results of the estimates for the size of the urban and rural population within the study area are shown in **Section 3.1**. The urban water requirements were estimated on the basis of the methodology developed for the National Demographic Study (NDS) (Schlemmer *et al*, 2001), which is outlined below.

4.1.2.1 Methodology developed for the National Demographic Study

This methodology provides a framework for the estimation of the present and projected water requirements per urban centre. The urban water requirements in each centre are divided into two main components - direct usage by the population, and indirect usage by commerce, industries, institutions and municipalities related to the direct use.

- **Direct water use**

  In order to estimate the direct water use, the urban population in each urban centre has been sub-divided into seven categories depending on the following criteria: economic strata, type of housing, and levels of water and sanitation service provided. Each category was then associated with a default unit water use per person. The default water use varies between 320 l/person/day for full water and sewer service on large properties to 6 l/person/day for settlements, where no formal water supply exists. These categories and the associated default unit water use are shown in **Appendix 4.1**.

- **Indirect water use**

  Indirect water use was estimated in terms of four categories, viz. commercial, industrial, institutional and municipal. The urban centres were classified according to shared characteristics related to indirect water use. This classification is shown in **Appendix 4.2.** A standard table relating the components of indirect water use to the total direct water use of an urban centre was developed, and is shown in **Appendix 4.3**.

4.1.2.2 Estimates of urban requirements in drainage region P

Using the methodology developed for the NDS, the water requirements for the urban centres within the study area were estimated as described below. Where accurate or updated information could be obtained, certain amendments were introduced to the default values and assumptions used by the NDS.

The population numbers in 2001 were obtained from the most recent Census 2001, the results of which became available in January 2004. These population figures were projected until 2025 as described in Section 3.1.

The population in each urban centre was divided into the seven categories of water use. This was done on the basis of the relevant data from Census 2001, as well as based on site information obtained during the course of this study. The relevant Census 2001 data relating to water supply service levels and type of housing is shown in **Appendix 3.4**. The unit water use per category as recommended by the NDS was applied in order to determine the direct water requirements.

The indirect water usage was estimated as a percentage of the direct usage as per the methodology of the NDS. For the purposes of this estimate it was assumed that adequate provision for the seasonal population is made through the estimated indirect water usage default values.

The distribution of urban water requirements determined on this basis is shown in **Tables 4.1.2A and 4.1.2B**, where bulk conveyance losses and distribution losses have been added to the estimated direct and indirect water requirements to derive the total water requirements. Owing to the lack of more accurate information, an allowance of 25% (of total use) has been made for bulk conveyance and distribution losses. More detail is available in **Appendix 4.5 and 4.6**.

Table 4.1.2A: Total urban water requirements per quaternary catchment

Quaternary Catchment	Total urban water requirements, x 10^6 m^3/ annum			
	2001	2005	2015	2025
P10A	0.00	0.00	0.00	0.00
P10B	0.04	0.04	0.04	0.05
P10C	0.00	0.00	0.00	0.00
P10D	0.21	0.34	0.42	0.42
P10E	0.19	0.22	0.21	0.20
P10F	0.00	0.00	0.00	0.00
P10G	0.66	0.91	1.21	1.49
P20A	0.69	0.87	1.25	1.28
P20B	0.00	0.00	0.00	0.00
P30A	0.00	0.00	0.00	0.00
P30B	0.00	0.00	0.00	0.00
P30C	0.00	0.00	0.00	0.00
P40A	4.51	5.00	5.65	5.97
P40B	0.00	0.00	0.00	0.00
P40C	1.53	2.49	3.43	4.31
P40D	0.05	0.08	0.12	0.16
TOTAL	**7.88**	**9.95**	**12.35**	**13.89**

Table 4.1.2B: Total water requirements per urban centre

Quaternary	Town	Total water requirements, 106 m3/ annum			
		2001	2005	2015	2025
P10B	Riebeeck East	0.04	0.04	0.04	0.05
P10D	Alicedale	0.21	0.34	0.42	0.42
P10E	Paterson	0.19	0.22	0.21	0.20
P10G	Kenton on Sea/ Bushmans/Marselle	0.66	0.91	1.21	1.49
P20A	Alexandria	0.52	0.62	0.79	0.76
	Boknes	0.09	0.13	0.23	0.26
	Cannon Rocks	0.09	0.12	0.23	0.26
P40A	Grahamstown	4.51	5.00	5.65	5.97
P40C	Port Alfred	1.27	2.16	3.04	3.90
	Bathurst	0.26	0.34	0.39	0.41
P40D	Kleinemonde	0.05	0.08	0.12	0.16
TOTAL STUDY AREA		**7.88**	**9.95**	**12.34**	**13.89**

4.1.3 Rural domestic water requirements

Rural water users include the population of farms, small rural settlements not classified as towns, and coastal resorts that are not classified as towns. No detailed and accurate information on rural water use is available for the study area. Based on the Census 2001 results, it can be concluded that the rural population in the study area constitutes only about 14% of the total. Therefore, the rural water use is relatively low when compared to the urban water use.

The present and projected rural population numbers were determined as described in **Section 3**.

The per capita water requirements assumed for the Fish to Tsitsikamma WRSA study were used. As per that study, rural users were considered to fall into three economic categories, with associated unit water requirements. These categories are "Rural", being people living far from towns and not part of the communities of large commercial farms, "Developing Urban" being people of the lower income group living close to towns and typically on smallholdings, and "Commercial Farming" being the owners of large commercial farms and their workers.

The assumed unit water requirements are shown in **Table 4.1.3A**. Total losses were assumed to be 20% of total water requirements, including losses.

Table 4.1.3A: Per capita water requirements in rural areas in 2001:

USER CATEGORY	UNIT WATER REQUIREMENTS			
	Direct Use (l/c/d)	Distribution loses		Total (l/c/d)
		(l/c/d)	(%)	
Rural	30	7,5	20	37,5
Developing urban	100	25	20	125
Commercial farming	150	38	20	188

The total rural domestic water requirements were calculated from the estimated number of people in each user category in each quaternary catchment. The results are summarised in **Table 4.1.3B**. Details are given in **Appendix 4.7**.

Table 4.1.3B: Estimated rural domestic water requirements

Quaternary Catchment	Projected Water Usage ($10^6 m^3/a$)			
	2001	2005	2015	2025
P10A	0.02	0.02	0.02	0.02
P10B	0.02	0.03	0.03	0.02
P10C	0.01	0.02	0.01	0.01
P10D	0.02	0.02	0.02	0.02
P10E	0.02	0.02	0.02	0.02
P10F	0.06	0.06	0.06	0.06
P10G	0.04	0.04	0.04	0.04
P20A	0.05	0.05	0.05	0.05
P20B	0.04	0.04	0.04	0.04
P30A	0.02	0.02	0.02	0.02
P30B	0.01	0.01	0.01	0.01
P30C	0.01	0.02	0.02	0.01
P40A	0.01	0.01	0.02	0.01
P40B	0.02	0.02	0.02	0.02
P40C	0.02	0.03	0.03	0.02
P40D	0.02	0.02	0.02	0.02
TOTAL	**0.40**	**0.42**	**0.42**	**0.39**

4.1.4 Livestock watering

Drinking water for livestock is also considered to be part of the rural water requirements and was calculated as 45 l/d per Equivalent Large Stock Unit (ELSU). The total livestock population in the study area is about 100 000 units, of which about 72 000 are cattle, 15 000 sheep, and 9 000 goats. The balance is split between horses, donkeys and pigs. The total number of ELSU in the study area is about 90 000.

The number of ELSU per quaternary catchment has been estimated in previous studies on the basis of the information from the 1994 livestock census.

The estimated water requirements for livestock watering are shown in the table below. It has been assumed that the grazing capacity of the area has been reached and that the livestock population and water requirements would not change significantly during the projection period.

Table 4.1.4: Livestock Numbers and Water Requirements

Quaternary Catchment	No of ELSU	Water requirements ($10^6 m^3/a$)
P10A	849	0.032
P10B	3 436	0.126
P10C	822	0.032
P10D	2 535	0.095
P10E	9 982	0.158
P10F	7 392	0.126
P10G	8 851	0.126
P20A	12 476	0.189
P20B	9 812	0.152
P30A	1 188	0.032
P30B	4 082	0.095
P30C	1 861	0.032
P40A	3 211	0.063
P40B	6 994	0.126
P40C	9 469	0.158
P40D	6 797	0.126
TOTAL	**89 757**	**1.666**

4.2 IRRIGATION WATER REQUIREMENTS

No comprehensive and accurate information about the extent of the irrigated land and the associated water use is available for the study area. The distribution of the irrigable land within the study area was done as described in **Section 3**.

The water requirements were estimated as per the approach used during the WRSA study. The irrigated crops in the area include mostly vegetables and pasture. The water requirements were calculated by applying a typical value for the field edge water requirement (12 000 m^3/ha/a) throughout the entire study area. In addition conveyance losses of 15% of the gross water requirements were provided.

The estimated irrigation water requirements per quaternary catchment are shown in the following table. It is assumed that the irrigated land and the irrigation requirements will not change during the projection period.

Table 4.2: Irrigation water requirements

Quaternary	Maximum area	Net requirement	Conveyance losses	Gross requirements
	ha	x10^{6}m³/a		
P10A	44	0.372	0.051	0.423
P10B	165	1.404	0.191	1.595
P10C	94	0.795	0.108	0.903
P10D	187	1.590	0.217	1.806
P10E	153	1.302	0.178	1.480
P10F	153	1.302	0.178	1.480
P10G	109	0.930	0.127	1.057
P20A	0	0.000	0.000	0.000
P20B	0	0.000	0.000	0.000
P30A	105	0.896	0.122	1.018
P30B	237	2.012	0.274	2.287
P30C	40	0.338	0.046	0.384
P40A	12	0.101	0.014	0.115
P40B	6	0.051	0.007	0.058
P40C	12	0.101	0.014	0.115
P40D	6	0.051	0.007	0.058
TOTAL	**1 323**	**11.246**	**1.533**	**12.779**

4.3 AFFORESTATION

Based on the available information the total area of the land presently used for afforestation is about 6.3 km^2. The prevailing species is pine. The potential for development of commercial forestry plantations is not high in the study area. This is owing to the relatively low mean annual precipitation, which is generally below 700 mm.

The reduction of runoff (water requirements) due to afforestation was modelled using the Affdem programme. The distribution of afforestation areas and the water requirements are shown in **Table 4.4** together with the reduction of runoff due to invasive alien plants.

4.4 INVASIVE ALIEN PLANTS

The study area is severely infested with IAP. About 230 km^2, or 4% of the land in drainage region P is overgrown by IAP. The most severe infestation occurs in the coastal area to the west of Kenton on Sea. This results in a notable reduction of the runoff.

The reduction of runoff has been modelled using the SHELL model and the results per quaternary catchment are shown in **Table 4.4.**

Table 4.4: Reduction of runoff due to afforestation and IAP

Quaternary Sub-catchment	Area afforestation (km^2)	Reduction runoff ($x10^6 m^3/a$)	Area IAP (km^2)	Reduction ($x10^6 m^3/a$)
P10A	2.14	0.05	5.27	0.38
P10B			4.51	0.30
P10C			0	0
P10D			0.26	0.04
P10E			0.78	0.06
P10F			11.2	0.51
P10G			0.41	0.04
P20A			51.1	4.60
P20B			57.19	3.64
P30A	3.40	0.09	22.12	1.64
P30B			5.49	0.29
P30C			0.38	0.01
P40A	0.75	0.02	40.11	3.22
P40B			5.62	0.32
P40C			10.98	0.69
P40D			13.51	1.07
TOTAL	**6.29**	**0.16**	**228.93**	**16.81**

4.5 ECOLOGICAL RESERVE REQUIREMENTS

The riverine component of the Ecological Reserve Requirements (ERR) (also known as Instream Flow Requirements) was determined for each quaternary catchment in the study area.

The estimates for the ER were produced on the basis of the desktop methodology applying the Hughes DSS model (decision support system) of Rhodes University's IWR. The ecological management classes, used as an input to the model, were assessed by a team of environmental specialists during a workshop in August 1999. The results of the application of the Kleynhans method for the determination of the "attainable" ecological management class (AEMC) are summarised in **Table 2.6.1.1**. The estimated incremental ERR per quaternary catchment are shown in **Table 4.5**. More detailed information including the monthly rule curves are attached in the Surface Water Resources Supporting Report.

Table 4.5: Estimated ERR per Quaternary (incremental)

Quaternary	River	AEMC	Naturalised MAR ($10^6m^3/a$)	ERR	
				% of MAR	10^6m3/a
P10A	Boesmansriviermond	C	4.54	18	0.80
P10B	Boesmansriviermond	C	12.19	18	2.2
P10C	Boesmansriviermond	C	2.39	18	0.43
P10D	Boesmansriviermond	C	6.77	18	1.26
P10E	Boesmansriviermond	D	8.85	11	0.96
P10F	Boesmansriviermond	D	13.6	11.2	1.54
P10G	Boesmansriviermond	D	9.6	11.00	1.08
P20A	Boknes	D	30.38	11.30	3.42
P20B	Boknes	D	15.27	11.20	1.72
P30A	Kariega	C	6.86	18.00	1.25
P30B	Kariega	C	11.69	17.30	2.02
P30C	Kariega	C	1.70	17.30	0.29
P40A	Kowie	C	13.73	18.00	2.45
P40B	Kowie	C	8.18	17.30	1.42
P40C	Kowie	C	14.02	18.00	2.55
P40D	Kowie	C	13.28	17.50	2.34
TOTAL			**173.05**		**25.74**

4.6 ALTERNATIVE SOURCES (INFLOWS)

4.6.1 Groundwater Usage

The groundwater consumption has been estimated and projected in broad terms for each quaternary catchment. The existing records of current usage from groundwater have been taken into account. The projected future groundwater usage was based on a regional scale desktop study, which assessed the potential for development of the groundwater resources in the area.

Table 4.6.1: Estimated usage of groundwater

Quaternary Sub-catchment	Projected Water Usage ($10^6 m^3/a$)			
	2001	2005	2015	2025
P10A	0.02	0.02	0.02	0.02
P10B	0.06	0.07	0.07	0.07
P10C	0.01	0.02	0.01	0.01
P10D	0.02	0.02	0.02	0.02
P10E	0.13	0.22	0.32	0.42
P10F	0.06	0.06	0.06	0.06
P10G	0.04	0.04	0.04	0.04
P20A	1.05	1.55	1.55	1.85
P20B	0.04	0.04	0.04	0.04
P30A	0.02	0.02	0.02	0.02
P30B	0.01	0.01	0.01	0.01
P30C	0.01	0.02	0.02	0.01
P40A	0.01	0.01	0.02	0.01
P40B	0.02	0.02	0.02	0.02
P40C	0.42	0.43	0.43	0.42
P40D	0.05	0.06	0.08	0.10
TOTAL	**1.97**	**2.60**	**2.73**	**3.11**

4.6.2 Return flows

The existing water treatment plants in the study area are listed in **Table 4.6.2A**.

Table 4.6.2A: Sources of urban return flows and sewage treatment works

Water User (Town or suburb)	Catchment	Capacity	Treatment Facility
Alexandria, Wentzel Park, KwaNonqubela	P20A	Unknown	Oxidation ponds
Cannon Rocks, Boknes	P20A	Unknown	Septic tanks with soakaways
Kenton on Sea, Boesmansriviermond, Klipfontein, Marselle, Ekuphumleni	P10G	Unknown	Septic tanks with soakaways, Activated sludge wastewater TW
Port Alfred, Nemato, Mimosa Farm	P40C	1.000 m^3/d	Oxidation ponds
Kleinemonde, Seafield	P40D	Unknown	Septic tanks with soakaways
Bathurst, Nolukhanyo, Freestone	P40C	Unknown	Septic tanks with soakaways

No accurate records are available for the actual return flows of treated sewage effluent from the treatment works. For the purposes of this study it has been assumed that about 40% of the total urban water usage in towns with water-borne sewer systems will return to the surface water system. It is not anticipated that water-borne sanitation will be installed in the rural areas. The projected irrigation requirements are relatively small and the potential return flows have been ignored.

Return flows of treated sewage effluent are estimated to have totalled approximately 3.2 million m^3/a in 2001. Of this, about 0.85 million m^3/a has been generated by the coastal towns and discharged directly into or close to the sea. This portion of the return flows is not included in the table below, as it does not contribute to the surface runoff.

Table 4.6.2B: Estimated return flows from treated sewage

Quaternary Sub-catchment	Return flows ($10^6 m^3/a$)*			
	2001	2005	2015	2025
P10A	0.00	0.00	0.00	0.00
P10B	0.01	0.02	0.02	0.02
P10C	0.00	0.00	0.00	0.00
P10D	0.09	0.14	0.17	0.17
P10E	0.08	0.09	0.09	0.08
P10F	0.00	0.00	0.00	0.00
P10G	0.00	0.00	0.00	0.00
P20A	0.21	0.25	0.32	0.31
P20B	0.00	0.00	0.00	0.00
P30A	0.00	0.00	0.00	0.00
P30B	0.00	0.00	0.00	0.00
P30C	0.00	0.00	0.00	0.00
P40A	1.85	2.05	2.32	2.45
P40B	0.00	0.00	0.00	0.00
P40C	0.11	0.14	0.16	0.17
P40D	0.00	0.00	0.00	0.00
TOTAL	**2.35**	**2.69**	**3.08**	**3.20**

* Return flows exclude the treated effluent from the coastal towns

4.6.3 Inter-basin transfers

The Lower Fish River Government Water Scheme transfers water from drainage region Q to P in order to augment the supply to Grahamstown. The scheme consists of a tunnel that diverts water from the Hermanuskraal Weir into the Glen Melville Dam, water treatment works and a bulk conveyance system. The actual volume transferred in 2001 was 2.31×10^6 m³. It is assumed that the full capacity of the system of 3.65×10^6 m³ will be reached in 2015.

4.7 SUMMARY OF CONSUMPTIVE WATER REQUIREMENTS

The results of the estimates for the consumptive water requirements (urban domestic and industrial, rural domestic, irrigation, stock watering and afforestation) as shown in the previous tables included in this Section are summarised in **Tables 4.7A** and **B** per quaternary catchment and per user sector respectively. For the purposes of modelling of the surface water hydrology, the contributing factors – return flows, inter-basin transfers and groundwater usage have been subtracted. The Ecological Reserve requirements are not included as these are specific for each development site. The naturalised incremental MAR per quaternary catchment is provided for reference.

As seen from **Table 4.7B** the total consumptive water requirements for the study area are estimated to be about 40 million m^3 for the year 2001 and 46 million m^3 for the year 2025. Taking into consideration the estimated contributions from return flows and the supply from groundwater, the total requirements from the surface water resources would be 33 x 10^6 m^3 for the year 2001 and 36 x 10^6 m^3 for the year 2025.

