water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

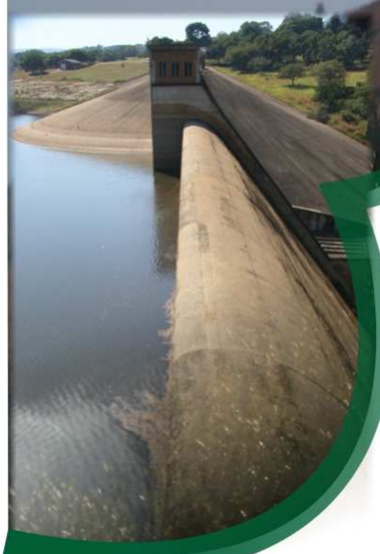
REPORT NO.: P WMA 02/B810/00/0608/1

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (GLeWaP)

TECHNICAL STUDY MODULE:

Main Report

VOLUME 1



MAY 2010

aurecon

Aurecon (Pty) Ltd
PO Box 494
CAPE TOWN
South Africa 8000

in association with

Semenya Furumele Consulting
KLM Consulting Services
Urban-Econ Developmental Economics
Schoeman & Associates

W45_2010/H505701

LIST OF STUDY REPORTS IN GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (BRIDGING STUDIES)

This report forms part of the series of reports, done for the Bridging Study phase of the GLeWaP. All reports for the GLeWaP are listed below.

REPORT NUMBER	REPORT TITLE
P WMA 02/B810/00/0508	**Project Coordination and Management Team**
P WMA 02/B810/00/0508/1	Project Coordination and Management Team: Executive Summary Report: Vol 1
P WMA 02/B810/00/0508/2	Project Coordination and Management Team: Main Report: Vol 2
P WMA 02/B810/00/0508/3	Project Coordination and Management Team: Register of Decisions: Vol 3
P WMA 02/B810/00/0508/4	Project Coordination and Management Team
P WMA 02/B810/00/0508/5	Project Coordination and Management Team
P WMA 02/B810/00/0608	**Technical Study Module**
P WMA 02/B810/00/0608/1	Technical Study Module: Main Report: Vol 1
P WMA 02/B810/00/0608/2	Technical Study Module: Review of Water Requirements: Vol 2
P WMA 02/B810/00/0608/3	Technical Study Module: Groundwater: Vol 3
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P WMA 02/B810/00/1110/1	Technical Study Module: Preliminary Design of Nwamitwa Dam: Vol 6 - Annexure 1: Appendices
P WMA 02/B810/00/1110/2	Technical Study Module: Preliminary Design of Nwamitwa Dam: Vol 6 - Annexure 2: Appendix B (Part 1): Geotechnical Investigations
P WMA 02/B810/00/1110/3	Technical Study Module: Preliminary Design of Nwamitwa Dam: Vol 6 - Annexure 3: Appendix B (Part 2): Geotechnical Investigations
P WMA 02/B810/00/1110/4	Technical Study Module: Preliminary Design of Nwamitwa Dam: Vol 6 - Annexure 4: Appendix H: Drawings
P WMA 02/B810/00/0608/7	Technical Study Module: Preliminary Design of the Raising of Tzaneen Dam: Vol 7
P WMA 02/B810/00/0608/8	Technical Study Module: Bulk Water Distribution Infrastructure: Vol 8
P WMA 02/B810/00/1110/5	Technical Study Module: Bulk Water Distribution Infrastructure: Vol 8 - Annexure 1 : Appendices
P WMA 02/B810/00/0708	**Environmental Management Module**
P WMA 02/B810/00/0708/1	Environmental Management Module: Scoping Report: Vol 1
P WMA 02/B810/00/0708/2	Environmental Management Module: Environmental Impact Assessment Report: Vol 2
P WMA 02/B810/00/0708/3	Environmental Management Module: Environmental Management Programme for Borrow Area 1 on the Farm Laborie 515: Vol 3
P WMA 02/B810/00/0708/4	Environmental Management Module: Environmental Management Programme for Borrow Area 2 on the Farm La Parisa 729 (Gubits Farm): Vol 4
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P WMA 02/B810/00/0708/10	Environmental Management Module
P WMA 02/B810/00/0808	**Public Involvement Program**
P WMA 02/B810/00/0808/1	Public Involvement Program: Main Report: Vol 1
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P WMA 02/B810/00/0808/5	Public Involvement Program

REPORT DETAILS PAGE

Project name:	***Groot Letaba Water Development Project***
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PSP
Approved for PSP by:

S C Vogel
Study Leader

PROJECT CO-ORDINATION AND MANAGEMENT TEAM
Approved for PCMT by:

R A Pullen
Project Coordinator

DEPARTMENT WATER AFFAIRS (DWA)
Approved for DWA by:

O J S van den Berg
Chief Engineer: Options Analysis North

L S Mabuda
Chief Director: Integrated
Water Resources Planning

EXECUTIVE SUMMARY

1. INTRODUCTION

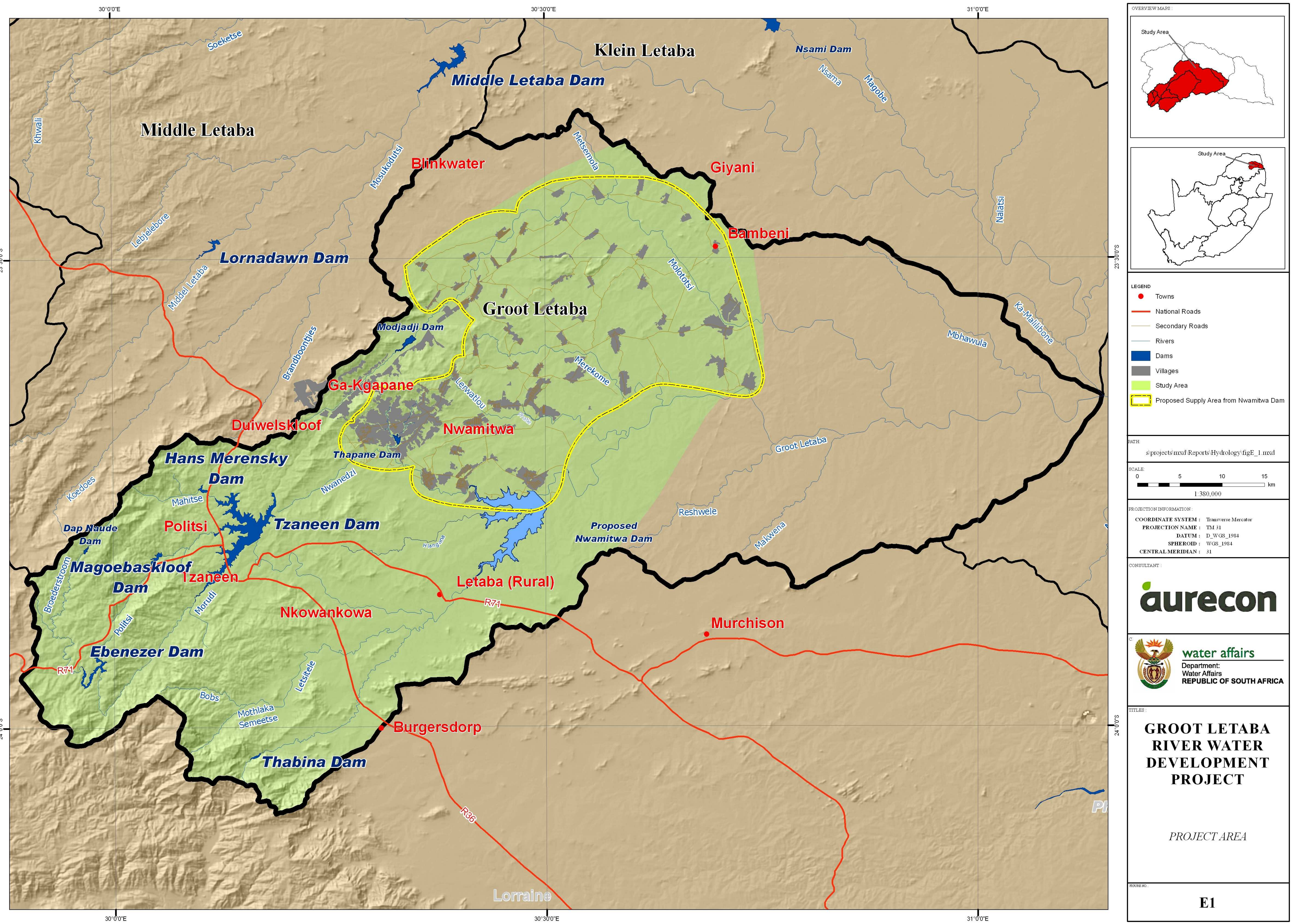
1.1 Background to Project

The catchment of the Groot Letaba River has various land uses with associated water requirements, such as irrigation, afforestation and tourism, as well as primary needs of the growing population. The water resources available in the catchment are limited, and considerable pressure has been put on these resources by growing water usage. This situation has been investigated at various levels over many years by the Department of Water Affairs (DWA).

The first major study undertaken for this area was the Letaba River Basin Study in 1985 (DWAF, 1990), which comprised the collection and analysis of all available data on water availability and use, as well as estimates of future water requirements and assessments of potential future water resource developments. This was followed by a Pre-feasibility Study (DWAF, 1994), which was completed in 1994. The focus of the Pre-feasibility Study was the complete updating of the hydrology of the Basin. The next study undertaken was a Feasibility Study of the Development and Management Options (DWAF, 1998), which was completed in 1998.

The Feasibility Study proposed several options for augmenting water supply from the Groot Letaba River. These included some management interventions, as well as the construction of a dam at Nwamitwa and the possible raising of Tzaneen Dam. These options would enable additional water to be allocated to the primary water users, would allow the ecological Reserve to be implemented and could also improve the assurance of supply to the agricultural sector.

This Bridging Study was initiated by the (then) Department of Water Affairs and Forestry in 2006 (now DWA) in order to re-assess the recommendations contained in the Feasibility Study in the light of developments that have taken place in the intervening 10 years.



30°0'0"E
30°30'0"E
31°0'0"E
23°30'0"S
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Klein Letaba
Middle Letaba
Groot Letaba
Middle Letaba Dam
Nsami Dam
Lornadawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Dap Naude Dam
Magoebaskloof Dam
Ebenezer Dam
Thabina Dam
Proposed Nwamitwa Dam
Blinkwater
Giyani
Bambeni
Ga-Kgapane
Duiwelskloof
Nwamitwa
Politsi
Tzaneen
Letaba (Rural)
Nkowankowa
Murchison
Burgersdorp
Lorraine
Soeketse
Khwali
Mosukodutsi
Lebjelebore
Middel Letaba
Brandboontjes
Metsemola
Nsama
Magobe
Nalatsi
Molototsi
Merekome
Lerwatlou
Ka-Malilibone
Mbhawula
Groot Letaba
Reshwele
Makwena
Nwanedzi
Mahitse
Koedoes
Broederstroom
Politsi
Morudi
Hlangana
Letsitele
Bobs
Mothlaka Semeetse
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R36
OVERVIEW MAPS :
Study Area
Study Area
LEGEND
Towns
National Roads
Secondary Roads
Rivers
Dams
Villages
Study Area
Proposed Supply Area from Nwamitwa Dam
PATH
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SCALE
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km
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PROJECTION INFORMATION :
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SPHEROID : WGS_1984
CENTRAL MERIDIAN : 31
CONSULTANT :
aurecon
water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA
TITLES :
GROOT LETABA RIVER WATER DEVELOPMENT PROJECT
PROJECT AREA
FIGURE NO.
E1

*The study area, shown in **Figure E1**, consists of the catchment of the Groot Letaba River, upstream of its confluence with the Klein Letaba River. The catchment falls within the Mopani District Municipality, which is made up of six local municipalities. The four local municipalities, parts or all of which are within the catchment area, are Greater Tzaneen, Greater Letaba, Ba Phalaborwa and Greater Giyane. The major town in the study area is Tzaneen, with Polokwane, the provincial capital city of Limpopo, located just outside of the catchment to the West. The site of the proposed Nwamitwa Dam is also shown on **Figure E1**.*

1.2 SCOPE AND ORGANISATION OF PROJECT

The Department's Directorate: Options Analysis (OA), appointed Aurecon in Association with a number of sub consultants to undertake this study. The official title of the study is: "The Groot Letaba Water Development Project: Bridging Studies".

The Bridging Study comprises a number of modules. This Report focuses on the scope of work for the Technical Study Module (TSM). The tasks comprising the TSM are listed below:

TASK 1: WATER REQUIREMENTS
TASK 2: WATER RESOURCE EVALUATION
TASK 3: PRELIMINARY DESIGN OF NWAMITWA DAM
TASK 4: RAISING OF TZANEEN DAM
TASK 5: BULK WATER DISTRIBUTION INFRASTRUCTURE
TASK 6: IMPLEMENTING PROGRAMME
TASK 7: WATER QUALITY

1.3 SCOPE OF THIS REPORT

This report summarises the results of the Technical Study Module, comprising Tasks 1 to 7, which are described in seven separate reports as listed below.

Tasks 1 (Water Requirements) is described in detail in the reports entitled Review of Water Requirements *(DWA, 2010 a) and* Groundwater (DWA, 2010 b)*. Task 2 (Water Resources Evaluation) is described in the reports entitled* Hydrology (DWA, 2010 c) *and* Water Resource Analysis (DWA, 2010 d)*.*

Tasks 3 (Preliminary Design of Nwamitwa Dam) and 7 (Water Quality) are reported on in the report entitled Preliminary Design of Nwamitwa Dam *(DWA, 2010 e, f, g, h and i).*

Task 4 (Raising of Tzaneen Dam) is described in the report Preliminary Design of the Raising of Tzaneen Dam (DEA, 2010 j).

Task 5 is described in the report Bulk Water Distribution Infrastructure (DWA, 2010 k and l)*.*

Task 6: Implementation Programme is described only in this Main Report*.*

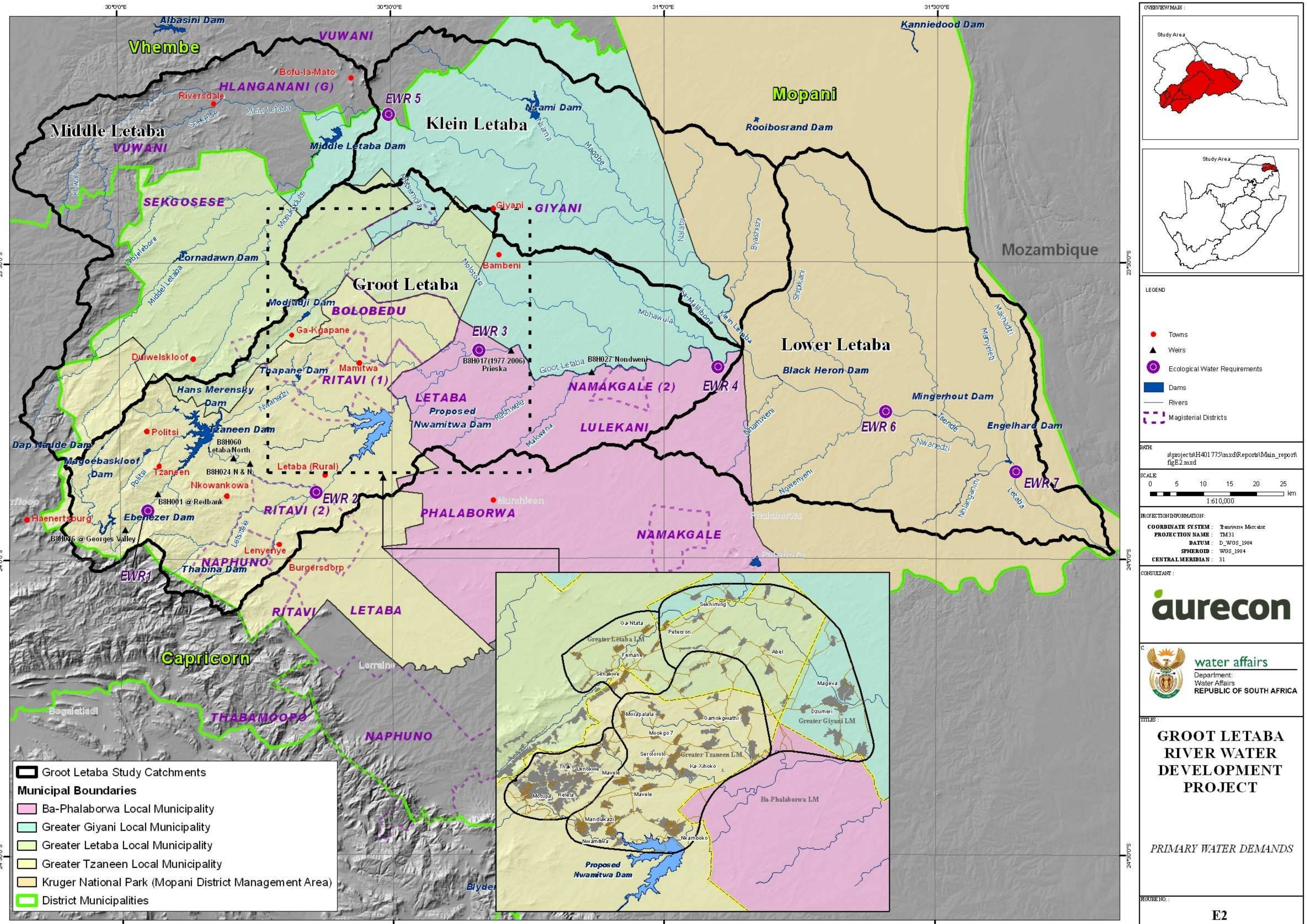
The overall conclusions and recommendations of the tasks covered are summarised in Sections 11 and 12 of this report. The references are contained in Section 13.

2. REVIEW OF WATER REQUIREMENTS

The water requirements in the catchment were investigated and reported on in the report entitled Review of Water Requirements (DWA, 2010 a)*. The following water requirements were described and quantified in that report: primary water requirements (domestic, industrial and mining water requirements), irrigation water requirements, afforestation water use, and the Ecological reserve.*

Water requirements throughout the catchment are met largely through surface water supply schemes, with very little being supplied from groundwater sources. Surface water is supplied from the Groot Letaba River and its tributaries to the towns of Polokwane (in the Sand River catchment), Tzaneen, Haenertsburg, Duiwelskloof as well as many rural villages. The main surface water supply schemes are centred around the Dap Naude, Ebenezer and Tzaneen Dams. The locations of the towns and rural settlements supplied, as well the dams in the Groot Letaba Catchment are shown in ***Figure E.2.***

Many of the existing surface water schemes in the Groot Letaba Catchment have existing allocations that excess their yields. The overall yield of the existing schemes in the Groot Letaba Catchment is 126 Mm³/a, and the total allocation from these schemes is 177 Mm³/a.



TITLES :

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

PRIMARY WATER DEMANDS

FIGURE NO. :

E2

Primary Water Requirements

The existing primary water requirement for the Groot Letaba Catchment is estimated to be 23.5 Mm³/a in 2007. This consists mainly of domestic requirements (22 Mm³/a) and a small industrial component (1.5 Mm³/a). More details of these demands and a comparison with the allocations are provided in ***Table E1****.*

Three methods were used to estimate the growth in water requirements (DWA, 2010 a), and Method 2 was chosen to be the most representative. This method made use of individual population growth rates for each main settlement area, and projected the growth in water requirements for each area independently. During the course of the study, further estimates of future water requirements were made for the area around Nwamitwa Dam, based on detailed work in the area (DWA, 2008). These estimates were considerably higher, mainly because they were based on higher levels of service. These additional future water requirements were added to the original estimates obtained using Method 2 to give the final estimated future water requirement.

Primary water requirements for the Groot Letaba Catchment were estimated to increase by 28.8 Mm³/a from 2007 to 2030, giving a total primary water use of 52.3 Mm³/a in 2030. It was assumed that the industrial component would remain constant at 1.5 Mm³/a. If one subtracts the industrial component from the figure of 52.3 Mm³/a it gives an estimated domestic water requirement of 50.8 Mm³/a in 2030. A breakdown of these additional future requirements per major settlement is given in ***Table E1****. It should be noted that the increase in domestic water requirement of 28.8 Mm³/a is influenced by higher service levels for the areas surrounding the proposed Nwamitwa Dam (Ritavi 1 (Letaba), Naphuno and Bolobedu (this includes Modjadji, Thapane and the Worcester-Molototsi areas)).*

The water demand projections indicate an ever increasing population, which translates directly into an increased demand for water. Bearing in mind that the current water supply schemes are largely over-allocated, this indicates that the need to supply more water will continue to intensify in future.

It is anticipated that the water requirement for primary water use from Tzaneen Dam and the proposed Nwamitwa Dam supply area will grow from 13.9 Mm³/a in 2007 to a value of approximately 35.2 Mm³/a in 2030. This additional growth in water requirement will need to be accommodated by the implementation of an additional water resource (e.g. raising of Tzaneen Dam, construction of the proposed Nwamitwa Dam or from groundwater schemes). At present, Polokwane is using more than their quota from the Groot Letaba Catchment.

Future mining developments

Three potential new mining developments, which together would require 21 Mm^3/a of water, were identified during the study. Due to the pressures on water availability in the Letaba Catchment, it is likely that water supplies to future mining developments outside the catchment will be supplied from other catchments where there is spare capacity.

Irrigation demands and losses

Irrigation comprises the largest water user sector in the Groot Letaba Catchment, and is estimated to be approximately 192 Mm^3/a (including losses) from surface water, and 29 Mm^3/a from groundwater.

The following differences in irrigation demands were found when the results of the 1995 Feasibility Study were compared to the Bridging Study Analysis :

- *The local demands supplied upstream of Tzaneen Dam increased by 8 Mm^3/a.*
- *Increase of 29 Mm^3/a along the Groot Letaba River from Tzaneen Dam to the Letaba Ranch. Part of this increase was from incorporating the proposed (as opposed to existing) supply of 22 Mm^3/a to emerging farmers downstream of the Nondweni Weir. The Feasibility Study reported that 7.9 Mm^3/a was supplied to the Masalal canal. This canal has not been maintained and is now unusable, therefore this water cannot be supplied via the canal.*

Table E1 Summary of Current and Projected Primary Water Requirements

Description	Place Name	Water Requirement in Mm³/a				
		Allocation 2006/7	**Usage 2006/7**	**Base Value used for Future Projections *1**	**Estimated Growth to 2030**	**Total Future Water Requirement (2030)**
(Domestic use in Groot Letaba catchment upstream of confluence with Klein Letaba River	Haenertsburg	0.0	0.0	0.0	0.00	0.00
	Tzaneen Town	2.4*1+ 1.2*2 = 3.6	2.2 + 1.0 = 3.2	3.6	12.89	16.49
	Politsi	2.0	2.1	2.0	1.38	3.38
	Duiwelskloof					
	Ga-Kgapane					
	Letsitele	0.4	0.3	0.3	0.70	1.00
	Ritavi 2	3.5	8.2	8.2	-3.41	4.79
	Naphuno	1.7	1.3	1.3	1.60	2.90
	Namakgale	0.0	0.8	0.8	0.00	0.80
	Ritavi 1	0.0	1.9	1.9	3.30	5.20
	Bolobedu	0.2	0.2	0.2	11.31	11.51
	Sub-total	**11.4**	**18.0**	**18.3**	**27.8**	**46.07**
Domestic use in Middle and Klein Letaba Catchments	Giyani	3.7	3.7	3.7	1.00	4.70
	Cumulative Sub-total	**15.1**	**21.7**	**22.0*2**	**28.8**	**50.8*4**
	Middle Letaba Dam WTW	2.3	2.3	2.3	No estimate made*3	--
	Sub-Total	**6.0**	**6.0**	**6.0**	**--**	**--**
Cumulative Sub-total		**17.4**	**24.0**	**24.3**	**--**	**--**
Domestic use outside of Letaba Catchment	Polokwane	18.5	4.6 + 18.8 = 23.4	23.4	No estimate made*3	--
Sub-total for domestic use		35.9	47.4	47.7	--	--
	Industrial use	3.3	1.5	1.5*2	--	--
Overall total of primary water requirements		**39.2**	**48.9**	**49.2**	**--**	**--**

*1 Note that where the base value differs from the allocation in the previous column, this was based on actual water usage in 2006/7.
*2 Current day primary water requirement for Groot Letaba Catchment = 23.5 Mm³/a (22.0 Mm³/a domestic + 1.5 Mm³/a industrial).
*3 Growth to be met from outside Letaba catchment.
*4 Future primary water requirement for Groot Letaba Catchment = 52.3 Mm³/a (50.8 Mm³/a domestic + 1.5 Mm³/a industrial)

Losses along each river reach were estimated and totalled approximately 28.7 Mm^3/a. Losses in the river system are a significant factor in the Groot Letaba catchment, as they affect the yield of the system, especially in the critical drawdown period. Losses also affect the releases made to supply environmental requirements in the Kruger National Park, and international agreements for the flow leaving South Africa and entering Mozambique.

Afforestation

Afforestation is a significant water user in the catchment, with an estimated 356 km^2 of commercial afforestation occurring in the catchment. The water requirements of afforestation modelled in this Bridging Study were found to differ from the afforestation demands in the digital WRYM setup available for the previous study. They were adjusted in order to match the afforestation demands in the previous study, so that the average flows for the common period would remain the same. In most cases, the adjustments increased the water use by afforestation, giving an overall increase of 13 Mm^3/a to a total afforestation water use of 78 Mm^3/a.

Ecological Reserve

A Preliminary Reserve Determination was drafted by DWA, and this document contains the rules describing the desired environmental flow requirements. The proposed EWR requirements consist of a low flow component of 16 Mm^3/a and a high flow component of 66 Mm^3/a, giving an average annual value of 82 Mm^3/a at EWR Site 4 (Letaba Ranch). It should be noted that these figures are average annual values, and so can be lower in a dry year and higher in a wet year.

It is important to note that this Reserve Determination was done prior to this study and did not take the proposed Nwamitwa Dam into consideration. A Reserve Determination study for the proposed Nwamitwa Dam still needs to be undertaken.

Summary

The water requirements discussed in this section of the report are summarised in ***Table E2***.

Table E2 Summary of Water Requirements in the Groot Letaba Catchment

Description	Water Requirements in Mm^3/a		
	2007	**Additional required to 2030**	**Total in 2030**
Primary – domestic (see **Table 2.11**)	22.0	28.8	50.8
Primary – industrial	1.5	0	1.5
Sub-total Primary	23.5	28.8	52.3
Irrigation (surface water) *1	192.3	0	192.3
Afforestation	77.6	0	77.6
Totals (excl. Environmental)	**293.4**	**28.8**	**322.2**
Primary – mining (to be supplied from outside the catchment)	0	21.00	21.00
Environmental *2	14.8 Mm^3/a = 0.469 m^3/s	min = 16 Mm^3/a max = 82 Mm^3/a For EWR Site 4	16 to 82 Mm^3/a at Site 4

*1 Irrigation supplied by groundwater is estimated to be an additional 29 Mm^3/a

*2 Note that the Environmental Requirement (non-consumptive use) cannot be added to the other water requirements.

3. GROUNDWATER

The current use of groundwater in the Groot Letaba catchment is estimated to be 29 Mm^3/a for irrigation, and 10.63 Mm^3/a for supply to villages, giving an estimated total current use of groundwater in the catchment of 39.63 Mm^3/a. The majority of the catchment has moderate groundwater potential, with significant portions of the catchment having high groundwater potential, particularly in the south and west. There are portions of the catchment with low groundwater development potential, particularly in the north and east of the catchment. Using a recharge volume of 90.86 Mm^3/a and the current estimated groundwater use of 39.63 Mm^3/a, approximately 51.23 Mm^3/a (without accounting for groundwater losses) is available for development.

4. UPDATING OF HYDROLOGY

The scope of this Study included an extension of the catchment modelling time period by 12 years to end in hydrological year 2004 instead of 1992, giving a total modelling period of 80 hydrological years (from 1925 to 2004). The scope of work specifically excluded the re-calibration of the Pitman rainfall-runoff model. The procedure followed for extending the naturalised flows is fully described in the study report entitled Hydrology (DWA, 2010 c)*.*

All input data to the model were adopted unchanged where available from the previous studies. The simple extension of modelled data by adding new observations has led to some uncertainties regarding the results of the extension of the hydrology.

Adjustments were made to the Bridging Study results to accommodate differences in afforestation and rainfall parameter selection, to ensure that the Bridging Study's extended natural streamflows and afforestation demands were broadly compatible with the original WRYM streamflows, which were available in digital format.