Table 4.7A: Surface Water Requirements per Quaternary

Quaternary Sub-catchment	Projected Water Requirements ($10^6 m^3/a$)				Naturalised MAR
	2001	2005	2015	2025	
P10A	0.88	0.88	0.88	0.88	4.54
P10B	2.01	2.00	2.00	2.00	12.19
P10C	0.93	0.93	0.93	0.93	2.39
P10D	2.07	2.14	2.19	2.19	6.77
P10E	1.70	1.63	1.52	1.42	8.85
P10F	2.12	2.12	2.12	2.12	13.60
P10G	1.88	2.13	2.43	2.72	9.60
P20A	4.27	3.90	4.22	3.96	30.38
P20B	3.79	3.79	3.79	3.79	15.27
P30A	2.78	2.78	2.78	2.78	6.86
P30B	2.67	2.67	2.67	2.67	11.69
P30C	0.43	0.43	0.43	0.43	1.70
P40A	3.77	3.57	3.30	3.29	13.73
P40B	0.50	0.50	0.50	0.50	8.18
P40C	1.99	2.92	3.84	4.71	14.02
P40D	1.28	1.30	1.31	1.33	13.28
TOTAL	**33.07**	**33.70**	**34.93**	**35.73**	**173.05**

Table 4.7B: Consumptive Water Requirements per User Sector

User Sector	Water Requirements ($10^6 m^3/a$)				Distribution, %	
	2001	**2005**	**2015**	**2025**	**2015**	**2025**
Urban domestic and industrial	7.88	9.95	12.35	13.89	22.4	33.6
Rural domestic	0.40	0.42	0.42	0.39	1.1	0.9
Stock watering	1.67	1.67	1.67	1.67	4.2	3.6
Irrigation	12.78	12.78	12.78	12.78	22.0	18.9
Afforestation	0.16	0.16	0.16	0.16	0.5	0.4
Invasive alien plants	16.81	16.81	16.81	16.81	49.7	42.6
Total consumptive requirements	**39.70**	**41.79**	**44.19**	**45.69**	**100.0**	**100.0**
Return Flows	-2.35	-2.69	-3.08	-3.20	-5.9	-7.0
Interbasin transfer	-2.31	-2.80	-3.45	-3.65	-5.8	-8.0
Groundwater supply	-1.97	-2.60	-2.73	-3.11	-5.0	-6.8
Total inflows	-6.63	-8.09	-9.26	-9.96	-16.7	-21.8
Total use from surface water	**33.07**	**33.70**	**34.93**	**35.73**	**83.3**	**78.2**

5. WATER SUPPLY SITUATION AT AFFECTED TOWNS

5.1 ALEXANDRIA

The supply area includes the town of Alexandria and the former townships of Wentzel Park and KwaNonqubela with a total population of about 7 800 people.

5.1.1 Levels of Service

Most of the population is serviced to house/yard connection level (in KwaNonqubela there are 643 households and 20 smallholdings that require access to formal water supply).

The townships of Wentzel Park and KwaNonqubela have 80% and 40% water-borne sewer services respectively, while Alexandria is fully serviced with a wastewater system that drains into an oxidation pond. This level of service needs to be provided at 643 households in KwaNonqubela and 80 erven in Phokoza Valley.

5.1.2 Description of Existing Water Supply Infrastructure

Figure S1 is a schematic layout of the existing water supply scheme in Alexandria.

Water is supplied from two major sources:

- Coastal springs near Cape Padrone (7 l/s over 12 hr)
- 2 well points near Fishkraal (12 l/s over 12 hr)

The total maximum source capacity is 0.836×10^6 m^3/a and 0.674×10^6 m^3/a during normal times and during drought periods respectively. The scheme is being operated by Ndlambe Municipality, through a water services contract with P & S Consulting Engineers. The existing conveyance system has a capacity of 19 l/s (1 642 m^3/d) but plans are underway to upgrade this to 24 l/s.

Raw water is being pumped from these sources to a transfer reservoir (240 m^3) located 10 km south of Alexandria and from there it is pumped (1 642 m^3/day) to bulk storage reservoirs (3 400 m^3) west of Alexandria. A separate pumping main supplies water to agricultural and afforestation consumers from the 240 m^3 transfer reservoir.

Water is supplied from the bulk storage reservoirs to all consumers via gravity reticulation networks. The total monthly production flows from the bulk storage reservoirs vary from 32 000 m^3 to 45 500 m^3 per month, with December and January being the peak months.

Information from the WSDP is available in **Appendix 5**.

5.1.3 Overview of Current Problems

The pumping main between the balancing reservoir and the bulk storage reservoir has insufficient capacity (1 642 m^3/day) and does not meet the peak demands.

5.2 CANNON ROCKS AND BOKNES

The existing scheme supplies the coastal resorts of Cannon Rocks and Boknes with a total permanent population of 931.

5.2.1 Levels of Service

Both towns are fully serviced with potable water at a yard connection level.

Sanitation is arranged through septic tanks.

5.2.2 Description of Existing Water Supply Infrastructure

Three boreholes (15 l/s at 12 h/day) located to the west of Cannon Rocks supply water (650 m^3/day) to two storage reservoirs – one at Cannon Rocks (470 m^3) and one at Boknes (530 m^3) through the reticulation system. These two reservoirs supply both towns, which have a joined reticulation system.

The present GAADD is about 500 m^3/d, while the peak requirements are about 1300 m^3/d. The boreholes are utilised for 24 h/day during peaks, which leads to over-pumping and deteriorated water quality.

Information from the WSDP is available in **Appendix 5**.

5.2.3 Overview of Current Problems

Water quality of the boreholes is poor because water is abstracted beyond the permissible rate that causes seawater intrusion.

The existing sources are sufficient to supply the area during normal periods, but insufficient during seasonal peaks. In addition about 200 new erven are being planned and will require some additional supply to that area.

5.3 BOESMANSRIVIERMOND AND KENTON ON SEA

The supply area includes the towns of Kenton on Sea and Boesmansriviermond and the former townships of Klipfontein, Marselle and Ekuphumeleni with a total population of about 9 500 people.

5.3.1 Levels of Service

Water is supplied to the entire population by means of house/yard connections.

The townships of Marselle, Klipfontein and Ekuphumeleni have water-borne sanitation services, while Boesmansriviermond and Kenton on Sea are serviced by septic tanks.

5.3.2 Description of Existing Water Supply Infrastructure

Figure S3 is a schematic layout of the existing water supply scheme for these towns. Currently raw water is obtained from the following sources:

- Six well points near Diaz Cross (average depth is 10 m) (822 m^3/d)
- Five "freshwater" boreholes near the Albany Coast Water Board (ACWB) offices (through a reverse osmosis (RO) plant)
- Eight seawater boreholes located near the mouth of the Bushmans River

  The total capacity of the last two sources is 1 600 m^3/d

Fresh water is being pumped from the well points at Diaz Cross (822 m^3/d) to a balancing reservoir (100 m^3) from where it is pumped directly to the bulk supply reservoirs (4 000 m^3) located at a high point above the town of Kenton on Sea. These wells supply about 60% of the total bulk water to the system, while the remaining 40% is being supplied from high salinity boreholes located near the coast at Boesmansriviermond.

Saline water from these boreholes with a capacity of 1 320 m^3/d is being pumped into plastic tanks (95 m^3). From there it is pumped through a RO desalination plant before being discharged into local storage (100 m^3). The RO plant consists of three separate modules with 20 m^3/h, 20 m^3/h and 10 m^3/h capacity respectively. Owing to the insufficient capacity of the power supply only two modules can operate simultaneously to a maximum capacity of 40 m^3/h. Owing to the limited capacity of the sea water and fresh water boreholes the maximum production capacity of the RO plant is limited to 25 m^3/h. The treated water is then pumped (600 m^3/d) to the bulk storage reservoirs. Desalination of this water is very expensive at R5/m^3 and the process is also not efficient (38%). Brine from the desalination plant is returned to the sea via the Bushmans River, which may have some negative environmental impact. A scoping report is currently being compiled and will outline the influence on the environment.

The total maximum daily production flow from all three sources is 1 422 m^3/d and the scheme is being operated by the Albany Coast Water Board.

The water is distributed from the bulk supply reservoirs via gravity reticulation, including the supply to a separate storage reservoir (100 m^3) at Boesmansriviermond. A separate pumping main (15 m^3/h) and 500 m^3 reservoir supply some farmers about 7 km to the north.

Daily usage varies between 1 200 m^3/day during normal periods to 1 800 m^3/day during peak season. Extreme daily peaks can reach 2 300 m^3/d during the December holidays.

5.3.3 Overview of Current Problems

The well points at Diaz Cross are being pumped beyond their permitted abstraction rate to comply with the peak demands that arise during holiday seasons. The total maximum capacity of all current sources is 1 780 m^3 per day that is not sufficient for the peak requirements. Most households currently augment their water supply by harvesting rainwater. Owing to the restricted availability of the water source at Diaz Cross as well as the power supply to the RO plant, the actual production capacity at present is about 1 400 m^3/d.

The water quality of the wells at Diaz Cross is poor. The current TDS of this water is about 1 400 mg/l, which is classified as class II, but when overexploited salinity levels can exceed 2 500 mg/l.

The bulk storage reservoirs have inadequate storage capacity during peak season and additional storage is required.

Owing to the system's inadequate water sources and low storage capacity, it cannot afford any downtime. Eskom's power supply is very unreliable and this results in insufficient supply to the bulk storage reservoir and puts constant stress on the water balance.

The situation in the towns is critical and needs immediate attention.

Information from the WSDP is available in **Appendix 5**.

5.4 PORT ALFRED

The supply area includes the town of Port Alfred, the former townships of Nemato and Mimosa Farm and the proposed township of Thornhill with a total current population of about 21 000 people. An additional 5 000 stands are proposed to be serviced in the Thornhill township within the next two years.

5.4.1 Levels of Service

Every stand in Port Alfred is supplied with water at erf connection level of service. 60% of the stands in Nemato are supplied with yard connections, while 20% are serviced with communal standpipes.

Port Alfred is 40% serviced with water-borne sanitation and 60% serviced with conservancy tanks. 50% of the township of Nemato has digestive systems with French drains, while the remaining 50% has VIP's.

5.4.2 Description of Existing Water Supply Infrastructure

Figure S4 is a schematic layout of the existing water supply scheme for this area.

Raw water is abstracted from a weir on the Kowie River and pumped (max 12 960 m^3/d) from pump station No.1 to an off-channel storage dam - Sarel Haywood Dam (2.5 x 10^6 m^3 storage and 1.55 x 10^6 m^3/a yield). From here water is conveyed via a 10.3 km long pipeline and two pump stations with a capacity of 4 320 m^3/d to a balancing dam (capacity 16 000 m^3) near the hospital.

Water is gravity fed from the balancing dam to the water treatment works (capacity 5 000 m^3/d), situated to the north of the town, via a 3 km long pipeline. Potable water from the treatment works discharges into a bulk storage reservoir and is then pumped (5 000 m^3/d) to four distribution reservoirs.

From the distribution reservoirs the water is distributed by gravity to the users.

Two well fields in the coastal sand dunes, located near the town of Port Alfred, are used during peak periods to augment the water supply to the town (max capacity 356 m^3/d). It is also possible to augment the water supply by gravity feeding raw water from Mansfield Dam (yield 45 Ml/a) to the water treatment works in the town. This system is however out of order. The pipeline is about 6,5 km long, 150 mm ND and has a maximum capacity of 15 l/s. The daily water use in Port Alfred is as follows:

- Average: 2.0 to 2.5 Ml/d
- Summer peak: 4.0 to 5.0 Ml/d
- Extreme peak: 6.0 to 7.5 Ml/d

The total yield of the existing water sources is as follows:

• Sarel Hayward Dam	1.55×10^6 m³/a
• Boreholes	0.13×10^6 m³/a
• Mansfield Dam	0.05×10^6 m³/a
Total yield	1.73×10^6 m³/a

Information from the WSDP is available in **Appendix 5**.

5.4.3 Overview of Current Problems

The quality of raw water is poor due to the marine origin of the soils underlying the dam basin. In order to meet the peak seasonal demands, the capacity of the bulk supply system needs to increase.

Additional bulk water supply infrastructure is required to meet the demands for the proposed developments in Thornhill (5 000 additional stands).

About 1 800 households in Nemato need access to yard connections.

5.5 BATHURST

Included in this particular supply area are the town Bathurst and the former townships of Nolukhanyo and Freestone with a total population of about 5 600 people.

5.5.1 Levels of Service

The population in Nolukhanyo and Freestone is serviced with potable water at yard connection level of service, while Bathurst relies on private water supplies like boreholes and harvesting rainwater.

Sanitation services are provided in Bathurst through both septic and conservancy tanks, while Nolukhanyo and Freestone are serviced with septic tanks and soakaways.

5.5.2 Description of Existing Water Supply Infrastructure

Figure S5 is a schematic layout of the existing water supply scheme for this area.

Existing water sources are the Golden Ridge Dam (0.25×10^6 m³/a with no provision for the ERR), private boreholes and the Mansfield Dam (0.05×10^6 m³/a).

Raw water is pumped from the Golden Ridge Dam (1 382 m^3/d) to a package treatment works in Bathurst (capacity 432 m^3/d). A second pump station transfers potable water (432 m^3/d) to the Toposcope reservoir (1 000 m^3). From the reservoir water is distributed by gravity to all households.

Ndlambe Municipality is operating this scheme.

The maximum capacity of the Water Treatment Works is 0.16 x 10^6 m^3/a. The capacity of the existing private boreholes is unknown.

Information from the WSDP is available in **Appendix 5**.

5.5.3 Overview of Current Problems

The water treatment works are currently operating at capacity, while the bulk storage is also not sufficient.

The Golden Ridge Dam needs to be investigated in terms of the ERR requirements. The current yield is about 0.25 x 10^6 m^3/a without ERR releases.

5.6 KLEINEMONDE AND SEAFIELD

The supply area includes East Kleinemonde and Seafield with a total population of 1 450.

5.6.1 Levels of Service

Both towns are fully serviced with potable water to house-connection level.

Sanitation services include septic tanks with soakaways at every stand.

The present GAADD is in the order of 230 m^3/d, but grows to about 500 m^3/d during peak season. The existing maximum capacity of the source of about 408 m^3/d is insufficient to meet the peak requirements. Furthermore during certain periods when the water quality in the Wellington Dam is poor, the total capacity of the system is limited to the capacity of the Water Treatment Works (90 m^3/d).

5.6.2 Description of Existing Water Supply Infrastructure

Figure S6 is a schematic layout of the existing water supply scheme for these towns.

The area is supplied with water from the Wellington Dam located 8 km north west of the town. Two coastal boreholes, located in the Seafield area, are utilised during peak seasons to augment the water supply.

Raw water is pumped from the Wellington Dam (360 m^3/d) to a balancing reservoir (40 m^3) situated 2 km south-east of the dam. From this reservoir the water is gravity fed to the treatment works (capacity 90 m^3/d) situated on the East Kleinemonde peninsula, where it is treated and pumped to a bulk storage reservoir (800 m^3) near Seafield. Connected to this pumping main are the two reticulation networks of the Peninsula and South Island that are directly supplied from this pumping main.

The Seafield reservoir supplies a portion of Seafield and a lower laying storage reservoir (60 m^3), which in turn gravity feeds a supply zone within Seafield.

A borehole near Seafield can supply 48 m^3/d, while one near the river mouth currently supplies 32 dwellings but it is highly susceptible to saline infiltration if the system is used at its peak demand. Water is pumped from the borehole situated east of Seafield to the Seafield reservoir, while water from the East Kleinemonde borehole is pumped to the lower-zone reservoir.

The total maximum daily production flow from the Wellington Dam and the borehole near Seafield is 408 m^3. During times when the salinity levels in the dam are very high, the purification capacity is only 90 m^3/d, which results in a maximum daily production flow of 138 m^3.

Ndlambe Municipality is operating these schemes.

More detailed information is available in **Appendix 5**.

5.6.3 Overview of Current Problems

The bulk supply and the reticulation systems are interconnected and lead to a high possibility for water losses.

Wellington Dam is situated in the centre of pine fields and this causes soil and pesticides to wash into the dam during heavy rains. This causes the TDS of the water to rise up to 2 500 parts per million, which is too high for domestic use.

The borehole at the river mouth is highly subjected to contamination owing to seepage from household septic tanks.

The maximum available water source is insufficient to meet peak requirements.

5.7 WATER CONSERVATION AND DEMAND MANAGEMENT

No detailed Water Demand Management (WDM) studies have been undertaken for any of the towns. The water losses in the reticulation networks are therefore unknown. However, owing to the severe limitations of the existing sources and the poor water quality, water is utilised very effectively at household level. Almost all households are fitted with rainfall harvesting facilities and people are forced to utilise this water owing to the lack of alternative sources.

Appendix 8 includes more information on the potential for water conservation and demand management.

6. WATER RELATED INFRASTRUCTURE

6.1 ORANGE - FISH TRANSFER SCHEME

The Orange-Fish Transfer Scheme was developed to utilise surplus water from the Orange River mainly for the purpose of irrigation, supply to urban areas and to generate hydro-electric power. Water is diverted from the Orange River to the Great Fish and Sundays River via a 82.9 km long, 5.4 m diameter tunnel that discharges into the Teebus Spruit. Water flows from the tunnel outlet to the Grassridge Dam on the Great Brak River, a tributary of the Great Fish River. The tunnel has a capacity of 1 700 x 10^6 m^3/a while the mean annual requirement was 560 x 10^6 m^3/a in the year 2002.

Water is released from the Grassridge Dam down the Great Fish River to Elandsdrift Weir. Here it is diverted into a 108 km long aqueduct, of which the Cookhouse Tunnel is the main feature that discharges water into the Little Fish River. Water not diverted into the aqueduct is released from the Elandsdrift Weir into the Great Fish River that supplies the Lower Fish River Government Water Scheme.

6.2 LOWER FISH RIVER GOVERNMENT WATER SCHEME

The Hermanuskraal Weir is used to divert water into the Fish–Ecca Tunnel, with a capacity of 500 x 10^6 m^3/a, which discharges into the Glen Melville Dam on the Ecca River. This dam is a balancing reservoir for raw water supplied to Grahamstown and the Lower Fish River Irrigation Scheme. A municipal pumping scheme conveys water from the WTW at the Glen Melville Dam to Grahamstown via a 350 mm diameter raising main.

The yield from Glen Melville Dam that has been allocated for transfer to Grahamstown is 7.3 x 10^6 m^3/a. At present, the existing bulk supply system supplying Grahamstown (pump station, water treatment works, pipeline) has a capacity of 3.65 x 10^6 m^3/a. If required the allocation for domestic use from the Glen Melville dam can be increased substantially.

6.3 DAMS IN DRAINAGE REGION P

Table 6.3A: Main dams

Dam	Quaternary Catchment	Wall Height (m)	Surface Area (ha)	Capacity (1 000 m^3)	Use
New Year's	P10B	22	96	4 700	Domestic Supply
Howiesonspoort	P30B	24	16	883	Domestic Supply & Irrigation
Settlers	P30B	21	101	5 620	Domestic Supply
Golden Ridge	P40B	13	13	400	Domestic Supply
Sarel Hayward	P40C	40	25	2 522	Domestic Supply
Mansfield	P40C	14	4	165	Domestic Supply
Mount Wellington	P40D	10	2	250	Domestic Supply & Irrigation

Table 6.3B: Registered farm dams

Dam	Quaternary Catchment	Wall Height (m)	Surface Area (ha)	Capacity (1 000 m³)
Jameson	P10A	13	15	575
Milner	P10A	24	7.7	255
Concorde	P10A	?	1	80
Grey	P40A	21	1	68
Kareeleegte	P10C	6	7	64
Blackburn	P10D	10	0	150
Teafontein	P10B	8	3	204
Table Hill Big	P10A	12	8	364
Oakwell	P10B	10	2	82
Mosslands	P30A	15	18	571
Brakkloof River	P10A	7	4	75
Strowan	P10A	9	6	139
Hilton	P10B	6	3	60
Shenfield Camp	P10B	10	2	60
Mountain View	P10F	11	1	250
Springvale	P10B	9	6	163
Proctorsfontein Dipping Tank	P30B	9	3	126
Proctorsfontein House	P30B	11	4	299
Lake Gum	P30B	9	7	251
Birmingham New	P30A	13	10	414
Dogplum	P30B	15	32	101
Yellow Wood	P30B	12	5	130
New Year Park	P30B	8	0	79
Arnhem	P10A	17	2	80
Rochester	P30B	8	0	202
Lindale	P30B	10	17	260
All’s Well	P30B	8	18	492
Assegaai	P30B	9	8	224
Doringkloof	P30B	11	7	198
Le Grange	P30B	8	0	130
Langley Park	P30A	7	5	90
Yarrow	P30B	11	8	462

Table 6.3B: Registered farm dams (Continued)

Dam	Quaternary Catchment	Wall Height (m)	Surface Area (ha)	Capacity (1 000 m³)
Endwell Farm	P30B	9	1	60
Fairfield	P30B	8.5	6	79
Hopeleigh	P30B	6	34	136
Homeleigh	P30B	9	2	82
Avondale	P30B	7	7	272
Weltevrede	P30B	8	10	205
Rosslyn	P40B	14	4	150
Kenkele	P40A	13	4	160
Pinedale	P40A	16	7	300
Willow Park	P40A	11	4	150
Gleniffer Dam 1	P40C	8	3	50
The Home	P40B	10	4	110
Gleniffer Dam 2	P40C	12	6	200
Lanpeter	P40B	10	5	120
Rockwoodvale	P40A	6	3	135
Rhema	P40A	13	2	150
Fairview	P40B	7.9	4	218
The Grove	P40D	11	2	70
Old Mill	P30B	8	4	76

More details regarding the registered dams in the study area are attached in **Appendix 5.2**.

6.4 OVERVIEW OF WATER SUPPLY AND SANITATION SITUATION IN THE STUDY AREA

The total population within the study area during 2001 was about 139 000 of which about 119 000 reside in urban areas. The rural population consists mainly of commercial farmers and farm labourers. The rural population is supplied from private water sources, mainly boreholes and small farm dams.

The urban population is supplied through ten different schemes (see **Figure 10.1**). The schemes supplying the coastal towns are described in detail in **Section 5**, while the schemes supplying the remaining urban towns are described in the following sections.

Service levels are generally above RDP standards. The total capacity of the water supply schemes is about 10.5 $x10^6$ m³/a and this relates to an average daily supply per person of 240 l.

Sanitation services are provided at all coastal towns through septic and conservancy tanks. The surrounding former townships have either water-borne sanitation or septic tanks, while about 800 households currently have no sanitation service. The townships around Port Alfred are provided with VIP's and digestive French drains.

The level of sanitation services in and around the remaining urban towns is generally lower than that for the coastal towns. About 4 000 households in Grahamstown are serviced with the bucket system, while about 800 households have no service. Alicedale currently have a high level of service with Riebeeck East and Paterson very low.

6.4.1 Grahamstown

Grahamstown is currently supplied from two different sources. The Glen Melville Dam supplies Grahamstown East via the James Kleynhans Water Treatment Works (WTW), while the Howieson's Poort, Settler's, Jameson and Milner dams supply Grahamstown West via the Waainek Water Treatment works.

Bulk water is supplied from the Orange-Fish Government Water Scheme to the off-channel Glen Melville Dam, approximately 15 km north-east of Grahamstown. From the 10 000 m^3/day water treatment works and pump station at the dam, water is pumped via a 350 mm diameter pipeline to the following reservoirs: the high level reservoir at Bothas's Hill (7 000 m^3), the Mayfield reservoir (3 000 m^3) and the Tantyai reservoir (2 500 m^3). From these reservoirs water is distributed by gravity reticulation networks to households in the east.

Raw water is pumped from Settlers Dam to Howieson's Poort Dam via two 250 mm diameter pipelines approximately 3.45 km long. Raw water is pumped (9 000 m^3/d) from the Howieson's Poort Dam to the Waainek WTW (capacity 9 000 m^3/d) via a 300 mm diameter pipeline. From the storage reservoir (16 000 m^3) at the WTW, purified water gravitates through a 375 mm diameter pipeline to the adjacent Waainek reservoir (2 250 m^3), the two Town Filter reservoirs (7 500 m^3) and a low level reservoir (3 000 m^3). From these reservoirs water is distributed through gravity reticulation networks to households in the west.

Water from the small Jameson an Milner dams gravitates to the old "Town Filters" from where it is pumped to the Waainek WTW through a 200 mm diameter pumping main 2.1 km long.

The Settlers/Howieson's Poort Dam system is currently used to maximum capacity. All future water requirements will have to be supplied from the Glen Melville Dam.

6.4.2 Alicedale

Raw water gravitates from the New Years Dam to the WTW (capacity 2 000 m^3/d) at Alicedale via a 300 mm and 200 mm pipeline. From the WTW water gravitates to three concrete reservoirs with a total capacity of 573 m^3. Water is supplied from these reservoirs to three different areas.

Water gravitates from the reservoirs via a 150 mm diameter cast iron pipe to supply the reticulation network in Alicedale.

A second gravity main, 250 mm diameter, feeds water to a pump station on the bank of the Bushmans River. Water is pumped from the pump station by means of a duplicate pumping system via a 150 mm and 75 mm diameter rising main to two reservoirs (total capacity 1 107 m^3) south of KwaNonzwakazi. From these reservoirs water is distributed through gravity reticulation networks to households in KwaNonzwakazi and Transriviere.

Shamwari Game Park south of Alicedale collects water by means of a tanker.

The raw water demand is very high with daily demand metered at an average of 1 050 m^3/d, which indicated that there must either be excessive system losses or high usage patterns. Alicedale has no high-pressure zones and low pressure in parts of the towns has been a problem in the past.

6.4.3 Riebeeck East

Water is pumped from two boreholes (86 m^3/day) with good water quality. Both these boreholes draw from the same aquifer and a number of privately owned boreholes in town, used mainly for small-scale farming, draw from the same aquifer. These boreholes supply two bulk reservoirs (combined capacity 180 m^3) from where it is pumped to a 43 m^3 elevated reservoir from which the entire town is supplied. Kwanomzamo and the remainder of the town is supplied separately and measured through two different bulk meters.

6.4.4 Paterson

A total number of 1 467 households in Paterson, Kwazenzele, Mandela, Zinyoka and Moreson are supplied from three boreholes (total yield 330 m^3/day), discharging into two reservoirs (combined capacity 750 m^3). Under normal conditions water gravitates from these two reservoirs directly into the distribution network, but when the pressure is insufficient water is pumped from a third town reservoir (500 m^3) into a 46 m^3 header tank.

Water shortages are experienced in the area at times and the possibility of augmenting the water supply by taking Orange River Water from the canal at Kommandokraal must be investigated.

Table 6.4: Existing water supply schemes as at 2001

Scheme Name (town)	Raw-water Source	Town/Township Supplied	Population Supplied	Present Water Use 10^6 m³/a	Max Source Capacity		
					l/c/d	10^6 m³/a	Limiting Factor
Alexandria	Coastal Springs 7 l/s 2 well points 12 l/s extra BH 1,5 l/s	Alexandria Wentzel Park KwaNonqubela	7 715	0.51	213	0.65	Pumping main
Cannon Rocks & Boknes	3 boreholes	Cannon Rocks Boknes	931	0.18	706	0.24	Boreholes, water quality
Boesmansriviermond Kenton on Sea	6 well points 5 freshwater boreholes 8 seawater boreholes	Boesmansriviermond Kenton on Sea Klipfontein, Marselle Ekuphumeleni	9 480	0.44		0.52	Diaz Cross RO Plant Reservoir Capacity Power supply
Port Alfred	Sarel Hayward Dam Wells in coastal dunes Mansfield Dam	Port Alfred Nemato Mimosa Farm	20 965	1.0	130	1.73	Pumping mains
Bathurst	Private boreholes Harvesting rainwater Golden Ridge Dam	Bathurst, Nolukhanyo Freestone	5 549	0.158		0.30	Treatment Works
Kleinemonde and Seafield	Wellington Dam 2 boreholes	Kleinemonde Seafield	1 450	0.09	156	0.15	Purification Plant Boreholes
James Kleynhans	Glen Melville Dam	Grahamstown East	61 759	1.10	162	3.65	WTW
Waainek	Howieson's Poort Dam Settlers Dam	Grahamstown West		2.40		2.20	WTW
Alicedale	New Years Dam	Alicedale KwaNonzwakazi Transriviere	5 950	0.38*	176	0.73	WTW
Riebeeck East	2 boreholes	Riebeeck East Kwanomzamo	689	0.031*	125	0.031	Boreholes
Paterson	3 boreholes (currently only one is operational)	Paterson, Kwazenzele, Mandela, Zinyoka, Moreson	4404	0.11*	75	0.12	Boreholes

* From WSDP

7. WATER RESOURCES

7.1 SURFACE WATER RESOURCES

7.1.1 Stream flow hydrology for drainage region P

The stream flow analysis for drainage region P has been undertaken on a quaternary catchment basis for the purposes of this study. The results of these analyses are described in detail in the supporting report **Surface Water Resources**. This section outlines the findings related to possible development of the surface water sources for the augmentation of the water supply to the affected coastal towns.

The Water Research Commission publication "Surface Water Resources of South Africa, 1990" (WR90) subdivides the study area into three rainfall zones (**Figure 4.1**) and a number of functional rainfall gauging stations have been identified in each zone within region P. The hydrological analyses for the area have been based on the Water Resources Yield Model (WRYM) parameters. The yield at the outlet of each quaternary catchment as well as for 3 dam sites has been determined.

A summary of the results for the surface water runoff per quaternary catchment and per river basin is provided in the following tables.

Table 7.1.1A: Surface Water Runoff per Quaternary Catchment

Quaternary Catchment	Catchment Area	MAP	Incremental MAR		
			Natural MAR	Natural MAR	Present day MAR
	(km^2)	(mm)	(mm/a)	($10^6m^3/a$)	($10^6m^3/a$)
P10A	126	600	36	4.54	3.66
P10B	508	531	24	12.19	9.92
P10C	281	386	8.5	2.39	1.46
P10D	564	432	12	6.77	4.83
P10E	466	493	19	8.85	7.15
P10F	469	557	29	13.6	11.48
P10G	343	550	28	9.6	8.38
P20A	422	715	72	30.38	25.59
P20B	332	635	46	15.27	11.48
P30A	176	623	39	6.86	4.08
P30B	403	559	29	11.69	4.54
P30C	68	536	25	1.7	1.27
P40A	312	635	44	13.73	10.31

Table 7.1.1A: Continue

P40B	264	570	31	8.18	7.68
P40C	342	616	41	14.02	11.51
P40D	246	666	54	13.28	11.96
TOTAL	**5322**		**537.5**	**173.05**	**132.03**

The distribution of the MAR throughout the study area is shown in **Figure 11.1**.

Table 7.1.1B: Surface Water Runoff for Main Rivers within the Study Area

River	Quaternary catchment	Catchment Area (km^2)	Virgin MAR ($10^6 m^3/a$)
Bushmans River	P10A to G	2757	57.94
Kariega River	P30A to C	647	20.25
Kowie River	P40A to C	918	35.93
Coastal Rivers	P20A & B, P40 D	1000	58.93

7.1.2 Yield Analysis

The WRYM was used to determine the yield at the outlet of the quaternary catchments and at three dam sites. The model was configured for two scenarios: with and without the Ecological Reserve (ERR) and the results are summarised in the table below. The total yield for the drainage region P is 4.63 x 10^6 m^3/a and 7.01 x 10^6 m^3/a respectively with and without taking the ecological reserve (ERR) into account.

The distribution of the cumulative yield per quaternary catchment is shown in **Figure 11.2**.

Table 7.1.2A: Cumulative Yield Results per Quaternary Catchment

Quaternary Catchment	Yield with Ecological Reserve Requirements ($10^6 m^3/a$)	Yield without Ecological Reserve Requirements ($10^6 m^3/a$)
P10A	0.00	0.00
P10B	0.19	1.00
P10C	0.00	0.00
P10D	0.00	0.00
P10E	0.54	2.49
P10F	0.54	2.62
P10G	0.57	2.74
P20A	0.00	0.10
P20B	0.00	0.00
P30A	0.00	0.00
P30B	0.00	0.00
P30C	0.00	0.00
P40A	0.00	0.00
P40B	0.00	2.76
P40C	4.05	4.14
P40D	0.00	0.03
TOTAL	**4.63**	**7.01**

The historic firm yield was determined for the following two existing dam sites: Sarel Hayward Dam and Golden Ridge Dam, as well as for a proposed dam site called Bushfontein Dam.

Golden Ridge Dam can yield 0.002 and 0.23 x 10^6 m³/a with and without provision for the ecological reserve requirements respectively. The following tables summarise the yield results for the two other dam sites.

Table 7.1.2B: Sarel Hayward Dam Yield - (10^6 m³/a)

Pump Rate	FSL 38.9 mamsl Vol = 2.52 x $10^6 m^3$	FSL 42.3 mamsl Vol = 3.41 x $10^6 m^3$	FSL 48.0 mamsl Vol = 5.12 x $10^6 m^3$	FSL 55.0 mamsl Vol = 8.46 x $10^6 m^3$
150	1.55	1.73	2.08	2.44
200	1.89	2.11	2.49	3.07
250	1.89	2.39	2.76	3.35
300	1.89	2.56	2.95	3.59

- Existing NGL at wall = 10.0 mamsl
- Existing Dead Storage Level (DSL) = 25 mamsl
- Existing Full Supply Level (FSL) = 38.9 mamsl

Bushfontein Dam Yield - (10^6 m³/a)

DSL (mamsl)	FSL (mamsl)	Capacity ($x\ 10^6 m^3$)	Yield Without ERR	Yield With ERR
290.2	298	1.919	6.11	4.51
286.3	288	0.049	4.35	2.32

The current net available yield of Sarel Hayward Dam is 1.55 x 10^6 m³/a, after allowing for some flushing of the dam in order to control the water quality. The objective is to get a future yield of about 3 x 10^6 m³/a by raising the existing dam wall and by upgrading the capacity of the abstraction pump station. From the yield results it is evident that the wall should be raised by 12 m to a Full Supply Level (FSL) of 50.9 mamsl and water should be supplied at a pumping rate of 250 l/s in order to achieve a yield of 3 x 10^6 m³/a.

According to the height-area-capacity curves, the proposed Bushfontein Dam will have a storage capacity of 0.049 x 10^6 m³ and 1.919 x 10^6 m³ in order to produce yields of 2.32 x 10^6 m³/a and 4.51 x 10^6 m³/a respectively.

7.1.3 Water Quality

Figure 5.1 illustrates the geological zones for the study area. From this figure it is evident that the Cape Supergroup covers the greatest portion of the northern, central, eastern and southern parts of drainage region P. The Cape Supergroup consists of the Bucketed and Wittenberg Groups that are both of marine origin. Rainfall on these terrains result in flushing of salts released by weathering and the leaching of salts by water percolating through the soils and weathered zone. Water leaching over the Bucketed Group shale’s result in 0.3 g salt/kg rock and water draining through soils developed over the Bucketed Group yield 0.8 – 4 g salt/kg soil. As a result, 25 – 50 tons of salt are expected to be leached per mm of rain, resulting in surface runoff having a TDS of over 2 200 mg/l, given rainfalls of 600 mm/a. Peak TDS is encountered during the first flush of runoff, with a lowering TDS generally appearing several days after peak flows. **Table 7.1.3** indicates the expected average TDS and upper level TDS after rainfall events in the main rivers for each tertiary catchment.

Table 7.1.3 TDS of Main Rivers

Tertiary Catchment	Quaternary Catchment	River	Mean TDS (mg/l)	Upper Level TDS (mg/l)
P10	P10A	New Years River	140	500
	P10B	New Years River	500	3 500
	P10E	Bushmans River	2 200	4 000
P30	P30A	Kariega River	250	1 400
	P30B	Kariega River	2 500	5 500
P40	P40A	Kowie River	825	1 300
	P40C	Kowie River	1 700	

The predicted runoff quality for each of the main rivers in the study area can be summarised as follows:

Bushman's River - P10

In the Bushmans River, good water quality (Class I) can be expected down stream to include Quaternaries P10A-D, which are the New Years and upper Bushmans rivers to Alicedale. South of Alicedale, water quality deteriorates rapidly due to significant salt loads originating from the Manage and Weltered Formations. Runoff continues to become progressively more saline downstream.

Kariega River – P30

In the Kariega catchment acceptable water quality is only present in the head waters of the Kariega, P10A and the headwaters of the Assegai, P30B, which is partially underlain by Westport quartzites. Below the Settlers Dam in catchment P30B water quality deteriorates rapidly due to salt loads from the Weltered shales and irrigation return flows.

Kowie River - P40

In the Kowie River, water quality is acceptable in the headwaters, which are underlain by Dwyka, Lake Mentz and Witpoort rocks (P40A). Water quality deteriorates once the river flows over Weltevrede rocks north of Bloukrans pass. Salinisation is also expected due to irrigation in the Belmont valley of the Bloukrans, south east of Grahamstown.

Boknes and Diepkloof rivers – P20

In the Boknes catchment, good quality water can only be expected from springs emanating from the Alexandria Formation at the base of the Nanaga Formation at its contact with the Bokkeveld. The Boknes River itself flows over Bokkeveld rocks and water quality deteriorates rapidly down channel.

The Diepkloof is an intermittent river with internal drainage into the back dune regions. Water quality of springs draining the Nanaga is generally poor.

7.2 GROUNDWATER

Details regarding the results of the groundwater resources investigations undertaken for this study are offered in the supporting report **Albany Coast Groundwater Potential**. The following paragraphs provide an overview and a brief summary of the results with specific reference to the development potential of the groundwater resources within the study area.

Regional perspective

Groundwater resources of drainage region P are currently not being utilised to their full potential. The present groundwater use in the study area is estimated to be in the order of 2.4×10^3 m³/a. In general, the groundwater harvest potential for the area is positive, subject to the water quality and environmental approval. Although many of the towns within the study are already rely on groundwater as the primary water source, more groundwater sources can be harvested in a sustainable manner to augment the water supply to certain areas. The minimum groundwater harvest potential along the coastal zone (where the biggest shortages occur), varies between 25×10^3 m³/a/km² and 50×10^3 m³/a/km², depending on the underlying geology. Groundwater harvest potential further inland varies between 7.5 x 10^3 m³/a/km² and 15 x 10^3 m³/a/km², again depending on the underlying geology. **Table 7.2A** summarises the harvest potential for every aquifer within the Ndlambe Municipal boundary.