*The extended naturalised flows resulting from this Bridging Study are summarised in **Table E3**. The naturalised MAR for the entire Letaba catchment for the period 1925 – 2004 is 613.82 Mm^3/a.*

Table E3 Summary of Bridging Study Flows for the Letaba Catchment

Catchment		Bridging Study time period 1925 – 2004		
		Bridging Study (after factoring: 1925-1987 = Pre-feasibility flows + 1988-2004= factored flows) Mm^3/a		
Name	Area (km^2)	Incremental	Cumulative	Percentage of Total
B8R001 Ebenezer Dam	169.2	48.77	48.77	8%
B8R005 Tzaneen	482.3	154.43	203.20	33%
B8H009 + B8H010 Letsitele	686.3	117.86	321.07	52%
B8H017 Prieska Weir	1184.1	60.54	381.60	62%
B8H008 Letaba Ranch	2083.8	50.19	431.79	70%
Groot Letaba ds from B8H008 to confluence with Klein Letaba (ungauged)	248.5	3.52	435.31	71%
Middle Letaba	2988.0	88.37	88.37	14%
Klein Letaba	2465.0	41.74	130.11	21%
Lower Letaba	981.0	48.40	613.82	100%

5. WATER RESOURCE EVALUATION

The simulated present day flows were compared with the gauged flows at selected points to see if the generated streamflows were reasonable. It was noticed that the observed freshets were missing in the simulated streamflows lower down the Groot Letaba River, a feature that was also evident in the original calibration. These freshets would contribute to the yield of Nwamitwa Dam as they would exceed the abstraction capacity of the irrigators, and because they would assist in meeting the environmental flow requirements. The observed records were used to estimate the magnitude of the freshets which would be about 8 Mm^3/a upstream of Nwamitwa, 5 Mm^3/a between Nwamitwa and Prieska and about 21 Mm^3/a between Prieska and Letaba Ranch. These *freshets were added to the WRYM simulated flows in order to more closely match the observed flows.*

The historical firm yield of the Nwamitwa Dam is very dependent on the downstream Reserve requirements that have to be met and on the amount of "system losses" which are applied. For the purposes of this Bridging Study provision was made for 50% "system losses" and for the proposed Nwamitwa Dam assisting to meet the Reserve requirements at EWR 3. Under these circumstances the yield of the proposed Nwamitwa Dam would be 14 Mm^3/a.

The yield from the proposed Nwamitwa Dam is relatively small because the dam is downstream of a large existing dam and a large proportion of the streamflow from the remaining tributaries is already being used by the efficient operation of irrigation systems in areas of jurisdiction of the Groot Letaba Water Users Association (GLWUA).

It was a requirement of the study that the incremental yield of a raised Tzaneen Dam be determined. The benefit of installing fuse gates or constructing a labyrinth weir to raise the full supply level of Tzaneen Dam by 3 metres (from a gross storage of 158 Mm^3 to 193 Mm^3) was an increase in the firm yield of the Tzaneen/Nwamitwa system of about 4 Mm^3/a.

Under present day conditions, the historical firm yield of Massingir Dam is 575 Mm^3/a. If Nwamitwa Dam was constructed (FSL of 479.5, Reserve requirements at EWR 3 met and 50% system losses) and operated at maximum firm yield, then the historical firm yield at Massingir Dam would be reduced to 573 Mm^3/a. If Tzaneen Dam is also raised by 3 m, then the historical firm yield of Massingir Dam reduces to 572 Mm^3/a. Constructing Rooipoort on the Olifants has a larger impact on the 1:50 year yield of Massingir Dam which would decrease from the present day 621 Mm^3/a to approximately 585 Mm^3/a.

It is important that Nwamitwa Dam and Tzaneen Dam are operated conjunctively to maximise the yield. Nwamitwa Dam should be drawn down first, primarily to minimise evaporation. Nwamitwa Dam has a larger surface area for a given storage volume than the Tzaneen Dam and a higher evaporation rate. Under this operating rule the average net evaporation from the Nwamitwa Dam is about 9 Mm^3/a. Were Nwamitwa Dam maintained at its full supply level the net evaporation would exceed 20 Mm^3/a.

The incremental increase in the firm yield of the Ebenezer/Tzaneen system from raising Ebenezer by 5 and 10 meters is 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa was constructed first, then the incremental firm yield from raising Ebenezer reduces from 4.5 to 3.9 Mm^3/a.

6. PRELIMINARY DESIGN OF NWAMITWA DAM

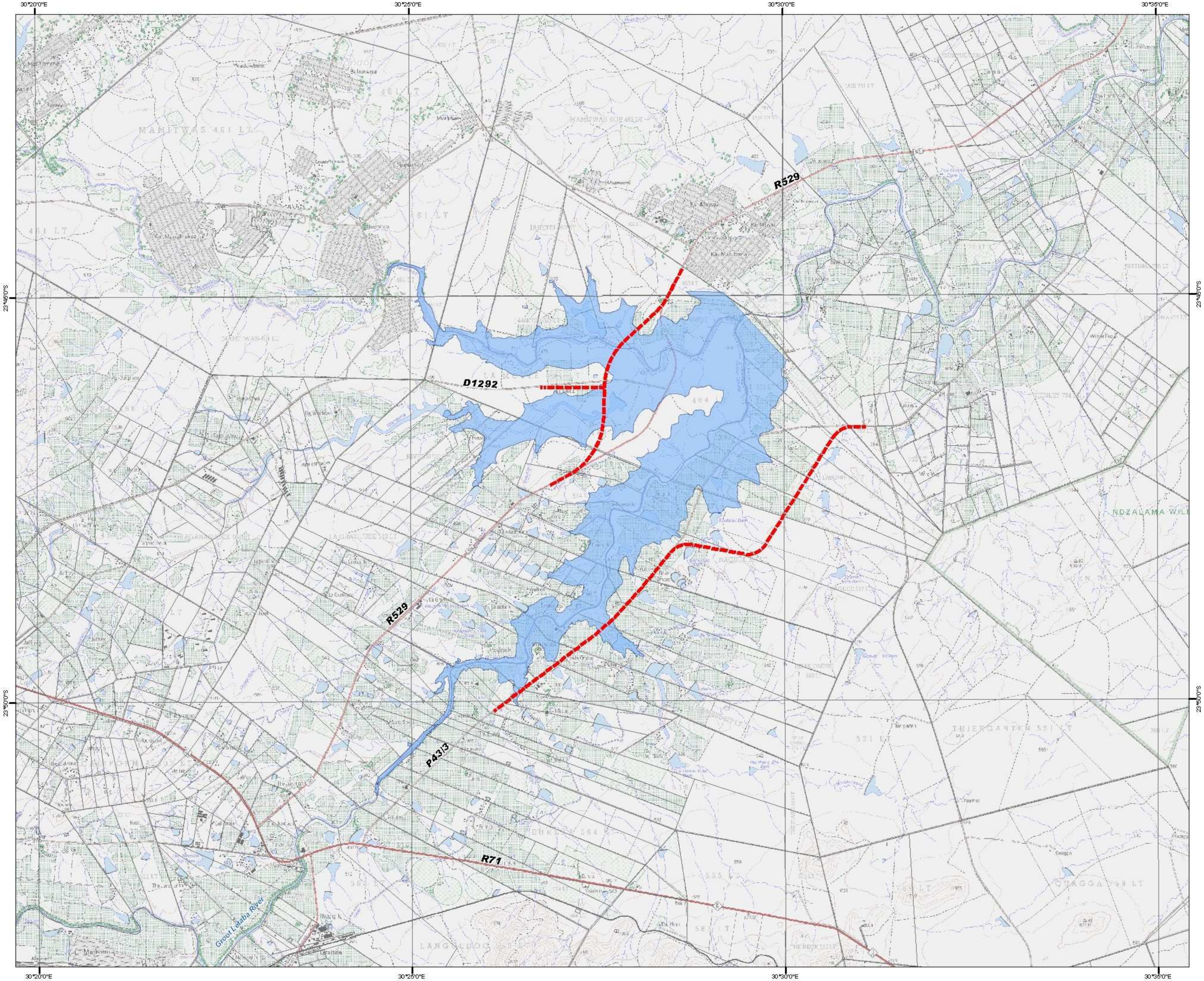
The valley shape factor at the Nwamitwa Dam site is in excess of 50, which is a clear indication that an embankment type dam would be the most appropriate dam type. Further dam type selection was therefore not undertaken and emphasis was placed on the selection of the spillway type.

Four types of spillways were investigated for the proposed Nwamitwa Dam, namely, a straight ogee spillway, a trough spillway, a labyrinth spillway, and a side channel spillway. Due to technical constraints, the side channel spillway option was discarded as an option without detailed evaluation. The straight ogee spillway was adopted in the preliminary design of Nwamitwa Dam as this spillway type proved to be the most cost effective.

A number of existing provincial roads are affected by the proposed dam. Possible routes for the re-alignment of these roads were investigated and preliminary costs determined before route alignments were selected for the preliminary design stage.

The proposed re-alignment of the various roads was discussed with the landowners and the Roads Agency Limpopo (RAL) before a preliminary design of the proposed re-alignments commenced. Further adjustments were made to the re-alignment of route P43-3 after further consultation with some of the affected land owners. Concerns expressed by the land owner which were submitted after completion of the preliminary design should be addressed during the detailed design phase of the project. The re-aligned Road R529 crosses the Hlangana and Nwanedzi Rivers at km 2.15 and km 3.76, respectively where bridges are required even for a low dam.

*The locality plan showing the layout of the proposed dam, proposed re-alignment of Road 529 and of Road P43-3, and proposed bridges is shown in **Figure E3**.*



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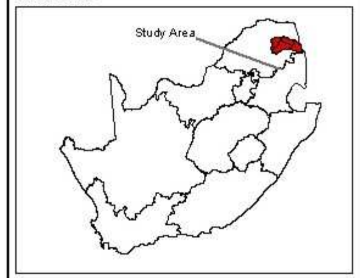

LEGEND

- Final Proposed Road Route
- Proposed Nwamitwa Dam FSL 479.5 masl
- Farm Boundaries

PATH : s:/projects/H401775/mxd/Reports/Main_Report/figE3.mxd

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CONSULTANT :

aurecon

CLIENT :

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLE :

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

LOCALITY PLAN

FIGURE NO. :

E3

Whilst the analysis did not point to an obvious "optimum" dam size, a dam with a FSL of 479.5 m, capacity 187 million m³ and a historical firm yield of 14 Mm³/a was proposed as the preferred dam size. This will ensure that sufficient yield is obtained to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, limit expropriation costs and limit the amount of evaporation from new storage.

Table E4 Optimisation of Dam Sizes

Dam size (factor of MAR*)	Dam capacity (Mm³)	Full Supply Level (masl)	Total Project Cost (R million) exc. VAT	Yield (Mm³/a)	Unit Cost (R/m³/a) Dam construction and land costs
0.41	66	473.50	989	4	247
0.85	137	477.50	1 180	9	131
1.16	187	479.50	1 285	14	91
1.50	241	481.50	1 409	17	82

** Natural incremental MAR between Tzaneen and Nwamitwa Dams = 160.9 Mm³/a*

7. RAISING OF TZANEEN DAM

This Bridging Study focussed on three alternative ways to raise Tzaneen Dam, namely: Hydroplus fuse gates, a Labyrinth Spillway, and a Side Channel Spillway. The comparison was made for a 3 m raising of the FSL to a level of 726.9 masl.

Hydroplus Ltd. provided a cost estimate for the conceptual design, the detail design and construction of the fuse gates. An estimate for the demolition cost of the top section of the existing spillway in order to accommodate the fuse gate was included in the cost estimate.

The detailed cost estimates of all three alternatives investigated is summarised in ***Table E5****. The cost estimates include P&Gs, contingencies, design and supervision costs, but exclude VAT.*

Table E5 **Cost estimates for the alternative methods of raising Tzaneen Dam**

Method of Raising	Cost of Raising
Hydroplus fuse gates	R59 million
Labyrinth spillway	R42 million
Side channel spillway	R72 million

The side channel, whilst technically feasible, was discarded as an option based on cost. Both the labyrinth spillway and Hydroplus fuse gate options are considered to be technically feasible. However, given the fact that the labyrinth spillway option is the most cost effective solution coupled with the fact that this option has no future maintenance costs, it is recommended that this method of raising be adopted.

Should it be discovered during the detailed design phase that the potential impact of the extreme flow events on the integrity of the Sybrand and Marietjie van Niekerk bridges is considered unacceptable, then the Hydroplus fuse gate option would become the preferred option for the raising of Tzaneen Dam.

8. RAISING OF EBENEZER AND DAP NAUDE DAMS

The potential raising of Ebenezer and Dap Naude Dams were investigated as part of the Bridging Study of the Groot Letaba Water Development Project. It was found that it was technically possible to raise Ebenezer Dam, but due to dam safety considerations, not technically feasible to raise Dap Naude Dam without a complete reconstruction.

A 5 m raising would cost R230 million for an incremental yield of 2.3 Mm^3/a. A 10 m raising would cost R276 million. The incremental yield from an 8.7 m raising was estimated to be 4.5 Mm^3/a without Nwamitwa Dam, and 3.9 Mm^3/a if Nwamitwa Dam was constructed.

9. TASK 5 : BULK WATER DISTRIBUTION AND INFRASTRUCTURE

A number of independent supply systems are located in close proximity to the proposed Nwamitwa Dam and could therefore be potentially supplied from the proposed Dam. The supply system together with the current water sources (indicated in brackets) are shown below:

- *the Letaba Ritavi System (the Letaba River and groundwater)*
- *the Thapane System (Thapane Dam and groundwater)*
- *the Modjadji System (Modjadji Dam and groundwater)*
- *the Worcester/Mothobeki System (Modjadji Dam and groundwater), and*
- *the Lower Molototsi System (Modjadji Dam and groundwater)*

For the purposes of this report, the Worcester/Mothobeki and Lower Molototsi systems are described as one System and are referred to in the report as the Worcester/Molototsi System.

Each system has a partial network of existing bulk water supply pipelines, some components of which are not fully utilised. From discussions with the operators of the various systems it became evident that critical shortages of treated potable water exist in the Letaba, Thapane and Worcester/Molototsi systems. These water shortages can be attributed to insufficient water resources, the lack of bulk water infrastructure and incorrect pump type selection.

The water treatment works at Nkambako comprises of a single module with a capacity of 6 Mℓ/d. An identical second module has been constructed, but has not yet been commissioned. After completion of the second module the plant will have a total design capacity of 12 Mℓ/d. The current treated water quality at Nkambako WTW does not meet SANS Class I requirements, but is generally within the Class II requirements.

In order to determine the logical supply area for the proposed Nwamitwa Dam the water requirements in the areas immediately surrounding the proposed dam were analysed and then compared to the anticipated yield from the proposed Nwamitwa Dam. The anticipated 2027 water requirement for the Letaba/Ritavi, Thapane and Worcester/Molototsi (including part of Giyani) systems is 11.2 Mm^3/a (water requirement increases to 13.3 Mm^3/a if the potential shortfall in the Mojadji system is also to be supplied from the proposed Nwamitwa Dam). This compares favourably to the historical firm yield of 14 Mm^3/a for the proposed Nwamitwa Dam which was determined for a dam with a Full Supply Level of 479.5 masl.

Regional bulk water supply reservoirs (called Command Reservoirs) and bulk water supply pipelines were identified as part of the conceptual masterplan. The required Regional Bulk Water Supply Infrastructure as well as the proposed logical supply area is shown in ***Figure E4****.*

It is estimated at the total cost to implement the proposed Regional Bulk Water Supply Infrastructure is approximately R313 million in 2009 terms. Costs include contingencies and professional fees but exclude VAT.

10. IMPLEMENTATION PROGRAMME

For the purposes of estimating a timeline for the implementation programme, it was assumed that the tender design phase of the project would start in July 2010 (i.e. design PSP would be appointed by this date). Should the milestone be later than July 2010, then the whole programme can be shifted out accordingly. It was assumed that quite a tight timeline would be established for the design and tender period and one year was according allocated for this task. The construction of Nwamitwa Dam would take *approximately 3.5 years to complete from mobilisation to first impoundment. Under this scenario the proposed dam would be completed by February 2015.*

The re-alignment of Road 529 and Road P43-3 and the construction of the bridges across the Hlangana and Nwanedzi Rivers could commence by August 2011. It is anticipated that all construction activities associated with the re-alignment of the two roads could be completed by June 2013.

The regional bulk water supply infrastructure should be phased in, in accordance with the budgetary constraints and service delivery needs of Mopani District Municipality.

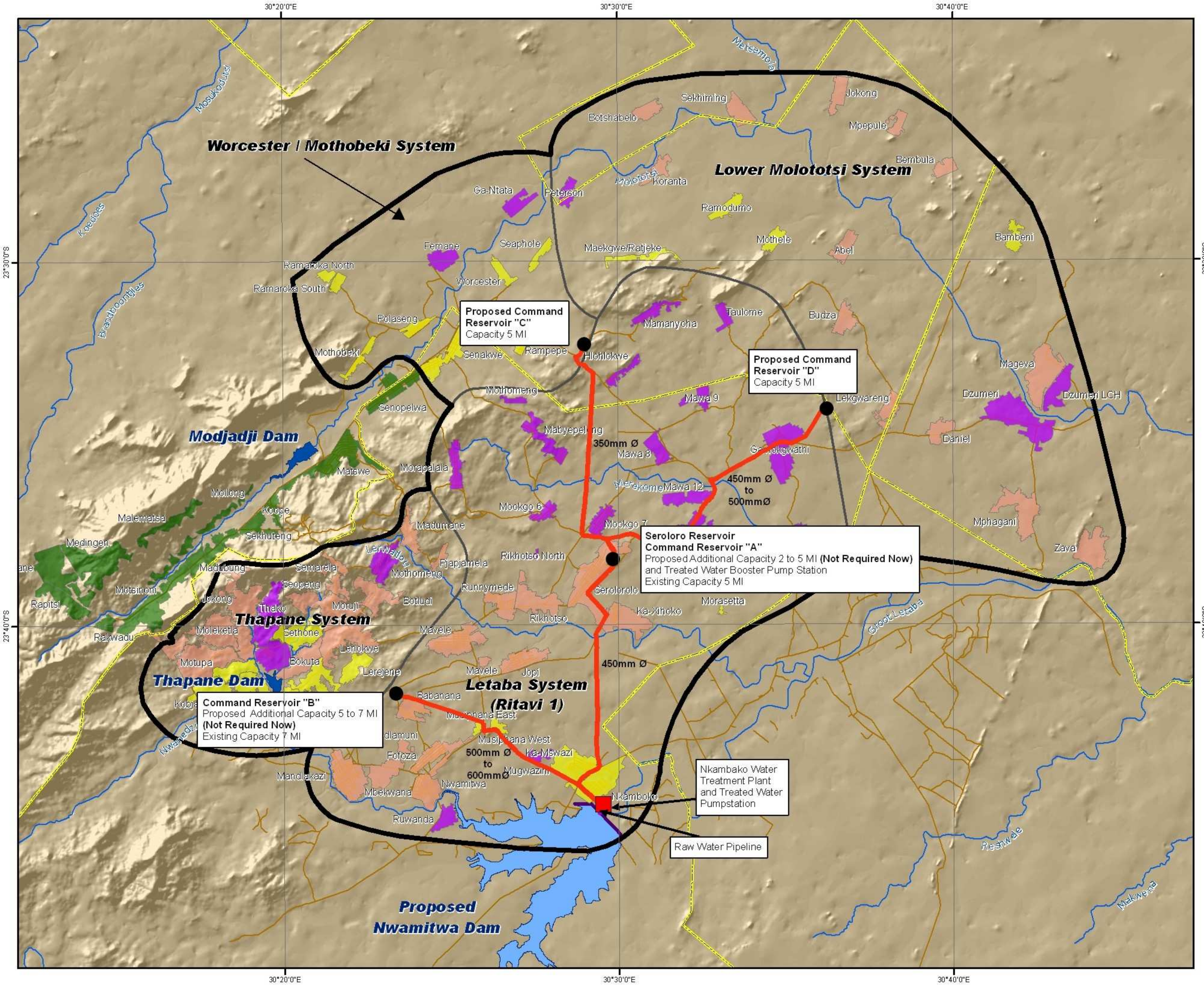
11. CONCLUSIONS

All the findings and conclusions emanating from the GLeWaP Technical Study Module are contained in this Main Report. The significant conclusions emanating from this Study are the following :

11.1 The water supplies available from the present major surface water schemes are over-allocated. The result of this pressure on the available surface water sources is that the supply of water for irrigation is curtailed to below the allocations on an ongoing basis. The recent determination of the Environmental Water Reserve (EWR) has introduced an additional requirement, which has increased the pressure on the available surface water.

11.2 The scope of this Study included an extension of the catchment modelling time period by 12 years to end in hydrological year 2004 instead of 1992, giving a total modelling period of 80 hydrological years (from 1995 to 2004). The scope of work specifically excluded the re-calibration of the Pitman rainfall-runoff model. The decision not to re-calibrate the hydrology has led to uncertainties regarding the availability of water for all user sectors and regarding the merits of development proposals.

11.3 One of the major conclusions from the water resource analysis is that the simulated hydrology does not adequately reflect the low flows in the system. If the extended hydrology is used unmodified, the proposed Nwamitwa Dam would have zero yield, mainly because of the obligation to meet the EWR. Once the additional freshets (a series of low flow events known to occur in observed flow records, with a MAR of 34 Mm^3/a) are added to the simulated streamflow using the existing model parameters, the yield of the proposed Nwamitwa Dam increased to 14 Mm^3/a.



LEGEND

- Water Treatment Works
- Proposed Reservoirs
- Rivers
- Secondary Roads
- Proposed Dam Wall
- Raw Water Pipe
- Recommended Pipeline Route
- Dams
- Proposed Supply Areas of Nwamitwa Dam
- Municipality Boundaries

Villages

- Access to water
- Critical
- Villages outside study area
- Poor

PATH: s:/projects/H401775/mxd/Reports/Main_Report/figE4.mxd

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CENTRAL MERIDIAN :	31

CONSULTANT:

aurecon

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLE:

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

Recommended Pipeline Routes

FIGURE NO.

E4

11.4 Given the modelling assumptions that had to be made regarding the freshets, the uncertainty regarding releases from storage for implementation of the EWR and the coarse assumptions regarding "river losses", the estimated yield from the proposed Nwamitwa Dam should be viewed as preliminary until confirmed by analysis of a recalibrated hydrology.

11.5 The proposed construction of the Nwamitwa Dam and raising of Tzaneen Dam will have very limited impact on the yield of Massingir Dam (reduction of 3 Mm^3/a on 575 Mm^3/a). The development of the proposed Rooipoort Dam will reduce the historical firm yield of Massingir Dam to 500 Mm^3/a.

11.6 It is important that the proposed Nwamitwa Dam and Tzaneen Dam are operated conjunctively to maximise the yield. Nwamitwa Dam should be drawn down first, primarily to minimise the evaporation.

11.7 A straight ogee spillway on an embankment dam with a FSL of 479.5 m and a historical firm yield of 14 Mm^3/a is recommended as the preferred dam size. This will ensure that sufficient yield is obtained to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, limit expropriation costs and limit the amount of evaporation loss from the proposed dam.

11.8 A labyrinth spillway, side channel spillway and Hydroplus fuse gates are all considered to be technically feasible options for the raising of Tzaneen Dam. A labyrinth spillway option is the most cost effective solution and also has low future maintenance costs.

11.9 The raising of the full supply level of Tzaneen Dam by 3 m to a level of 729.9 masl will increase the firm yield of the Tzaneen/Nwamitwa system by about 4 Mm^3/a.

11.10 The raising of Ebenezer Dam is technically feasible. The incremental increase in firm yield of the Ebenezer/Tzaneen System for a raising of Ebenezer Dam by 5 and 10 metres will be 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa Dam were constructed first, then the incremental firm yield reduces from 4.5 Mm^3/a to 3.9 Mm^3/a for the 10 meter raising option.

11.11 During a recent dam safety inspection it was found that the Dap Naude Dam is unstable and significant upgrading works had subsequently been undertaken. A raising of the dam would therefore effectively involve a complete reconstruction of the existing dam and is not favoured.

11.12 It is evident that critical shortages of treated potable water exist in the Letaba, Thapane and Worcester Molototsi systems. These water shortages can be attributed to *insufficient water resources, the lack of bulk water infrastructure and inappropriate pumping equipment. In order to alleviate these shortages, it is imperative that the upgrading and expansion of the regional bulk water supply infrastructure as recommended in this report be implemented.*

11.13 There is uncertainty regarding the current and future water requirements in the area of supply of the proposed Nwamitwa Dam. It is therefore imperative that Mopani District Municipality take responsibility for the operation, maintenance, metering and monitoring of all the proposed bulk water supply schemes. The expansion of the Nkambako WTW could be undertaken modularly as the water requirements and availability increases in the future.

11.14 Groundwater could potentially supply a significant portion of the future water requirements in the logical supply area of the proposed Nwamitwa Dam, either through blending with potable supplies or by onsite treatment prior to conveying the treated water to the regional bulk water supply reservoirs. More detailed investigations have to be undertaken in order to determine and develop the full potential of groundwater in the area.

12. RECOMMENDATIONS

A comprehensive list of all the recommendations from the individual reports is contained in the Main Report. The significant recommendations emanating from this Study are summarised below:

12.1 Given the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important that verification and validation of water use in the Groot Letaba Catchment is undertaken urgently and in a thorough manner.

12.2 It is important that municipalities measure and monitor water use in their areas of jurisdiction so that, in future, accurate data are available for analysis and planning.

12.3 The implementation of water demand/water conservation measures in the catchment is strongly recommended in order to achieve early and meaningful impact on demand-side water supply management.

12.4 A comprehensive groundwater investigation should be undertaken so suitable quality groundwater can be located and developed with greater certainty. These investigations should be focussed on mobilising specific groundwater resources for integration in the water supply system on a regional basis in the supply area currently envisaged for the proposed Nwamitwa Dam.

12.5 The potential yields, costs and environmental implications associated with a potential groundwater "regional government water scheme" should be determined and compared with the yields, costs and environmental implications of the proposed Nwamitwa Dam development.

12.6 A complete re-calibration of the rainfall – runoff model should be undertaken with a focus on achieving a good match in the low to medium flow events (freshets), to enable reliable modelling of the EWR requirements in the WRYM.

12.7 The historical firm yield of the proposed Nwamitwa Dam should be re-determined once the results of the abovementioned further investigations are available and once the rainfall runoff model has been re-calibrated.

12.8 An embankment type earthfill dam should be constructed at Nwamitwa, with a central ogee spillway with a full supply level of 479.5 masl. This will ensure that sufficient yield is obtained to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, minimise expropriation costs and limit the amount of evaporation from the proposed dam.

12.9 A labyrinth spillway option is recommended for the raising of Tzaneen Dam. This is the most cost effective solution and has the lowest future maintenance costs. The fuse gate option could still be considered during the detailed design phase of the project to mitigate possible unacceptable negative impacts of high flood events on the Sybrand and Marietjie van Niekerk bridges.

12.10 The Regional Bulk Water Supply Infrastructure as proposed in the report should be implemented and taken further into the detailed design phase.

12.11 Mopani District Municipality should implement a comprehensive water metering and monitoring system in order to ascertain what the actual water requirements are and how the water requirements change with implementation of the recommended regional bulk water supply and connector bulk infrastructure.

12.12 The capacity of the Babanana Reservoir (Command Reservoir B) and the Serelorolo Reservoir (Command Reservoir A) should be increased when the future water requirements reach the stage that there is insufficient emergency and balancing storage in the respective supply areas.