Table 7.2A: Minimum Harvest Potential per Aquifer

Aquifer	**Area** (km^2)	**Harvest Potential** (m^3/a/km²)	**Potential Supply /day** ($10^3 m^3$/d)	**Potential Supply** ($10^6 m^3$/a)
Unconsolidated (Schelmhoek Fm)	39.17	100 000	10 700	3.92
Semi-Consolidated (Nanaga Alexandria Fms)	340.27	25 000	23 300	8.51
Arenaceous Fractured Rock (Witpoort Fm)	501.55	15 000	20 600	7.52
Argillceous Fractured Rock (Bokkeveld, Lake Mentz, Weltevrede, Ecca, Dwyka Fms)	1 125.72	10 000	30 800	11.26
TOTAL	**2 006.71**		**85 500**	**31.21**

The actual exploitation potential of an aquifer is lower than the harvest potential and an exploitation factor is applied to the harvest potential to determine the quantity that can practically be abstracted. From the total harvest potential quantity for the Ndlambe Municipal area, only **7.49 x 10^6 m³/a** can be utilised in a sustainable manner without overexploiting the sources. **Table 7.2B** includes the total utilisable groundwater resources for the different aquifers.

Table 7.2B: Utilisable Groundwater Resources by Aquifer

Aquifer	**Area** (km^2)	**Exploitation Factor**	**Exploitation Potential** ($10^6 m^3$/a)	**Utilisable Resources***1 ($10^6 m^3$/a) Exp. Fact Cl I	**Utilisable Resources***2 ($10^6 m^3$/a) Exp. Fact Cl II
Witpoort Fm (Western Belt)	190.47	0.50	2.86	0.46	0.97
Witpoort Fm (Central Belt)	59.22	0.50	0.89	0.14	0.30
Witpoort Fm (Eastern Belt)	251.77	0.50	3.78	0.60	1.28
Weltevrede Fm	660.97	0.30	2.54	0.28	0.63
Bokkeveld Gp	222.70	0.20	0.57	0.00	0.00
Lake Mentz Fm	220.33	0.30	0.85	0.08	0.12
Nanaga & Alexandria Fms	340.27	0.30	2.35	0.26	1.00
Karoo SuperGp	21.72	0.30	0.08	0.01	0.02
Schelmhoek Fm	39.17	0.65	5.70	0.79	3.16
TOTAL	**2 006.62**		**19.62**	**2.62**	**7.48**

*1: The total utilisable groundwater of quality equal to Class 0 or I

*2: The total utilisable groundwater of quality equal to Class II

Table 7.2C provides a summary of the maximum utilisable groundwater within each quaternary catchment of the Ndlambe Municipal area. This area covers all the coastal towns where the major water supply problems are experienced.

Table 7.2C: Utilisable Groundwater per Quaternary Catchment

Quaternary Catchment	Area (km^2)	Average Yield per Borehole	Harvest Potential ($10^6 m^3/a$)	Exploitation Potential ($10^6 m^3/a$)	Max Utilisable Groundwater ($10^6 m^3/a$)
P10G	256	1.40	3.87	1.93	0.00
P20A	270	1.17	9.51	4.75	1.87
P30B	195	0.88	2.48	1.24	0.15
P30C	68	1.02	1.99	0.99	0.50
P40A	51	0.59	0.65	0.26	0.08
P40B	257	0.90	3.26	1.63	1.14
P40C	342	0.69	13.11	5.24	2.04
P40D	246	1.76	3.14	1.89	0.63
Q93D	321	1.09	3.80	1.9	0.89
TOTAL	**2 006**		**41.81**	**19.83**	**7.30**

A few areas from the fractured Witpoort Aquifer are considered to have relatively high groundwater potential and have been identified throughout the study area; these are listed below:

- **Bushfontein Farm:** Situated about 22 km north-west of the town Kenton on Sea, potential yield of 800 m^3/d
- **Merville Farm:** Situated about 18 km north of the town Kenton on Sea, potential yield of 800 m^3/d
- **Barville Park / Glendower Farm:** Situated about 6 km west of the town Port Alfred, potential yield of 1 000 m^3/d
- **Fords Party:** Situated about 10 km east of the town Bathurst, potential yield of 1 000 m^3/d
- **Palmietheuval Farm:** Situated about 4 km north-east of the town Kleinemonde, potential yield of 800 m^3/d
- **The Grove Farm:** Situated about 10 km north-east of the town Bathurst, potential yield of 800 m^3/d

Another source with high potential yields is the Intergranular Coastal Aquifers. Boreholes drilled in those areas are expected to yield in the order of 3 to 5 l/s of Class I and Class II water. **Table 7.2B** provides a summary of these sources and its potential yields.

Table 7.2B: Potential of Dune Aquifer Systems

Well Field / Aquifer	Area (km²)		Storage Capacity	Available to Develop	
	Dunes	Back Dunes	($10^6 m^3$)	(m^3/d)	($10^6 m^3/a$)
Cape Padrone - Fishkraals	11.00	13.00	12.00	2 274	0.83
Apies River	9.70	15.30	6.25	2 082	0.76
Diaz Cross	1.08	7.00	4.00	603	0.22
Kwaaihoek	0.52	4.50	2.50	329	0.12
Sunshine Coast Nature Reserve	1.30	10.20	3.00	767	0.28
Bushman's River Mouth	0.42	1.20	0.81	192	0.07
Port Alfred East	0.80	1.76	1.28	329	0.12
Rufanes River	0.80	1.65	0.61	575	0.21
Riet River	0.80	1.30	0.52	300	0.11
Claytons Rock	0.80	0.95	0.43	300	0.11
Fish River Lighthouse	0.80	1.15	0.49	300	0.11
TOTAL	**28**	**58**	**31.89**	**8 055**	**2.84**

Some of the sources from the dune aquifer system, like Kwaaihoek and Sunshine Coast well fields, fall within the jurisdiction of the Sanparks and permission from the Department of Environmental Affairs and Tourism (DEAT) is required before any implementation processes for the development of these sources can commence.

In general, supplementing the supplies with groundwater can eliminate some of the current and projected shortages at the coastal towns. Drilling depths will vary between 100 m to 180 m with success rates of between 30% and 60%. Groundwater resources are available to augment the supplies to the coastal towns and are less expensive to develop than surface water for instance. Supply from groundwater sources can be a relatively quick and inexpensive solution to some of the current problems, but it is not enough to meet the total demand up to the year 2025. Conjunctive use of groundwater sources and alternative sources such as surface water or desalinated water is inevitable and has been investigated and results are discussed in more detail in **Section 8** of the report.

Groundwater Quality

Marine lithologies, shale-dominant and limestones, account for 72% of the surface area by outcrop, whereas chemically inert quartzites make up the remaining 28%. This marine-originated geology causes salinization or mineralisation of groundwater, which results in poor quality water. Generally the quality of groundwater varies between a Class I and II. Over-pumping of coastal aquifers result in saline intrusions that cause the water quality to deteriorate. This is currently the phenomenon during peak seasons when water demands are higher than during normal periods. **Table 7.2C** gives an indication of the mean TDS of the groundwater for each quaternary catchment.

Table 7.2C: TDS of Groundwater for each Quaternary Catchment

Quaternary	P10A	P10B	P10C	P10D	P10E	P10F	P10G	P20A
Mean TDS (mg/l)	353	1 342	1 088	896	2 957	2 828	2 642	2 334
Quaternary	**P20B**	**P30A**	**P30B**	**P30C**	**P40A**	**P40B**	**P40C**	**P40D**
Mean TDS (mg/l)	2 537	600	2 197	1 151	2 481	2 508	2 364	2 151

Economic Considerations

The costs of exploring and developing groundwater sources will be considerably lower than to transfer surface water due to the long distances and high pumping heads of the possible surface water schemes. The cost of establishing and maintaining a groundwater supply scheme may, in certain coastal area, prove to be a factor encouraging its development.

As a first order estimate, the average yield of the coastal dune aquifer well points in the study area is expected to be in the order of 2.0 to 3.0 l/s per borehole, while the fractured aquifers have an average yield of 4 l/s per borehole. It is recommended that environmental impact assessments be initiated if groundwater is considered to be an acceptable solution for the current problems at the coastal towns.

8. DEVELOPMENT OPTIONS

This part of the report deals with the identification, sizing, costing and evaluation of the development options required to augment the sources of water supply in certain towns within the study area, which were specified in the Terms of Reference.

8.1 POPULATION NUMBERS IN THE AFFECTED TOWNS

The present and projected population numbers in the affected towns were estimated in accordance with the methodology described in detail in **Section 3.1.** The results are shown in the table below.

Table 8.1: Projected population numbers per urban centre

Quat.	Town	Population numbers				
		2001	2005	2015	2025	Seasonal
P10G	Kenton on Sea/ Bushmans	9 480	12 745	13 734	14 539	15 000
P20A	Alexandria	7 715	8 371	9 178	8 720	-
	Boknes / Cannon Rocks	931	1 422	2 573	2 949	2 500
P40C	Port Alfred	20 965	27 526	35 376	40 542	15 000
	Bathurst	5 549	6 497	6 445	6 227	-
P40D	Kleinemonde	1 450	1 833	2 156	2 471	2 000

As seen from the above table the projected population growth rates vary substantially – from 0.5% per annum in the case of Alexandria to 5% per annum in the case of Boknes and Cannon Rocks. The estimated additional seasonal population is also shown.

8.2 PROJECTED WATER REQUIREMENTS FOR THE AFFECTED TOWNS

The projected water requirements have been estimated on the basis of the methodology described in detail in **Section 4.1.**

Table 8.2: Projected water requirements, capacity of existing source and deficit

Town	Total gross water requirements 10^6 m^3/a				Exist. source 10^6 m^3/a	Growth %	Deficit %
	2001	2005	2015	2025	2005	2005 to 2025	in 2005
Kenton on Sea/ Bushmans	0.66	0.91	1.21	1.49	0.52	64%	-75%
Alexandria	0.52	0.62	0.79	0.76	0.65	23%	5%
Cannon/Boknes	0.18	0.25	0.46	0.53	0.24	109%	-5%
Port Alfred	1.27	2.16	3.04	3.90	1.73	81%	-25%
Bathurst	0.26	0.34	0.39	0.41	0.30	23%	-12%
Kleinemonde	0.05	0.08	0.12	0.16	0.15	88%	44%

For the period 2005 to 2025 the water requirements are expected to grow from as little as 23% in Alexandria and Bathurst, to 88% in Port Alfred, and 109% in Cannon Rocks and Boknes. The growth in the water requirements is illustrated in **Figure 13.2**.

The deficit in the capacity of the existing water source, compared to the water requirements in 2005 is the greatest for Kenton on Sea/Boesmansriviermond (-75%) followed by Port Alfred (-25%). This indicates that the water supply situation in these towns is the most critical.

8.3 OUTLINE OF PLANNING CONSIDERATIONS

8.3.1 Reasons for water supply problems

Most of the affected towns currently experience severe water supply problems, which are related to one or more of the following reasons:

- **Poor water quality**. All towns except Alexandria are supplied with water with salinity levels exceeding the ones recommended for long-term use (TDS less than 1 000 mg/l). During normal periods the TDS for the water supplied to these towns exceeds 1 400 mg/l, but during certain periods could reach levels as high as 3 000 mg/l. This is associated with the specific geological conditions in the lower part of the drainage region, where these towns are located.
- **Inadequate capacity of the existing water sources**. The water resources with acceptable water quality in the drainage region are very scarce. As seen from **Table 8.2** the water sources for some of the affected towns have inadequate capacity to meet the present water requirements and an urgent augmentation is required. None of the sources are adequate to meet the 2025 requirements.
- **Inadequate capacity of the bulk supply infrastructure**. Some of the affected towns located in the coastal area are holiday destinations. The summer peak factors (SPF) in these towns vary in the range of 1.5 to 1.8 of the annual average daily demands (AADD), while the extreme peaks can reach as high as 3 times the AADD. In some cases the bulk supply infrastructure (water treatment plants, storage reservoirs, bulk supply conveyance system) have inadequate capacity to provide for the peak requirements.

8.3.2 Possible sources of supply

Owing to the high ecological reserve requirements (see **Table 4.5B**), the available run-of-river yields are insufficient to supply the demands of the study area at the required assurance level of 98%. Therefore, run-of-river schemes are considered not feasible and do not form part of the proposed development options. More detailed information is available in the supporting report on surface water quality.

The surface water quality is poor in the middle to lower reaches (a belt within about 40 to 50 km from the coast line) of the study area, with expected TDS levels varying between 1 000 to 2 500 mg/l. Any surface water sources located within these reaches are expected to yield water of poor quality. Conveying water from surface sources located beyond the problematic areas is expected to be costly. More detailed information is available in the supporting report on stream flow hydrology.

At present, groundwater sources are considered to be under-utilised with only some coastal aquifers currently developed. Areas with high potential for groundwater development were identified during the course of this study. Exploration drilling was also done. The results of the groundwater investigations are summarised in **Section 7.2**, and detailed in the supporting report **"Groundwater Resources"**. In general, the yields per borehole are expected to be low (not exceeding 4 l/s), and the water quality in the lower reaches of the study area is expected to be poor (possibly Class II and higher). However, potential sites with superior water quality have been identified mostly in the coastal aquifer.

The expected yield of acceptable quality groundwater appears to be sufficient to supply the towns of Alexandria, Cannon Rocks/Boknes and partially Kenton on Sea. However, some of the identified sources are located within the environmentally sensitive coastal dunes. Any exploration of these resources will be subject to acceptable environmental impact management measures.

Desalination of seawater through the process of reverse osmosis is currently used as one of the sources of supply to Kenton on Sea and Boesmansriviermond. Subject to the acceptability of the high operation and maintenance costs, this technology is suitable for the study area as it produces water of a superior quality.

8.3.3 Water usage and conservation

No sufficient data was available to assess the current losses in the distribution networks of the affected towns. The water requirement projections were based on the assumption that best water conservation and demand management practices will be maintained.

At present, the water is generally being used wisely. Owing to the poor water quality supplied to most of the affected towns, most of the households have rainwater harvesting facilities. Most of the upmarket houses and some of the public developments are also equipped with a dual internal plumbing system, which distributes only the harvested rainwater for domestic use. In these cases the municipal supply is used predominantly for gardening. The usage of bottled water for cooking and drinking purposes is a common practice for those who can afford it.   The effect of the utilisation of rainwater has not been considered as this source of supply generally has low assurance.

The water requirements have been estimated assuming that normal levels of water consumption will occur. The reducing effect on the projected consumption caused by the present supply of water with sub-standard quality has not been taken into account because the water supplied in future can be of a better standard.

8.4 IDENTIFICATION OF DEVELOPMENT OPTIONS

This section describes the criteria for identification of development options to meet the water requirements until 2025 for each of the affected towns. A detailed description of the existing infrastructure and its capacity is available in **Section 5**. The layouts of the proposed development options are illustrated in **Figures 13.1 and schematic diagrams S1 to S6**. The milestone parameters for all options described in the sub-sections below are summarised in a tabular form in **Table 8.4** at the end of this section.

8.4.1 Alexandria

Background

The overall water supply situation at Alexandria is considered not to be critical yet. Alexandria had a total water usage of 0.52×10^6 m³/a in 2001 and the projected requirement for the year 2025 is 0.76×10^6 m³/a. The growth of the projected water requirements is moderate when compared to some of the coastal towns. The summer peak factor is low at 1.2.

Currently the town is supplied with groundwater abstracted from coastal springs near Cape Padrone and two well points near Fishkraal, both located some 20 km to the south of the town. The existing water source yields water of good quality and has a capacity of 0.65×10^6 m³/a, which will meet the projected requirements until 2007. The existing bulk conveyance system has a capacity of 0.60×10^6 m³/a, which is inadequate to meet the peak requirements. Projects to upgrade the capacity of this system to match the capacity of the existing source have been identified and are included in the water services development plan.

Development options

In order to meet the projected water requirements until 2025, additional water sources with a capacity of 0.11×10^6 m³/a would be required.

The supply from surface water does not appear to be economically and technically feasible. The water quality of potential surface sources located within an economical distance would be inadequate for human consumption. An option to supply the town from the existing New Years Dam, which has acceptable water quality, has been investigated at a conceptual level. Owing to exceptionally high costs this option was abandoned. Similarly, the option to supply the town from a regional scheme via Port Alfred and Kenton on Sea was found not to be feasible.

Owing to the relatively low additional source capacity required, it appears that the supply from groundwater would be appropriate. Apart from the dune aquifer source, part of which is currently used to supply the town, no other suitable groundwater development sites are available. The nearest other potential groundwater source is located on the farm Bushfontein, some 15 km away from the town. That source has however been utilised for the development options to supply Kenton on Sea.

An additional source with a capacity of 0.40×10^6 m³/a has been identified. This source is located in the dune aquifer adjacent to the existing well fields at Fishkraal and has been used for the development option to supply Alexandria (**Option 1A: GW**) described below. The layout of the proposed scheme is shown in **Figure S1**.

The proposed development entails:

- Develop and equip 6 boreholes at the Fishkraal dune source - total yield 11 l/s (for 12 hours pumping per day)
- Construct a new conveyance system from the water source to the town, including 19 km of pipeline (12.5 l/s), 2 pump stations (12,5 l/s), 2 break pressure tanks (50 m³ each) and an additional bulk reservoir of 800 m³.

It should be noted that the proposed water source is located within an environmentally sensitive National Park, which falls under the jurisdiction of the Sanparks. The implementation of this development option will be subject to acceptable environmental considerations. An environmental impact assessment (EIA) report has been submitted for consideration by the relevant authorities. The outcome is being awaited.

Should developments in the coastal dunes not be allowed, further investigations to identify alternative groundwater sources are recommended.

If no suitable groundwater resources can be identified, the last resort would be to include Alexandria into a regional scheme via Kenton on Sea at a very high capital cost.

8.4.2 Cannon Rocks and Boknes

Background

The overall water supply situation at Cannon Rocks and Boknes is not ideal. The total water usage in 2001 is estimated at 0.18×10^6 m³/a and the projected requirement for the year 2025 at 0.53×10^6 m³/a. The towns are holiday resorts with summer peak factors exceeding 1.5. Substantial housing developments in the towns are already evident.

Currently the town is supplied with groundwater abstracted from 3 boreholes located within the boundaries of Cannon Rocks, with a total capacity of 0.24×10^6 m³/a. The water quality of the source is poor. Although the source has sufficient capacity to meet the present average daily requirements, the capacity is inadequate during peak periods. At present the boreholes supply 2 reservoirs with a total capacity of 1 000 m³ through the joint reticulation system of the towns.

Development options

In order to meet the projected water requirements until 2025, an additional water source with a capacity of 0.29×10^6 m³/a will be required. The supply from surface water does not appear to be economically and technically feasible. The water quality of potential surface water sources located within an economical distance would be inadequate for human consumption.