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FIGURES

Aurecon Electronic Reference: I:\HYDRO\401775 Groot Letaba\Reports\Vol 1 Technical Study Main Report\Technical Study Module - Main Report - Vol 1 (Final).doc

ABBREVIATIONS

AADD	Average annual daily demand
DCM	Design criteria memorandum
DWAF	Department of Water Affairs and Forestry
DWA	Department of Water Affairs
EMC	Ecological management class
EWR	Ecological water requirement
FSL	Full Supply Level
GLeWaP	Groot Letaba River Water Development Project
GLWUA	Groot Letaba Water Users Association
GRIP	Ground Water Information Project
HFY	Historical firm yield
IWR	Integrated water resources
m^3/a	cubic metres per annum
Mm^3/a	million cubic metres per annum
MAP	Mean Annual Precipitation
MAE	Mean Annual Evaporation
MAR	Mean Annual Runoff
MASE	Mean annual S-pan evaporation
mbgl	metres below ground level
NOC	Non-overspill crest
OA	Options Analysis
ORWRDP	Olifants River Water Resources Development Project
PCMT	Project Co-ordination and Management Team
PGRWSS	Polokwane Government Regional Water Supply Scheme
PSP	Professional Service Provider
RCC	Roller Compacted Concrete
RDF	Recommended Design Flood
RESDSS	Reserve Decision Support System
RI	Return interval
RMR	Rock Mass Rating
ROL	Roads Agency Limpopo
RWSS	Rural Water Supply Scheme
SEF	Safety Evaluation Flood
WR90	Water Resources of South Africa, 1990
WRYM	Water Resources Yield Model
WTW	Water Treatment Works

1. STUDY INTRODUCTION

1.1 BACKGROUND TO PROJECT

The catchment of the Groot Letaba River has many and varied land uses with their associated water requirements. These include significant use by agriculture in the form of long established irrigation of high value crops, commercial afforestation, tourism (particularly linked to the Kruger National Park, which lies partially within the catchment), as well as primary demands by the growing population in the catchment, all with aspirations for a higher quality of life. The water resources available in the catchment are limited, and considerable pressure has been put on these resources in the past through intense usage, with periods of severe and protracted water restrictions occurring over the past 25 years. This situation has been investigated at various levels by the Department of Water Affairs (DWA) over many years.

The first major study undertaken for this area was the Letaba River Basin Study in 1985 (DWAF, 1990), which comprised the collection and analysis of all available data on water availability and use, as well as future water requirements and potential future water resource developments. This was followed by a Pre-feasibility Study (DWAF 1994), which was completed in 1994. The focus of the Pre-feasibility Study was the complete updating of the hydrology of the Basin. The next study undertaken was the Feasibility Study of the Development and Management Options (DWAF, 1998), which was completed in 1998.

The Feasibility Study proposed several options for augmenting water supply from the Groot Letaba River. These included some management interventions, as well as the construction of a dam at Nwamitwa and the possible raising of Tzaneen Dam. These options would enable additional water to be allocated to the primary water users, would allow the ecological Reserve to be implemented and could also improve the assurance of supply to the agricultural sector.

This Bridging Study was initiated by the (then) Department of Water Affairs and Forestry (now DWA) in 2006 in order to re-assess the recommendations contained in the Feasibility Study in the light of developments that have taken place in the intervening 10 years. Other contributing factors to the DWA's decision to undertake Bridging Studies were the promulgation of the Water Services Act and the National Water Act in 1997 and 1998 respectively, and the recently completed Reserve Study on the Letaba River.

The project area is shown in **Figure 1.1**. It consists of the catchment of the Groot Letaba River, upstream of its confluence with the Klein Letaba River. The catchment falls within the Mopani District Municipality, which is made up of six Local Municipalities. The four Local Municipalities that lie fully or in part within the catchment area are Greater Tzaneen, Greater Letaba, Ba Phalaborwa and Greater Giyani. The major town in the study area is Tzaneen, with the Limpopo capital city of Polokwane located just outside of the catchment to the West.

The site of the proposed Nwamitwa Dam is also shown on **Figure 1.1**. The focus of the Feasibility Study was the Groot Letaba catchment, with the catchments of the other rivers being included to check that environmental flow requirements into the Kruger National Park were met, and international agreements regarding flow entering Moçambique were met. This focus was kept for the Bridging Study.

1.2 SCOPE AND ORGANISATION OF PROJECT

The Department's Directorate: Options Analysis (OA), appointed Aurecon in Association with a number of sub consultants (listed below) to undertake this study. The official title of the study is: "The Groot Letaba Water Development Project: Bridging Studies: Technical Study Module".

An association exists between the following consultants for the purposes of this study:

- Aurecon (previously Ninham Shand)
- Semenya Furumele Consulting
- KLM Consulting Services
- Urban-Econ Developmental Economists
- Schoeman & Vennote

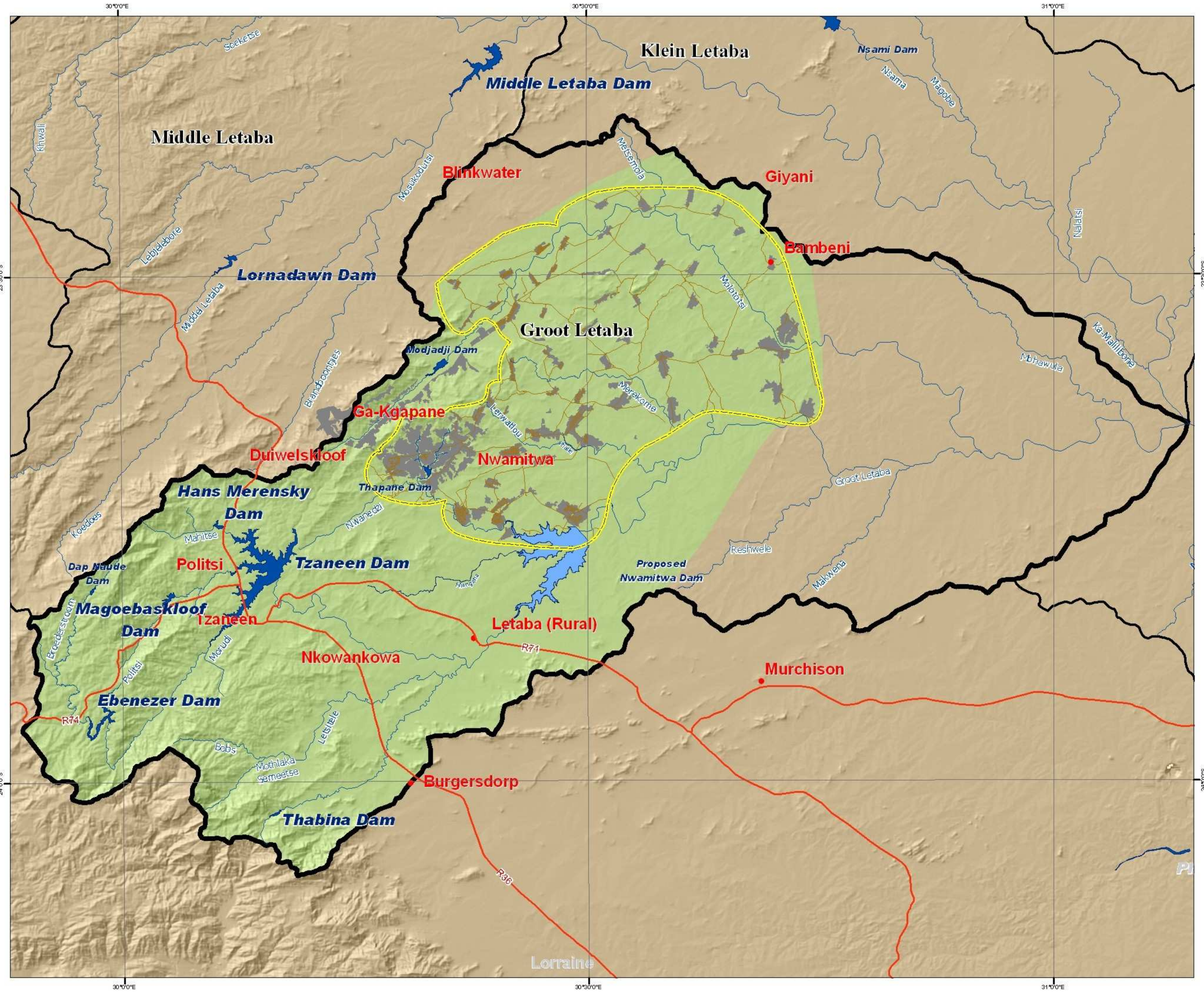
The Bridging Study comprises a number of modules, namely: an Environmental Management Module (EMM), a Public Involvement Programme (PIP) and a Technical Study Module (TSM). This Report focuses on part of the scope of work for the TSM.

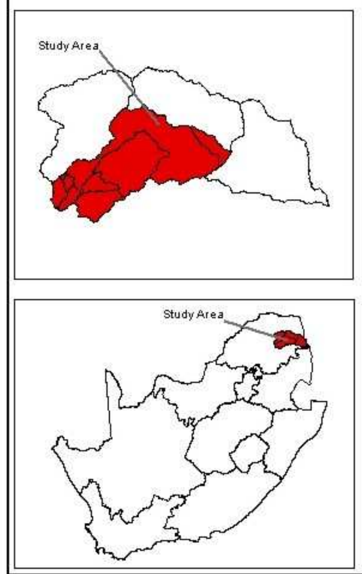
The tasks comprising the TSM are summarised below:

TASK 1: WATER REQUIREMENTS

The objective of this Task is to:

- review the current estimates of future water requirements in all user sectors,
- establish present levels of water use in these sectors,
- assess the availability of ground water in the project area.





LEGEND

- Towns
- National Roads
- Secondary Roads
- Rivers
- Dams
- Villages
- Study Area
- Proposed Supply Area from Nwamitwa Dam

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CONSULTANT :

aurecon

C :

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLES :

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

PROJECT AREA

FIGURE NO. :

1.1

TASK 2: WATER RESOURCE EVALUATION

The objective of this Task is to:

- Assess the present availability of surface water from the Groot Letaba River System.
- Assess the increase in yield of the proposed new developments, taking account of the flow regime required to maintain the ecological Reserve.

TASK 3: PRELIMINARY DESIGN OF NWAMITWA DAM

The objective of this Task is to:

- Determine the most suited dam type and position for the proposed Nwamitwa Dam
- Optimise the proposed development proposal
- Provide an updated estimate of the costs of implementing Nwamitwa Dam

TASK 4: RAISING OF TZANEEN DAM

The objective of this Task is to:

- Determine the benefits from raising Tzaneen Dam, in terms of water availability and security of supply;
- Determine the optimum method of raising Tzaneen Dam;
- Optimise the proposed development proposal; and
- Provide an updated estimate of the costs of raising Tzaneen Dam

TASK 5: BULK WATER DISTRIBUTION INFRASTRUCTURE

The objective of this Task is to:

- Assess infrastructure currently available to make bulk water supplies available to the rural areas
- Undertake conceptual planning for the areas to be supplied from Nwamitwa Dam
- Undertake a preliminary design and cost estimate for the proposed new bulk water distribution infrastructure

TASK 6: IMPLEMENTATION PROGRAMME

The objective of this Task is to determine a realistic programme for the implementation of the proposed developments.

TASK 7: WATER QUALITY

The objective of this Task is to undertake an in-lake water quality analysis of the proposed Nwamitwa Dam, to inform the design of the outlet structure of the dam.

1.3 SCOPE OF THIS REPORT

This report summarises the results of the entire TSM, which includes Tasks 1 to 7. These tasks are fully described in eight separate reports that comprise deliverables from this study.

The tasks, the name of the report in which the tasks are described in detail, and section of the Main Report where the tasks are summarised, are given in **Table 1.1**.

Table 1.1 List of Tasks and Reports

Task	Report Name and Reference	Section in Main Report
TASK 1 : Water Requirements	Review of Water Requirements (DWA, 2010 a)	Section 2
	Groundwater (DWA, 2010 b)	Section 3
TASK 2 : Water Resource Evaluation	Hydrology (DWA, 2010 c)	Section 4
	Water Resource Analysis (DWA, 2010 d)	Section 5
TASK 3 : Preliminary Design of Nwamitwa Dam	Preliminary Design of Nwamitwa Dam (DWA, 2010 e, f, g, h and i)	Section 6
TASK 7 : Water Quality		
TASK 4 : Raising of Tzaneen Dam	Raising of Tzaneen Dam (DWA, 2010 j)	Section 7
Raising of Ebenezer and Dap Naude Dams	Main Report	Section 8
TASK 5 : Bulk Water Distribution Infrastructure	Bulk Water Distribution Infrastructure (DWA, 2010 k and l)	Section 9
TASK 6 : Implementation Programme	Main Report	Section 10

2. REVIEW OF WATER REQUIREMENTS

This section summarises the findings of the Study Report entitled *Review of Water Requirements (DWA, 2010 a)*. Water requirements throughout the catchment are largely met through surface water supply schemes with very little being supplied from groundwater sources.

2.1 EXISTING WATER SUPPLY SCHEMES

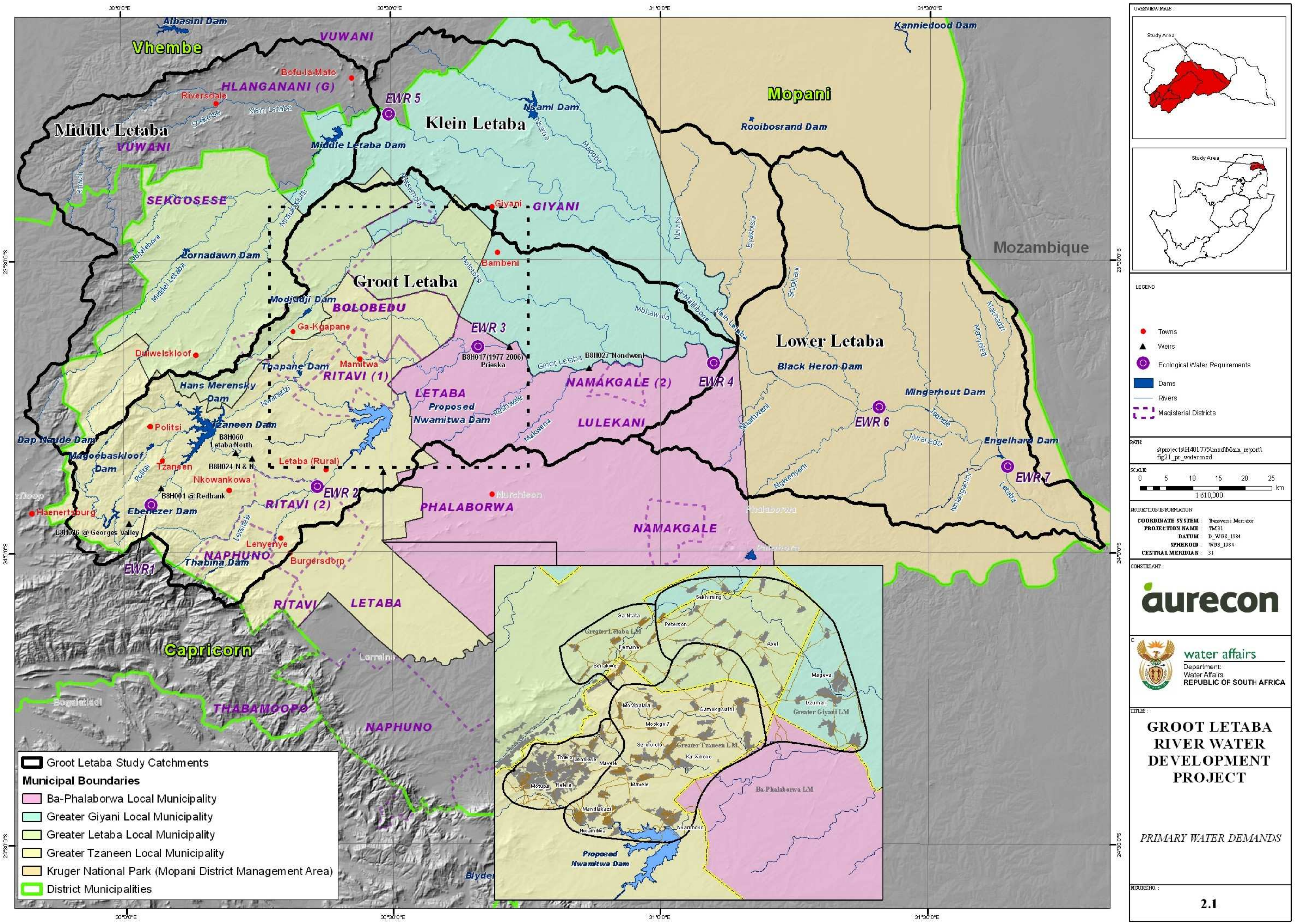
Surface water is supplied from the Groot Letaba River and its tributaries to the towns of Polokwane, Tzaneen, Haenertsburg, Duiwelskloof as well as too many rural villages. The main surface water supply schemes draw from the Dap Naude, Ebenezer and Tzaneen Dams, and these schemes are listed below. The locations of the towns and rural settlements supplied, as well the dams mentioned below are shown in **Figure 2.1**.

- Dap Naude Water Supply Scheme
- Ebenezer Dam Water Scheme
- Magoebaskloof Dam and Vergelegen Dam Scheme
- Hans Merensky Dam Scheme
- Tzaneen Dam Scheme
- Thapane Dam Scheme
- Thabina Dam Scheme
- Letsitele Run-of-River Scheme
- Modjadji Dam

The following water resource scheme is in the Middle Letaba catchment and is also shown in **Figure 2.1**.

- Middle Letaba Rural Water Supply Scheme (RWSS)

Many of the surface water schemes in the Groot Letaba catchment have existing allocations that exceed their yields. The overall yield of the schemes in the Groot Letaba catchment is 126 Mm^3/a, and the total allocation from these schemes for domestic, industrial and irrigation usage is 177 Mm^3/a.



Groot Letaba Study Catchments
Municipal Boundaries
Ba-Phalaborwa Local Municipality
Greater Giyani Local Municipality
Greater Letaba Local Municipality
Greater Tzaneen Local Municipality
Kruger National Park (Mopani District Management Area)
District Municipalities
Middle Letaba
Klein Letaba
Groot Letaba
Lower Letaba
Vhembe
Mopani
Capricorn
Mozambique
VUWANI
HLANGANANI (G)
SEKGOSESE
GIYANI
BOLOBEDU
RITAVI (1)
RITAVI (2)
LETABA
NAMAKGALE (2)
LULEKANI
PHALABORWA
NAMAKGALE
NAPHUNO
THABAMOOPO
RITAVI
Albasini Dam
Kanniedood Dam
Middle Letaba Dam
Nsami Dam
Rooibosrand Dam
Lornadawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Dap Naude Dam
Magoebaskloof Dam
Ebenezer Dam
Thabina Dam
Proposed Nwamitwa Dam
Black Heron Dam
Mingerhout Dam
Engelhard Dam
EWR 1
EWR 2
EWR 3
EWR 4
EWR 5
EWR 6
EWR 7
Bofu-la-Mato
Riversdale
Giyani
Bambeni
Ga-Kgapane
Duiwelskloof
Mamitwa
Politsi
Tzaneen
Letaba (Rural)
Nkowankowa
Haenertsburg
Lenyenye
Burgersdorp
Murchison
B8H017(1977 2006) Prieska
B8H027 Nondweni
B8H060 Letaba North
B8H024 N & N
B8H001 @ Redbank
B8H076 @ Georges Valley
Greater Letaba LM
Greater Tzaneen LM
Greater Giyani LM
Ba-Phalaborwa LM
OVERVIEW MAPS :
Study Area
LEGEND
Towns
Weirs
Ecological Water Requirements
Dams
Rivers
Magisterial Districts
PATH :
s\projects\H401775\mxd\Main_report\fig21_pr_water.mxd
SCALE :
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1:610,000
PROJECTION INFORMATION :
COORDINATE SYSTEM : Transverse Mercator
PROJECTION NAME : TM31
DATUM : D_WGS_1984
SPHEROID : WGS_1984
CENTRAL MERIDIAN : 31
CONSULTANT :
aurecon
water affairs
Department: Water Affairs REPUBLIC OF SOUTH AFRICA
TITLES :
GROOT LETABA RIVER WATER DEVELOPMENT PROJECT
PRIMARY WATER DEMANDS
FIGURE NO. :
2.1

2.2 PRIMARY WATER REQUIREMENTS

The report on the investigation into primary water requirements is contained as an appendix in the report on the Water Requirements Task (Study Report entitled *Review of Water Requirements)* (DWA, 2010 a). The main findings of the report are summarised in this section. The report focussed on primary water requirements for the Groot Letaba catchment only. Some information for the Middle, Klein and lower Letaba catchments has been added where appropriate, but the emphasis is on the Groot Letaba catchment.

For the purposes of this report, primary water requirements are defined as:

- domestic water requirements (both urban and rural)
- industrial water requirements
- mining water requirements

2.2.1 Current Primary Water Requirements

The existing primary water requirements in the Groot Letaba Catchment are summarised in **Table 2.1**.

The water usage for the towns and settlements in the study area is given for the year 2006/7 (Column 4), and the allocation to each settlement as at 2006/7 is also shown in the table (Column 3). The allocation of 11.4 Mm^3/a for the Groot Letaba catchment was exceeded in 2006/7 when the usage was 18 Mm^3/a.

A base volume was required in order to estimate future water requirements. This was selected from the allocation and usage information in Columns 3 and 4 of **Table 2.1** and is given in Column 5. In most cases the 2006/7 usage was chosen as the base volume. The exceptions were Tzaneen Town and the settlements of Politsi, Duiwelskloof and Ga-Kgapane where the allocation was chosen as the base volume.

a) Groot Letaba Catchment

The current base domestic water requirement in the Groot Letaba catchment is estimated to be 18.3 Mm^3/a. This increases to 22 Mm^3/a when adding the domestic use for Giyani. Giyani is included because it obtains water from the Groot Letaba catchment. An additional requirement of 1.5 Mm^3/a for industrial use in the catchment gives a total present day primary water requirement of 23.5 Mm^3/a in the Groot Letaba catchment.

Table 2.1 Summary of Current and Projected Primary Water Requirements

Description	Place Name	Water Requirement in Mm^3/a				
		Allocation 2006/7	**Usage 2006/7**	**Base Value used for Future Projections** [*1]	**Estimated Growth to 2030**	**Total Future Water Requirement (2030)**
(Domestic use in Groot Letaba catchment upstream of confluence with Klein Letaba River	Haenertsburg	0.0	0.0	0.0	0.00	0.00
	Tzaneen Town	2.4*[1]+ 1.2*[2] = 3.6	2.2 + 1.0 = 3.2	3.6	12.89	16.49
	Politsi	2.0	2.1	2.0	1.38	3.38
	Duiwelskloof					
	Ga-Kgapane					
	Letsitele	0.4	0.3	0.3	0.70	1.00
	Ritavi 2	3.5	8.2	8.2	-3.41	4.79
	Naphuno	1.7	1.3	1.3	1.60	2.90
	Namakgale	0.0	0.8	0.8	0.00	0.80
	Ritavi 1	0.0	1.9	1.9	3.30	5.20
	Bolobedu	0.2	0.2	0.2	11.31	11.51
	Sub-total	**11.4**	**18.0**	**18.3**	**27.8**	**46.07**
Domestic use in Middle and Klein Letaba Catchments	Giyani	3.7	3.7	3.7	1.00	4.70
	Cumulative Sub-total	**15.1**	**21.7**	**22.0**[*2]	**28.8**	**50.8***[4]
	Middle Letaba Dam WTW	2.3	2.3	2.3	No estimate made[*3]	--
	Sub-Total	**6.0**	**6.0**	**6.0**	**--**	**--**
Cumulative Sub-total		**17.4**	**24.0**	**24.3**	**--**	**--**
Domestic use outside of Letaba Catchment	Polokwane	18.5	4.6 + 18.8 = 23.4	23.4	No estimate made[*3]	--
Sub-total for domestic use		35.9	47.4	47.7	--	--
	Industrial use	3.3	1.5	1.5[*2]	--	--
Overall total of primary water requirements		**39.2**	**48.9**	**49.2**	**--**	**--**

*1 Note that where the base value differs from the allocation in the previous column, this was based on actual water usage in 2006/7.
*2 Current day primary water requirement for Groot Letaba Catchment = 23.5 Mm^3/a (22.0 Mm^3/a domestic + 1.5 Mm^3/a industrial).
*3 Growth to be met from outside Letaba catchment.
*4 Future primary water requirement for Groot Letaba Catchment = 52.3 Mm^3/a (50.8 Mm^3/a domestic + 1.5 Mm^3/a industrial)

b) Greater Tzaneen Local Municipality

The location of the Greater Tzaneen Local Municipality which includes the town of Tzaneen is shown on **Figure 2.1**. The most recent estimate of the population in the Greater Tzaneen Local Municipality was 459 485 in 2007. This appeared in Section D2 of the latest Water Services Development Plans 2008 for Mopani District Municipality. Of this, an estimated 34 900 people live in the town of Tzaneen.

The town of Tzaneen has a total water allocation of 3.6 Mm^3/a. Part of this allocation (2.4 Mm^3/a) is from Ebenezer Dam, and the rest (1.2 Mm^3/a) from Tzaneen Dam. The total usage in 2006/2007 was 3.2 Mm^3/a, which is less than the total allocation.

The settlement of Ritavi 2 used 8.2 Mm^3/a in 2006/2007, which was more than double its allocation of 3.5 Mm^3/a. The overall usage in the Greater Tzaneen Local Municipality was 18.0 Mm^3/a, which exceeds its total allocation of 11.4 Mm^3/a. Part of Ritavi 1 and Bolobedu in this municipal area fall within the supply area of the proposed Nwamitwa Dam.

c) Ritavi 1 (area to be supplied by the proposed Nwamitwa Dam)

The bulk water supply system serving the current Ritavi 1 area draws its water from a weir in the Groot Letaba River. Raw water is pumped through a 300 mm diameter pipe to a raw water storage dam at Nkambako water treatment works (WTW). The Nkambako WTW currently has a design capacity of 6 Mℓ/d (2.2 Mm^3/a). The construction of an extension to the WTW of an additional 6 Mℓ/d has been completed, but has not yet been commissioned.

The bulk water supply system was constructed prior to 1994, whereafter a significant number of upgrading and extension works were undertaken. The most recent of the extensions was the construction of a 5 Mℓ command reservoir at Serolorolo and a 315 mm diameter rising main from Nkambako WTW to Serolorolo command reservoir. The 5 Mℓ reservoir has, however, never been commissioned due to a lack of supporting infrastructure.

No records of the flow leaving Nkambako WTW are available, but it is estimated that current water usage is approximately 1.9 Mm^3/a.

2.2.2 Projected Primary Water Requirements for the Groot Letaba Catchment

Future domestic water demands in the Groot Letaba catchment were projected by using three different methods. A base water requirement of 22 Mm^3/a in 2006/2007 was used as a starting point for all the projections (Column 5 of **Table 2.1**). All the methods involved determining population growth rates and using these growth rates together with unit water use rates in order to project future water requirements up to 2030. It was assumed that the growth in Polokwane's water requirement would not be met from the Groot Letaba River catchment, and that there would be no growth in the industrial demand. The full details of the methodology used are given in the Report entitled *Review of Water Requirements (DWA, 2010 a)*, and a brief summary is given here.

Method 1

The first method made use of a range of three population growth rates (low, medium and high) for the entire catchment as a whole. These varied as follows:

- Low population growth rate: 4.38% from 2007 to 2010 to 6.57% from 2025 to 2030
- Medium population growth rate: 6.44% from 2007 to 2010 to 11.82% from 2025 to 2030
- High population growth rate: 9.85% from 2007 to 2010 to 18.77% from 2025 to 2030

The results of this method gave a range of projected water requirements for the Groot Letaba in 2030 from 29.97 Mm^3/a for the low growth rate, to 36.18 Mm^3/a for the medium growth rate, to 46.98 Mm^3/a for the high growth rate.

Method 2

The second method made use of separate population growth rates for each main settlement area, and projected the growth in water requirements independently. The growth rates varied from a negative growth rate of -5.32 Mm^3/a p.a. for Ga-Kgapane, to a zero growth rate for Politsi to a positive growth rate of 6.84% p.a. for the town of Tzaneen. This method resulted in an estimated future water requirement of 34.31 Mm^3/a and was chosen to be the most representative.

Method 3

The third method was a combination of the first two methods, using the "medium" growth rate from Method 1 to apply to each settlement area. As expected, this method came to the same result as that for the medium growth scenario for Method 1.

More Recent Estimates

During the course of the study, further estimates of future water requirements were made for the area around Nwamitwa Dam, based on detailed work in the area (DWA, 2008). These estimates were considerably higher, mainly because they were based on higher levels of service. These additional future water requirements were added to the original estimates obtained using Method 2 to give the final estimated future water requirements.

Summary

The three methods give a future water requirement between 29.97 Mm^3/a and 46.98 Mm^3/a for the Groot Letaba catchment in 2030, with a medium growth scenario of between 34.31 Mm^3/a and 36.18 Mm^3/a. If the more recent water requirement estimates of the area around the proposed Nwamitwa Dam are used, a total future water requirement of 50.77 Mm^3/a is obtained, which is closer to the high scenario of 46.98 Mm^3/a. It must be noted that the figure of 50.77 Mm^3/a is based on a high service level for the areas of Ritavi 1 (Letaba) and Thapane, Modjadji and parts of the Worchester-Mothobeki and the Lower Molototsi areas (Bolobedu), as well as Naphuno.

The results of the water demand projections using all three methods indicate an ever increasing population, which translates directly into an increased demand for water. Bearing in mind that the current water supply schemes are largely over-allocated, this indicates that the need to supply more water will continue to intensify in future.

a) Greater Tzaneen Local Municipality

The population in the Greater Tzaneen Local Municipality was estimated to be 459 485 in 2007 and is estimated to grow to 549 763 by 2030 at growth rates ranging from 1.017% p.a. in 2004 to 1.009% p.a. in 2026.

The annual growth in water consumption in the town of Tzaneen from 1997 to 2003 averaged at approximately 7.8% per annum. The water demand peaked at 3.5 Mm^3/a in 2003 (Tzaneen town's allocation is 3.6 Mm^3/a). The average growth rate for the period 2004 to 2007 averaged at 3.65% per annum, dropping below 3.0 Mm^3/a in 2004, and rising to approximately 3.25 Mm^3/a in 2007. The lower growth rate is the result of recent water restrictions in the area, so it is difficult to ascertain the actual unrestricted water demands as well as the future projected growth in water demand for the town and the local municipality. The growth in water requirement for Tzaneen Municipality suggested by Urban Econ is 6.84% per annum (see Appendix B in Review of Water Requirements DWA, 2010 a)).

b) Ritavi 1 (area to be supplied by the proposed Nwamitwa Dam)

EVN Africa Consulting Services were appointed by DWA Limpopo to undertake a water services planning study to determine the future water requirements, potential supply zone and connector bulk infrastructure required for the area to be supplied from the proposed Nwamitwa Dam. The GLeWaP Report Bulk Water Distribution Infrastructure (DWA, 2010 k) details the outcome of this investigation. The GLeWaP 2027 High Service Level Scenario water demand figures, received from EVN Africa Consulting Engineers, were used to determine the 2027 infrastructure requirements and have also been included in this section of the report to give an indication of the possible future primary water requirement from Nwamitwa Dam. The High Service Level Scenario was chosen as the basis upon which to design the future infrastructure requirements as this represents the Water Service Authorities ultimate goal of providing water to each household as opposed to the current level of service using communal standpipes.

The supply systems (sub-systems) which are to be augmented by the proposed Nwamitwa Dam are:

- the Worcester-Mothobeki sub-system,
- the Lower Molototsi sub-system,
- parts of the Greater Giyani sub-system,
- the Ritavi/Letaba system (Letaba system), and
- the Thapane system

It is estimated that the 2027 water requirement (excludes the water requirement which can be supplied from Thapane Dam) to provide a high service level to the above mentioned sub systems is approximately 11.2 Mm^3/a (excluding bulk water supply losses). In addition, the proposed Nwamitwa Dam may also have to make up a water resource shortfall in the Modjadji system of up to 2 Mm^3/a. This could make the primary water requirement on the proposed Nwamitwa Dam to be in the order of 13 Mm^3/a. Currently the water requirement in the Ritavi 1 area is 1.9 Mm^3/a. The current water requirements for the other sub systems are not known, as water requirement figures were not available. The supply areas to be served by the proposed Nwamitwa Dam are shown in **Figure 2.1**.

c) Future Mining Developments

Three potential new mining developments outside but close to the Letaba catchment were identified during the course of the study. These are summarised in **Table 2.2**. Due to the pressures on water availability in the Letaba Catchment, it is likely that water supplies to future mining developments outside the catchment will not be supplied from this source.

Table 2.2 Summary of Water Requirements of Potential New Mines outside the Letaba River Catchment Area

Source	Potential Future Water Requirement (Mm^3/a)
Tivani Mine	13
Gravelotte Heavy Minerals Mine	5
Expansion of existing Metorex Mine	3
Total	**21**

The additional water requirements expected in the Groot Letaba River catchment by the year 2030 (Table 2.1), amounts to 28.8 Mm^3/a, and excludes the indicated future requirement of 21 Mm^3/a for mining (Table 2.2).

2.2.3 Summary of Water Requirement from Tzaneen and Nwamitwa Dams

It is anticipated that the water requirement for primary use from Tzaneen Dam and the proposed Nwamitwa Dam supply area will grow from 13.9 Mm^3/a in 2007 to a value of approximately 35.2 in 2030. **Table 2.3** details the current and projected future primary water requirements from Tzaneen Dam and the proposed Nwamitwa Dam.

Table 2.3 Primary Water Requirements from Tzaneen and Nwamitwa Dam

<table>
<tr><th colspan="2">Source</th><th>Current Usage (Mm^3/a)</th><th colspan="3">Additional Requirement (Mm^3/a)</th><th>Total Future Requirement (Mm^3/a)</th></tr>
<tr><td rowspan="7">Existing and Future Sources</td><td>Tzaneen Dam</td><td>13.9 *1</td><td colspan="3">10.18</td><td>22.18 *2</td></tr>
<tr><td rowspan="6">Nwamitwa Dam (excludes current groundwater use)</td><td rowspan="6"></td><td>Ritavi 1</td><td>5.2</td><td rowspan="6">Approx 13</td><td rowspan="6">Approx 13</td></tr>
<tr><td>Thapane (excludes Thapane Dam)</td><td>1.8</td></tr>
<tr><td>Worcester Mothobeki</td><td>0.95</td></tr>
<tr><td>Lower Molototsi</td><td>0.92</td></tr>
<tr><td>Giyani</td><td>2.29</td></tr>
<tr><td>Deficit in Modjadji</td><td>< 2</td></tr>
<tr><td colspan="6">Total</td><td>35.18</td></tr>
</table>

**1 includes Ritavi 1*
**2 excludes Ritavi 1 (13.90 + 10.18 - 1.9)*

2.3 IRRIGATION DEMANDS

Information regarding water use for irrigation was sourced from two main studies as described below:

- An initial study of a general nature undertaken by Hennie Schoeman & Vennote into the irrigation taking place in the Groot Letaba catchment, which did not form part of this Bridging Study (DWAF, 2007).

- The second study by Hennie Schoeman & Vennote was commissioned as part of this Bridging Study. The outcome is documented in a report entitled Groot Letaba Study : Irrigation Assessment, and contains a detailed survey of the irrigated areas and storage on each of the properties in the Great Letaba River Catchment. A copy of this report is contained in Appendix C of the Study Report entitled Review of Water Requirements (DWA, 2010 a).

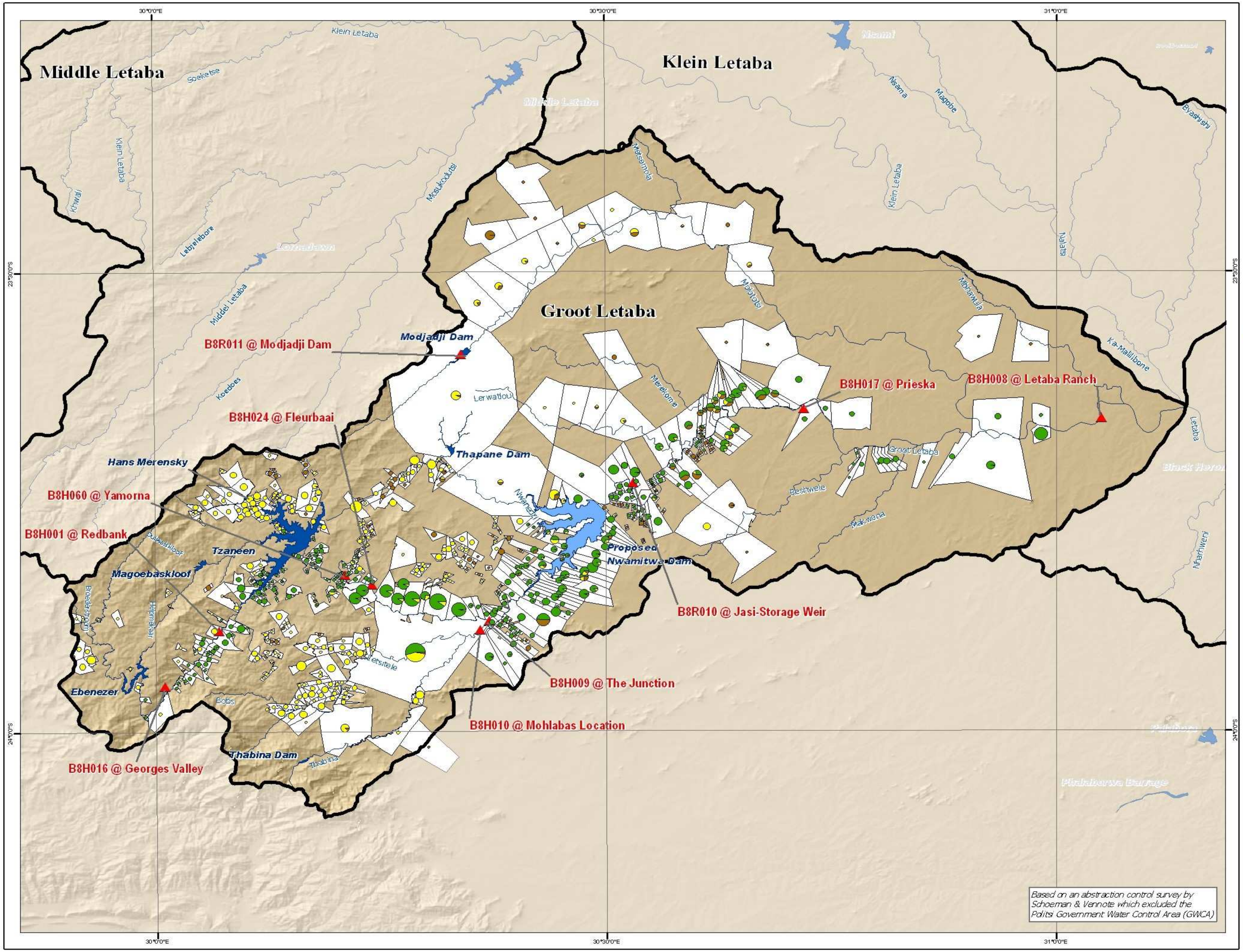
The distribution of the irrigated areas and the relative proportion supplied from groundwater, the Groot Letaba Water Users Association (GLWUA) and from other sources (e.g. municipal sources) is illustrated schematically in **Figure 2.2**.

The irrigation requirements are summarised in **Table 2.4**. The estimated annual irrigation use from surface water sources in the Groot Letaba catchment is 163.6 Mm^3/a, and from groundwater is 29.0 Mm^3/a.

Losses along each river reach were estimated and totalled a maximum of approximately 28.7 Mm^3/a, giving a total irrigation requirement from surface water of 192.3 Mm^3/a for the Groot Letaba catchment. Losses are important because the yield of the system is affected by the average losses over the critical drawdown period.

Differences in irrigation demands were found when the results of the 1995 Feasibility Study were compared to the 2007 Bridging Study Analysis. These are listed below:

- The local demands supplied upstream of Tzaneen Dam increased by 8 Mm^3/a.
- Increase of 29 Mm^3/a along the Groot Letaba River from Tzaneen Dam to the Letaba Ranch. Part of this increase was from incorporating the proposed (as opposed to existing) supply of 22 Mm^3/a to emerging farmers downstream of the Nondweni Weir.



OVERVIEW MAPS :

Study Area

Study Area

LEGEND

Weirs

Rivers

Dams

Groot Letaba Study Catchments

Irrigation Per Property

Other

Letaba

Borehole

Only 2 800 areas shown

PATH:

s/H401775/mxd/Reports/Main-../fig2_2_irrig.mxd

SCALE

0 5 10 15 km

1:400,000

PROJECTION INFORMATION :

COORDINATE SYSTEM :	Transverse Mercator
PROJECTION NAME :	TM31
DATUM :	D_WGS_1984
SPHEROID :	WGS_1984
CENTRAL MERIDIAN :	31

CONSULTANT :

aurecon

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLES :

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

IRRIGATION IN THE GROOT LETABA CATCHMENT

FIGURE NO. :

2.2

Table 2.4 Summary of Irrigation Requirements

Description	Field Edge Requirements (excluding losses) (Mm^3/a)			Estimated Losses	Total Requirements including losses
	Local Users	GLWUA	Total		
Groot Letaba Catchment	73.1	90.5	163.6	28.7	192.3
Middle Letaba	37.4	N/A	37.4	--	37.4
Klein Letaba	14.0	N/A	14.0	--	14.0
Grand Total	**124.5**	**90.5**	**215.0**	**28.7**	**243.7**

2.4 AFFORESTATION

Significant areas of commercial plantations (afforestation) and some indigenous forests occur in the wetter parts of this study area, mainly in areas with an average MAP of around 900 mm. These areas are concentrated in the upper reaches of the Groot Letaba, Letsitele, and Middle Letaba and Klein Letaba River catchments. Afforested areas are planted with mainly gum tree species (Eucalyptus), with pine tree species (Pinus spp) being planted to a lesser extent. In the previous studies, the areas covered with forest in 1925 were assumed to be indigenous forests, since the afforestation industry only began to grow significantly from 1930 onwards.

There is very little likelihood that further development of afforestation took place in the catchment, since the Letaba catchment was categorised as "Category 1" in terms of the 1984 Forestry Act (Act 122 of 1984), which implies that new licences were not permitted in the catchment (DWAF, 1998). This happened as far back as 1972.

Updated information on the forestry areas (indigenous and afforested) and the growth of the areas was obtained for the purpose of this study from 2005 aerial photography. The total area of afforestation in 2005 was estimated to be 356 km^2.

Afforestation Water Use

When the water requirements of afforestation modelled in this Bridging Study were compared to the monthly afforestation demands from the previous study, significant differences were found. In most sub-catchments, there were differences in the average afforestation demands between the two studies. The Bridging Study afforestation demands were adjusted in order to match the afforestation demands in the previous study, so that the average flows for the common period would remain the same. In most cases, the adjustments increased the water use by afforestation, giving an overall increase of 13 Mm^3/a to a total afforestation water use of 78 Mm^3/a. The adjustments made are summarised in **Table 2.5.**

Table 2.5 Summary Water Use by Afforestation

Sub-catchment Name	Afforested area in 2005 used in Bridging Study (km²)	Water use by afforestation (Mm³/a)		Factor used to adjust Bridging Study results to match pre-feasibility results	Water use by afforestation (Mm³/a	
		Pre-feasibility Study (SSI) (1925-1987)	Bridging Study (1925 - 1987)		Bridging Study after adjustment	
					1925 -1987	1925 - 2004
B8R001 – Ebenezer Dam catchment	95.5	11.2	6.2	1.8	11.2	15.0
B8R005 – Tzaneen Dam catchment	103.2	29.7	22.7 (incl B81B)	1.3	29.7	40.1
BH009 and B8H010	62.0	7.4	8.9	0.8	7.4	10.1
B8H017	17.2	2.8	1.7	1.6	2.8	4.2
B8H008	5.6	0.0	0.5	1.0	0.0	0.0
Ungauged sub-catchment downstream of B8H008 to confluence with Klein Letaba (J01)	0.0	0.0	0.0	1.0	0.0	0.0
Middle Letaba	74.5	5.7	3.2	1.8	5.7	8.1
Klein Letaba	0	0.0	0.0	1.0	0.0	0.0
Groot Letaba downstream of confluence with Klein Letaba, to entry to KNP	0	0.0	0.0	1.0	0.0	0.0
TOTAL	**358.0**	**56.7**	**43.4**	**1.3**	**56.7**	**77.6**

2.5 ECOLOGICAL RESERVE

A number of different studies have been undertaken by DWA over the years to determine the Ecological Water Requirement (EWR) for the Groot Letaba Catchment. The location of the EWR sites determined by these previous studies is shown in **Figure 2.1**. The present EWR release is 14.8 Mm^3/a (0.469 m^3/s) from Tzaneen Dam (via Nondweni Weir).

A Preliminary Reserve Determination (DWAF, 2006) was undertaken recently by DWA in which the ecological water requirements at each EWR site were generated using the RESDSS model. A Preliminary Reserve Determination was put forward by DWA, including the rules describing the desired environmental flow requirements. The latest EWR is higher than the present EWR release mentioned earlier, but has not yet been implemented. It consists of a low flow component of 16 Mm^3/a and a high flow component of 66 Mm^3/a, giving an average annual value of 82 Mm^3/a at EWR Site 4 (Letaba Ranch). It should be noted that these figures are average annual values, and so can be lower in a dry year and higher in a wet year.

It is important to note that the Preliminary Reserve Determination did not take the proposed Nwamitwa Dam into account. A separate Reserve Determination study for this still needs to be undertaken.

2.6 SUMMARY

The water requirements discussed in this section of the report are summarised in **Table 2.6**.

Table 2.6 Summary of Water Requirements in the Groot Letaba Catchment

Description	Water Requirements in Mm^3/a		
	2007	**Allowance for growth (additional to 2030)**	**Total in 2030**
Primary – domestic (see **Table 2.6**)	22.0	28.8	50.8
Primary – industrial	1.5	0	1.5
Sub-total Primary	23.5	28.8	52.3
Irrigation (surface water) *1	192.3	0	192.3
Afforestation	77.6	0	77.6
Totals (excl. Environmental)	**293.4**	**28.8**	**293.4**
Primary – mining (to be supplied from outside the catchment)	0	21.0	21.0
Environmental *2	14.8 Mm^3/a = 0.469 m^3/s	min = 16 Mm^3/a max = 82 Mm^3/a For EWR Site 4	16 to 82 Mm^3/a at Site 4

*1 Irrigation supplied by groundwater is estimated to be an additional 29 Mm^3/a.
*2 Note that the Environmental Requirement (non-consumptive use) cannot be added to the other water requirements.

A summary of the water use, allocations and yields from existing sources is given in **Table 2.7**Table 2.7 along with the future estimates of water use.

Table 2.7 Summary of Existing and Future Sources and their Usage

<table>
<tr><th colspan="2" rowspan="2">Source</th><th colspan="2" rowspan="2">Historic Firm Yield (Mm^3/a)</th><th colspan="3">Allocation</th><th rowspan="2">Use Primary Water Current Use 2006/7 (Mm^3/a)</th><th colspan="2">Gross Irrigation Water Use Values used in this Study *[6]</th></tr>
<tr><th>Primary (Mm^3/a)</th><th>Irrigation (Mm^3/a)</th><th>Total *[1] (Mm^3/a)</th><th>Requirement (Mm^3/a)</th><th>Supply (Mm^3/a)</th></tr>
<tr><td rowspan="10">Existing Sources</td><td>Dap Naude Dam</td><td colspan="2">3.2</td><td>6.5</td><td>0.00</td><td>6.5</td><td>4.6</td><td>1.1</td><td>1.1</td></tr>
<tr><td>Ebenezer Dam</td><td colspan="2">23.9*[2]</td><td>14.4</td><td>12.9</td><td>27.3</td><td>21.0</td><td>13.0</td><td>10.5</td></tr>
<tr><td>Magoebaskloof and Vergelegen Dams</td><td>9.1</td><td rowspan="2">15.9</td><td rowspan="2">2.0</td><td>11.9*[6]</td><td rowspan="2">8.3</td><td>2.1</td><td>12.0</td><td>11.6</td></tr>
<tr><td>Hans Merensky Dam and Selokwe River</td><td>6.8</td><td>13.3*[4]</td><td>--</td><td>13.3</td><td>13.3</td></tr>
<tr><td>Tzaneen Dam</td><td colspan="2">74.6</td><td>8.4</td><td>105.00</td><td>113.4</td><td>13.7</td><td>105.5*[4]</td><td>85.0*[4]</td></tr>
<tr><td>Thabina Dam</td><td>2.9</td><td rowspan="2">8.0</td><td rowspan="2">Uncertain 1.9</td><td rowspan="2"></td><td rowspan="2">Uncertain 1.9</td><td rowspan="2">1.5</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Modjadji Dam</td><td>5.1</td></tr>
<tr><td>**Total**</td><td colspan="2">**125.6**</td><td>**33.2**</td><td>**143.2**</td><td>**177.4**</td><td>**42.9**</td><td>**144.9**</td><td>**121.5**</td></tr>
<tr><td>Local sources from d/s Tzaneen to confluence with Klein Letaba</td><td colspan="2"></td><td></td><td>47.3*[3]</td><td>47.3</td><td>--</td><td>47.3*[4]</td><td>36.5*[4]</td></tr>
<tr><td>Overall Total</td><td colspan="2">125.6</td><td>34.2</td><td>190.5</td><td>224.7</td><td>42.9</td><td>192.2</td><td>158.0</td></tr>
</table>

1. Please note that these totals are at different assurances of supply.
2. 1:50 year assurance.
3. Existing water use.
4. No irrigation allowed in the Kruger National Park below the Letaba Ranch weir. All losses below this point are not caused by irrigation and are not included in the gross irrigation requirement or supply.
5. Although Sapeko no longer uses its allocation, the allocation was assumed to continue as the Magoeba tribe wish to claim this allocation. Includes 11.0 from Magoebaskloof + 0.87 Mm^3/a from Debengeni Stream (of which 0.3 is actually domestic).
6. For more detail, please refer to the detailed table in the Water Balance Section of the *Water Resource Analysis Report.*

3. GROUNDWATER

The objectives of the groundwater study were to:

- determine the present and future use of groundwater in the project area
- determine the groundwater potential in the bulk water distribution area and to
- determine the groundwater potential for the entire project area.

The use of information from DWA's Ground Water Information Project (GRIP) programme was utilised in the evaluation of groundwater availability and suitability. The information was evaluated in relation to known aquifers or water bearing geological structures. No exploration or field testing was undertaken.

This section summarises the findings of the Study Report entitled *Groundwater (DWA, 2010 b)*.

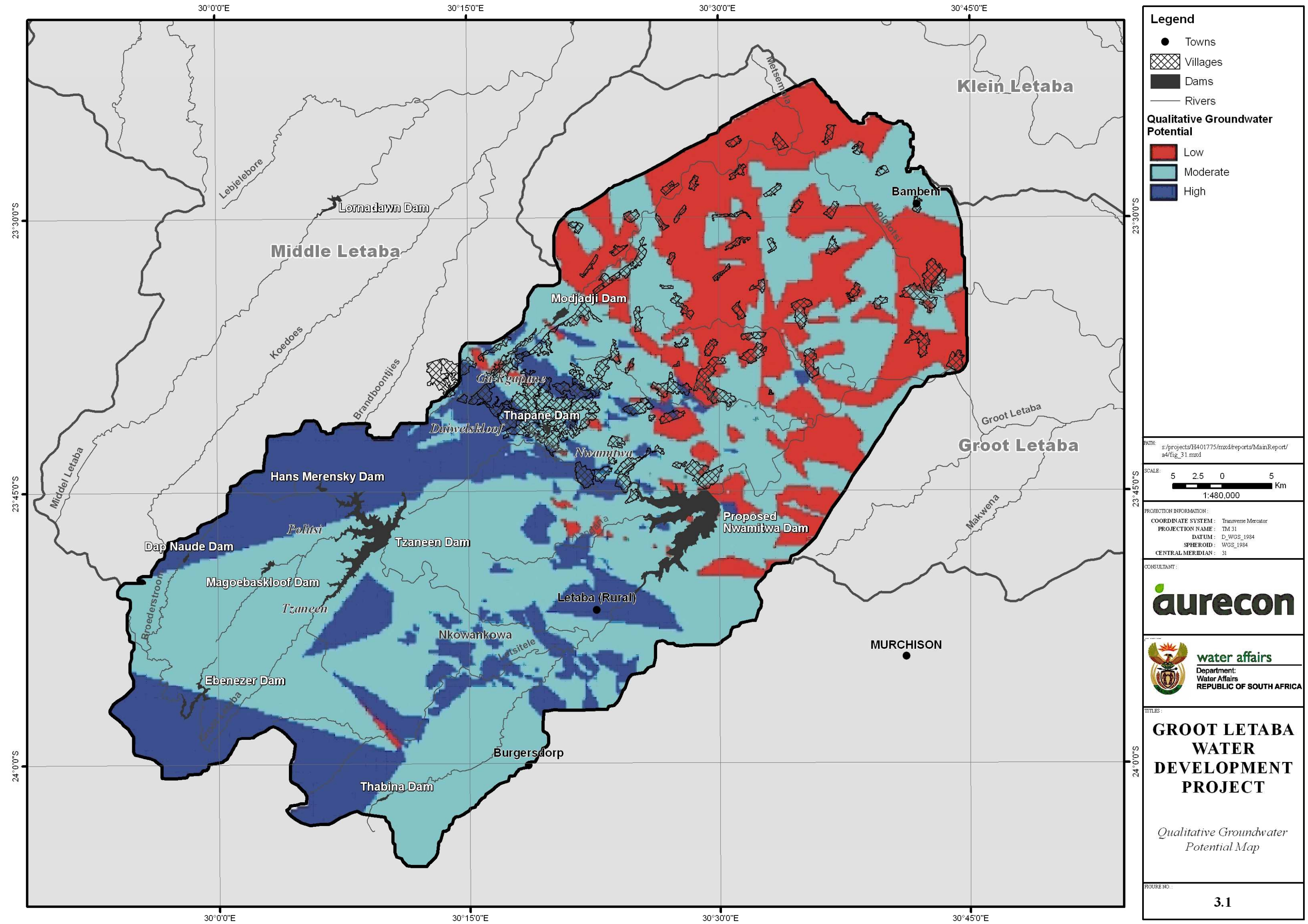
3.1 PRESENT AND FUTURE USE OF GROUNDWATER

The current use of groundwater in the Groot Letaba catchment for supply to villages is estimated to be 10.6 Mm^3/a. The most recent estimate of groundwater use for irrigation is 29 Mm^3/a (DWA, 2007) and has been adopted for use in this study. Therefore the total current use of groundwater in the catchment is estimated to be 39.6 Mm^3/a.

3.2 GROUNDWATER POTENTIAL

The groundwater development potential in the Groot Letaba catchment is shown in **Figure 3.1**. The majority of the catchment has moderate groundwater potential, with significant portions of the catchment having high groundwater potential, particularly in the south and west. There are portions of the catchment with low groundwater development potential, particularly in the north and east of the catchment.

There is significant rainfall recharge of the groundwater in the project area, and it reduces from west to east across the project area. It is estimated that a total volume of 90.86 Mm^3/a is added to the groundwater annually from rainfall.


Legend
Towns
Villages
Dams
Rivers
Qualitative Groundwater Potential
Low
Moderate
High
Klein Letaba
Middle Letaba
Groot Letaba
Lornadawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Dap Naude Dam
Tzaneen Dam
Magoebaskloof Dam
Ebenezer Dam
Thabina Dam
Proposed Nwamitwa Dam
Letaba (Rural)
Nkowankowa
Burgersdorp
Bambeni
MURCHISON
Lebjelebore
Koedoes
Brandboontjies
Middel Letaba
Makwena
Politsi
Tzaneen
Duiwelskloof
Nwamitwa
30°0'0"E
30°15'0"E
30°30'0"E
30°45'0"E
23°30'0"S
23°45'0"S
24°0'0"S
1:480,000
Km
aurecon
water affairs
Department: Water Affairs REPUBLIC OF SOUTH AFRICA
GROOT LETABA WATER DEVELOPMENT PROJECT
Qualitative Groundwater Potential Map
3.1

Using the above recharge value, and the current groundwater use of 39.6 Mm^3/a, approximately 51.2 Mm^3/a (without accounting for groundwater losses) is available for development.

3.3 RECOMMENDATIONS FOR GROUNDWATER DEVELOPMENT

Since groundwater represents a significant potential water resource for the area, it is recommended that a comprehensive groundwater investigation on a regional scale should be undertaken so that the location and availability of suitable quality groundwater can be determined with greater certainty. These investigations should be focussed on specific groundwater supply schemes which could be located in the supply area currently envisaged for the proposed Nwamitwa Dam.

The potential yields, costs and environmental implications associated with a groundwater "government water scheme" should be determined and compared with the yields, costs and environmental implications of the proposed Nwamitwa Dam development.