Owing to the relatively low additional source capacity required, it appears that the supply from groundwater would be appropriate. A potential groundwater source with adequate water quality and capacity has been identified in the dune aquifer at Apies River, some 2 km to the west of Cannon Rocks. In addition, a private borehole yielding about 0.06×10^6 m³/a is available close to Cannon Rocks, which, subject to negotiations with the property owner, can be used in the interim to bridge the high peak requirements.

The development option to supply the towns of Cannon Rocks and Boknes (**Option 2CR: GW**) is described below. This option is based on the groundwater source at Apies River.

- Develop and equip 12 boreholes at the Apies River dune source - total yield 34 l/s at 12 hours pumping per day (0.56×10^6 m³/a).
- Construct a new conveyance system from the water source to Cannon Rocks, including 2.5 km of pipeline (34 l/s), pump station (34 l/s), 2 bulk reservoirs with a total capacity of 1 800 m³.

The layout of the proposed scheme is shown in **Figure S2**. It should be noted that the proposed water source is located within an environmentally sensitive National Park, which falls under the jurisdiction of the Sanparks. The implementation of this development option will be subject to acceptable environmental considerations. An environmental impact assessment (EIA) report has been submitted for consideration by the relevant authorities and the outcome is being awaited.

Should developments in the coastal dunes not be allowed, further investigations to identify alternative groundwater sources are recommended.

As it is unlikely that groundwater with acceptable quality standards can be identified in the area, the development of brackish groundwater sources in combination with reverse osmosis desalination facilities could provide an alternative, but at higher capital and running costs.

8.4.3 Kenton on Sea and Boesmansriviermond

Background

The overall water supply situation at Kenton on Sea and Boesmansriviermond is critical. The total water usage in 2001 has been 0.44 x 10^6 m³/a, but the projected requirements for the years 2005 and 2025 are estimated at 0.91 x 10^6 m³/a and 1.49 x 10^6 m³/a respectively. This is owing to expected growth within the existing towns, as well as owing to considerable proposed new housing developments of about 1 100 houses. The towns are holiday resorts with summer peak factors exceeding 1.5. At present the total production flows from all water sources are 0.52 x 10^6 m³/a, which is insufficient to meet the present requirements even during low demand periods. The water supply system is completely inadequate to supply the peak holiday requirements. Water restrictions and outages are often evident, despite the facts that water is being used wisely and that rain water harvesting facilities are available at each stand. Urgent measures to upgrade the capacity of the water sources are required.

Currently the towns are supplied with water from 6 well points at Diaz Cross, which is mixed with desalinated water from a Reverse Osmosis (RO) plant that is fed from both seawater and brackish water boreholes.

The Diaz Cross well field has a total capacity 0.30 x 10^6 m³/a. The water quality is typically class II with TDS values around 1 400 mg/l. However, owing to continuous supply deficit this capacity is often exceeded, leading to over-exploration of the resource and the intrusion of sea water. The water is pumped from the source to the bulk reservoirs in town, where it is being mixed with the desalinated water from the RO plant.

The RO plant has a total installed membrane capacity of 50 m^3/hr (0.44 x 10^6 m³/a). It is supplied from 6 brackish water and 5 sea water boreholes with a total yield of 1 600 m^3/day (0.60 x 10^6 m³/a). The RO plant has an average output efficiency of 38% (water in/water out). Owing to problems with various components of the RO plant system the total present production flows are limited to 25 m^3/hr (0.22 x 10^6 m³/a). The following interventions for the upgrading of the capacity of the RO plant have been identified and included in the WSDP:

- Upgrading of the power supply to the RO plan
- Upgrading of the brine disposal infrastructure
- Construction of a direct sea water intake
- Installation of an additional module to the RO plant with a capacity of 10 m^3/h.

The implementation of the proposed interventions is subject to the acceptance of an environmental management plan, which has already been submitted. The outcome is still pending. If implemented these interventions will lead to the increase of the production capacity of the RO plant to 60 m^3/hr (0.53 x 10^6 m^3/a). The total capacity of the available water sources will then be 0.83 x 10^6 m^3/a, which is equal to the estimated requirements in 2004.

Future water sources

In order to meet the projected water requirements until 2025, after the upgrading of the RO plant, additional water sources with a capacity of 0.63 x 10^6 m^3/a would be required.

The supply from surface water as a local scheme does not appear to be economically and technically feasible. The water quality of potential surface sources located within an economical distance from the town would be inadequate for human consumption. Even if the water quality issue is ignored, the available assured run-of-river flows in the Bushmans and Kariega Rivers are insufficient to meet the future requirements. An option to develop a dam at the Bushfontein site was investigated at conceptual level, but was found to be unacceptable owing to prohibitively high costs and water quality problems.

It is considered that the only feasible option based on surface water would be to supply the town as part of a larger regional scheme. In order to achieve economic viability, such a scheme has to include the supply to Port Alfred. This option has been investigated and is described below.

However, owing to the fact that the augmentation of the water source is very urgent, and that the development of a major regional scheme is expected to take considerable time, options to develop groundwater resources have been investigated. The immediate implementation of available groundwater resources can provide a relief to the critical situation and can postpone the time for the development of a regional scheme.

The following groundwater development sources have been identified during this study:

- Dune aquifer at Kwaaihoek with an estimated capacity of 0.11 x 10^6 m^3/a near Boesmansriviermond.
- Bushfontein field within the Witpoort FM with and estimated capacity of 0.29 x 10^6 m^3/a, about 22 km north west of the town.
- Merville field within the Witpoort FM with an estimated capacity of 0.29 x 10^6 m^3/a, about 17 km north of the town.

Based on the desktop analysis of the hydrogeological conditions it appears likely that additional economically feasible groundwater resources could be available within the Witpoort belt, to the south east of Merville. The exact position of such developments has not been identified with certainty during this study, therefore no specific conveyance infrastructure has been sized and costed.

Development options

All options described below include the following common components:

- Upgrading of the capacity of the RO plant as described above to 60 m^3/hr (0.53 x 10^6 m^3/a) at a cost of R5.33 million including VAT.

- Development of the Kwaaihoek groundwater source with a capacity of 0.11 x 10^6 m³/a at a cost of R0.82 million including VAT.
- The existing groundwater source at Diaz Cross with a capacity of 0.30 x 10^6 m³/a and its conveyance system are utilised.

Both developments are however subject to acceptable environmental management plans and approval by the environmental authorities. An application for approval of the upgrading for the RO plant has been submitted, but the outcome is still pending. Owing to objections from one single property owner the approval has been delayed.

The following options for the supply of Kenton on Sea have been identified and evaluated.

Option 3: KOS: GW: This option is based on the existing resources and on the development of new groundwater resources. It includes the utilisation of the existing Diaz Cross well field, the upgrading of the RO plant, the development of the Kwaaihoek well field and the development of both Merville and Bushfontein groundwater resources. The associated infrastructure includes the following components and its layout is shown in **Figure S 3.1 and S 3.2**:

- Develop and equip 4 boreholes at the Kwaaihoek well field with a total yield of 6.9 l/s (12 hr).
- Install a pipeline (6.9 l/s, length 1000 m) discharging into the existing 100 m³ balancing reservoir currently supplied from the Diaz Cross boreholes. The existing pumping station and rising main conveying the flows from the balancing reservoir have sufficient capacity to utilise the additional flows and do not need to be upgraded.
- Upgrade the capacity of the existing RO desalination plant to 60 m³/hr (0.29 x 10^6 m³/a).
- Develop and equip 3 boreholes at the Bushfontein well field with a total yield of 18.5 l/s (12 hr), or 0.29 x 10^6 m³/a.
- Develop and equip 5 boreholes at the Merville Farm well field with a total yield of 18.5 l/s (12 hr), or 0.29 x 10^6 m³/a.
- Build a new conveyance system from the Merville and Bushfontein sources to the new town reservoirs. This system includes about 26 km of pipeline with 2 balancing reservoirs and 3 break pressure tanks (BPT), 4 pump stations, each with a balancing reservoir.
- Construct 2 new reservoirs with a capacity of 1 500 m³ each.
- Construct an earth fill balancing reservoir with a capacity of 13 000 m³, to provide sufficient storage capacity to meet the exceptionally high seasonal peak requirements.

Option 4a: KOS: RO1: This option is based on the existing resources and on the development of a new reverse osmosis plant designed to desalinate sea water. It includes the utilisation of the existing Diaz Cross well field, the upgrading of the existing RO plant to 60 m^3/hr, and the construction of an additional sea water RO plant with a capacity of 100 m^3/hr. The associated infrastructure includes the following:

- Develop and equip 4 boreholes at the Kwaaihoek well field with a total yield of 6.9 l/s (12 hr).
- Install a pipeline (6.9 l/s, length 1000 m) discharging into the existing 100 m^3 balancing reservoir currently supplied from the Diaz Cross boreholes. The existing pumping station and rising main conveying the flows from the balancing reservoir has sufficient capacity to utilise the additional flows and do not need to be upgraded.
- Upgrade the capacity of the existing RO desalination plant to 60 m^3/hr (0.29 x 10^6 m^3/a).
- Install 8 sea water desalination RO plant units with a total production capacity of 2 400 m^3/d (0.90 x 10^6 m^3/a).
- Construct a sea water intake and filtration infrastructure with a capacity of 6 000 m^3/d (2.2 x 10^6 m^3/a).
- Construct a brine disposal facility with a capacity of 3 600 m^3/d (1.3 x 10^6 m^3/a).
- Install power supply infrastructure.
- Install a conveyance system from the RO plant to the town reservoirs consisting of a pump station, balancing reservoir (100 m^3) and a rising main (3.5 km).
- Construct 2 new reservoirs with a capacity of 1 500 m^3 each.
- Construct an earth fill balancing reservoir to provide sufficient storage capacity, to meet the exceptionally high seasonal peak requirements, with a capacity of 13 000 m^3.

Option 4b: KOS: RO2: This option is based on the existing resources and on the development of a new reverse osmosis plant designed to desalinate brackish water. It includes the utilisation of the existing Diaz Cross well field, the upgrading of the existing RO plant to 60 m^3/hr, and the construction of an additional brackish water RO plant with a capacity of 100 m^3/hr. The associated infrastructure includes the following:

- Develop and equip 4 boreholes at the Kwaaihoek well field with a total yield of 6.9 l/s (12 hr).
- Install a pipeline (6.9 l/s, length 1000 m) discharging into the existing 100 m^3 balancing reservoir currently supplied from the Diaz Cross boreholes. The existing pumping station and rising main conveying the flows from the balancing reservoir have sufficient capacity to utilise the additional flows and do not need to be upgraded.
- Upgrade the capacity of the existing sea water RO desalination plant to 60 m^3/h (0.53 x 10^6 m^3/a).

- Install 8 brackish water desalination RO plant units with a total production capacity of 2 400 m³/d (0.90 x 10^6 m³/a).
- Develop brackish water well fields and a conveyance system to the RO plant with a capacity of 3 800 m³/d (1.4 x 10^6 m³/a). It has been assumed that a groundwater source with the required capacity would be available and that its development would be environmentally acceptable.
- Construct a brine disposal facility with a capacity of 1 400 m³/d (0.50 x 10^6 m³/a).
- Install power supply infrastructure.
- Install a conveyance system from the RO plant to the town reservoirs consisting of a pump station, balancing reservoir (100 m³) and a rising main (3,5 km).
- Construct 2 new reservoirs with a capacity of 1 500 m³ each.
- Construct an earth fill balancing reservoir with a capacity of 13 000 m³.

Option 5: KOS: SW: This option is based on the existing resources and on the development of a new conveyance system to supply water from a regional scheme via Port Alfred. It includes the utilisation of the existing Diaz Cross well field, the upgrading of the existing RO plant to 60 m^3/hr, the development of the Kwaaihoek well field and the construction of the necessary infrastructure required for the supply of Kenton on Sea as part of a larger regional scheme. Glen Melville Dam is to be used as a water source for the regional scheme. Possible layouts are shown in **Figure 13.1**. This option has been developed in order to test the feasibility of a possible future regional scheme, when compared to the local schemes described above. More details about this option are available in **Section 8.4.4**. The infrastructure includes:

- Develop and equip 4 boreholes at the Kwaaihoek well field with a total yield of 6.9 l/s (12 hr).
- Install a pipeline (6.9 l/s, length 1000 m) discharging into the existing 100 m³ balancing reservoir currently supplied from the Diaz Cross boreholes. The existing pumping station and rising main conveying the flows from the balancing reservoir have sufficient capacity to utilise the additional flows and do not need to be upgraded.
- Upgrade the capacity of the existing sea water RO desalination plant to 60 m³/h.
- Install a new conveyance system to supply water from Port Alfred to Kenton on Sea (2 400 m³/d, 23 km).
- In order to determine the incremental cost associated with the supply to Kenton on Sea of the jointly utilised infrastructure (water treatment and conveyance from Glen Melville to Port Alfred) the regional scheme supplying Port Alfred has been sized and costed for two options – with and without provision for the supply of Kenton on Sea. See Options 6 and 7 in the following section.

An option to supply the regional scheme from the existing New Years Dam has been investigated at a conceptual level. It was found that this option is not competitive and was not investigated any further.

Option: Recharge the coastal aquifer with treated effluent: Late during the course of the study the idea to consider the utilization of treated effluent from the existing water treatment plants to recharge the coastal aquifer was suggested by the DWAF. Although this is an interesting idea, which can contribute to the solution of the problems, we did not have sufficient time to investigate it in detail. However the following comments are offered:

- At present the effluent is discharged in wetlands from where it is disposed of by means of evaporation and infiltration.
- It is technically possible to divert the discharge into the natural stream, which terminates at the back of the dunes currently used as a source of brackish water for the RO plant. There is a direct geohydrological link between the stream and the coastal aquifer. Therefore the aquifer can be recharged and can increase the exploration capacity, which can be utilised in conjunction with Option 4b.
- Owing to the environmental sensitivity of the area, the implementation of the above is subject to an EIA and approval. One matter of concern is that this method is likely to substantially increase the salinity levels of the aquifer, beyond acceptability. Previous studies indicated that salinity could be increased by about 300 mg/l per cycle. In the case of the coastal aquifers, which are already saline, any additional increase of TDS may have an irreversible environmental impact.
- Only the newly-developed suburbs to the north of the main road are provided with water-borne sanitation and the effluent is treated at two purification works at Ekuphumeleni and at Marselle. The main towns of Boesmansriviermond and Kenton on Sea are not serviced. The volumes of discharged effluent are not being measured, but rough estimates show that these are not significant - in the order of 0.15×10^6 m³/a, which is only about 16% of the water requirements in 2005.

More detailed investigations, including an EIA are required before further consideration to this option can be given.

Option: Dual water supply system: An option to implement a dual water supply and distribution system (two separate systems: one with good quality water for potable use, and another with inferior quality for other household use) in Kenton on Sea was investigated superficially at a conceptual level. It was found that this option would be costly and was not considered any further. The following comments are offered:

- The implementation of such a system is likely to reduce the requirements from the RO plant, but not the overall requirements. This is expected to somewhat reduce the running costs for the bulk supply system. The development of additional sources would however still be required. The effect on the overall capital requirements to meet future demands is not expected to be significant.
- The cost to construct a new duplicate system was estimated at about R30 million including construction costs, professional fees and VAT. This however excludes the internal plumbing work within each property, which could cost an additional R5 million.
- The above costs exclude the costs for the development of the additional water resources required to meet the future demands

8.4.4 Port Alfred

Background

At present the overall water supply situation at Port Alfred is not critical as far as the water source is concerned. However, the town reservoirs and the internal reticulation system do not have sufficient capacity to meet the peak seasonal water requirements. The water quality of the source is poor, with salinity levels often exceeding 1 700 mg/l. The total water usage in 2001 was 1.27 x 10^6 m³/a, but the projected requirements for the years 2004 and 2025 are estimated at 1.6 x 10^6 m³/a and 3.90 x 10^6 m³/a respectively. The substantial growth in water requirements from 2005 onwards can be attributed to a great extent to the significant low-cost housing development planned to be implemented shortly (5 000 new houses and 1 800 stands to be upgraded to house connections). This would render the existing source insufficient and would require urgent augmentation. The town is a holiday resort with summer peak factors exceeding 1.8.

At present the assured yield of all water sources supplying the town is about 1.73 x 10^6 m³/a. The existing water sources and bulk supply systems are described below:

Sarel Hayward Dam: This is an off-channel storage dam constructed in 1988 with a gross storage capacity 2.5 x 10^6 m³ and assured yield of 1.55 x 10^6 m³/a. The dam is situated about 13 km north west of Port Alfred. It has an earth fill embankment wall with a height of 40 m, which regulates the small catchment of a tributary to the Kowie River. The dam is being supplied with water from run-of-river flows collected at the weir constructed across the Kowie River. The water is pumped from the weir to the dam by a pump station through a rising main (700 m long, 350 mm ND, steel), both with a maximum capacity of 150 l/s. Provision for the release of the Ecological Reserve has been made. From the dam, the water is conveyed to an earth-fill balancing reservoir (16 000 m^3) near the hospital by a conveyance system consisting of 2 pump stations and a pipeline (11 km long, 300/250 mm ND) with a capacity of 50 l/s. From there water gravitates to the water treatment works (5 000 m^3/day) in town, about 2 km further to the south east. From the treatment works the water is pumped to 4 distribution reservoirs.

Mansfield Dam: This dam has a gross storage capacity of 0.17 x 10^6 m³ and assured yield of 0.05 x 10^6 m³/a. The dam is situated about 10 km north of Port Alfred. It is an earth fill embankment dam with a wall height of 14 m. The water from the dam can gravitate into the balancing reservoir in Port Alfred through a 6.5 km, 150 mm ND pipeline with a capacity of 15 l/s. The pipeline is currently out of order.

Dune well fields: two well fields located to the east of Port Alfred, with a combined yield of 0.13 x 10^6 m³/a have been developed to exploit the coastal aquifer. Water from the wells is being pumped directly into the East Bank distribution reservoir during times of peak requirements.

Future water sources

In order to meet the projected water requirements until 2025 the development of additional water sources with a capacity of 2.17 x 10^6 m³/a would be required. This is a significant increase of 125% compared to the existing capacity.

The groundwater resources in the area have been investigated during this study and two potential drilling sites with an estimated combined yield of 0.63 x 10^6 m³/a were identified. The sites (the Glendower field and the Sunshine Coast dune field) are located some 7 km to the west of the West Bank reservoir of Port Alfred.

Further potential groundwater development sites could possibly be located within the Witpoort belt to the east of the town, but the exact position of such developments could not be identified with any degree of certainty. Therefore, only the afore-mentioned well fields have been used as possible development options.

In general, taking into consideration the substantial additional capacity of the water source required to meet future demands, it is unlikely that the long term requirements from the source can be met by groundwater alone. The exceptionally high seasonal peak factors applicable to this system further support that statement. We are of the opinion that a surface water storage scheme would eventually be required to meet the long-term requirements. However, the development of the available groundwater resources would provide the much needed relief to the present water supply situation and will postpone the timing for the implementation of a regional surface water storage scheme.

The water quality of potential surface sources located within an economical distance from the town is inadequate. Even after regular flushing of the Sarel Hayward Dam, the water quality of this source is poor (class II). Water with superior quality can be sourced from other dams located further inland.