A flow chart illustrating the recommended steps that would form part of a groundwater development strategy for the region is given in **Figure 3.2**

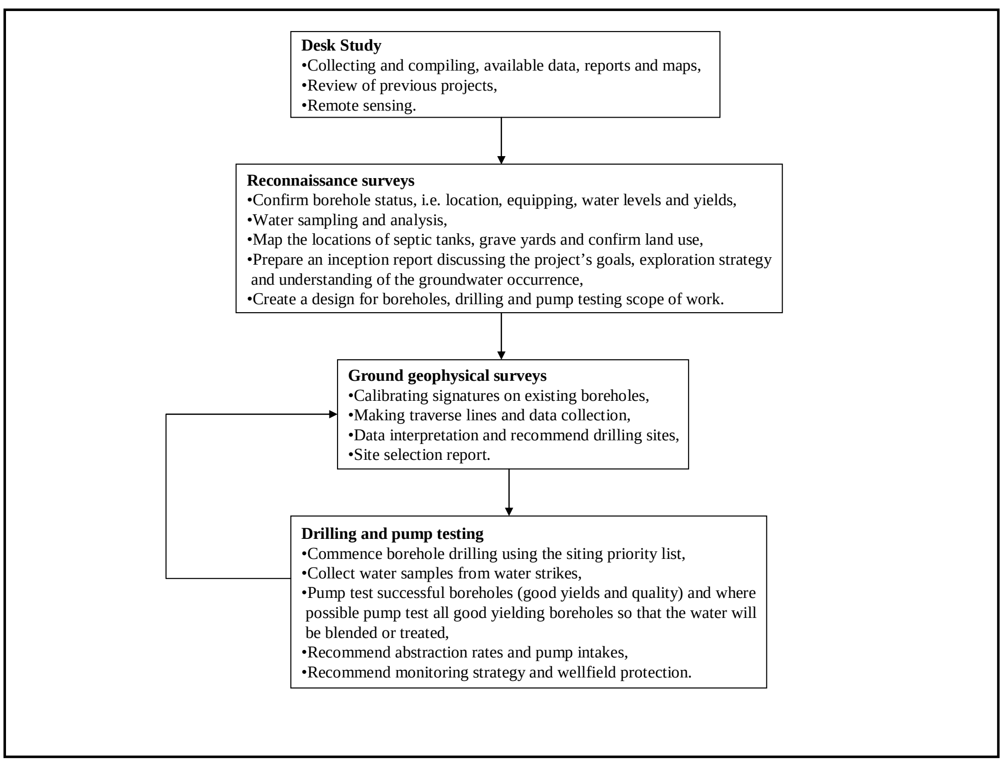


Figure 3.2 Flow Chart of Groundwater Development Strategy

The conjunctive use of surface and groundwater resources should be considered as an option in the bulk supply area in order to optimise the use of both surface and groundwater resources. The higher quality surface water could be used to blend with the lower quality groundwater in some areas in order to achieve the required DWA standards with minimal water treatment.

4. UPDATING OF HYDROLOGY

The scope of this portion of the Study included an extension of the catchment modelling time period by 12 years to end in hydrological year 2004 instead of 1992, giving a total modelling period of 80 hydrological years (from 1925 to 2004). The scope of work specifically excluded the re-calibration of the Pitman rainfall-runoff model (Pitman, 1973).

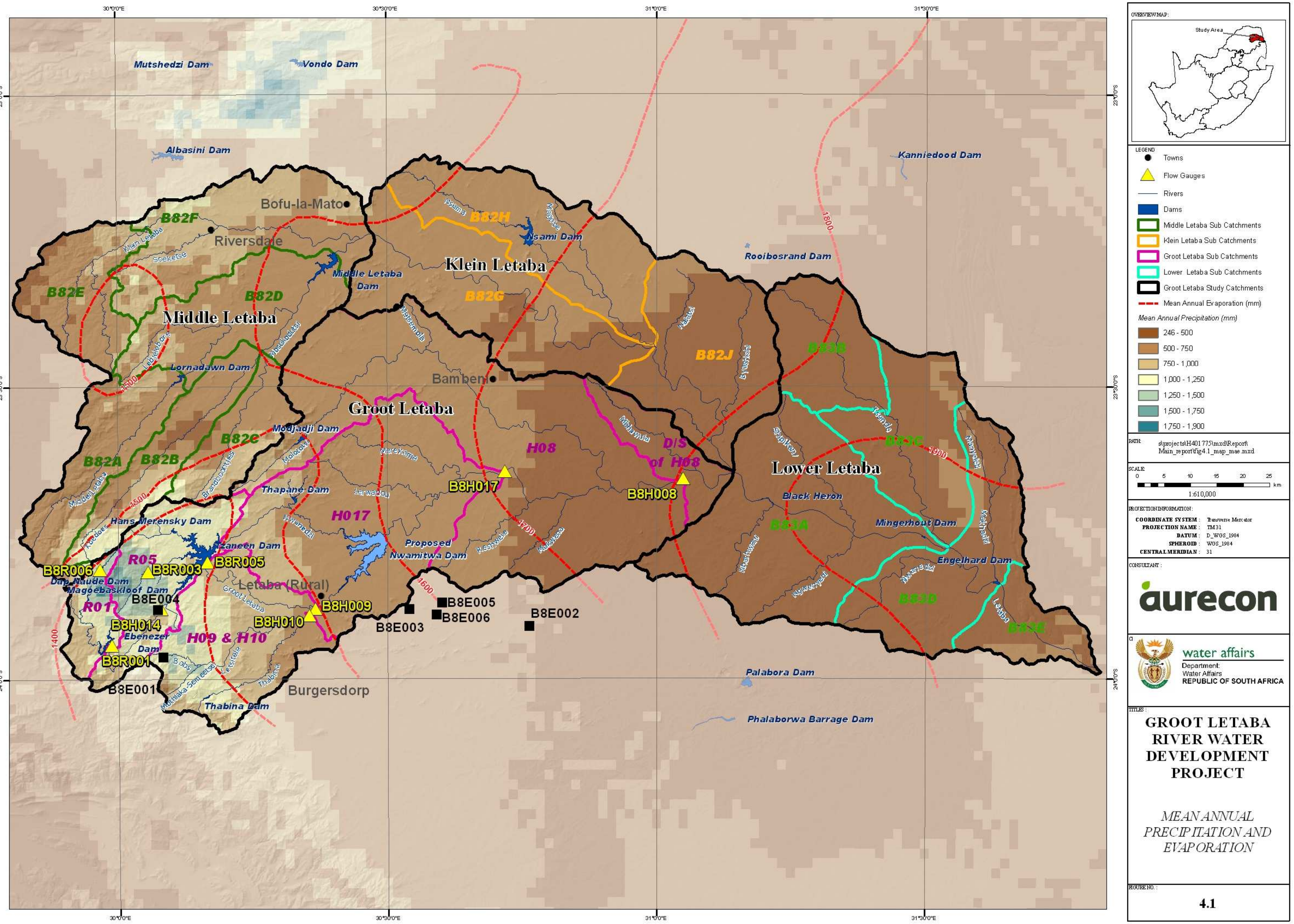
The procedure followed for extending the naturalised flows is fully described in the Hydrology Report (Section 3 and Appendix E of Study Report entitled *Hydrology* DWA, 2010 c). It entailed obtaining updated input data for the model (monthly rainfall, evaporation, land use and water demands) for hydrological years 1993 to 2004. All input data to the model were adopted unchanged where available from the previous studies.

The simple extension of modelled data by adding new observations has led to uncertainties regarding the results of the extension of the hydrology. Significant difficulty was also experienced in obtaining details of existing model input data in time to meet project deadlines. This led to assumptions being made in order to allow the study to progress, leading in turn to differences in modelling results. The most significant cases are the modelling of afforestation influences, and the rainfall data used as input to the Pitman rainfall-runoff model. Adjustments were made in both cases to ensure that the Bridging Study's extended natural streamflows and afforestation demands were broadly compatible with the original WRYM streamflows, which were available in digital format.

The mean annual precipitation and mean annual evaporation for the catchment are shown in **Figure 4.1**.

4.1 METHODOLOGY AND DIFFERENCES FROM PRE-FEASIBILITY STUDY

The study area was divided into four main hydrological sub-catchments. The most detailed work was done for the Groot Letaba catchment, based on the 37 sub-catchments used in previous studies. The hydrology for the other three sub-catchments (Middle, Klein and Lower Letaba) was based on WR90, and was modelled on a quaternary sub-catchment basis.



OVERVIEW MAP:
Study Area
LEGEND
Towns
Flow Gauges
Rivers
Dams
Middle Letaba Sub Catchments
Klein Letaba Sub Catchments
Groot Letaba Sub Catchments
Lower Letaba Sub Catchments
Groot Letaba Study Catchments
Mean Annual Evaporation (mm)
Mean Annual Precipitation (mm)
246 - 500
500 - 750
750 - 1,000
1,000 - 1,250
1,250 - 1,500
1,500 - 1,750
1,750 - 1,900
PATH:
s\projects\H401775\mxd\Report\Main_report\fig4.1_map_mae.mxd
SCALE:
0 5 10 15 20 25 km
1:610,000
PROJECTION INFORMATION:
COORDINATE SYSTEM : Transverse Mercator
PROJECTION NAME : TM 31
DATUM : D_WGS_1984
SPHEROID : WGS_1984
CENTRAL MERIDIAN : 31
CONSULTANT :
aurecon
CI
water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA
TITLES :
GROOT LETABA RIVER WATER DEVELOPMENT PROJECT
MEAN ANNUAL PRECIPITATION AND EVAPORATION
FIGURE NO. :
4.1
Middle Letaba
Klein Letaba
Groot Letaba
Lower Letaba
B82A
B82B
B82C
B82D
B82E
B82F
B82G
B82H
B82J
B83A
B83B
B83C
B83D
B83E
R05
R01
H017
H08
H09 & H10
D/S of H08
Mutshedzi Dam
Vondo Dam
Albasini Dam
Kanniedood Dam
Rooibosrand Dam
Nsami Dam
Middle Letaba Dam
Lornadawn Dam
Modjadji Dam
Thapane Dam
Hans Merensky Dam
Tzaneen Dam
Dap Naude Dam
Magoebaskloof Dam
Ebenezer Dam
Thabina Dam
Proposed Nwamitwa Dam
Black Heron
Mingerhout Dam
Engelhard Dam
Palabora Dam
Phalaborwa Barrage Dam
Bofu-la-Mato
Riversdale
Bambeni
Letaba (Rural)
Burgersdorp
B8R006
B8R003
B8R005
B8R001
B8H014
B8H010
B8H009
B8H017
B8H008
B8E001
B8E002
B8E003
B8E004
B8E005
B8E006
1400
1500
1600
1700
1800
1900
30°0'0"E
30°30'0"E
31°0'0"E
31°30'0"E
23°0'0"S
23°30'0"S
24°0'0"S

The main differences in approach to the hydrology tasks between this study and previous studies are listed below.

- The rainfall-runoff model was not re-calibrated, but the simulation period was merely extended to hydrological year 2004 (ending in September 2005).

- Different rainfall stations and groupings were used in the Bridging Study because details of these from previous studies were not available.

- Different afforestation areas were used which required that Bridging Study afforestation demands to be adjusted to match those of previous studies.

- Updated values for irrigation and domestic demands were used.

- Bridging Study simulated naturalised flows were different from those of previous studies, so were factored to match the flows from previous studies for the common time period.

4.2 AVAILABILITY AND QUALITY OF BASE DATA

There is a lack of both rainfall and evaporation data for this area, particularly in the eastern part of the catchment. Only six evaporation stations are located in or near the catchment. Out of the possible 194 rainfall stations in and near the catchment, only 34 passed the screening criteria and were patched. Of these 34 rainfall stations, only 12 showed stationarity after patching and were used as input to the rainfall-runoff model. This is a very low number for such a large catchment, and combined with the poor distribution of the stations, is cause for concern. It is recommended that every effort should be made to maintain the existing evaporation and rainfall stations and to ensure that the data collected is of a suitable quality for use in rainfall-runoff modelling.

4.3 RESULTS OF EXTENSION OF HYDROLOGY

The extended naturalised flows resulting from this Bridging Study are summarised in **Table 4.1**. The naturalised MAR for the entire catchment for the period 1925 – 2004 is 613.82 Mm^3/a.

Table 4.1 Summary of Bridging Study Flows for the Letaba Catchment

Catchment		Bridging Study time period 1925 – 2004		
		Bridging Study (after factoring: 1925-1987 = Pre-feasibility flows + 1988-2004= factored flows) Mm^3/a		
Name	Area (km^2)	Incremental	Cumulative	Percentage of Total
B8R001 Ebenezer Dam	169.2	48.77	48.77	8%
B8R005 Tzaneen	482.3	154.43	203.20	33%
B8H009 + B8H010 Letsitele	686.3	117.86	321.07	52%
B8H017 Prieska Weir	1184.1	60.54	381.60	62%
B8H008 Letaba Ranch	2083.8	50.19	431.79	70%
Groot Letaba ds from B8H008 to confluence with Klein Letaba (ungauged)	248.5	3.52	435.31	71%
Middle Letaba	2988.0	88.37	88.37	14%
Klein Letaba	2465.0	41.74	130.11	21%
Lower Letaba	981.0	48.40	613.82	100%

5. WATER RESOURCE EVALUATION

5.1 INTRODUCTION

This section of the report primarily covers the determination of the historical firm yield and long-term stochastic yield characteristics for three different dam capacities for the proposed Nwamitwa Dam, with and without a raised Tzaneen Dam and with and without environmental water requirements.

All the variables which could influence the yield of the proposed Nwamitwa Dam (e.g. implementation of the environmental water requirements and the impact of "system losses") were considered and their impacts were evaluated. A comparison was also made with the outcome of the water resource analysis undertaken in the 1995 Feasibility Study. The impacts of the development proposals on the yield of Massingir Dam were also evaluated.

5.2 HISTORIC FIRM YIELD OF THE PROPOSED NWAMITWA DAM

5.2.1 Analysis of Present Day Flows

Prior to determining the historical firm yields based on the estimated future water requirements, the Water Resource Yield Model (WRYM) was set up to approximate present day conditions, taking account of present levels of abstraction and water use.

The terms of reference calls for the Pitman Model, which was calibrated on the Groot Letaba River system for the period 1925 to 1992, to be used for synthesizing flow records at quaternary sub-catchments for that period, and for the same model parameters to be used to extend the hydrology to 2005. The additional data were simply to be added to the synthesized record.

It soon became clear that the 1995 Pitman Model does not adequately reproduce streamflow actually recorded during the period 1992 to 2005. The main shortcoming was illustrated in the record for B8H010 on the Lesitele where important freshets (relatively low peaks in runoff following rainfall events) were recorded but not simulated by the model. This discrepancy was evident in streamflow records further down the system in the Groot Letaba River.

This component of the flow regime is particularly important because of its role in (a) satisfying Ecological Water Requirements (the Reserve) and (b) contributing to the yield available from storage dams in the system. A cursory examination of the Pitman Model indicated that the model calibration could be significantly improved to better reproduce freshets in the flow regime. There was no reason to doubt the reasonableness of the flow records.

In order to progress the estimate of yield available from the system with the proposed new storage units, without recalibrating the hydrology, the difference between the synthesized runoff (without the presence of freshets) and the observed runoff for the same period was estimated and simply added to the synthesized flow sequences. This empirical adjustment added about 8 Mm^3/a to the flow at Nwamitwa, increasing downstream to the confluence with the Olifants River. A volume of 5 Mm^3/a was added between Nwamitwa and Prieska and about 21 Mm^3/a between Prieska and Letaba Ranch. These freshets (total volume of 34 Mm^3/a) were added to the WRYM simulated flows in order to more closely match the observed flows.

5.2.2 Historical Firm Yield

The historical firm yield of Nwamitwa Dam was estimated for a number of scenarios. All the scenarios evaluated are discussed in detail in the Water Resource Analysis Report.

Table 5.1 Effect of EWR and system losses on the HFY of Nwamitwa Dam

HFY of Nwamitwa Dam (Mm^3/a)					
System Loss Factor	**Present Day**	**"Optimised" Scenario 7 at all EWR sites (777)**	**Full EWR at EWR 3 "Optimised" Scenario 7 at EWT 4,6 and 7. (t77)**	**Full EWR at 3 and 4 "Optimised" Scenario 7 at EWR 6 and 7 (tt7)**	**Full EWR at all EWR sites (ttt)**
0.0	27	26	18	16	13
0.5	27	21	14	14	7
1.0	27	13	6	3	0

Table 5.1 above illustrates how the historical firm yield of the Nwamitwa Dam is very dependent on at which EWR site the Reserve requirements have to be met from the proposed Nwamitwa Dam, and upon the amount of "system losses" which are applied. System losses are defined as the reduction in river flow due to evaporation from the exposed water surface, evapo-transpiration from vegetation on the river banks and also from seepage. Scenario 777 represents the “optimised” scenario contained in the Preliminary Reserve Determination Report. Scenario t77 represents the Scenario where flood releases are made from the proposed Nwamitwa Dam to satisfy the stipulated Reserve requirements at EWR Site 3, immediately downstream of the proposed Nwamitwa Dam. For Scenario tt7 the Reserve requirements were met at EWR Site 4 and for Scenario ttt the Reserve requirements were met at EWR Site 6. The supply to existing irrigators was maintained at the present level. For Scenario t77 the historical

firm yield at Nwamitwa decreases from 18 to 6 Mm^3/a, depending on the factor applied to the losses downstream of the Letaba Ranch. For the purposes of this bridging study it was assumed that 50% “system losses” (a factor of 0.5) would apply and that the proposed Nwamitwa Dam would have to assist in meeting the Reserve requirements at EWR 3. Under these circumstances the yield of the proposed Nwamitwa Dam would be 14 Mm^3/a.

The current historical firm yield of the Nwamitwa Dam of 14 Mm^3/a for scenario t77 assumed that :

- Nwamitwa Dam is constructed to RL479.5 (187 Mm^3 storage capacity).
- The Preliminary Reserve Requirement is supplied at Site 3 (Prieska) but that the sites lower down must rely on accruals for those environmental water requirements exceeding "Scenario 7".
- The supply from Tzaneen remains unchanged.
- The current operating rules at Tzaneen Dam remain unchanged.
- The average losses over the critical drawdown period are half the observed losses during the low flow period (factor of 0.5).
- About 34 Mm^3/a of freshets are missing from the WRYM simulation and these will contribute about 8 Mm^3/a extra inflow to Nwamitwa and to the environmental highflow requirements downstream of Nwamitwa Dam.
- Polokwane was limited to its allocation from Ebenezer and Dap Naude
- The full capacity is available for the yield (no deductions for dead storage or sedimentation).

Tzaneen Dam is currently operated above its firm yield, which means it is drawn down more than if it were operated at its firm yield. To replicate this behaviour an operating rule was included to start applying curtailments in April or September if the storage dropped too low. The monthly water supply to the three reaches of the Groot Letaba River downstream of Tzaneen Dam kept constant. This meant that the same demand sequences could be re-applied to the system when Nwamitwa Dam is in place to ensure that the reliability of supply to the existing irrigators remained identical after the introduction of Nwamitwa Dam.

It must be noted that the yield of the proposed Nwamitwa Dam is very dependent on certain of the assumptions and changing these assumptions will have a significant impact on the yield.

5.2.3 Factors which could impact on the yield of the Proposed Nwamitwa Dam

The yield from the proposed Nwamitwa Dam is relatively small because the dam is downstream of a large existing dam and a large proportion of the streamflow from the remaining tributaries is already being used, due to the efficient operation of the Groot Letaba Water Users Association. The factors which could significantly affect the yield of the dam are listed below:

- The efficiency with which the irrigators upstream of the dam can abstract water using their canals and pumps.
- The amount of water that must be released from the dam for ecological requirements and the extent to which accruals downstream of the dam contribute toward this requirement.
- The river channel losses acting on the release as it enters the Kruger Park and how much extra must be released to counter this loss.
- The current hydrology does not replicate the freshets in the catchments downstream of the Letsitele River.
- Revised demand and loss data have been obtained and should be used when the rainfall-runoff model for the catchment is re-calibrated to ensure that the runoff generated matches the historical observed values.

Table 5.2 summarises the possible impact of the abovementioned variables on the assumed yield of 14 Mm^3/a of the proposed Nwamitwa Dam (referred to as the "base case scenario"). Negative impacts are associated with a decrease in yield, while positive impacts result in an increase in yield.

Table 5.2 Assumptions Affecting the Yield of the Proposed Nwamitwa Dam

Assumption	Yield increase or decrease compared to base case scenario (Mm^3/a)	Yield of Nwamitwa Dam (Mm^3/a)
Base case scenario described in Section 5.2.2	--	14
Require Tzaneen Dam to first meet the ecological water requirements downstream prior to the construction of Nwamitwa Dam. In the t77iH scenario the yield of Nwamitwa increased by about 9 Mm^3/a	+9	23
Increase EWR at the Letaba Ranch and in the Kruger National Park from "Scenario 7" to the full Preliminary Reserve Requirement (t77H *vs* tttH)	-7	7
Increase average losses over the critical drawdown period from half to the full observed losses during the low flow period (Scenario t77F *vs* t77H)	-8	6
Omit freshets (-t77H *vs* t77H)	-12	2
Reduce efficiency of abstraction by the GLWUA at the Letaba North and N&N canals and the pump irrigators	+1	15
Reduce usage of surplus water not included with the allocation	+0 to +5.9	14 to 19.9
Sedimentation over 50 years	-1	13

5.2.4 Comparison with the 1995 Feasibility Study Results

At the onset of the Bridging Study there appeared to be confusion regarding the yield of the proposed Nwamitwa Dam, based on the Feasibility Study undertaken in 1995. It was originally thought that the historic firm yield of the proposed Nwamitwa Dam was 45 Mm^3/a. Further investigation, however, showed that the figure of 45 Mm^3/a was the historic firm yield of the proposed Nwamitwa Dam if one assumed that the demands on the dams upstream of the proposed Nwamitwa Dam were equal to the historic firm yields of the upstream dams. If one used the actual 1995 demands and allocations in the modelling the historical firm yield was shown to be 22 Mm^3/a in the 1995 Feasibility Study Report.

The primary differences between the earlier Feasibility Study and the current Bridging Study are:

- The bridging study introduced additional freshets averaging about 34 Mm^3/a into the WRYM as a stopgap measure to introduce freshets that were missing in the hydrology.
- The urban requirements in the bridging study were fixed at about the 2007 level of development, rather than the 2020 level of development.
- Following the detailed survey of the Groot Letaba catchment (excluding the Politsi Government Water Control Area) by Schoeman & Vennote, the irrigation and farm

dams capacities were increased by 37 Mm^3/a and 27 Mm^3 respectively, primarily along the Groot Letaba River downstream of the Tzaneen Dam.

- Subsequent to the Feasibility Study, the ecological water requirements were updated in the Letaba Catchment – Reserve Determination Study. The total ecological water requirements from both studies, i.e. the original full maintenance requirement and the later preliminary reserve determination, differ, but the original drought requirements and the requirements for the "Scenario 7" adopted in the Reserve Determination Study are similar.
- The Feasibility Study determined the additional average supply to irrigation possible for each of the scenarios while the Bridging Study determined the additional firm yield available at Nwamitwa, assuming that the irrigation supply remained identical to pre-Nwamitwa conditions.

5.3 HISTORICAL FIRM YIELD OF A RAISED TZANEEN DAM

It was a requirement of the study that the incremental yield of a raised Tzaneen Dam also be determined. The benefit of installing fuse gates or constructing a labyrinth weir to raise the full supply level of Tzaneen Dam by 3 metres (from a gross storage of 158 Mm^3 to 193 Mm^3) was an increase in the firm yield of the Tzaneen/Nwamitwa system of about 4 Mm^3/a. This increase in firm yield assumed that the proposed Nwamitwa Dam was already in place. Without the proposed Nwamitwa Dam the firm yield of the raised Tzaneen Dam remained at 4 Mm^3/a. This is primarily because the yield of Nwamitwa Dam is primarily determined by floods coming down the Letsitele River and not by spills from Tzaneen Dam.

5.4 STOCHASTIC ANALYSIS OF YIELDS

In the historical firm yield analysis the supply to the existing users was fixed at their current level, but in the stochastic analyses it was assumed that the current system would have to make "optimised" baseflow releases, which effectively reduces the supply to the existing users to support these baseflow releases. Because the existing users are contributing toward a portion of the EWR requirements the benefit of the additional schemes increases, as less yield from the new scheme is required to support the EWR.

In the case of raising Tzaneen Dam the 1 in 50 year yield increases from 3 Mm^3/a to about 7 Mm^3/a if the "optimised" baseflow releases are supplied by the existing users. If the EWR requirement remains as a 14.7 Mm^3/a release from Nondweni then the benefit of raising Tzaneen is about 9 Mm^3/a.

If the optimised baseflows are supplied by the current users, then constructing Nwamitwa to FSLs of 473.5, 477.5 and 479.5 will increase the 1 in 50 year yield of the system by 12, 20 and 23 Mm^3/a respectively. The yields are summarised **Table 5.3**.

Table 5.3 Incremental Yields of Proposed Schemes in the Groot Letaba Catchment

Scenario		HFY previously reported assuming that Nwamitwa provides all the increased EWR releases	Updated yields assuming that Irrigation from Tzaneen is reduced to allow for "optimised' EWR releases					
			HFY of Nwamitwa	1 in .. year risk of failure				
				10	20	50	100	200
1	Raise Tzaneen with present day compensation releases		8	26	18	9	6	4
2	Reduce supply to irrigators to supply "optimised" EWR baseflows - then raise Tzaneen Dam		5	18	13	7	5	3
3	Maintain present day supply to irrigators then raise Tzaneen (+3m) and supply "optimised" EWR baseflows		2	17	11	4	0	0
4	Nwamitwa (FSL 473.5m) with prelim reserve downstream at Site 3	4	7	22	16	12	9	7
5	Nwamitwa (FSL 477.5m) with preliminary reserve downstream at Site 3	9	13	34	30	20	15	12
6	Nwamitwa (FSL 479.5m) with preliminary reserve downstream at Site 3	14	17	38	33	23	19	15
7	Raise Tzaneen (+3m) plus Nwamitwa (FSL 479.5m) with preliminary reserve down-stream at Site 3	18	22	44	39	27	22	18

5.5 IMPACTS OF THE FUTURE DEVELOPMENTS ON MASSINGIR DAM

This section of the report covers the determination of the historical firm yield and long-term stochastic yield characteristics of Massingir Dam, considering the implications of a constructed Nwamitwa Dam, raised Tzaneen Dam as well as the construction of an additional dam on the Olifants River,

The historical firm yield of Massingir Dam was determined for different upstream developments and ecological water requirements. The base scenario assumed the following:

- Tzaneen Dam unraised and operated according to the current day rules at above its firm yield and supporting a release of 14.7 Mm^3/a from the downstream Nondweni Weir in the Groot Letaba River.

- The Olifants River system was operated according to the target drafts adopted in the Olifants River Water Resources Development Project (ORWRDP):
  - Flag Boshielo Dam raised 10 m and supplying a target draft of 80 Mm^3/a
  - De Hoop Dam constructed to 915 m and supplying 80 Mm^3
  - Massingir Dam was assumed to be raised by 10 m to RL125 m.

As the available streamflow records for the Olifants System only extend to September 1986, the historical firm yield was determined for the period from October 1926 to September 1986, instead of to September 2005.

Under present day conditions, the historical firm yield of Massingir Dam (assuming that the dam starts full in October 1926) is 575 Mm^3/a. If Nwamitwa Dam was constructed (FSL of 479.5, Reserve requirements at EWR 3 met and 50% system losses), then the historical firm yield at Massingir Dam reduced to 573 Mm^3/a. If Tzaneen Dam is raised by 3 m, then the historical firm yield of Massingir Dam reduces to 572 Mm^3/a. This means that the EWR releases largely compensate for the impoundment of water during the critical period, even though the spillage from the system will decrease if Nwamitwa Dam is constructed.

Table 5.4 shows the impact of the upstream developments on the yields at Massingir Dam. The 1 in 50 year yields decrease from about 628 (Scenario 1) down to 617 Mm^3/a when Nwamitwa Dam is constructed upstream (Scenario 7). Constructing Rooipoort on the Olifants has a larger impact and reduces the yield to about 585 Mm^3/a.

Table 5.4 Impacts of upstream developments on the yield of the Massingir Dam

Scenarios		HFY	Yields for different recurrence intervals				
			10	20	50	100	200
1	Present day	575	794	718	621	557	501
2	Reduce supply to irrigators to supply "optimised" EWR baseflows	580	794	723	628	561	504
3	Raise Tzaneen with present day compensation releases	574	794	717	623	557	502
4	Nwamitwa (FSL 473.5m) with preliminary reserve downstream at Site 3	574	785	719	623	560	502
5	Nwamitwa (FSL 477.5m) with preliminary reserve downstream at Site 3	573	776	714	622	557	500
6	Nwamitwa (FSL 479.5m) with preliminary reserve downstream at Site 3	573	767	714	621	557	501
7	Raise Tzaneen (+3m) plus Nwamitwa (FSL 479.5m) with preliminary reserve downstream at Site 3	572	766	713	618	557	499
8	Raise Tzaneen (+3m) plus Nwamitwa (FSL 479.5m) with preliminary reserve downstream at Site 3 Rooipoort (RL734)	500	745	662	585	518	469

5.6 FILLING TIMES

The "filling" time of Nwamitwa Dam was determined assuming that Nwamitwa Dam is constructed without additional demands being placed on the dam. Even without additional requirements the dam does not remain full, as its full supply area is 25 km^2 and the evaporation from that surface is of the same order of magnitude as the system yield. When the storage of the system with Nwamitwa Dam exceeded the other system by a volume equal to the capacity of Nwamitwa then it was assumed that Nwamitwa had been filled, even if the difference diminished thereafter. **Figure 5.1** shows that there is a 50% chance that the dam will "fill" within about 4 years and an 80 % chance that it will "fill" within 8 years.

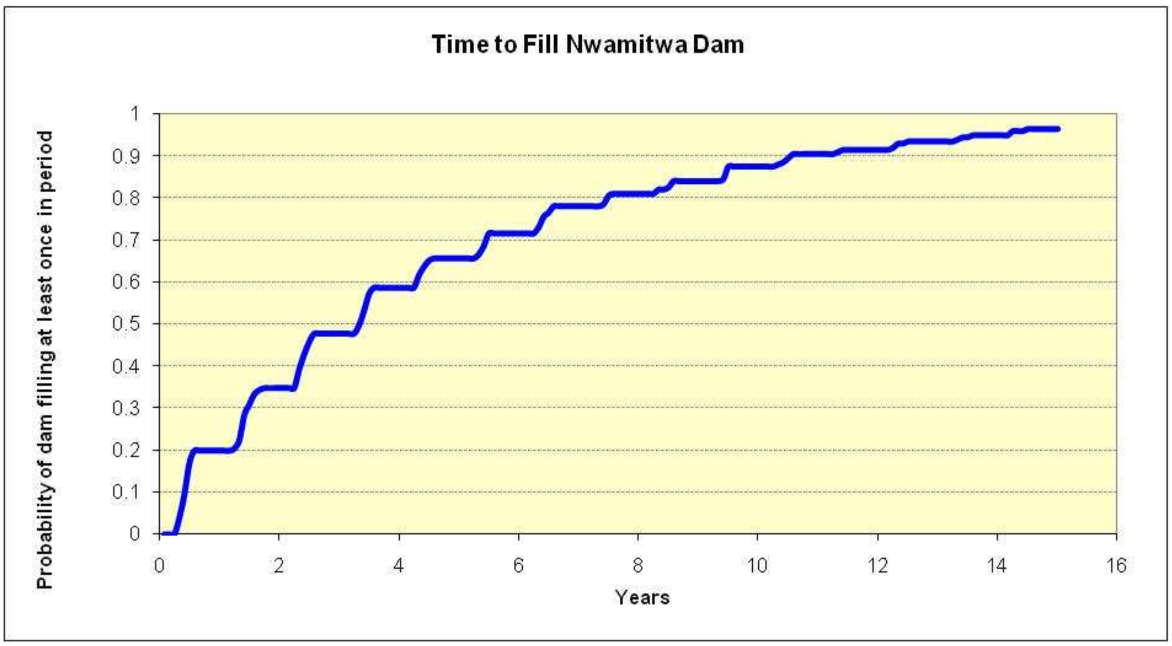


Figure 5.1 Filling time of the proposed Nwamitwa Dam

5.7 OPERATING RULES

It is important that Nwamitwa Dam and Tzaneen Dam are operated conjunctively to maximise the yield. Nwamitwa Dam should be drawn down first, primarily to minimise evaporation, as the Nwamitwa Dam has a larger surface area for a given storage volume than the Tzaneen Dam and a higher evaporation rate. Under this operating rule the average net evaporation from the Nwamitwa Dam is about 9 Mm^3/a. Were Nwamitwa Dam maintained at its full supply level the net evaporation would exceed 20 Mm^3/a. A secondary benefit of drawing down the Nwamitwa Dam first, is that this also maximises the storage available to intercept floods from the Letsitele River and Tzaneen Dam.

One of the challenges of operating the Nwamitwa and Tzaneen Dams as a system is the equitable distribution of water between two user groups with very different reliability requirements. On the one hand the domestic and industrial consumers require a high reliability of water supply, whereas the irrigators have adapted to a lower reliability of supply. The allocation to the urban consumers must be based on the additional yield from the Nwamitwa Dam to ensure that the irrigators continue to receive the same water at the same reliability. The supply to the irrigators must be curtailed in time to assure the domestic consumers, a sufficiently reliable source. This curtailment of the irrigators and, and in more extreme cases, the domestic consumers would be based on the combined total storage in the Tzaneen and Nwamitwa Dams through the year. If the Hans Merensky and Magoebaskloof Dams are under-utilised then the storage in these dams could also be considered. Unless all stakeholders understand the operating rule there could be conflicts when the irrigators are curtailed and there is still a fair amount of water available in the Tzaneen Dam.

Theoretically it could be possible to keep track of the additional water accruing in the Nwamitwa Dam that would not have been usable by the current irrigators. In this way Nwamitwa would be treated as a separate dam storing water for the domestic consumers. The disadvantage of this approach is that the evaporation from the system would increase.

5.8 EBENEZER AND DAP NAUDE DAMS

The incremental increases in the firm yield of the Ebenezer/Tzaneen system from raising Ebenezer by 5 and 10 meters were 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa was constructed first, then the incremental firm yield from raising Ebenezer reduces from 4.5 to 3.9 Mm^3/a.

The potential increase from raising the Dap Naude Dam will be significantly less and was not evaluated.

6. PRELIMINARY DESIGN OF NWAMITWA DAM

6.1 BACKGROUND

The feasibility study of the development and management options in the Groot Letaba River which was completed in 1998, proposed the construction of a dam at Nwamitwa and the possible raising of Tzaneen Dam as options for augmenting water supply from the Groot Letaba River. Approximately 10 years had passed since the Feasibility Study was completed. DWA decided to embark on Bridging Studies to update the information and to re-assess the recommendations contained in the Feasibility Study.

A key component of the development proposals of the Groot Letaba River is the construction of the Nwamitwa Dam at the confluence of the Groot Letaba and Nwanedzi Rivers. The principal components of the Nwamitwa Dam are: -

- a clay core earthfill embankment
- RCC spillway and stilling basin
- outlet works
- relocation of roads in the dam basin
- bridges in dam basin

6.2 DESIGN CRITERIA

A Design Criteria Memorandum Report was drafted as part of this Bridging Study which sets out the basis upon which the **feasibility design** of these components will be undertaken. The valley shape factor for the Nwamitwa Dam site is in excess of 50, which is a clear indication that the most appropriate dam type would be an embankment type dam. Further dam type selection was therefore not undertaken, as a greater emphasis was placed on the selection of the spillway type.

6.3 SPILLWAY TYPE SELECTION

The following four types of spillways were investigated for the proposed Nwamitwa Dam:

- Straight ogee spillway
- Trough spillway
- Labyrinth spillway
- Side channel spillway

Due to technical constraints, the side channel spillway option was discarded as a viable option. The length of the proposed spillway would be almost double that of the largest side channel spillway constructed to date. Preliminary designs and associated cost estimates were undertaken for the remaining three options. The costs of the proposed Nwamitwa Dam for the three alternative spillway arrangements are given in **Table 6.1** . *Please note that these cost estimates are comparative cost estimates (May 2008), and were based on preliminary spillway sizes and road relocation costs. Updated cost estimates are contained in **Table 6.5** of this report.*

Table 6.1 Cost of alternative spillway arrangements

Type of Spillway	Cost of proposed Nwamitwa Dam
Straight ogee spillway	R 777 million
Trough spillway	R 1 160 million
Labyrinth spillway	R 857 million

It was therefore recommended that the straight ogee spillway be implemented in the preliminary design of Nwamitwa Dam. For a detailed description, layout drawings and costing, please refer to Appendix D1 (*Spillway Type Selection Report*) of the report entitled *Preliminary Design of Nwamitwa Dam*.

6.4 GEOTECHNICAL INVESTIGATIONS

A number of engineering geological studies were undertaken prior to the current Bridging Study. These are listed below:

- A **reconnaissance-level appraisal** of the proposed dam site, then known as the Janetsi site was conducted initially.
- **Feasibility-level engineering geological investigations** were conducted in 1996 during which a total of seventeen rotary core boreholes were drilled, at two possible centre-lines. Investigations shifted to the upstream centre-line after initial boreholes at the downstream site revealed unfavourable conditions.
- A **materials investigation** was conducted by the DWA Materials Laboratory in 1996.

As part of this study, the following further geotechnical studies were undertaken:

- Desk study of available geological information,
- Field mapping,

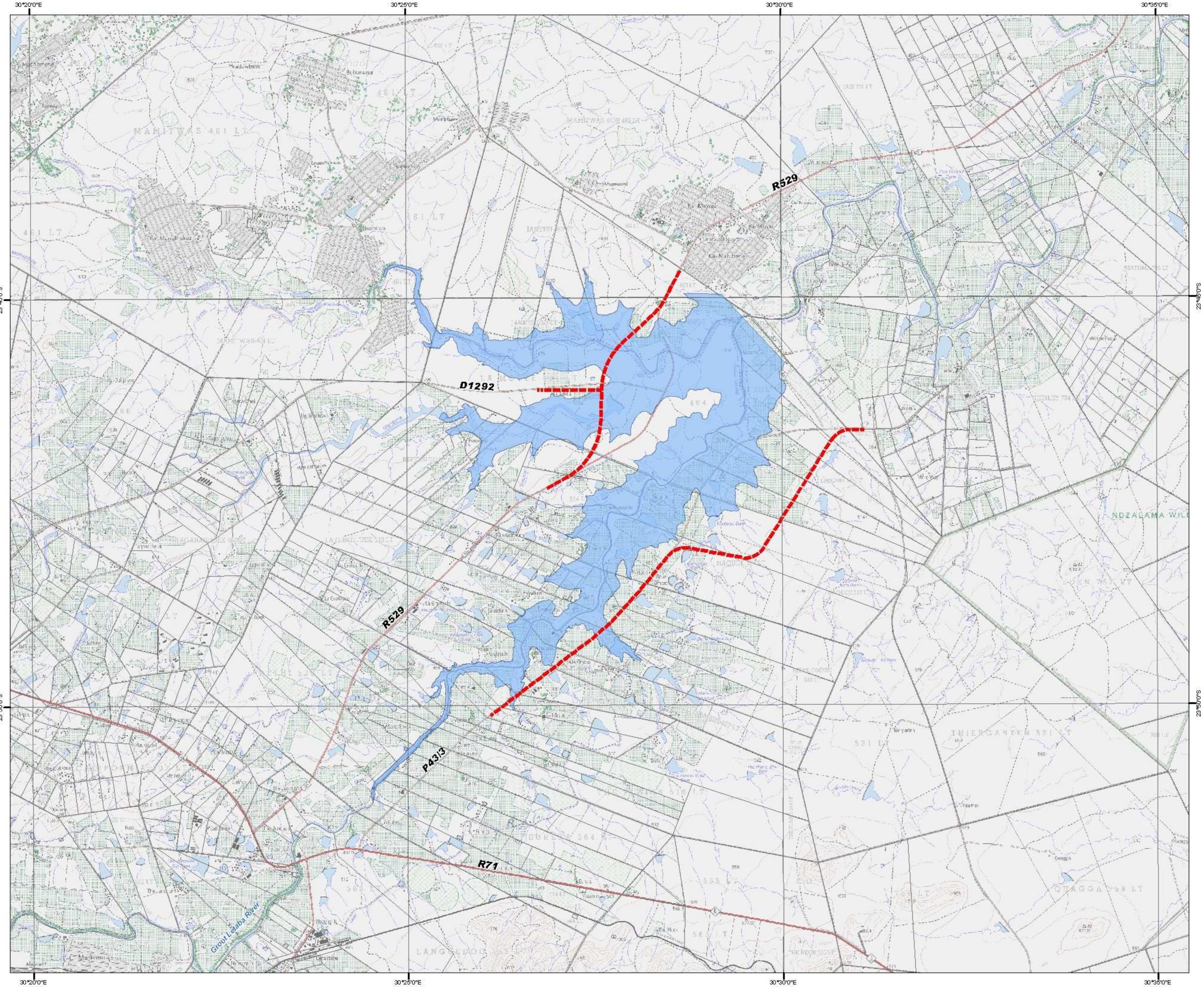
- Geophysical surveys,
- Additional rotary core drilling,
- Test pitting,
- Water pressure (Lugeon) testing and measurement of the water table,
- Laboratory testing, and
- Seismic hazard assessment.

The location of the proposed Nwamitwa Dam is underlain by Mesoaechean granitoid gneisses, specifically the Groot Letaba Gneiss (previously Goudplaats Gneiss) which has been intruded by younger diabase dykes. No major faults occur in the vicinity of the dam but a number of lineaments are present. The level of seismic hazard may be described as moderate. At the dam site, shallow colluvial soils cover the left flank while the right flank is partly covered by reworked alluvial gravels and the remainder by colluvial sands; underlain by thin residual soils. Thick alluvial deposits occur within the river section. The granite bedrock generally occurs at shallow depth on the left flank but is deeply and variably weathered. On the right flank the bedrock is generally moderately or highly weathered. Within the river section the underlying bedrock is generally unweathered.

The results of the above investigations are detailed in Annexures 2 and 3 (Appendix B: Geotechnical Investigations) of the report entitled "Technical Study Module: Preliminary Design of Nwamitwa Dam: Volume 6", *(DWA,2010g, and h).*

6.5 DESIGN CONSIDERATIONS

The locality plan of the proposed Nwamitwa Dam is shown in **Figure 6.1**. Whilst the design considerations are described in detail in the report entitled "Technical Study Module: Preliminary Design of Nwamitwa Dam: Volume 6" (DWA, 2010e) a summary of the key considerations is provided below.



OVERVIEW MAP :

Study Area

LEGEND

Final Proposed Road Route

Proposed Nwamitwa Dam FSL 479.5 masl

Farm Boundaries

PATH :
s:/projects/H401775/mxd/Reports/Main_Report/fig61.mxd

SCALE :
0 1 2 3 Km
1:80,000

PROJECTION INFORMATION :

COORDINATE SYSTEM :	Transverse Mercator
PROJECTION NAME :	TM31
DATUM :	D_WGS_1984
SPHEROID :	WGS_1984
CENTRAL MERIDIAN :	31

CONSULTANT :

aurecon

CLIENT :

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLES :

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

LOCALITY PLAN

FIGURE NO. :

6.1

6.5.1 Spillway Design Floods and Freeboard

The following flood peaks were selected to size the spillway:

- Recommended Design Flood (RDF) (1:200 year RI) 1 860 m^3/s
- Safety Evaluation Flood (SEF) ($RMF_{+\Delta}$) 6 800 m^3/s

The required freeboard above the FSL of the dam was determined in accordance with the publication *"Interim Guidelines on Freeboard for Dams"* (SANCOLD, 1990). In order to allow for the SEF to go over the spillway, a freeboard of 6.5 m is required.

6.5.2 River Diversion

In addition to the spillway design floods, 10 year, 20 year and 50 year return interval (RI) flood hydrographs for a range of durations were estimated at the proposed Nwamitwa Dam site. The river diversion floods were calculated to be between 1 500 and 2 500 m^3/s depending on the chosen recurrence interval. Due to the significant size of these floods, it is proposed that the floods be scaled down as described below.

As the Tzaneen Dam does not frequently overflow, it is considered reasonable to assume that floods with low recurrence intervals that are generated in the catchment area upstream of Tzaneen Dam would be partially absorbed by Tzaneen Dam.

This implies that low recurrence interval river diversion floods at Nwamitwa Dam would mainly be generated from the incremental catchment downstream of Tzaneen Dam. As this phenomenon would be reflected in the peak flow record at Gauge B8H009, the flood frequency analysis at this gauge implicitly already accounts for this absorption. Based on this assumption, the calculated 1:10 year flood peak at Gauge B8H009 has scaled up based on the ratio of the square not of the incremental catchment downstream of Tzaneen. Dam (1294 km^2) to the incremental gauge catchment downstream of Tzaneen Dam (201 km^2). For the 1:50 year recurrence intervals flood peaks, it was assumed that although some flood absorption might occur in Tzaneen dam, some spilling might also occur. For this flood event, the calculated flood peak at Gauge B8H009 was adjusted based on the full catchment areas at Nwamitwa Dam and at the gauge respectively, ie $\sqrt{1944}$ / $\sqrt{851}$. For the 1:20 year peak, both methods were applied and the average value was then calculated.

The scaled river diversion floods at Nwamitwa Dam therefore results in the following figures:

- 1:10 yr 1 000 m^3/s
- 1:20 yr 1 450 m^3/s
- 1:50 yr 2 100 m^3/s

The Design Criteria Memorandum (DCM) calls for river diversion floods with a 1 in 20 year RI for a composite dam consisting of both concrete and earth fill sections and with a 1 in 50 year RI for an earth fill embankment. The first stage river diversion must protect the spillway foundation construction works, and the diversion works were therefore sized to handle a 1 in 20 year flood of 1 450 m^3/s. The second stage river diversion is required to protect the earth embankment during construction and has been designed to accommodate the 1 in 50 year flood of 2 100 m^3/s. It is recommended that the second stage of the river diversion strategy commence at the onset of the dry season in order to facilitate the installation of a diversion culvert 4 m wide by 3 m high with its invent at the river bed level of 454 masl in the middle of the spillway section. On the right hand side of the culvert a 60 m wide section of the spillway must be kept 3 m lower than the rest of the spillway for the duration of the spillway construction. The discharge capacity of the low section will be approximately 500 m^3/s, which will allow for the passing of floods during the dry season. The diversion culvert will keep the upstream water level at approximately the river bed level during normal dry season flow. As the dam is raised, the flood absorption capacity of its basin will increase. The 1 in 20 year flood volume will be absorbed when the embankment is at level 469 masl, and the 1 in 50 year flood volume when it is at level 470.4 masl.

6.5.3 Ogee Spillway

The ogee spillway would be constructed across the river channel, which would require significant widening to accommodate the 190 m long mass gravity RCC section. Tongue walls with a total length of 161 m would be provided on either side to accommodate the outlet works and to tie into the earth embankments.

For the most part the granite gneiss underlying the river section comprises unweathered, very hard rock, although upper, weathered horizons are present. The founding level below the spillway was based on the Rock Mass Rating (RMR) 40 level of approximately 442.5 masl. This will involve excavation depths of 10 m in the river section increasing to 16 m on the left bank and 27 m on the right bank respectively.

A nominal stilling basin / apron with a length of 16 m has been provided to protect the toe of the spillway as well as to provide a stilling basin for the river releases from the outlet works.

6.5.4 Outlet Works

The outlet works need to fulfil the following duties:

- Release the active storage capacity in accordance with the demand curve
- Release the environmental water requirements (EWR)
- Empty the dam during emergency drawdown conditions

The outlet pipework was based on the EWR as set out in the Preliminary Reserve Determination Study Scenario 7 at Site 3 (DWAF, 2006). The recommended Class II flood release category at EWR Site 3 at Prieska calls for discharge capacities of 12 to 18 m^3/s. As it is common practice to allow for 100% redundancy in the outlet pipework for operational flow releases, two pipe stacks were provided. Due to the infrequent nature and short duration of the EWR, it is considered prudent from a cost point of view to use both pipe stacks to release the EWR. Each pipe stack was therefore sized to discharge 9 m^3/s.

The outlet works will consist of two DN 1 200 mm pipe stacks. The intakes to the pipe stacks will be staggered at 4.5 m intervals to allow for flexibility in selecting the most appropriate abstraction level. The maximum flow velocity during drawdown conditions will be 9 m/s. The two DN 1000 mm sleeve valves on the downstream side will be able to discharge 21 m^3/s with the water level in the dam at FSL.

The outlet pipework will be housed in an integral outlet block on the left hand side of the spillway. It will be equipped with precast concrete trash racks, stainless steel fine screens and a maintenance gate to close off the intakes to the pipe stacks.

6.5.5 Water Quality

A water quality analysis of the proposed Nwamitwa Dam was undertaken to inform the design of the outlet structure of the dam, as well as the mitigating effects of installing a multi-level outlet structure. A detailed Water Quality Report is contained in the report entitled *Preliminary Design of Nwamitwa Dam*. Based on the analysis undertaken the following conclusions could be drawn:

- Oxygen depletion (to anoxic levels) of the hypolimnion can be expected during a large proportion of the year, only to be re-oxygenated by cooler, oxygen-rich inflows that can plunge into this zone.

- Limited mitigation of in-lake de-oxygenation is provided by the multi level outlet structure and this concern would have to be addressed in an alternative approach, possibly looking at other engineering solutions.

The Water Quality Report recommended that a multi-level outlet structure should be considered as it provides more flexibility in mixing water from different levels in the dam and provides an increased probability of meeting the downstream water quality requirements.

6.5.6 Sedimentation

A review of the expected sedimentation rates at the proposed Nwamitwa Dam site was undertaken. Three alternative methods were used to determine sediment yields. The method used and associated sediment yields are contained in **Table 6.2**.

Table 6.2 Sediment Yields

Method	Sediment yield ($t/km^2/a$)
Review of findings of previous studies	280 $t/km^2/a$
Analysis of sediment yields of existing dams on the Groot Letaba and other rivers in the region	245 to 293 $t/km^2/a$
Analysis of sediment yields based on suspended sediment data observed on the Groot Letaba River	278 $t/km^2/a$ at Letaba Ranch

The future land use could affect the sediment yield. The current land use consists mainly of forestry, irrigated commercial farming, urban areas and subsistence farming. The catchment area of the Nwamitwa Dam falls in the high and medium soil erosivity regions of the Rooseboom (1992) method. If due to future land degradation the medium region changes to high erosivity, the maximum possible sediment yield would be 350 $t/km^2/a$ based on a 95 percentile assurance.

Based on the Brune (1953) sediment trapping efficiency relationship, it was assumed the proposed reservoir would trap 100% of the incoming sediment load. The sediment density of deposited sediment was assumed to be 1.35 t/m^3 after a 50 year period. An effective catchment area of 1 352 km^2 downstream of the Tzaneen Dam was used for

Nwamitwa Dam. Based on the abovementioned assumptions, the anticipated sediment volume after 50 years is estimated to be 17.53 million m^3.

6.6 RE-ALIGNMENT OF ROADS

A number of existing provincial roads are affected by the proposed dam. Possible routes for the re-alignment of these roads were investigated and preliminary costs determined before a decision was made regarding the route alignments that were selected for the preliminary design stage.

The proposed re-alignment of the various routes was discussed with the landowners and the Roads Agency Limpopo (RAL) before a preliminary design of the proposed re-alignments commenced. Some adjustments were made to the re-alignment of route P43-3 after further consultation with some of the affected land owners. Concerns expressed by the land owner which were submitted after the completion of the preliminary design of the roads should to be addressed during the detailed design phase of the project.

The plan view of the proposed re-alignment of Road 529 and of Road P43-3 is shown in **Figure 6.1** and described in more detail below.

6.6.1 Affected Roads

Road R529

This road follows a north/south alignment to the west of the Groot Letaba River. The road is affected over a length of approximately 6.1 km and 5 (five) alternative re-alignments were investigated before the preliminary design commenced. The alignment that follows the existing road as far as possible was selected by RAL as the most suited re-alignment. This alignment is also the shortest option and would have the least impact in the long term on the road users in terms of travel time and running costs. The road crosses the proposed dam basin between km 1.6 and km 4.6, a section of approximately 3.0 km. The road will be constructed on an earthfill embankment with rock protection (rip-rap) where it crosses the dam basin to protect the fill against wave action. Two bridges are planned where the road crosses the Hlangana and Nwanedzi Rivers. A short section of road D1292 (approximately 1.4 km long) will have to be re-aligned to join into road R529 at km 2.79.

Road P43-3

Road P43-3 follows a north/south alignment along the eastern side of the Groot Letaba River. The road is affected by the proposed dam where it crosses a number of small tributaries. The existing road has to be raised to the NOC (non-overspill crest) level where it crosses these tributaries. A section of 1.1 km of the existing road must be raised over three sections along the current horizontal alignment. The road was re-aligned horizontally from km 5.5 from where it crosses a number of small farms in conjunction with the landowners to minimise the impact it will have on their farming operations.

The re-aligned road follows a fairly flat topography with no major cuts or fills, and crosses a number of small streams where culverts are necessary.

The positions of access to the various properties have been agreed with the landowners including positions for services ducts to install future pipes for the landowner's uses.

6.6.2 Bridges

The re-aligned Road R529 crosses the Hlangana and Nwanedzi Rivers at km 2.15 and km 3.76 respectively where major bridges are required.

The total road width is 12.4 m, made up of 2 x 3.7 m lanes and 2 x 2.5 m shoulders. A total bridge width of 13.35 m is therefore required.

The road embankment is between 18 and 25 m high at these crossings, and will have side batters of 1V:3H, with 2 m wide terraces at 5 m vertical intervals. For road embankments of this order of height, and relative flatness of the side slopes, longer bridge structures with "spill-through" abutments are considerably more economical than the equivalent bridges with closed abutments. A spill-through type structure is proposed for both bridges, as the cost of the additional length of deck and piers is substantially less than the cost of the long and high walls that are required to retain the embankment. Both bridge structures have been configured to have an odd number of spans, in order that the main river channel is unobstructed by a central pier at low dam levels.

6.7 ALTERNATIVE DAM CAPACITIES INVESTIGATED

6.7.1 Alternative Dam Sizes Investigated

The following dam sizes were investigated:

Table 6.3 Selected Dam Sizes

Dam size	Capacity (Million m^3)	FSL (masl)	NOC (masl)
0.41 MAR*	66	473.5	480.0
0.85 MAR*	137	477.5	484.0
1.16 MAR*	187	479.5	486.0
1.50 MAR*	241	481.5	488.0

* Based on natural incremental MAR between Tzaneen and Nwamitwa Dams = 160.9 Mm^3

6.7.2 Expropriation Costs

The expropriation costs up to the 1 in 100 year RI flood level were included in the overall cost of the dam. The expropriation line, which depicts the minimum land purchase requirements due to dam construction, was determined according to the *Policy and Guidelines for the Acquisition of Land Rights at Departmental Dams* (DWAF, 2001). This document defines the expropriation line as the minimum of 1.5 m vertically above the 1:100 year flood line or at least 15 m horizontally outside the 1:100 year flood line, whichever results in the greater horizontal distance. The 1:100 year flood line baseline information, which is needed for developing the expropriation line, was determined through backwater analysis of the system of rivers flowing into Nwamitwa Dam with the aid of an unsteady HEC-RAS (version 4.0) model. The preliminary expropriation line is shown in **Figure 6.2**.

The expropriation costs for the alternative dam sizes considered are given in **Table 6.4** below.

Table 6.4 Expropriation Costs for Alternative Dam Sizes

Dam size (Factor of MAR)	FSL (masl)	Expropriation Area (ha)	Expropriation costs (R million)
0.41	473.5	800	92
0.85	477.5	1600	137
1.16	479.5	2250	164
1.50	481.5	2900	212

6.7.3 Dam Costs

Construction cost estimates were prepared for the four dam sizes that were used for the dam size optimisation. The costing of the various dam capacities was based on an earthfill embankment dam with a 190 m long central ogee spillway, being sufficient to discharge the RMF.

The cost estimates allow for the relocation of services (roads, electricity and telecommunications), contingencies, planning, design and supervision costs and expropriations costs.