The combined available assured run-of-river flows in the entire drainage region P are insufficient to meet the augmentation requirements for the town. Therefore a storage scheme would be required. The following surface water sources have been considered:

Glen Melville Dam: This is an off-channel storage dam located on the Ecca River (Fish River catchment) some 68 km north of Port Alfred. The water in the dam is supplied from the Orange River via the Hermanuskraal weir and the Fish-Ecca tunnel, which has a capacity of 500 x 10^6 m³/a. The dam has an assured yield of 7.3 x 10^6 m³/a, but this yield can be increased by increasing the transfers from Orange River. It is currently being used as a balancing reservoir for the supply to Grahamstown. The existing bulk supply system from the dam to Grahamstown, consisting of water treatment works, a pump station and a rising main, has a capacity of 3.65 x 10^6 m³/a. The present quantity of water supplied to Grahamstown is in the order of 2.4 x 10^6 m³/a. Therefore, sufficient yield in the dam is available for transfers to Port Alfred. Spare capacity in the bulk supply system is also presently available, but later this system can be upgraded. Furthermore, the water supplied from this dam is of a good quality, with salinity levels about 600 mg/l.

Settlers Dam: This dam is located on the Kariega River, some 45 km north west of Port Alfred. The dam has a wall height of 21 m, gross capacity of 5.6 x 10^6 m³ and assured yield of 3.1 x 10^6 m³/a, of which 2.2 x 10^6 m³/a is used for the supply of Grahamstown. The quality of water supplied from this dam is good. Due to its more favourable position, this dam can be used as a source of supply for Port Alfred, but in this case the supply from Glen Melville Dam to Grahamstown has to be increased.

Sarel Hayward Dam: The yield of this dam can be increased by rising of the dam wall and by upgrading the capacity of the weir pump station and the conveyance system. The water quality supplied will however not improve (currently in the order of 1 700 mg/l).

New Years Dam: This dam has sufficient surplus capacity and its water quality is of a good standard. An investigation at conceptual level has been done to use this dam as a source for augmentation of the supply to Port Alfred. However, due its location about 120 km away from Port Alfred, this option was found to be less attractive and was abandoned.

Development options

All options described below include the utilisation of the existing water resources together with the development of the groundwater resources at Glendower and the Sunshine Coast. These developments will meet the requirements until about 2010, which will provide sufficient time for further investigations and implementation of additional schemes.

- Development of the Glendower/Barville groundwater source with a capacity of 0.36 x 10^6 m³/a. Equip 5 boreholes with a total yield of 23 l/s (12 hr).
- Development of the Sunshine coast groundwater source with a capacity of 0.27 x 10^6 m³/a. Equip 9 boreholes with a total yield of 18 l/s (12 hr).
- Develop a conveyance system to deliver the water from the source to the West Bank reservoir in town. This system consists of 4 km rising mains, 5 km gravity mains and a 500 m³ balancing reservoir.

Both developments are however subject to acceptable environmental management plans and approval by the environmental authorities.

The following development options have been sized to supply the balance of the requirements for Port Alfred in 2025, which is 1.55 x 10^6 m³/a.

Option 6: PA: GM1: PA, BT and KoS: This option is based on the existing resources, the development of the proposed two groundwater resources, together with the construction of the necessary infrastructure from Glen Melville Dam. This option has been sized to supply a regional scheme, which includes the towns of Port Alfred, Bathurst and Kenton on Sea. It includes the utilisation of the existing water sources at each town and provides for the supply of the deficit in available resources (2.25 x 10^6 m³/a) to meet the water requirements in year 2025. The associated infrastructure includes the following components and its layout is shown in **Figure 13.1.**

- Develop groundwater resources in Barville / Glendower and the Sunshine Coast and the associated conveyance system to Port Alfred, as specified above. Develop and equip 9 boreholes at the well field - total yield 18 l/s (12 hr).
- Construct a new conveyance system from the existing Glen Melville Dam via Grahamstown and Bathurst to Port Alfred and further to Kenton on Sea. This system includes:
  - the upgrading of the dam intake works
  - the upgrading of the capacity of the water treatment works and the pump station at the dam (144 l/s). Despite the fact that the existing infrastructure currently has sufficient capacity to convey the required additional flows, a provision for the upgrading has been made as the required transfers for Grahamstown are expected to increase with time.
  - a new rising main (8.5 km, 400 mm ND, steel) from the dam to the reservoir site in Grahamstown
  - new balancing reservoir in Grahamstown with a capacity of 2 500m³
  - new gravity main from Grahamstown to Port Alfred via Bathurst, 59 km, 400 mm and 300 mm ND
  - 4 break pressure tanks, 250 m³ each
  - New gravity main from Port Alfred to Kenton on Sea, 23 km, 200 mm ND
  - New reservoirs at Bathurst (1 200 m³) and at Port Alfred (15 000 m³).

Option 7: PA: GM2: PA and BT: This option is identical to Option 6, but excludes the supply to Kenton on Sea. It is sized to supply only the additional requirements based on the existing resources, the development of the proposed two groundwater resources, together with the construction of the necessary infrastructure from Glen Melville Dam. This option has been sized to supply a regional scheme, which includes the towns of Port Alfred and Bathurst. It includes the utilisation of the existing water sources at each town and provides for the supply of the deficit in available resources (1.69 x 10^6 m³/a) to meet the water requirements in year 2025. The associated infrastructure includes the following components and its layout is shown in **Figure 13.1.**

- Develop groundwater resources in Barville / Glendower and the Sunshine Coast and the associated conveyance system to Port Alfred, as specified above. Develop and equip 9 boreholes at the well field - total yield 18 l/s (12 hr).
- Construct a new conveyance system from the existing Glen Melville Dam via Grahamstown and Bathurst to Port Alfred. This system includes:
    - the upgrading of the dam intake works
    - the upgrading of the capacity of the water treatment works and the pump station at the dam (113 l/s).
    - a new rising main (8.5 km, 450 mm ND, steel) from the dam to the reservoir site in Grahamstown
    - new balancing reservoir in Grahamstown with a capacity of 2 000m³
    - new gravity main from Grahamstown to Port Alfred via Bathurst, 59 km, 300 mm ND
    - 4 break pressure tanks, 150 m³ each
    - New reservoirs at Bathurst (1 200 m³) and at Port Alfred (15 000 m³).

Option 8a: PA: SH: This option is based on the existing resources, the development of the proposed two groundwater resources, together with the raising of Sarel Hayward Dam and the upgrading of the pumping and conveyance system. This option has been sized to supply the deficit in available resources (1.55 x 10^6 m³/a) only for Port Alfred. The associated infrastructure includes the following and its layout is shown in **Figure S4.**

- Develop groundwater resources in Barville / Glendower and the Sunshine Coast and the associated conveyance system to Port Alfred, as specified above. Develop and equip 9 boreholes at the well field - total yield 18 l/s (12 hr).
- Raise the Sarel Hayward Dam wall by 12 m and increase the capacity of the weir pump station and rising main to 250 l/s.
- Develop a new conveyance system from the Sarel Hayward Dam to the water treatment works in Port Alfred consisting of about 13 km of pipeline (93 l/s, 300 mm ND), 2 balancing reservoirs (200 m³ each), 3 delivery pump stations, additional storage capacity of 15 000 m³ in the town, and upgrading of the water treatment works with an additional capacity of 5 000 m³/d.

Option 8b: PA: SH &RO: This option is identical to Option 8a, but includes a RO plant with a capacity to desalinate 50% of the water supplied from Sarel Hayward Dam. When mixed with the rest of the raw water the salinity levels are expected to drop from the current 1 700 mg/l to 850 mg/l. The quality of water supplied by Sarel Hayward Dam is inferior to that supplied from the other surface sources considered for Port Alfred. This option has been investigated in order to bring the various competitive options to the same basis in terms of water quality supplied, so that the options could be compared more realistically. In addition to the infrastructure described above, this option includes the following:

- A RO plant located close to the water treatment works with a capacity of 4 000 m³/d (1.50 x 10^6 m³/a) including the necessary supporting infrastructure.
- A clear water pump station and a 1.3 km rising main to convey the desalinated water to the bulk supply reservoir in town.
- A balancing reservoir with a capacity of 300 m³.

Option 9: PA: SD: This option is similar to Option 6, but instead of supplying the water from Glen Melville Dam, it supplies it from the Settlers Dam. This option is based on the existing resources, the development of the proposed two new groundwater resources, together with the construction of the necessary infrastructure to deliver water from the Settlers Dam to Port Alfred. It also includes the upgrading of the bulk supply infrastructure from the Glen Melville Dam to Grahamstown and a new link pipeline from Botha's Hill Reservoir (currently supplied by the Glen Melville Dam) to the town reservoirs in the south (currently supplied from the Settlers Dam). This infrastructure is provided in order to compensate Grahamstown for the lost yield from Settlers Dam. This option is sized to supply only Port Alfred with a total yield of 1.55 x 10^6 m³/a. The associated infrastructure includes the following components and its layout is shown in **Figure 13.1.**

- Develop groundwater resources in Barville / Glendower and Sunshine Coast and the associated conveyance system to Port Alfred, as specified above. Develop and equip 9 boreholes at the well field - total yield 18 l/s (12 hr).
- Develop a new conveyance system from the Settlers Dam to Port Alfred consisting of about 45 km of pipelines (capacity of 93 l/s, 300 mm ND) with 4 break pressure tanks (200 m³ each) and a raw water pump station.
- Construction of additional storage reservoirs with a capacity of 15 000 m³ and upgrading of the existing water treatment works at Port Alfred with an additional capacity of 5 000 m³/d.
- Upgrading of the existing water treatment works and clear water pump station at Glen Melville Dam with an additional capacity of 5 000 m³/d.
- Construction of a new rising main from Glen Melville Dam to Botha's Hill reservoir (8.5 km, 350 mm ND) and a by-pass gravity main linking Botha's Hill reservoir with the town reservoirs to the south of Grahamstown (105 km, 300 mm ND).

Option 10: PA: RO: This option is based on the existing resources, the development of the proposed two new groundwater resources, together with the construction of a new RO plant to desalinate sea water and the associated infrastructure. The system consists of the following components:

- Develop groundwater resources in Barville / Glendower and the Sunshine Coast and the associated conveyance system to Port Alfred. Develop and equip 9 boreholes at the well field - total yield 18 l/s (12 hr).
- Install 26 sea water desalination RO plant units with a total production capacity of 7 800 m³/d (2.8 x 10^6 m³/a).
- Construct sea water intake works (or sea water boreholes) including a conveyance system with a capacity of 19 200 m³/d (7.0 x 10^6 m³/a).
- Construct a brine disposal facility with a capacity of 11 400 m³/d (4.20 x 10^6 m³/a).
- Install power supply infrastructure.
- Install a conveyance system from the RO plant to the town reservoirs consisting of a pump station, balancing reservoir (200 m³) and a rising main (2,6 km).
- Construct additional storage reservoirs with a capacity of 15 000 m³ in Port Alfred.

8.4.5 Bathurst

Background

The overall water supply situation in Bathurst is considered to be less critical than that for the coastal towns. The total water usage in Bathurst was estimated at 0.26 x 10^6 m³/a for 2001 and the projected requirement for the year 2025 is 0.41 x 10^6 m³/a, a moderate growth in water use. The summer peak factor is low at 1.2.

Currently, the town is supplied from private boreholes, household rainwater harvesting facilities and mostly from the Golden Ridge Dam (yield 0.25 x 106 m³/a, but without provision for the release of the Ecological Reserve), located about 8 km north of the town. The water is conveyed (capacity 0.5 x 106 m³/a) from the dam via the WTW (0.16 x 106 m³/a) into a bulk supply reservoir (1 000 m³). From there, the water is reticulated into the townships of Nolukhanyo and Freestone. The main town is not provided with water services and relies on private resources. The actual usage from the public water sources (Golden Ridge Dam) is estimated at 0.12 x 106 m³/a. The balance of the water requirements is assumed to be supplied from private sources in the old town.

The existing Mansfield Dam, with an estimated yield of 0.05 x 10^6 m³/a can also be used for the supply of the town, but the conveyance system (0.16 x 10^6 m³/a) is currently out of order.

The total yield from the available water sources is therefore 0.30 x 10^6 m³/a (excluding the private sources), which will be sufficient to meet the present requirements until 2006. The water quality in not good and salinity levels exceed 1500 mg/l. If water services are provided to the old town, the water source has to be augmented. The conveyance system from the Golden Ridge Dam has sufficient capacity (16 l/s, 200 mm ND) to meet the peak requirements. The capacity of the water treatment plant is currently the limiting component.

Development options

In order to meet the projected water requirements until 2025, an additional water source with a capacity of 0.11 x 10^6 m³/a would be required, if the old town is provided with water services. However, an assessment of the Ecological Reserve for the stream on which

Golden Ridge Dam is build needs to be undertaken in order to determine the maximum allowable abstraction from this dam.

The supply from surface water from a local scheme does not appear to be economically and technically feasible. The water quality of potential surface sources located within an economical distance would be inadequate for human consumption.

If a regional scheme supplying Port Alfred from the Glen Melville Dam is developed, the long-term requirements for Bathurst will be supplied. This is covered in Option 6, described in Section 8.4.4.

Owing to the relatively low additional source capacity required, it appears that the supply from groundwater would be feasible. Considering that the implementation of a regional scheme may take some time, it is recommended that a hydrogeological study be undertaken in order to identify potential groundwater development targets. If the augmentation of the water source becomes urgent, the groundwater sources could be developed.

The upgrading of the capacity of the water treatment works would result in an immediate improvement of the water supply situation.

8.4.6 Kleinemonde / Seafield

The overall water supply situation in Kleinemonde is considered to be less critical than that for most of the other coastal towns. The total water usage in Kleinemonde was estimated at 0.05×10^6 m³/a for 2001 and the projected requirement for the year 2025 is 0.16×10^6 m³/a. The summer peak factor is about 1.8. The water quality in not good and salinity levels often exceed 2 000 mg/l.

Currently, the town is supplied from 2 boreholes and from Mount Wellington Dam located about 8 km north west of the town. The total yield of the water sources is about 0.15×10^6 m³/a. The system has sufficient capacity to meet the water requirements during normal periods, but is inadequate to supply the peak seasonal requirements. In order to improve the performance of the system the water treatment works and the storage capacity should be upgraded.

Development options

The supply from surface water from a local scheme does not appear to be economically and technically feasible. The water quality of potential surface sources located within economical distance would be inadequate for human consumption.

Owing to the relatively low additional source capacity required, it appears that the supply from groundwater could be feasible. During the course of this reconnaissance study we have been unable to identify suitable groundwater targets with acceptable quality in the vicinity of the town.

Further hydrogeological investigation on a local scale would be required in order to identify suitable groundwater sources.

Table 8.4 provides a summary of the relevant development options and a brief description of the conveyance system.

The possible timing of implementation of the various components of the development options is shown in **Figure 13.2.**

Table 8.4: Summary of the development options

Option No	Option Name	Towns Supplied	Water Source	Primary Conveyance System
1	Alexandria – GW (1 A : GW)	Alexandria	- Fishkraal GW	- Develop GW with 6 BH's (11 l/s, 12 hr) & 2 PS's (12,5 l/s) - CWRM of 10.5 km (12,5 l/s) - 50 m³ Bal Res, 150 m³ BPT - CWGM of 8.5 km (12,5 l/s) - 800 m³ reservoir
2	Cannon Rocks – GW (2 CR : GW)	Cannon Rocks and Boknes	- Apies River mouth GW	- Develop GW with 12 BH's (34 l/s) - 1 PS (34 l/s) - CWRM of 2.5 km (34 l/s) - 2 town reservoirs (1 800 m³)
3	Kenton on Sea – GW (3 KOS : GW)	Kenton on Sea Boesmansriviermond	- Upgrade RO - Kwaaihoek GW - Merville GW - Bushfontein GW	- Upgrade existing RO plant to 60 m³/hr - Develop Kwaaihoek GW with 4 BH's (6.9 l/s) - CWRM1 of 1 km to existing PS (6.9 l/s) - Develop Merville GW with 5 BH's (18.5 l/s) - 1 CWPS & 3 km CWRM with a 100 m³ Bal Res - Develop Bushfontein GW with 3 BH's (18.5 l/s) - 3 CWPS & 9 km CWRM with a 300 m³ Bal Res - CWGM of 13.5 km & 3 BPT's - New PE lined Bal Dam of 13 000 m³ & new Res's of 3 000 m³
4a	Kenton on Sea – RO1 (4a KOS : RO1)	Kenton on Sea Boesmansriviermond	- Upgrade existing RO - Kwaaihoek - New RO (seawater)	- Upgrade existing RO plant to 60 m³/hr - Develop Kwaaihoek GW with 4 BH's (6.9 l/s) - CWRM1 of 1 km to existing PS (6.9 l/s) - New RO (seawater) plant – 2 400 m³/d - 1 CWPS with a 100 m³ Bal Res & CWRM of 3.5 km - New PE lined Bal Dam of 13 000 m³ & new Res's of 3 000 m³
4b	Kenton on Sea – RO2 (4b KOS : RO2)	Kenton on Sea Boesmansriviermond	- Upgrade existing RO - Kwaaihoek - New RO (brackish water)	- Upgrade existing RO plant to 60 m³/hr - Develop Kwaaihoek GW with 4 BH's (6.9 l/s) - CWRM1 of 1 km to existing PS - Develop brackish water source (3 800 m³/d) & RWRM of 3.3 km - New RO (brackish) plant – 2 400 m³/d - 1 CWPS with a 200 m³ Bal Res & CWRM of 2.5 km - New PE lined Bal Dam of 13 000 m³ & new Res's of 3 000 m³

5	Kenton on Sea – SW (5 KOS : SW)	Kenton on Sea Boesmansriviermond	- SW from Glen Melville Dam	- Upgrade existing RO plant to 60 m³/hr - Develop Kwaaihoek GW with 4 BH's (6.9 l/s) - CWRM1 of 1 km to existing PS - Surface water (2 400 m³/d) from Glen Melville Dam via PA - New PE lined Bal Dam of 13 000 m³ & new Res's of 3 000 m³
6	Port Alfred – GM 1 (6 PA : GM1: PA, BT, KoS)	Port Alfred Bathurst Kenton on Sea	- Barville / Glendower - Sunshine Coast - SW from Glen Melville Dam	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to a 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to Bal Res - CWGM of 5 km to PA (54 l/s) - WTW at Glen Melville Dam (144 l/s) & 1 CWPS - CWRM of 8.5 km & a 2 500 m³ Bal Res - CWGM of 83 km with 4 x 250 m³ BPT's - Bathurst Res 1 200 m³ & PA Res 15 000 m³
7	Port Alfred – GM2 (7 PA : GM 2: PA, BT)	Port Alfred Bathurst	- Barville / Glendower - Sunshine Coast - SW from Glen Melville Dam	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to a 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to Bal Res - CWGM of 5 km to PA (54 l/s) - WTW at Glen Melville Dam (112 l/s) & 1 CWPS - CWRM of 8.5 km & a 2 000 m³ Bal Res - CWGM of 59 km with 4 x 150 m³ BPT's - Bathurst Res 1 200 m³ & PA Res 15 000 m³
8a	Port Alfred – SH (8a PA : SH)	Port Alfred	- Barville / Glendower - Sunshine Coast - SW from Sarel Hayward Dam	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to a 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to the 500 m³ Bal Res - CWGM of 5 km to PA (54 l/s) - WTW at Port Alfred (106 l/s) - 1 RWPS (250 l/s) at river abstraction - 2 RWPS's (106 l/s) with Bal Res's - RWRM of 7.7 km (93 l/s) & a 200 m³ Bal Res - RWGM of 2.6 km (93 l/s) with a 200 m³ Bal Res - RWGM of 3 km (93 l/s) to WTW - Port Alfred Res 15 000 m³ - Raise Sarel Hayward Dam wall by 12 m, from FSL 38.9 to 50.9