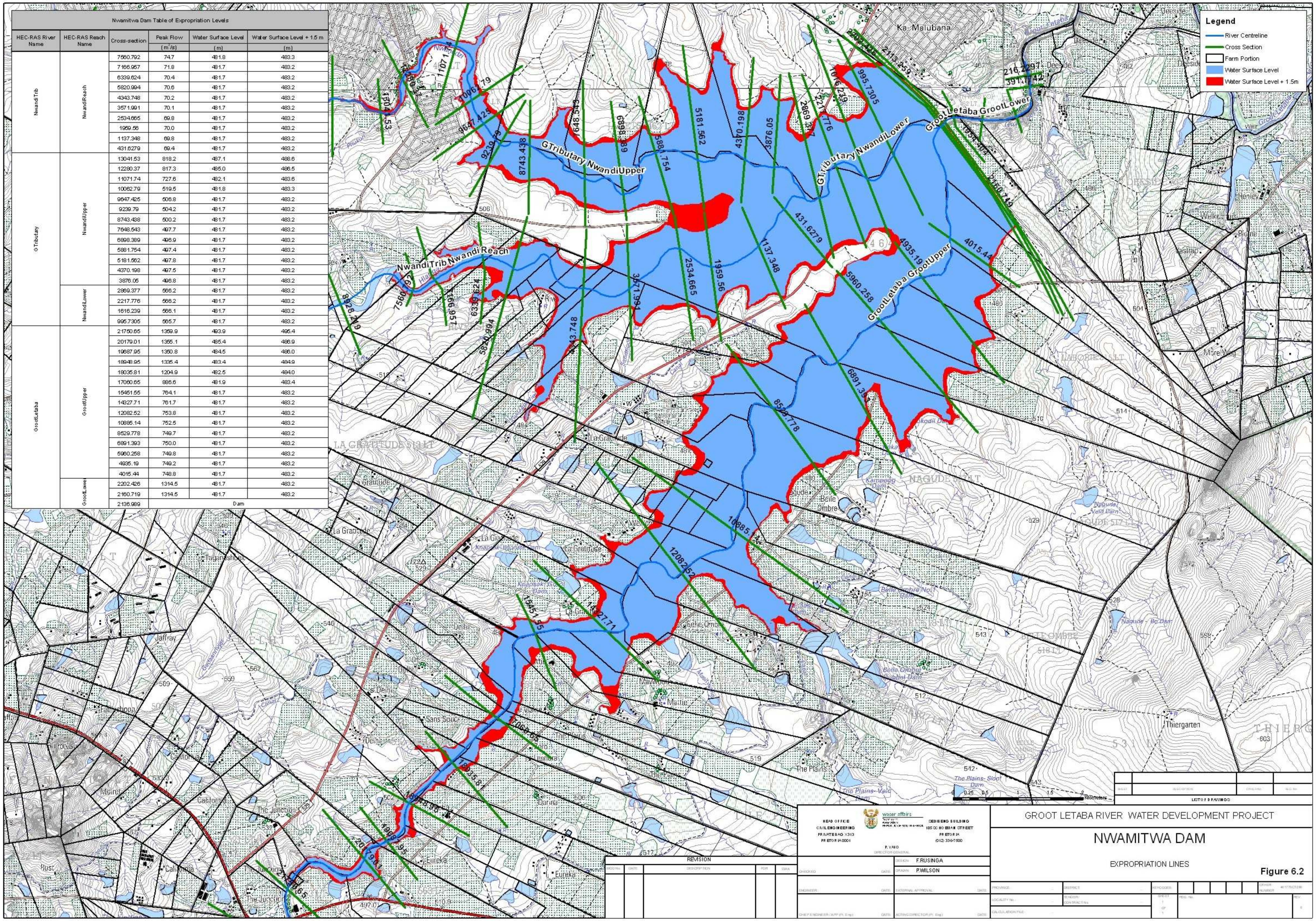
The cost estimates are summarised in **Table 6.5**.

Table 6.5 Optimisation of Dam Sizes

Dam size (factor of MAR*)	Dam capacity (Mm^3)	Full Supply Level (masl)	Total Project Cost (R million) exc. VAT	Yield (Mm^3/a)	Unit Cost ($R/m^3/a$)
					Dam construction and land costs
0.41	66	473.50	989	4	247
0.85	137	477.50	1 180	9	131
1.16	187	479.50	1 285	14	91
1.50	241	481.50	1 409	17	82

* *Natural incremental MAR between Tzaneen and Nwamitwa Dams = 160.9 Mm^3/a*

Nwamitwa Dam Table of Expropriation Levels					
HEC-RAS River Name	HEC-RAS Reach Name	Cross-section	Peak Flow (m^3/s)	Water Surface Level (m)	Water Surface Level + 1.5 m (m)
NwandiTrib	NwandiReach	7560.792	74.7	481.8	483.3
		7166.957	71.8	481.7	483.2
		6339.624	70.4	481.7	483.2
		5820.994	70.6	481.7	483.2
		4343.748	70.2	481.7	483.2
		3571.991	70.1	481.7	483.2
		2534.665	69.8	481.7	483.2
		1959.56	70.0	481.7	483.2
		1137.348	69.8	481.7	483.2
		431.6279	69.4	481.7	483.2
GTributary	NwandiUpper	13041.53	818.2	487.1	488.6
		12280.37	817.3	485.0	486.5
		11071.74	727.6	482.1	483.6
		10062.79	519.5	481.8	483.3
		9647.425	506.8	481.7	483.2
		9239.79	504.2	481.7	483.2
		8743.438	500.2	481.7	483.2
		7648.543	497.7	481.7	483.2
		6898.389	496.9	481.7	483.2
		5881.754	497.4	481.7	483.2
		5181.562	497.8	481.7	483.2
		4370.198	497.5	481.7	483.2
		3876.05	496.8	481.7	483.2
	NwandiLower	2869.377	566.2	481.7	483.2
		2217.776	566.2	481.7	483.2
		1616.239	566.1	481.7	483.2
		995.7305	565.7	481.7	483.2
GrootLetaba	GrootUpper	21750.65	1359.9	493.9	495.4
		20179.01	1355.1	485.4	486.9
		19687.95	1350.8	484.5	486.0
		18948.95	1335.4	483.4	484.9
		18035.81	1204.9	482.5	484.0
		17060.65	886.6	481.9	483.4
		15451.55	764.1	481.7	483.2
		14327.71	761.7	481.7	483.2
		12082.52	753.8	481.7	483.2
		10885.14	752.5	481.7	483.2
		8529.778	749.7	481.7	483.2
		6891.393	750.0	481.7	483.2
		5960.258	749.8	481.7	483.2
		4935.19	749.2	481.7	483.2
		4015.44	748.8	481.7	483.2
	GrootLower	2202.426	1314.5	481.7	483.2
		2160.719	1314.5	481.7	483.2
		2136.989	Dam		



LIST OF DRAWINGS

HEAD OFFICE
CIVIL ENGINEERING
PRIVATE BAG X313
PRETORIA 0001

water affairs

SEDIBENG BUILDING
185 SCHOEMAN STREET
PRETORIA
(012) 336-7500

P. YAKO
DIRECTOR GENERAL

DESIGN F.RUSINGA
DRAWN P.WILSON

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

NWAMITWA DAM

EXPROPRIATION LINES

Figure 6.2

Figure 6.3 shows the relationship between the unit cost of alternative dam sizes and the increase in historical firm yield from the system derived from each dam capacity. Whilst the analysis did not point to "one" optimum size, a dam with a FSL of 479.5 m and a historical firm yield of 14 Mm^3/a was taken forward in the preliminary design. This size will ensure that sufficient yield is obtained in order to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, limit expropriation costs and limit the amount of evaporation from the proposed dam.

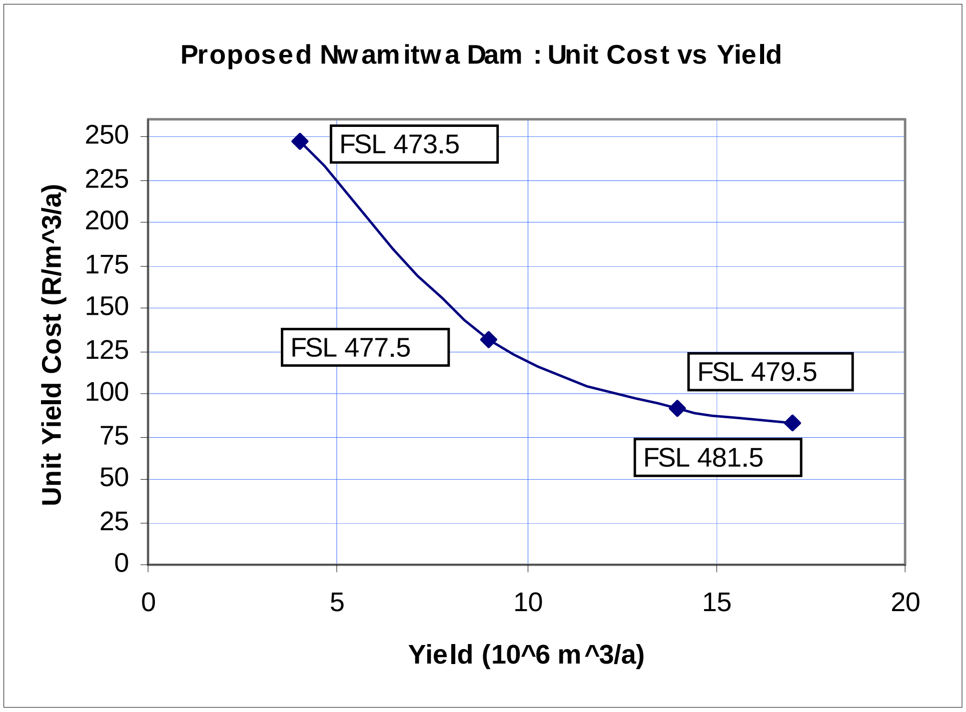


Figure 6.3 **Nwamitwa Dam: Unit Cost vs Yield Curve**

6.8 SUMMARY OF DETAILS OF THE PROPOSED NWAMITWA DAM

The principal details of the proposed Nwamitwa Dam are summarised in **Table 6.6** below.

Table 6.6 Principal Details of Proposed Nwamitwa Dam

Classification		
Size	Large	
Hazard potential	High	
Classification	III	
Site		
Location	23º44' 40" S 30º30' 11" E	
Catchment area including Tzaneen Dam	1944	km^2
Mean Annual Runoff (MAR)	161 x 10^6	m^3
Probable Maximum Flood (PMF)	16 864	m^3/s
Regional Maximum Flood (RMF) (K value 5.2)	5 495	m^3/s
Regional Maximum Flood ($RMF_{+\Delta}$) (K value 5.4)	6 807	m^3/s
1:200 year RI peak inflow	3 580	m^3/s
1:100 year RI peak inflow	3 032	m^3/s
1:20 year RI peak inflow	1 903	m^3/s
Estimated average annual sediment load	350 000	m^3
Full supply level (FSL)	479.5	masl
Gross storage capacity at FSL	187 x 10^6	m^3
Surface area of water at FSL	2 700	ha
Firm yield	14 x 10^6	Mm^3/a
Recommended Design Flood (RDF) = 1:200 year RI routed flood peak	1 860	m^3/s
Safety Evaluation Flood (SEF) = Unrouted $RMF_{+\Delta}$	6 800	m^3/s
Dam Embankment		
Type of embankment	Earthfill	
Maximum height of embankment (above river bed level at d/s toe)	34	m
Embankment crest length (including spillway)	3 500	m
Base width of embankment at maximum cross section	126	m
Crest width of embankment	10	m
Non Overspill Crest elevation (excluding settlement allowance)	986.0	masl
Upstream slope	1V : 3H	m/m
Downstream slope	1V : 2H	m/m
Total embankment volume above original ground level	1 430 000	m^3
River Diversion		
Channel width	30	m
Discharge capacity	1 100	m^3/s

Spillway		
Type	Ogee	
Crest length	190	m
Crest level	479.5	masl
Total freeboard	6.5	m
Design discharge	6 800	m^3/s
Elevation at design discharge	486.0	masl
Energy dissipation	Stilling basin 16m long	
Total concrete volume (including outlet works)	263 000	m^3
Outlet Works		
Pipe stacks	DN1200 x 2	mm
Upstream isolating valves	DN1200 butterfly x 5	mm
Downstream isolating valves	DN1200 butterfly x 2	mm

7. RAISING OF TZANEEN DAM

7.1 BACKGROUND

The raising of Tzaneen Dam remains a cost effective way to both create additional storage in the Letaba System as well as to provide additional yield to the system. The previous study on the raising of Tzaneen Dam (BKS, 1998) identified the following options for the raising of Tzaneen Dam.

- Hydroplus Fuse Gates
- Fishbelly Flap Gates
- TOPS Gates

The latter two gates are both of an all-steel construction with a significant number of moving parts, which will require ongoing maintenance and inspections. With the present skills shortage in South Africa it is not recommended that such a system be implemented.

This Bridging Study also focussed on three alternative ways to raise Tzaneen Dam. The following alternatives were considered:

- Hydroplus Fuse gates
- Labyrinth Spillway
- Side Channel Spillway

The comparison was made for a 3 m raising of the FSL to a level of 726.9 masl. The amount by which the full supply level and non overspill crest can be raised is limited by the soft levels of the Sybrand and Marietjie van Niekerk bridges and the fact that additional land may have been acquired for the dam basin and surrounding buffer strip. There is very little difference in the incremental system yield if Tzaneen Dam were raised by 3 or 4 m. It is therefore most likely that the ultimate raising height will be governed by the factors mentioned above.

7.2 PRINCIPAL DETAILS

Tzaneen Dam was completed in 1977. It comprises a mass concrete gravity spillway section flanked by earthfill embankments. The spillway is an uncontrolled ogee type

91.44 m long with a crest level of 723.90 masl. The NOC is 1 063.5 m long with a crest level of 730.60 masl. Both upstream and downstream faces of the earth embankments are protected by interlocking concrete blocks.

The gross storage capacity of the dam is 157.3 Mm^3 (DWAF, 1999). This would be increased to 193 Mm^3 with a 3 m raising of the FSL. The firm yield from the dam would be increased from 60 to 64 Mm^3/a.

7.3 FLOOD HYDROLOGY

The flood hydrology for the raised Tzaneen Dam was investigated as part of the Preliminary Design Report for the proposed Nwamitwa Dam. The Tzaneen Dam is a large dam (>30 m high) with a high hazard potential (due to extensive downstream developments) and has been classified as a Category III dam in terms of the Dam Safety Regulations. As the proposed raising of the dam would constitute a new design, it was considered "necessary to perform hydrological calculations appropriate to the site" for a Category III dam in accordance with Sub-Clause 3.4.2 of the SANCOLD Guidelines (SANCOLD, 1991).

The SANCOLD Guidelines and the ICOLD Bulletin 59 specifically mention the use of the PMF method in designing spillways for large dams with a significant or high hazard rating, as in the case of Nwamitwa Dam. However, in the case of the PMF approach being followed, the SANCOLD Guidelines also recommend upper limits of 6.0 and 2.0, respectively, to the PMF equivalent K-value and the PMF/RMF ratio. In the case of Nwamitwa Dam, these upper limits are exceeded: The equivalent PMF K-value is 6.2, while the PMF/RMF ratio is in the order of 3.0. Therefore, taking cognisance of the HRU 1/72-based PMF-related concerns expressed in the findings of the Water Research Commission (WRC) Study on Extreme Design Floods, the use of a SEF lower than the PMF-routed values determined during this study, but higher than the RMF (unrouted), is recommended as an alternative to the HRU 1/72-based PMF.

The 1 in 100 year and 1 in 200 year flood peaks (in accordance with the HRU 1/72 regional unit hydrograph method) were obtained by routing the respective hydrographs through the Tzaneen Dam reservoir with a 3 m raising of the FSL in place.

The following spillway floods were selected to size the raised spillway:

- 1 in 100 year RI flood 1 170 m^3/s
- Recommended Design Flood (RDF) (1:200 year RI) 1 360 m^3/s
- Safety Evaluation Flood (SEF) (RMF+Δ) (Region 5.4) 4 120 m^3/s

The SEF resembles an unrouted flood peak. In order to generate an incoming hydrograph for the Hydroplus option, the Probable Maximum Flood (PMF) hydrograph producing the highest outgoing flood peak of 4 700 m^3/s was scaled down in the ratio 4 120/4 700.

7.4 OPTIONS FOR RAISING OF TZANEEN DAM

The section below discusses the characteristics of the three alternative ways for the raising of Tzaneen Dam.

7.4.1 Hydroplus Fuse Gates

The fuse gate system consists of independent free standing blocks made in steel or concrete set on a flattened spillway weir and designed to tip-off during extreme flood events when the reservoir level reaches a predetermined elevation. The application of this system enables a progressive and controlled release of floods for exceptional flood conditions and ultimately prevents overtopping of the dam during the maximum design flood.

The Hydroplus proposal for the raising of Tzaneen Dam comprises the installation of ten 6.3 m high fuse gates on the spillway. The existing spillway crest level will be lowered by 3.3 m to form a platform which will carry the fuse gates. No tipping of any fuse gate will occur up to the RDF, an event which has only a 0.5% probability of occurrence in any specific year. The SEF will be passed over the spillway with the maximum water level at the present NOC of 730.6 masl. The details of the preliminary design proposal for Hydroplus fuse gates is contained in Appendix B of the Report entitled *Raising of Tzaneen Dam*.

A study has been carried out by W V Pitman, M D Watson and W D Hakin on behalf of DWA involving 30 river catchments in South Africa to assess the possible impact on the firm yield of a reservoir caused by the rotation of a fuse gate. The results indicated that the risk of fuse gate rotation impacting on the firm yield is extremely low, especially if the first tip is designed to occur for floods of 1 in 100 year recurrence interval or greater, and that the reinstatement period is only of a few month’s duration.

7.4.2 Labyrinth Spillway

A labyrinth spillway is an overflow spillway folded in plan view to provide a longer, total effective crest length for a given overall spillway width. The total length of the labyrinth weir is usually three to five times the spillway width, while its capacity varies with head, and is typically about twice that of a standard ogee crest of the same overall spillway width. Consequently, over the design head range, labyrinth weirs require considerably less spillway and discharge channel width.

A maintenance free option to raise the FSL of Tzaneen Dam would be to modify the top of the existing overflow structure to accommodate a labyrinth spillway. The preliminary layout comprises 8 cycles with 15º wall angles. The top 7.5 m of the existing structure would have to be demolished to accommodate the 2 m thick labyrinth base and 8.5 m high labyrinth walls, thereby raising the FSL by 3 m. The upstream apexes of the labyrinth would be cantilevered 2 m upstream of the existing structure to reduce the amount of overhang on the downstream side. On the downstream side, the existing structure would have to be widened by 3.7 m by placing mass concrete on the downstream face to support the downstream apexes. In order to accommodate the SEF a gravity wall 2.4 m high would have to be constructed over the full length of the non-overspill crest (NOC). The implications of a raised NOC are discussed further in Section 7.5. The RDF would be discharged over the labyrinth with the water level in the dam 1.6 m below the existing NOC.

The initial sizing of the labyrinth was based on research where water was discharged into a sub-critical downstream pool, thereby creating high downstream water levels and a consequent reduction in the discharge capacity of the labyrinth. If a labyrinth were to be constructed on top of the existing spillway structure, the outgoing water would be discharged freely. This could improve the overall discharge capacity of the labyrinth thereby reducing the height of the gravity wall. The potential higher discharge capacity would have to be confirmed by a hydraulic model study if the labyrinth option were to be ultimately selected for the final design.

The structural stability of the proposed labyrinth spillway was checked in accordance with the publications *Concrete Gravity Dams* and *Gravity Dam Structures* and was found to comply with all the required criteria.

7.4.3 Side Channel Spillway

The topography of the left abutment of the dam lends itself to the construction of a side channel spillway. As an alternative to the labyrinth spillway, a 3 m high fixed raising of the existing spillway was investigated supplemented by a 45 m long side channel spillway. A gravity wall 2.4 m high would still have to be constructed over the full length of the NOC.

In order to continue discharging the smaller floods over the ogee spillway, the overflow crest level of the side channel spillway was set 1.1 m higher than the raised FSL of the dam. The raised ogee spillway would be able to discharge 3 000 m^3/s, whilst the remainder of the SEF of 1 120 m^3/s would be discharged by the side channel spillway.

7.5 IMPACT OF RAISED NOC FOR THE LABYRINTH AND SIDE CHANNEL SPILLWAY OPTIONS

The raising of Tzaneen Dam with a labyrinth or side channel spillway would require a 2.4 m raising of the NOC. Expropriation information obtained from DWA for Tzaneen Dam indicates that the land around the dam has been expropriated up to the current NOC level of the dam (730.8 masl). A 3 m raising of the FSL to a level of 726.9 masl would therefore not involve any additional expropriation. This assumes that the new expropriation line would be determined in accordance with the criteria set out in Section 6.7.2 of this report.

On 9 April 2008 a site visit was conducted to gain a clearer perspective of what structures would be influenced by raising the FSL and what information would be required to fully assess the impact of the raising.

From the 1:50 000 topographical map 2330CC Tzaneen specific areas of interest were identified where a rise in water level could possibly influence and/or damage existing infrastructure. Of primary concern were the Sybrand and Marietjie van Niekerk Bridges.

Measurements at the Sybrand and Marietjie van Niekerk Bridges indicated that the soffit of the bridge deck is at a level of approximately 731.0 masl. The bridge deck itself is at a level of approximately 734.0 masl. The raised NOC of the dam would be at level 733.0 masl. The integrity of the two bridges during the SEF therefore requires a detailed study in the design phase.

None of the culverts or the other bridges identified would require significant improvement. The railway bridge runs parallel to the Van Niekerk bridges. Visual inspection indicated that the elevation of the railway bridge is much higher than the Van Niekerk bridges.

7.6 COST ESTIMATE

Hydroplus provided a cost estimate for the conceptual design and the detail design and construction stages of the fuse gates. An estimate for the demolition cost of the top section of the existing spillway in order to accommodate fuse gates was included in the cost estimate.

The detailed cost estimates of all three alternatives investigated is contained in the report *Raising of Tzaneen Dam*, and are summarised in **Table 7.1.**

Table 7.1 Cost estimates for the alternative methods of raising Tzaneen Dam

Method of Raising	Cost of Raising
Hydroplus fuse gates	R59 million
Labyrinth spillway	R42 million
Side channel spillway	R72 million

The cost estimates include P&Gs, contingencies, design and supervision costs, but exclude VAT.

7.7 COMPARISON OF OPTIONS

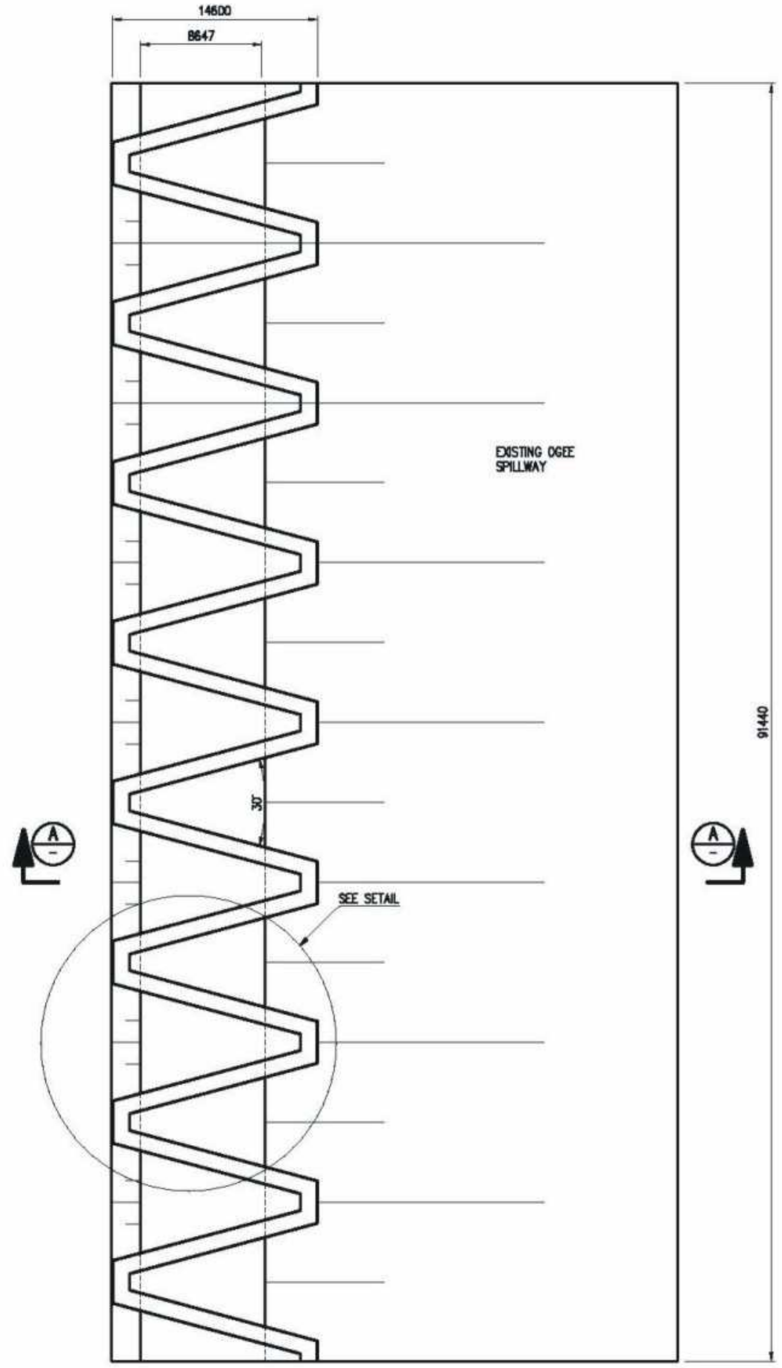
The side channel option whilst technically feasible, was discarded as an option based on cost. Both the labyrinth spillway and fuse gate options have a number of advantages and disadvantages which are set out in **Table 7.2**.

Table 7.2 Summary of Advantages and Disadvantages

Option	Advantages	Disadvantages
Labyrinth spillway	1) Potentially lowest cost solution 2) Minimum maintenance 3) Low risk	1) Potential impact on the integrity of the Sybrand and Marietjie van Niekerk bridges during very high flood conditions (flood peak in excess of 1:1 000 year RI) 2) NOC has to be raised by 2.4 m
Hydroplus fuse gates	1) Least construction impact on the dam wall itself 2) No impact on Sybrand and Marietjie van Niekerk bridges 2) NOC of dam wall does not have to be raised	1) Loss in storage if fuse gate topples (flood peak in excess of 1:200 year RI) 2) Potential loss in yield if a critical period follows directly after a 1: 200 year flood event - probability of occurrence regarded as very low, but nevertheless remains a risk 3) Replacement cost of the fuse gates should they topple 3) Long term maintenance costs associated with major maintenance

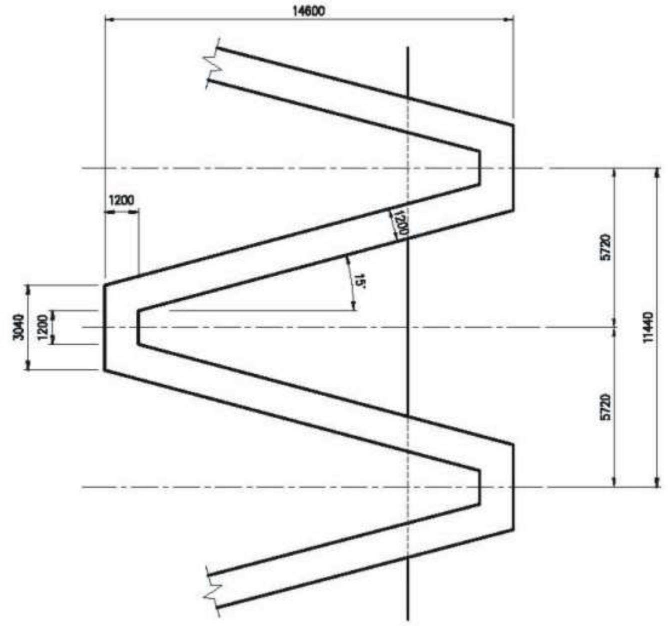
Both the labyrinth spillway and the Hydroplus fuse gate options are considered to be technically feasible. However, given the fact that the labyrinth spillway option is the most cost effective solution coupled with the fact that this option has very low maintenance costs, it is recommended that this method of raising be adopted. Should it be discovered during the detailed design phase that the potential impact of the extreme flow events on the integrity of the Sybrand and Marietjie van Niekerk bridges is considered unacceptable, then the Hydroplus fuse gate option would become the preferred option for the raising of Tzaneen Dam.

A layout sketch of the labyrinth option is shown in **Figure 7.1**.