8b	Port Alfred – SH & RO (8b PA : SH & RO)	Port Alfred	- Barville / Glendower - Sunshine Coast - SW from Sarel Hayward Dam - Treat 4 000m³/d by RO	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to a 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to the 500 m³ Bal Res - CWGM of 5 km to PA (54 l/s) - WTW at Port Alfred (106 l/s) - 1 RWPS (250 l/s) at river abstraction - 2 RWPS's (106 l/s) with Bal Res's - RWRM of 7.7 km (93 l/s) & 1 200 m³ Bal Res - RWGM of 2.6 km (93 l/s) with 1 200 m³ Bal Res - RWGM of 3 km (93 l/s) to WTW - Port Alfred Res 15 000 m³ - Raise Sarel Hayward Dam wall by 12 m, from FSL 38.9 to 50.9 - Treat 4 000 m³/d of SW through 14 RO units - 1 CWPS (56 l/s) with a 300 m³ Bal Res at RO plant - RWGM of 0.5 km (76 l/s) from WTW to RO plant - CWRM of 1.3 km (56 l/s) from RO to town Res
9	Port Alfred – SD (9 PA : SD)	Port Alfred	- Barville / Glendower - Sunshine Coast - SW from Settlers Dam	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to a 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to the 500 m³ Bal Res - CWGM of 5 km to PA (54 l/s) - WTW at Port Alfred (106 l/s) - 1 RWPS (106 l/s) at Settlers Dam - RWRM of 2 km (93 l/s) & 1 200 m³ Bal Res - RWGM of 42.5 km with 4 x 200 m³ BPT's - WTW at Glen Melville Dam (106 l/s) - 1 CWPS (96 l/s) with Bal Res from WTW to Botha's Hill Res - CWRM of 8.5 km (93 l/s) from GM WTW to Botha's Hill Res - CWGM of 10.5 km (93 l/s) from Botha's Hill Res to GTown Res - Port Alfred Res 15 000 m³

10	Port Alfred – RO (10 PA : RO)	Port Alfred	- Barville / Glendower - Sunshine Coast - RO plant (seawater)	- Develop Barville/Glendower GW with 5 BH's (23 l/s) - CWRM of 2 km (30 l/s) to 1 x 500 m³ Bal Res - Develop Sunshine Coast GW with 9 BH's (18 l/s) - CWRM of 2 km (24 l/s) to the 500 m³ Bal Res - CWGM of 5 km to PA (54 l/s) - Develop GW source at coast with 15 BH's (155 l/s) - 1 RWPS (155 l/s) with a 250 m³ Bal Res - RWRM of 2.1 km (155 l/s) & 1 250 m³ Bal Res - New RO (seawater) plant – 7 650 m³/d - 1 CWPS (110 l/s) with a 200 m³ Bal Res - CWRM of 0.5 km (110 l/s) to the town Res - Port Alfred Res 15 000 m³

8.5 SIZING AND COSTING OF DEVELOPMENT OPTIONS

This section describes the methodology applied for the sizing and costing of the development options and should be read in conjunction with **Section 8.4**, which describes the infrastructure components for each development option. The layouts for the development options are shown in **Figure 13.1 and diagrams S1 to S7.** The longitudinal sections for the main conveyance systems are shown in **diagrams L1 to L7.**

All major components of the identified development options have been sized at a reconnaissance level of detail, in accordance with the criteria specified in the following paragraph. The sizing for all system components has been for the projected water requirements in 2025, taking into consideration the available capacities of the existing water sources and the bulk infrastructure. No optimisation of the system components has been done at this stage.

8.5.1 General Sizing Criteria: Design Capacities and Flows

The sizing flows for the main infrastructure components are shown per development option in **Table 8.4** and **Appendix 9**. The criteria used are summarised in the table below.

Table 8.5.1: Design capacities and flow rates for sizing of infrastructure components

System component	Demand definition	Sizing criteria
Sizing criteria		
Regulated water source	Gross Average Annual Daily Demand (GAADD)	AADD * (1+LFr + LFw)
Water treatment works & raw water pump stations	Summer Daily Demand (SDDww)	SPF * GAADD * 24/Op time
Clear water bulk pipelines, clear water pump stations	Summer Daily Demand (SDDpl)	SPF * GAADD * (1-LFw) * 24/operation time
System reservoir storage		AADD * Hours
Boreholes & borehole pump stations	Summer Daily Demand (SDDpu)	SPF * GAADD * (1-Lfw) 24/bh operation time
Selected values		
Parameter	**Parameter**	**Selected values**
Conveyance loss	LFr	10 %
Water treatment loss	LFw	10 %
Summer Peak Factor	SPF	Varies (1.2 to 1.8)
Operating period: WTW, pipelines	Hours per day	20
Reservoir capacity: Single Source	Hours	48
Operating period boreholes	Hours per day	12

8.5.2 Dams: Sarel Hayward Dam

The development options do not include the construction of new dams and weirs. The required additional storage at Sarel Hayward Dam was determined by using the Water Resources Yield Model (WRYM) as described in detail in the supporting report **Stream flow Hydrology**. A number of possible scenarios were modelled, which included variations in the sizes of the two components of the system – pump station and dam capacity. The low flow duration curves and the required Ecological Reserve releases in the Kowie River were taken into account. Provision for flushing (1.4 x 10^6 m^3/a) of the dam in order to manage the water quality has been made. The area-capacity curve for the dam was used to determine the required raising height (12 m).

The dam raising was sized in accordance with the guidelines developed for the VAPS study. The cost models developed for the study were used, but the unit rates were escalated to the April 2004 price levels.

8.5.3 Groundwater Development

The sizing parameters for each identified groundwater development were determined site specifically as detailed in Table 13 of the supporting report **Groundwater Resources**. These parameters include: anticipated yield for the entire well field and per borehole, drilling depth, dynamic water level and success rates. It has been assumed that the boreholes will discharge into a collective storage reservoir or pump sump positioned at a command location, from where the water is transferred to the town reservoirs via rising or gravity mains. The sizing of the supporting infrastructure required for the development of the source was done accordingly. The following supporting infrastructure was sized and the relevant costs were estimated for each groundwater development:

- Source development: Siting, EIA scoping and licensing, drilling and testing
- Provision of power supply to each borehole
- Equipping of boreholes: positive displacement pumps driven by electrical motors, housed in a pump houses, including necessary controls and wiring.
- Rising mains from boreholes to balancing reservoirs
- Conveyance system from the balancing reservoir to the main system reservoir.

8.5.4 Conveyance Systems

The layouts of the conveyance system associated with each development option are shown in **Figure S1** to **S7.** The system components are described in detail in **Section 8.4** and summarised in **Table 8.4**. Each option includes some or all of the following components:

- Raw water pump stations (RWPS)
- Raw water rising mains (RWRM) of raw water gravity main (RWGM)
- Water treatment works (WTW)
- Clear water pump station (CWPS)
- Clear water rising main (CWRM) or clear water gravity main (CWGM)
- Storage reservoir (RES)
- Break pressure tank (BPT), or balancing reservoir (BAL RES)

All components have been sized in accordance with the applicable design flow criteria shown in **Table 8.5.1**. The conceptual longitudinal profiles for selected pipeline routes are shown in **Figures L1 to L7**.

The gravity mains have been sized on the basis of available head, while the pumping mains have been sized on the basis of optimal velocities (in the order of 1.5 m/s). A provision for 50% standby capacity at all pump stations has been made.

The position of the new proposed storage reservoirs has been selected to be in the close vicinity of the existing reservoirs, allowing the feeding of the secondary distribution system by gravity. The reservoirs have been sized for 48 hours of storage capacity.

Some of the development options considered in this study may already include some of the components listed above as part of its existing infrastructure, while others will be newly developed schemes. Where applicable, provision for the upgrading of the existing infrastructure and/or for the development of new infrastructure has been made.

The secondary and tertiary distribution systems, that transfer the water from the town reservoirs to the consumers, have not been investigated and do not form part of this study.

The costing of all components has been done by using cost models, based on all-in-one costs based on the salient parameter of each component: length of pipe with specific size and type, volume of treated water (WTW), volume of storage capacity (reservoirs), etc. The cost for the major mechanical equipment (RO plant, pumps, etc) has been determined on the basis of current actual prices. The cost models are attached in **Appendix 10.1**.

8.6 SUMMARY OF CAPITAL COSTS

A summary of the estimated capital costs per development option is provided in the **Table 8.6.1**. A breakdown per component is shown in **Table 8.6.2**. More detail is available in **Appendix 10**. The capital costs have been estimated at April 2004 price levels and include provisions for preliminary and general items (P&G), contingencies, professional fees and VAT. The economic evaluation taking into account the operation and maintenance, running costs and residual values for all options, is discussed in **Section 8.7**.

Table 8.6.1: Summary Capital Cost Per Development Option

Opt No.	Development Option	Capital costs, R million		
		Water Source	Conveyance	Total
1	Alexandria – 1 A: GW	R 0.255	R 10.354	R 10.609
2	Cannon Rocks – 2 CR: GW	R 0.729	R 4.890	R 5.619
3	Kenton on Sea –3 KoS: GW	R 4.037	R 24.077	R 28.114
4a	Kenton on Sea –4a KoS: RO1	R 19.601	R 15.045	R 34.646
4b	Kenton on Sea – 4b KoS: RO2	R 12.841	R 15.926	R 28.767
5	Kenton on Sea – 5 KoS: SW	R 2.961	R 38.374	R 41.335
6	Port Alfred – 6 PA: GM – PA, BT, KoS	R 2.386	R 128.521	R 130.907
7	Port Alfred – 7 PA: GM – PA, BT	R 2.386	R 95.855	R 98.241
8a	Port Alfred – 8a PA: SH	R 17.159	R 38.025	R 55.184
8b	Port Alfred – 8b PA: SH & RO	R 33.539	R 39.996	R 73.535
9	Port Alfred – 9 PA: SD	R 2.386	R 98.07	R 100.456
10	Port Alfred – 10 PA: RO	R 60.821	R 23.287	R 84.108

8.7 EVALUATION OF DEVELOPMENT OPTIONS

8.7.1 Economic Analysis Model

The most efficient scheme is not necessarily the one associated with the lowest capital costs. Running expenses, which influence the total project cost over the design life of the scheme, such as operation, maintenance and energy costs have to be taken into account. Furthermore the volume and quality of water supplied also has to be weighted in the comparative evaluation of alternatives.

Two economic indicators of performance of the scheme have been employed in accordance with the VAPS guidelines and economic evaluation models:

- Net present cost (NPC)
- Net present value of water (NPV)

The economics model calculates the NPC at various discount rates, based on the capital costs, and the operational and maintenance costs. No phasing in the implementation of the infrastructure has been considered at this stage. The NPV of water has been calculated by applying the same discount rates on the projected annual water supplies. The economic evaluation has been undertaken on the basis of the unit reference value of water (URV = NPC/NPV) estimated for each option. The economic analysis was performed for a 20-year horizon using the following parameters pertaining to the calculation of the operation, maintenance, energy and chemical costs:

- A discount rate of 6% was used, but sensitivity to variation of the rate was tested for 4% and 8%.
- The residual values at the end of evaluation period were established for each scheme component, on the basis of the following assumed design life:
    - 45 years for civil works
    - 30 years for M&E items and pipelines
    - 20 years for boreholes
    - 10 years for borehole pumps and diesel engines.
- The annual operation and maintenance (O&M) costs were estimated as a percentage of the total capital costs. The following percentages were applied for the various types of schemes and components.

Table 8.7.1A: O&M costs as a percentage of the capital costs per type of works

Type of works	Surface Scheme	Boreholes
Civil works	0.5%	1%
Mechanical and Electrical works	4%	10%
Pipelines	1%	2%
Boreholes		3%

Table 8.7.1B: O&M costs as a percentage of the capital costs per component

Development Component	RO Plant	SW Source	GW Source	BH Equip	Pump Station	WTW	RES	Pipe-line
% of capital cost	3.00%	0.85%	1.00%	5.50%	2.78%	1.73%	0.50%	1%

- An estimate of the annual energy costs has been done, and the following rates determined:
    - Energy charge 22.22 c / kWh
    - Demand charge R5.43 / kVA per month
    - Costs of chemicals 63 c / m³

8.7.2 Results of Economic Analysis

The calculated residual values, O&M costs, and energy costs for each option are provided in **Appendix 10.2**. The economic models, including the calculated NPC and URV are provided in **Appendix 10.4**. The following table summarises the results of the economic analysis for all development options.

Table 8.7.2: Results of the Economic Analysis

Option No.	Development Option	Tot Capital Cost (R mil)	Tot Annual O&M (R mil)	Residual Value (R mil)	Max Energy (R mil)	URV of Water, 6 % discount (R/m³)
1	Alexandria – GW	R 10.609	R 0.151	R 3.674	R 0.056	R 15.22
2	Cannon Rocks – GW	R 5.619	R 0.104	R 1.746	R 0.043	R 5.02
3	Kenton on Sea – GW	R 28.114	R 0.425	R 10.008	R 0.483	R 10.08
4a	Kenton on Sea – RO1	R 34.646	R 0.771	R 14.750	R 0.937	R 13.56
4b	Kenton on Sea – RO2	R 28.767	R 0.606	R 9.709	R 0.739	R 11.33
5	Kenton on Sea – SW	R 41.335	R 0.499	R 14.681	R 0.716	R 10.21
6	Port Alfred – GM 1	R 130.907	R 1.538	R 48.291	R 1.539	R 10.68
7	Port Alfred – GM 2	R 98.241	R 1.196	R 36.947	R 1.212	R 9.97
8a	Port Alfred – SH	R 55.184	R 0.622	R 24.331	R 0.496	R 5.70
8b	Port Alfred – SH & RO	R 73.535	R 1.148	R 31.617	R 1.290	R 8.27
9	Port Alfred – SD	R 100.456	R 1.292	R 38.524	R 1.282	R 10.91
10	Port Alfred – RO	R 84.108	R 2.030	R 31.744	R 2.447	R 10.85

It should be noted that the figures regarding the URV in the above table are very rough and are provided only for comparison purposes. Owing to the reconnaissance nature of this study, the phased implementation of the components associated with the development options has not been taken into account in the determination of the URV's. This may have resulted in certain inaccuracy.

8.7.3 Evaluation of Development Options

The evaluation of the development options has been undertaken on the basis of technical viability, economic feasibility, and ecological acceptability, taking into consideration other factors that may influence the developments such as operation and maintenance costs, ecological sensitivity, etc.

Alexandria

Option 1: A: GW: The proposed scheme to augment the water supply to Alexandria by developing additional groundwater resources from the Fishkraal coastal aquifer was the only feasible option identified during this study. The proposed scheme will meet the water requirements in Alexandria until 2025 and the water supplied will be of good quality. The estimated costs associated with this option are: capital costs of R10,61 million, annual running costs R0,15 million and URV R15,22/m^3. The high URV for the scheme is associated with the relatively long and expensive conveyance system.

Despite the high URV, this is the only feasible scheme identified on the basis of the information available at present. The costs to supply water from a possible regional scheme based on sources from either the New Years Dam or the Glen Melville Dam, which can provide water of similar quality, would be higher. No alternative groundwater sources could be identified during the course of this study.

The development of the Fishkraal coastal aquifer located with the Sanparks Nature Reserve is ecologically sensitive and needs to be approved by the Department of Environmental Affairs and Tourism. An EIA report has been prepared and submitted for consideration, but the record of decision is still pending. Should the ecological impacts be unacceptable, the following alternatives should be considered:

- Further groundwater resources investigations to identify alternative resources. If necessary and if water quality is an issue, groundwater developments can be combined with desalination facilities for brackish water
- If no suitable groundwater resources can be identified, the last resort would be to include Alexandria into a regional scheme via Kenton on Sea at a very high capital cost.

Cannon Rocks and Boknes

Option 2: CR: GW: This was the only feasible option identified during this study to augment the water supply to Cannon Rocks and Boknes by developing additional groundwater resources from the Apies River coastal aquifer. The proposed scheme will meet the water requirements until 2025 and the water supplied will be of good quality. The estimated costs associated with this option are: capital costs of R5,62 million, annual running costs R0,10 million and URV R5,02/m^3.

The development of the coastal aquifer located within the Sanparks Nature Reserve is ecologically sensitive. An EIA report has been prepared and submitted for consideration, but the record of decision is still pending. If the ecological impacts are unacceptable, further groundwater investigations should be carried out to identify alternative sources. If necessary and if water quality remains an issue, further groundwater developments can be combined with desalination facilities for brackish water.

Kenton on Sea and Boesmansriviermond

A number of options for the augmentation of the water supply to these towns have been considered. All options include the continued utilisation of the existing Diaz Cross well field (0,3 x 10^6 m³/a), the upgrading of the existing RO plant to a total capacity of 0.53 x 10^6 m³/a and the development of the proposed Kwaaihoek well field with a capacity of 0.11 x 10^6 m³/a. The evaluation of the competitive options follows.

Option 3: KOS: GW: The proposed scheme provides for the augmentation of the water supply by developing additional groundwater resources at Merville and Bushfontein. This scheme can meet the water requirements until 2015 and the water supplied will be of marginal quality (Class II). The estimated costs associated with this option are: capital costs of R28,11 million, annual running costs R0,42 million and URV R10,08/m^3.

This scheme provides the lowest URV of water compared to all options considered for Kenton on Sea, and also requires the lowest capital. The additional advantages of this option are that it is a stand-alone scheme, which is independent from regional developments, implementation can start immediately and can be phased. However, the water quality supplied would be of an inferior standard compared to that for the other options. The capacities of the available groundwater resources in the area are limited (even when considering that some additional resources can be developed in the Witpoort). Therefore, the development of either another local scheme based on RO desalination, or a regional surface water scheme could eventually be required to meet the water demands for 2025. The implementation of this option would however result in an immediate relief of the water supply situation and would postpone the timing for the development of a regional scheme.

The implementation of this option is recommended, subject to the approval of an EIA scoping report.

Option 4a: KOS: RO1: The proposed scheme provides for the augmentation of the water supply by the construction of an additional RO desalination plant based on treatment of sea water. This scheme can meet the water requirements until 2015 and the water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R34,65 million, annual running costs R0,77 million and URV R13,56/m^3.

This scheme provides the highest URV of water compared to all options considered for Kenton on Sea. The URV for this option is about 35% higher than option 3. The implementation of this option is therefore not recommended.

Option 4b: KOS: RO2: The proposed scheme provides for the augmentation of the water supply by the construction of an additional RO desalination plant based on treatment of brackish water. It has been assumed that a groundwater source with the required capacity would be available and that its development would be environmentally acceptable. This scheme can meet the water requirements until 2015 and the water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R28,77 million, annual running costs R0,61 million and URV R11,33/m^3.

The URV for this scheme is about 11% higher than for Option 3, which is in the range of inaccuracy of the models used during this reconnaissance stage. This option is feasible, supplies water of good quality and can be implemented either as a stand-alone scheme, or in conjunction with Option 3 (to meet the requirements beyond 2015), but subject to environmental acceptability and the availability of a suitable source of groundwater.

Option 5: KOS: SW: The proposed scheme provides for the augmentation of the water supply from a regional surface water scheme, which uses the Glen Melville Dam as a source. This scheme can meet the long-term water requirements and the water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R41,33 million, annual running costs R0,51 million and URV R10,21/m^3.

The URV for this scheme is about the same as for Option 3, but the capital required is substantially higher. The advantages of this option are that it can provide a once-off long-term solution (capacity of source is unlimited) and the water quality is of a superior standard. However, the development of this scheme requires substantial capital investment and further more detailed studies to identify the best regional scheme, before implementation can commence. Furthermore, this scheme would only be feasible if developed as part of a regional scheme that includes Port Alfred. It is therefore recommended that this scheme can be considered for future augmentation, but immediate steps to improve the situation should be taken by developing Option 3 first.

The identification of the best regional scheme is discussed in more detail in the next paragraphs.

Port Alfred and Regional Schemes

A number of options for the augmentation of the water supply to Port Alfred have been considered. All options include the continued utilisation of the supply from the existing Sarel Hayward Dam (1.55 x 10^6 m^3/a) and the coastal aquifers to the east of the town (0.11 x 10^6 m^3/a). In addition all options include the implementation of the proposed groundwater developments of the Glendower and Sunshine Coast aquifers to the west of the town with a total yield of 0.63 x 10^6 m^3/a. The following has been established during the course of this study:

- The development of the groundwater resources in the Glendower and Sunshine Coast aquifers can be implemented immediately, subject to environmental acceptability, which needs to be confirmed.
- That development would provide the much needed relief to the present water supply situation and will allow time for further investigations to identify the additional development options
- Despite the fact that additional potential groundwater development sites could possibly be identified within the Witpoort belt to the east of the town, taking into consideration the substantial growth in the water requirements, it can be concluded that it is unlikely that the capacities of those resources would be sufficient to meet the long term requirements of the town (or the region).
- Therefore, it is likely that a regional surface water storage scheme would eventually be required to meet the long-term requirements.

- Owing to the fact that the URV for most options investigated are in a narrow range of ± 20% of average (within the error margin for reconnaissance level) it has not been possible during this reconnaissance study to isolate the best development scheme. Further more detailed studies would be required.

Option 6: PA: GM: PA, BT & KoS: The proposed scheme provides for the augmentation of the water supply for the towns of Port Alfred, Bathurst and Kenton on Sea as a regional scheme, based on water supplied from the existing Glen Melville Dam. This scheme can meet the water requirements in the region until 2025 and the water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R130,91 million, annual running costs R1,54 million and URV R10,68/m^3.

The advantages of this option are that it has practically unlimited capacity and the water quality is good. However, although the URV for this scheme is in line with the others, its capital requirements are the highest.

Option 7: PA: GM: PA & BT: This scheme is identical to Option 6, but provides for the augmentation of the water supply only for the towns of Port Alfred and Bathurst. The estimated costs associated with this option are: capital costs of 98,24 million, annual running costs R1,20 million and URV R9,97/m^3.

The scheme can be compared directly with Option 8b (supply from the Sarel Hayward Dam combined with desalination) and Option 9 (supply from the Settlers Dam). The URVs are very similar and a selection could not be made on the basis of the reconnaissance level of investigation.

Option 8a: PA: SH: This option provides for the augmentation of the water supply to Port Alfred based on increasing the yield from the Sarel Hayward Dam achieved by rising of the dam wall and upgrading of the associated infrastructure. The water quality will not improve from current levels (Class II). This option offers the best economic parameters of all options considered: capital costs of R55,18 million, annual running costs R0,62 million and URV R5,70/m^3. However, the quality of water supplied would not be of the same standard as for the other options. It should also be noted that the Sarel Hayward Dam is located in a very environmentally sensitive area and the raising of the wall will be subject to an acceptable EIA.

Option 8b: PA: SH & RO: This option is identical to Option 8a, but in addition it also includes a RO desalination infrastructure with a capacity to desalinate 50% of the water supplied from the Sarel Hayward Dam. This option has been investigated in order to bring the quality of the water supplied from the Sarel Hayward Dam to a level similar to the one supplied from the other options. This would allow for more realistic comparison of the options.

The estimated costs associated with this option are: capital costs of R73,54 million, annual running costs R1,15 million and URV R8.27/m^3. The URV of water supply is lower than that for the other options supplying good quality water, but a final decision cannot be made at this early stage. The development of this option is subject to an acceptable environmental impact associated with the raising of the Sarel Hayward Dam and the construction of a RO plant near the town.

Option 9: PA: SD: The proposed scheme provides for the augmentation of the water supply to Port Alfred, based on water supplied from the existing Settlers Dam. This option is similar to Option 7, and in fact relies on the surplus yield available at the Glen Melville Dam, but through a different conveyance system. The water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R100,45 million, annual running costs R1,30 million and URV R10,91/m^3. The economic parameters are similar to the ones for Option 7.

Option 10: PA: RO: The proposed scheme provides for the augmentation of the water supply to Port Alfred, based on water supplied through a newly proposed RO desalination plant. The water supplied will be of good quality (Class I). The estimated costs associated with this option are: capital costs of R84,11 million, annual running costs R2.03 million and URV R10,85/m^3. The economic parameters are similar to the ones for Options 6, 7 and 9.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 DEVELOPMENT OPTIONS/SCHEMES

9.1.1 Introduction

The water supply situation in most of the affected towns is not ideal and steps for the augmentation of the water sources need to be taken. However, the situation in Kenton on Sea/Boesmansriviermond, Cannon Rocks/Boknes and Port Alfred is critical and emergency measures for augmentation of the water sources for these towns are urgently required.

Where possible, this study has identified solutions to the water supply problems that present themselves for immediate implementation. In other cases, more detailed investigations have been recommended to be undertaken before final decisions on the best solutions can be made. A summary of the cost estimates for the proposed augmentation schemes is given in **Section 8.6** and more detail is available in **Appendix 10**. A detailed description of the components of the proposed schemes is given in **Section 8.4** and a summary in **Table 8.4.**

The specific recommendations for each town are offered in the next paragraphs. The responsibility for further actions is indicated in brackets and in bold print after each recommended action. Where the Ndlambe Local Municipality (NLM) has been identified as the responsible institution, they will most likely have to rely on Municipal Infrastructure Grant (MIG) funding. The NLM should draw up an implementation strategy, based on the recommendations in this report. Provision of direct financial assistance from DWAF for implementation of infrastructure is unlikely. However, when the implementation strategy is completed, NLM can approach DWAF for further advice and assistance. Where possible, it terms of current legislation, DWAF will do its best to assist.

When estimating the water requirements it has been assumed that the best water demand management measures would be implemented. In all towns, projects are recommended to assess the levels of existing losses in the bulk supply and reticulation systems, to propose measures for the reduction of those losses and to undertake the necessary remedial work. This will ensure that the limited resources are utilized in the most efficient manner. **(NLM, but DWAF can provide assistance in terms of advice).**

The NLM should not allow substantial housing developments in the most affected towns before solutions to the severe water supply problems are identified and implemented.

9.1.2 Alexandria

- The existing water source (Fishkraal coastal aquifer) has sufficient yield to meet the projected water requirements until 2007. Thereafter the source needs to be augmented.
- The water quality of the source is of acceptable standard.

- The additional water source from the Fishkraal coastal aquifer, identified during the course of this study, has sufficient capacity to meet the water requirements until 2025 and beyond. The development of this source can commence as soon as a record of decision from the Department of Environmental Affairs and Tourism (DEAT) is received. (**NLM, funding from MIG, but DWAF can assist with advice).**

- The NLM should follow up with the DEAT with regards to the outcome of the application for approval of the further exploration of the Fishkraal costal aquifer submitted earlier.

- If the Fishkraal coastal aquifer development is acceptable from an environmental point of view, the source should be developed and the phasing of the upgrading of the bulk supply system should be optimized. The total capital cost for this development is estimated at R10.6 million at April 2004 price levels (**NLM, but DWAF can assist with advice).**

- The existing bulk supply system is undersized and needs to be upgraded urgently. However, a decision on the likely additional water source needs to be made before the upgrading of this system. (**NLM, funding from the MIG as budgeted for in the Water Services Development Plan (WSDP)).**

- If the Fishkraal coastal aquifer development is not acceptable, the existing bulk supply system should be upgraded to the capacity of the source. This will ensure adequate water supply until 2007. Further groundwater investigations should be undertaken at the same time in order to identify alternative groundwater sources. Investigations should include studies and exploration drilling. (**NLM to appoint a specialised consultant, but DWAF can assist with advice).**

- It should be noted that at a capital cost exceeding R10 million the proposed scheme based on the Fishkraal coastal aquifer is already relatively expensive. Owing to the shortage of water sources with acceptable water quality standards in the area, the alternatives to that scheme, which include the utilization of inland surface water, or groundwater, are expected to be prohibitively expensive.

9.1.3 Cannon Rocks/Boknes

- Although the existing Cannon Rocks water source (boreholes) is theoretically adequate to meet the projected water requirements of Cannon Rocks and Boknes until 2005, the water is of poor quality and the pattern of demand makes supply during the peak holiday season very expensive and unreliable. The water source needs to be augmented urgently.

- Additional storage capacity will be required within the bulk supply system to meet the growing peak requirements **(NLM).**

- The coastal aquifer at the Apies River has sufficient supplementary yield of acceptable quality to meet the projected future requirements at least until 2025. Subject to the approval of the EIA report, this source should be developed at an estimated cost of R5,6 million. (**NLM, but DWAF can be approached for advice).**

- The NLM should follow up with the DEAT with regards to the application for the development of the Apies River coastal aquifer submitted earlier.

- If the Apies River development is not acceptable, further investigations should be undertaken in order to identify alternative groundwater sources. Investigations should include studies and exploration drilling (**NLM to appoint a specialised consultant, but DWAF can be approached for advice)**.

- As it is unlikely that groundwater with acceptable quality standards will be identified in this coastal area, the use of brackish groundwater in combination with reverse osmosis desalination facilities could be considered as an alternative to the proposed Apies River coastal aquifer development. (**NLM to appoint a specialised consultant, but DWAF can be approached for advice).**

9.1.4 Kenton on Sea and Boesmansriviermond

- The existing water sources (Diaz Cross aquifer and a sea water desalination plant) are unable to meet the present water requirements even during low consumption periods. The system is severely stressed during peak periods. Water restrictions and even water outages are common. Urgent measures for the augmentation of the water source need to be taken.

- The water of the coastal aquifer sources (Diaz Cross and Kwaaihoek) is saline, but when mixed with desalinated water, the product is of an acceptable quality.

- The coastal aquifer at Kwaaihoek with a yield of 0.11 million m³/a can be developed reasonably quickly as the existing bulk supply system from Diaz Cross has sufficient capacity to convey the additional flows. The development of this source at an estimated cost of R800 000 will bring some relief to the water supply situation, but the total yield of all sources will still be insufficient to meet the present water requirements.

- The Albany Coast Water Board (ACWB) on behalf of NLM should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of this source for approval by DEAT.

- If approval is granted, the source should be developed urgently as a fast track project (**ACWB and NLM, but DWAF will support with advice).**

- Concurrently with the above, the ACWB should follow up with the DEAT on the application submitted earlier regarding the proposed upgrading of the RO plant.

- If the upgrading is approved, the proposed upgrading of the RO plant should be implemented urgently as a fast track project at an estimated cost of R6.0 million. This will increase the combined capacity of the water sources by 0.3 million m³/a. The combined available yield will then be sufficient until 2006. (**ACWB and NLM, funding from the MIG as budgeted for in the WSDP).**

- The ACWB should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of the proposed Merville and Bushfontein groundwater sources and the associated bulk supply conveyance systems**.**

- Concurrently, a geohydrological consultant should be appointed to evaluate the potential for development of the rest of the Witpoort formation to the south east of Merville. The study should include exploration drilling and testing. **(ACWB and NLM, but DWAF can be approached for advice).**

- Once the extent of the possible future development of the overall Witpoort formation is established and DEAT approval is received, the Merville groundwater source (yield 0.29 million m³/a) should be developed and the bulk conveyance system between Merville and Kenton on Sea should be optimised and constructed as a fast track project. The capital cost of this development is estimated at R12 million. If this source is developed the total combined yield of all sources will be sufficient until about 2010. (**ACWB and NLM, funding from the MIG).**

- The development of the Bushfontein groundwater source (yield 0.29 million m³/a) and/or other groundwater sources, which may be identified within the Witpoort aquifer, together with the associated conveyance system should follow when required for further augmentation of the source. The incremental cost for the development of the Bushfontein source is estimated at R9 million. If this source is developed the total combined yield of all sources will be sufficient until about 2015. (**ACWB and NLM, possible funding from the MIG, DWAF can assist with advice).**

- At that later stage, the water supply situation will have to be reviewed through additional studies, which need to identify the best further development options to follow. **(NLM, but DWAF can be approached to provide assistance in terms of management and funding for the study)**. At least the following options should be considered:

    - Construction of an additional RO plant sourced by sea water, or brackish water, including a possibility to recharge the coastal aquifer with effluent (subject to confirmation of the availability of a brackish water source with the required capacity, acceptable environmental impact, and if the water quality problems associated with the creation of a closed loop can be resolved).

    - Development of a regional surface water scheme, which would include the supply to Port Alfred. Such a regional scheme is discussed in the following section.

9.1.5 Port Alfred and Regional Schemes

- At present the existing water sources (Sarel Hayward Dam and boreholes) are sufficient. However, substantial proposed new housing developments will most likely necessitate the urgent upgrading of the source before 2006.

- The water quality of the existing sources is below the acceptable standard.

- The internal reticulation system and balancing storage reservoirs do not have sufficient capacity to meet the peak seasonal requirements and urgent upgrading is required **(NLM, MIG funding).**

- Additional groundwater sources with anticipated acceptable water quality and a total yield of 0.64 million m³/a have been identified to the west of the town in the areas of Glendower and Sunshine Coast. With the development of these sources the water requirements will be met until about 2007, which will provide much needed relief to the present water supply situation and will allow time for further investigations to identify the best augmentation option to follow.

- The NLM should immediately appoint a consultant to prepare and submit an EIA and scoping report for the development of this source for approval by DEAT.

- If approval is granted, the source and the associated conveyance system should be developed urgently as a fast track project at an estimated cost of R 8,0 million **(NLM, but DWAF can assist with advice).**

- A more detailed study should urgently be commissioned in order to assess the feasibility of a possible regional scheme (inter-basin transfer, or joint inter-municipal water supply scheme) to supply Port Alfred and to other towns in the area. Such scheme should be implemented before 2008 at an estimated cost varying between R47 million and R92 million depending on the option selected. **The study can possibly be funded and managed by the DWAF, but the NLM should formally request the Regional Office of the Department for assistance).**

The study should include the following components and activities:

Engineering aspects:

- o Overall study management and co-ordination of the multidisciplinary team
- o Review of water requirements and water resources
- o Review and identification of competitive options. Consider supply from: groundwater, raising of the Sarel Hayward Dam, Glen Melville Dam, Settlers Dam, desalination of sea or brackish water, etc.
- o Site investigations and surveys: geotechnical, land surveys, etc as required
- o Engineering sizing and costing based on preliminary designs and site specific information
- o Economic models and evaluation
- o Implementation strategy, including programmes and funding sources

Hydrogeological aspects:

- o Undertake further hydro-census and field investigations into the potential for development of groundwater sources for the supply of Port Alfred, Bathurst, Kleinemonde and Kenton on Sea.
- o Undertake exploration drilling and testing in order to determine the parameters of each identified source

Ecological aspects:

- o Undertake site surveys and acquire necessary field information
- o Determine the Ecological Reserve at specific surface water development sites
- o Produce EIA and scoping reports for approval by the DEAT for the selected development options
- o Public participation and shareholder involvement

It is anticipated that such study can be completed in 18 months at an estimated cost of about R3,0 million.

- A decision on the implementation of further augmentation options should be taken on completion of the afore-mentioned study. **A number of institutions should be party to such a decision, e.g. DWAF, Cacadu DM, NLM, Makana DM, DEAT, etc.**

9.1.6 Bathurst

- The existing water source (Golden Ridge Dam) has sufficient yield to meet the present water requirements until about 2006. However, if the old town is provided with water services, the water source will have to be upgraded. Also an Ecological Reserve determination should be carried out to verify the yield of the Golden Ridge Dam. This should be included in the scope of services for the study referred to in the previous section.
- The water quality of the existing sources is below the acceptable standard.
- The capacity of the existing water treatment works is insufficient and needs to be upgraded urgently as a fast track project **(NLM, MIG funding).**
- The augmentation of the existing water source can be done through one of two options:
    - Supply from a possible regional scheme, which is developed to supply Port Alfred, if the bulk supply system runs near Bathurst. Clarity on this longer term option will be available on completion of the study referred to in the previous section.
    - If augmentation is urgent, local groundwater sources should be sited and developed **(NLM, but DWAF can assist with advice)**.

9.1.7 Kleinemonde / Seafield

- The existing water sources (Mount Wellington Dam and boreholes) have sufficient capacity to meet the present water requirements during normal periods, but not during peak season. Normal requirements can be supplied until about 2015.
- The water quality of the existing sources is below the acceptable standard.
- The capacity of the existing water treatment works is insufficient and needs to be upgraded urgently as a fast track project **(NLM, MIG funding).**
- The capacity of the existing storage reservoirs should be increased in order to provide for peak requirements **(NLM, MIG funding).**
- The NLM should appoint a consultant to verify the yield of the Mount Wellington Dam **(NLM, DWAF can be approached for technical assistance).**
- The augmentation of the available water source could be done through the development of additional groundwater sources. The NLM should appoint a specialised consultant to identify potential drilling sites. **(NLM, but DWAF can assist with advice).**

9.2 IMPLEMENTATION STRATEGY

- NLM is the institution responsible for the implementation of the actions recommended in this report.
- NLM should draw up an implementation strategy for the actions recommended in this report, taking into account the water supply situation in each town, the availability of funds and resources within the municipality and the timing for implementation.
- NLM can appoint a consultant, familiar with the water infrastructure and the water resources in the area, to assists with the compilation of such strategy.
- In the implementation strategy, NLM should make provision for water demand and water loss management project in the affected towns.
- On the basis of the implementation strategy, NLM should seek assistance and support (financial, advisory, etc.) form the Cacadu District Municipality and other institutions and authorities. DWAF should also be approached to discuss the details of the advisory assistance that can be provided.
- NLM should not allow new substantial developments before solutions to the severe water supply problems can be found and implemented.