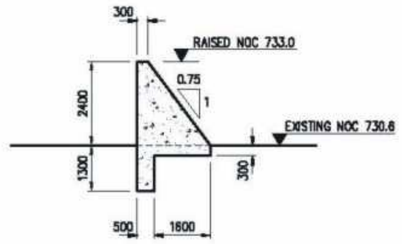
LAYOUT OF LABYRINTH

SCALE 1:500



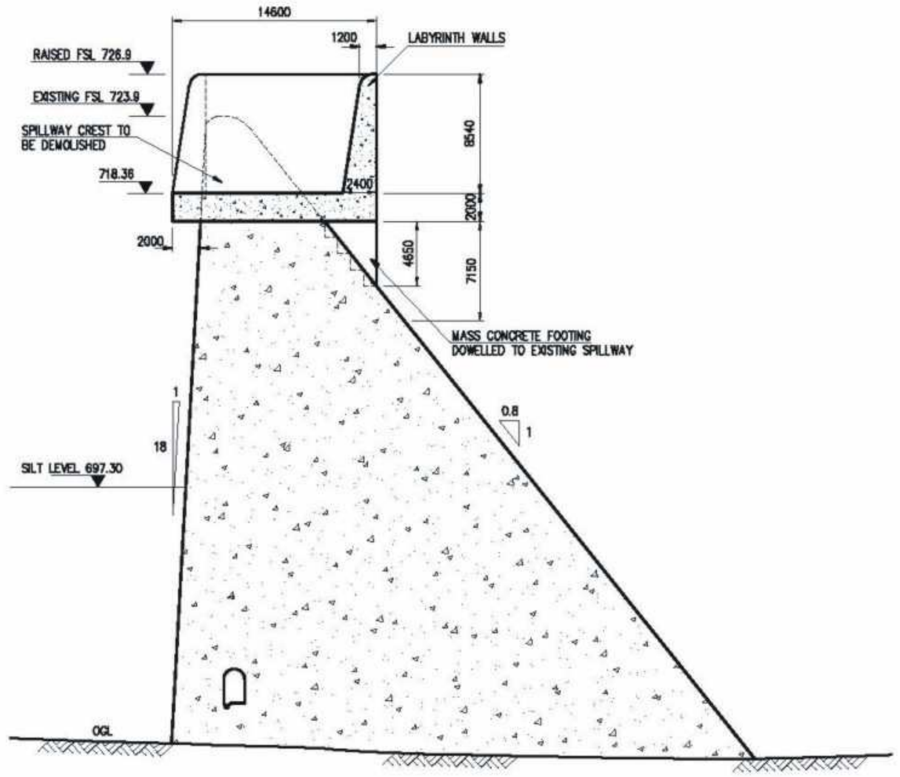
DETAIL OF LABYRINTH

SCALE 1:250



TYPICAL SECTION THROUGH NOC WALL

SCALE 1:100



SECTION A–A

SCALE 1:250

SCALE 1:100 — 0 1 2 3 4 5 10 20 m

SCALE 1:250 — 0 10 20 30 40 12.5 25 m

SCALE 1:500 — 0 5 10 15 20 25 50 m

Figure 7.1

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.
2. ALL LEVELS ARE IN METRES ABOVE SEA LEVEL.

LEGEND:

OGL = ORIGINAL GROUND LEVEL

NOC = NON OVERSPILL CREST

FSL = FULL SUPPLY LEVEL

PRELIMINARY

No	AMENDMENTS	APPR.	DATE
B	ADDED GRAVITY WALL		JUN 09
A	MOVED LABYRINTH UPSTREAM		NOV 08

DESIGNED	HS
DESIGN CHECKED	DWW
DRAWN	RB
DRAWING CHECKED	DWW

PROJECT MANAGER

DATE

Pr Eng

PROJECT DIRECTOR

DATE

aurecon

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

RAISING OF TZANEEN DAM

PROPROSED LABYRINTH SPILLWAY LAYOUT AND SECTION

SCALE AS SHOWN

SHEET 1 OF 1

DRAWING No

401775 CEN 20 REV B

8. RAISING OF EBENEZER AND DAP NAUDE DAMS

8.1 RAISING OF EBENEZER DAM

8.1.1 Introduction

The Ebenezer Dam is situated on the Groot Letaba River just downstream of the confluence of the Helpmekaarspruit and Broederstroom Rivers. It was completed in 1959 to supply domestic and irrigation water demands in the Tzaneen and Polokwane areas. The possibility of raising Ebenezer Dam was investigated as part of the Bridging Study of the Groot Letaba Water Development Project.

8.1.2 Principal Characteristics of Ebenezer Dam

The principal characteristics of the Ebenezer Dam are as follows:

Type of Dam	Zoned Earthfill
Maximum height (rel NGL)	50 m
Maximum depth of water (at FSL)	45 m
Length of crest	312 m
Gross storage capacity	69 million (1.24 MAR)
Spillway type	Drop-inlet (Morning Glory)
Crest length of spillway	26.7 m
Maximum freeboard	4.88 m
Outlet	2 x 609 mm dia jet dispersion valves with a combined capacity of 2 x 5.66 m^3/sec

8.1.3 Proposed Raising

a) Storage capacity

The virgin MAR at the dam is 55.7 Mm^3. It is unlikely that a dam size larger than 2 x MAR would be attractive. This would be achieved by raising the FSL to approximately level 1362 masl (8.7 m raising). For comparative purposes an intermediate raising by 5 m to level 1358.3 masl was also investigated. The options are summarised in **Table 8.1**.

Table 8.1 Proposed Options for Raising of Ebenezer Dam

Raising	Full Supply Level (masl)	Storage Capacity (million m^3)
Existing	1353.31	69
5	1358.31	90
8.7	1362.00	110

b) Design Flood

In accordance with the rationale adopted for the preliminary design of the proposed Nwamitwa Dam, the SEF was selected as the $RMF_{+\Delta}$, ie the RMF for Region 5.4. With a catchment area of 170 km^2, the SEF = 2 220 m^3/s.

c) Increase in Yield

The increases in system firm yield achieved by raising Ebenezer Dam by 5 and 10 metres are 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa Dam were constructed first, then the incremental firm yield reduces from 4.5 Mm^3/a to 3.9 Mm^3/a for the 10 meter raising option.

8.1.4 Embankment

a) Horizontal alignment

The embankment would be raised by placing material on the downstream side. The upstream slope of the rockfill zone would be maintained to the new NOC level. The NOC centreline would move 17 m and 28 m downstream of the existing centreline for the 5 m and 8.7 m raising respectively. The alignment would extend on both flanks to intersect the natural ground profile at NOC level.

b) Cross section

Non-overspill crest

In order to limit the fill quantities required for a raising, the width of the NOC was taken as 8 m instead of the existing 10.66 m. A bridge would be required on the left hand side to provide access across the side channel spillway.

Core zone

The impervious core zone would be extended to the new NOC level parallel to the upstream slope. It is expected that the top 2 m of the embankment would be removed to provide sufficient keying into existing core zone.

Cut-off trench

The existing cut-off trench would have to be extended on both flanks by 20 m and 40 m for the 5 m and 8.7 m raising respectively.

General fill zone

The downstream section of the embankment would be constructed from general fill material up to the raised NOC level. Part of the fill material would be sourced from the excavation for the side channel spillway, with the remainder coming from borrow pits still to be investigated.

Chimney and blanket drains

It is proposed that a new chimney drain be constructed between the inclined contact of the existing general fill and the new general fill. This would be extended to the level of the raised core zone as per existing construction detail.

A blanket drain will also be provided at the rock toe.

Upstream slope protection

The raised portion of the upstream slope would be protected with the same thickness of rip-rap as on the existing dam.

Downstream slope protection

The downstream rockfill protection would be removed to temporary stockpile to make way for construction of the general fill zone. The rockfill layer would be re-established during the raising operation.

c) Materials

Core and general fill material, filter sand, rip-rap and concrete aggregates would be required for the raising of Ebenezer Dam. Significant quantities of fill material would be sourced from the excavation for the spillway, which is estimated to produce some

300 000 m^3 of material. The bulk of this material is expected to be suitable for use into works as general fill material, subject to complying with suitability tests.

Borrow areas for additional material should be investigated taking into account previous investigation reports. Adequate sources of filter sand and rockfill material still need to be investigated.

8.1.5 Spillway

a) Spillway type

The rated discharge capacity of the existing drop inlet (Morning Glory) spillway is 610 m^3/s. Raising of the spillway would involve some technical challenges. The spillway tower stands some 40 m (1353.31-1316.74) proud of the NGL. Raising the spillway would increase the free standing height to 45 m and 49 m for the 5 m and 8.7 m raising respectively. This increase in height would inevitably require stiffening of the tower inside the reservoir. The raised spillway would still not be able to discharge the SEF of 2 220 m^3/s and a side channel spillway was considered a viable option due to its technical and hydraulic advantages. A side channel could work as an auxiliary spillway or as the main spillway.

b) Design Flood

A flood peak of 2 220 m^3/s was used for the design of the spillway. The freeboard was increased to 6 m.

c) Description of Spillway

The side channel spillway would be located on the left bank, consisting of a side channel 70 m long and 22 m wide. The discharge chute would terminate in a deflector bucket discharging into the existing pool downstream of the dam.

8.1.6 Outlet Works

The existing downstream toe line would migrate further downstream by some 36 m and 54 m corresponding to a 5 m and 8.7 m raising respectively. This would encroach onto the outlet structure. The feasible options are either to maintain the position of the outlet structure and construct a gabion (retaining) wall to contain the embankment or to extend the outlet structure further downstream. Construction of a retaining wall might be plausible for the 5 m raising. Maintaining the position of the outlet structure would involve minimal work on the stilling basin and should be further investigated for both options. If the position of the outlet works were to be moved, this would entail extending the spillway conduit and outlet pipes into the stilling basin. This would also result in modification of the stilling basin. Both options are considered feasible.

8.1.7 Cost Estimates

The costing models available in this study were mainly developed for estimating the cost of new dams. The raising of a dam is somewhat different from the development of new sites and hence the available models were not considered applicable. Gross rates were therefore used for the bulk quantities to come up with a ballpark figure, as calculated in **Table 8.2** and **Table 8.3** below.

The estimated cost of raising the Ebenezer Dam by 5 m is R230 million and by 8.7 m is R276 million (excluding VAT).

Table 8.2 Cost Estimate for 5 m Raising of Ebenezer Dam

Description	Unit	Rate Apr 09 Rand	Quantity	Amount Rand
Excavation	m^3	50	320 500	16 025 000
Embankment	m^3	82	298 000	24 436 000
Concrete works	m^3	2 000	29 000	58 000 000
Mechanical	Sum			5 000 000
Miscellaneous	%	10	103 461 000	10 346 100
Sub Total A				**113 807 100**
Preliminary and General (% of subtotal A)	%	40	113 807 100	45 522 840
Sub Total B				**159 329 940**
Contingencies (% of subtotal B)	%	25	159329 940	39 832 485
Sub Total C (% of subtotal C)				**199 162 425**
Planning design and supervision	%	15	199 162 425	29 874 363
TOTAL COST (excl VAT)				**229 036 789**

Table 8.3 Cost estimate for 8.7 m Raising of Ebenezer Dam

Description	Unit	Rate Apr 09 Rand	Quantity	Amount Rand
Excavation	m^3	50	321 200	16 060 000
Embankment	m^3	82	510 000	41 820 000
Concrete works	m^3	2 000	31 000	62 000 000
Mechanical	Sum			5 000 000
Miscellaneous	%	10	124 880 000	12 488 000
Sub Total A				**137 368 000**
Preliminary and General (% of subtotal A)	%	40	137 368 000	54 947 200
Sub Total B				**192 315 200**
Contingencies (% of subtotal B)		25%	192 315 200	48 078 800
Sub Total C				**240 394 000**
Planning design and supervision (% of subtotal C)		15%	240 394 000	36 059 100
TOTAL COST (excl VAT)				**276 453 100**

8.2 RAISING OF DAP NAUDE DAM

During a recent dam safety inspection it was found that the Dap Naude Dam is unstable and significant upgrading works have subsequently been undertaken. Raising of the dam would therefore effectively involve a complete reconstruction of the existing dam.

The increase in yield that would result from raising Dap Naude Dam was found to be negligible (less than 2.3 Mm^3/a), and was not investigated further (as reported on in Section 5.8 of this report).

9. TASK 5 : BULK WATER DISTRIBUTION INFRASTRUCTURE

The primary purpose of Nwamitwa Dam would be to supply primary water requirements in rural settlements close to the proposed dam. This section of the report assesses the adequacy of the existing bulk water supply infrastructure, defines the potential supply area of the proposed Nwamitwa Dam and conceptualises regional bulk water supply infrastructure required to serve the settlements in the supply area.

9.1 SITUATION ASSESSMENT

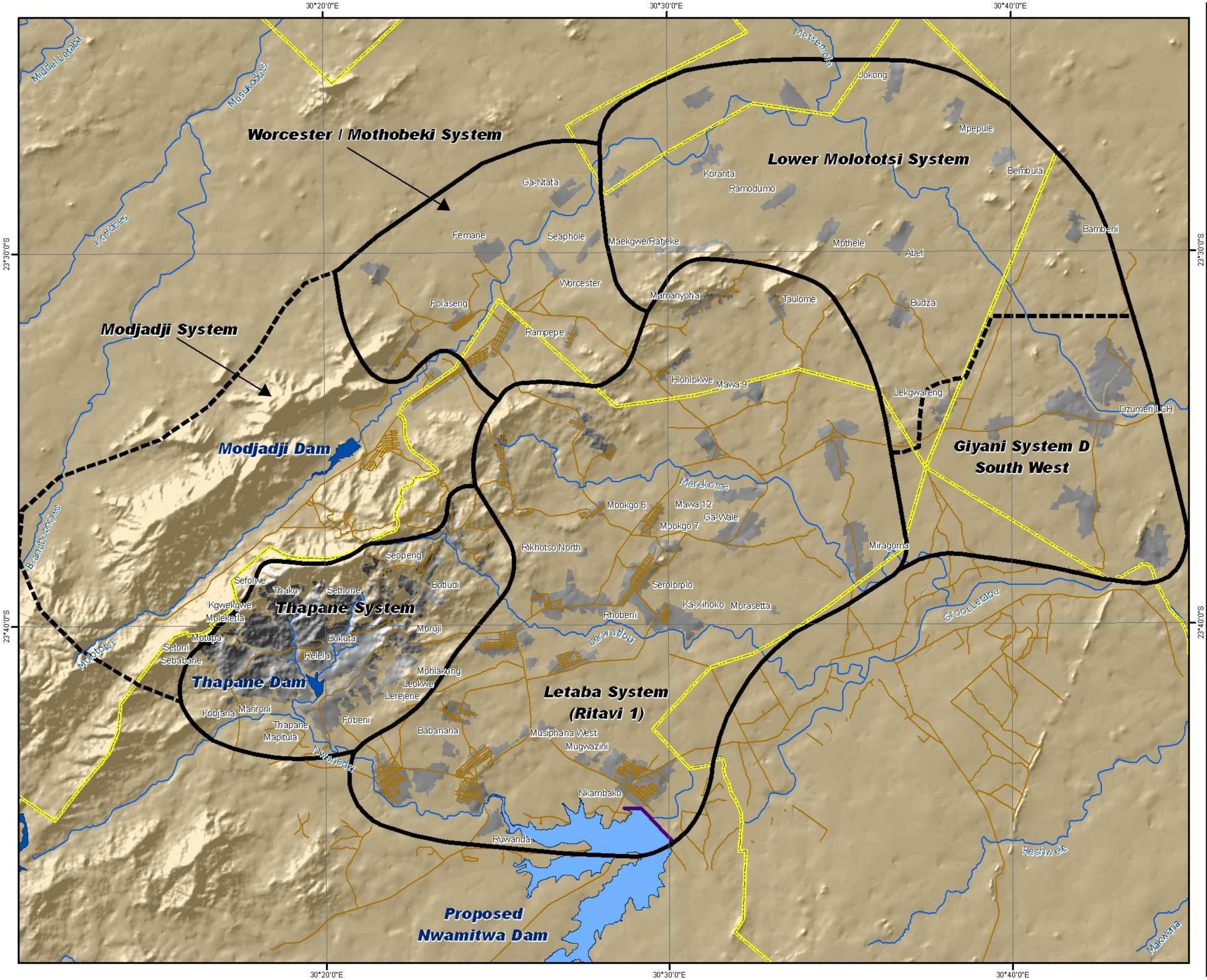
9.1.1 Existing Supply Schemes

A number of independent supply systems are located in close proximity to the proposed Nwamitwa Dam and could therefore be potentially supplied from the proposed Dam. The supply system together with the current water sources (indicated in brackets) are shown below:

- the Letaba Ritavi System (the Letaba River and groundwater)
- the Thapane System (Thapane Dam and groundwater)
- the Modjadji System (Modjadji Dam and groundwater)
- the Worcester/Mothobeki System (Modjadji Dam and groundwater), and
- the Lower Molototsi System (Modjadji Dam and groundwater)

For the purposes of this report, the Worcester/Mothobeki and Lower Molototsi systems are described as one System and are referred to in the report as the Worcester/Molototsi System.

Figure 9.1 shows the location of the five systems referred to above. Each system has a partial network of existing bulk water supply pipelines. This infrastructure is currently not fully utilised. Discussions were held with the owners and operators of each of the systems in order to be able to get a good understanding of the operation of the existing infrastructure and it is evident that critical shortages of treated potable water exist in the Letaba, Thapane and Worcester/Molototsi systems. These water shortages can be attributed to insufficient water resources, the lack of bulk water infrastructure and incorrect pump type selection.



LEGEND

- Rivers
- Secondary Roads
- Proposed Dam Wall
- Dams
- Villages
- Municipality Boundaries
- Proposed Supply Areas of Nwamitwa Dam

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CONSULTANT:

aurecon

CLIENT:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

TITLE:

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

Supply Systems

FIGURE NO.

9.1

9.1.2 Existing Water Treatment Works

Surface water is currently pumped from an existing weir on the Letaba River, just downstream of the proposed Nwamitwa Dam. The raw water is treated at the Nkambako Water Treatment Works. The treated water quality should comply with Class I as recommended for potable water in SANS 241-2006 South African Bureau of Standards (SABS). The available data on water quality produced at Nkambako reveals that the primary function of the treatment works is the removal of turbidity and disinfection of the treated water which complies with Class II specifications.

The water treatment works comprises a module with a capacity of 6 Mℓ/d and an identical second module which has not yet been commissioned. After completion of the second module the plant will have a total capacity of 12 Mℓ/d.

The treatment process at the WTW comprises of flocculation, sedimentation and filtration. Perusal of the plant records showed that treated water quality failed to meet SANS Class I requirements and generally complies with the Class II requirements. With improved rapid mix of chemicals into the raw water, adequate sludge removal and repair of the filter backwash plant, the treatment works should be capable of producing a treated water in compliance with Class I requirements.

9.1.3 Existing Groundwater Use

A desktop study (based on information in the Ground Water Information Project (GRIP) database) was undertaken to ascertain the present use of groundwater in the study area as well as the potential supply from groundwater. The census of groundwater infrastructure indicates that many of the regions which are not connected to the existing bulk water supply network, have access to enough groundwater to satisfy only the current basic survival demand of 16 litres/capita/day (ℓ/c/d). The Thapane system and most of the Letaba system has existing groundwater supply, which is augmented with water from the bulk supply network. High yielding boreholes are not homogeneously distributed throughout the study area. In other words, boreholes with a high yield are not always located close to villages with a high demand.

Most of the good quality groundwater is found in the relatively wetter western part of the study area. The north-eastern part of the region, namely the villages in the Worcester-Molototsi system rely on boreholes yielding Class III and IV water, which is unsuitable for potable use. Elevated concentrations of calcium and magnesium are in most cases responsible for the poor water quality. There are also boreholes which are sited in villages and are consequently contaminated with nitrates from nearby pit latrines.

The boreholes situated outside the villages have dedicated pipelines supplying central storage tanks. These boreholes were installed to target geological shear or fault zones and, as such, are more reliable, both in terms of yield and water quality.

9.2 INFRASTRUCTURE NEEDS

9.2.1 Water Requirements

The future water requirements for all the rural settlements in the Study Area were supplied to the Study Team by EVN Africa. EVN Africa were appointed by the Department of Water Affairs and Forestry (study entitled: Nwamitwa RWS: LPR 006) to assess the water requirements of the area taking into account *inter alia* service levels, socio economic development, water losses and the type of development. The estimated water requirements were derived from the population data within each settlement and a water requirement in litres/capita/day related to the level of service delivered. The water requirements were based on the "high water requirement" for the study area. This assumed that basic human needs would require 35 ℓ/c/d and the full urban requirement would be 200 ℓ/c/d. It was further assumed that persons receiving the basic level of service would comprise 70% of the supply volume in 2007 decreasing to 40% of the supply volume by 2027. The full urban level of service would comprise 10% of the supply volume in 2007 increasing to 25% of the supply volume by 2027. The balance of the population would receive 120 ℓ/c/d. A summary of the anticipated water requirements for the Study area is given in **Table 9.1**, where recognition is given to the fact that 1.5 Mm^3/a is available from Thapane Dam. The total water requirement from the proposed Nwamitwa Dam is estimated to be 11.2 Mm^3/a in 2027 when a higher level of service should be provided.

Table 9.1 Future water requirements in the study area

	Water Requirements for different Service Levels (Mm^3/a)								
	Survival			Standard			Higher		
	2007	2012	2027	2007	2012	2027	2007	2012	2027
Letaba Ritavi	1.6	1.8	2.1	2.7	3.2	3.9	3.7	4.3	5.2
Thapane	0.9	1.0	1.3	1.6	1.9	2.4	2.1	2.6	3.3
Less Thapane Source	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Thapane *				0.1	0.4	0.9	0.6	1.1	1.8
Worcester +Lower Molototsi	0.6	0.7	0.8	1.1	1.2	1.4	1.5	1.6	1.9
Greater Giyani	0.5	0.6	0.9	0.9	1.0	1.7	1.2	1.4	2.3
TOTAL	**2.7**	**3.0**	**3.7**	**4.7**	**5.8**	**7.9**	**7.0**	**8.4**	**11.2**

Note : Excludes the 1.5 Mm^3/a demand already supplied from Thapane Dam

Table 9.2 below shows the expected shortfall in the Modjadji system.

Table 9.2 Supply to the Modjadji System

	Water Requirements for different Service Levels (Mm3/a)								
	Survival			Standard			Higher		
	2007	2012	2027	2007	2012	2027	2007	2012	2027
Modjadji water requirements	1.4	1.7	2.4	2.6	3.2	4.8	3.5	4.3	6.4
Supply available from Modjadji Dam	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Modjadji shortfall	--	--	--	--	--	**0.5**	--	--	**2.1**

The total requirement from the proposed Nwamitwa Dam could be increased by 2.1 Mm^3/a to 13.3 Mm^3/a if the potential shortfall in the Mojadji system were to be supplied from Nwamitwa Dam in 2027.

9.2.2 Logical Supply Area

In order to determine the logical area for the proposed Nwamitwa Dam the water requirements in the areas immediately surrounding the proposed dam were analysed and then compared to the anticipated yield from the proposed Nwamitwa Dam. The water resource analysis (refer to DWA, 2010 d) indicates that 13 Mm^3/a could safely be supplied from Nwamitwa Dam at a 98% level of assurance for domestic use. The anticipated 2027 domestic water requirement in the Letaba/Ritavi, Thapane and Worcester/Molototsi (including part of Giyani) supply areas is 11.2 Mm^3/a. This can be supplied from the yield of 13 Mm^3/a which was determined for a dam with a Full Supply

Level of 479.5 masl. It is proposed that the bulk water supply infrastructure to the Worcester/Molototsi System be used to supplement any future shortfalls in the Modjadji system prior to the full high water requirement being required in the Worcester/Molototsi system.

The villages Daniel, Dzumeri, Nogeva, Mphagani and Zava which should be supplied by the Giyani sub-system are included in the logical supply area, as these villages currently receive no potable water because of infrastructure capacity constraints and inadequate supplies. These villages currently rely solely upon groundwater.

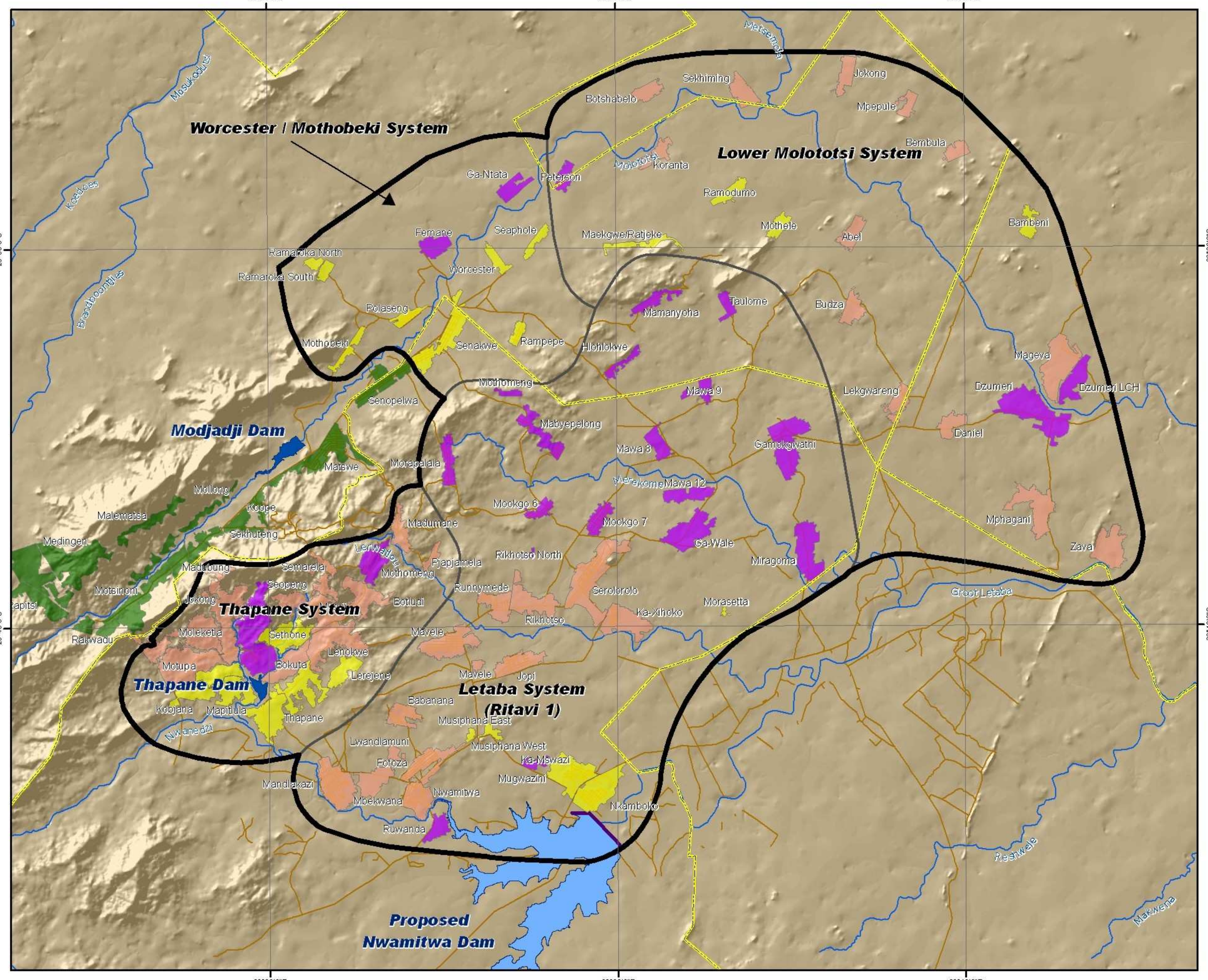
Figure 9.2 shows the logical supply area to be served from Nwamitwa Dam and the current water availability in each settlement. The settlements identified as "water critical" have limited or poor groundwater supply and either no bulk water supply infrastructure or bulk water supply infrastructure which is not utilised. The settlements identified as "water poor" have limited or poor groundwater supply and limited or rationed access to potable water.

9.3 INFRASTRUCTURE MASTER PLAN

Once the logical supply area was defined, the next step was to determine where to site the Regional Bulk Water Command Reservoirs, which areas the Command Reservoirs should serve and what the capacity of the Command Reservoirs should be. The ability to supply water under gravity, the flexibility of supply, and system redundancy (for future system expansion) were primary considerations when deciding where to site the Command Reservoirs.

9.3.1 Command Reservoirs

Currently all supply systems include a number of village reservoirs as well as a few main regional reservoirs. The purpose of the regional reservoirs (or Command Reservoirs) is to provide balancing storage as well as emergency storage in the case of a disruption of supply.



LEGEND

- Rivers
- Secondary Roads
- Proposed Dam Wall
- Dams
- Proposed Supply Areas of Nwamitwa Dam
- Municipality Boundaries

Villages

- Access to water
- Critical
- Villages outside study area
- Poor

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GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

Logical Supply Area

FIGURE NO.:

9.2

It is proposed to provide bulk command reservoirs in the Worcester-Molototsi system (including a service to parts of the Giyani system), Thapane and Letaba/Ritavi systems by constructing two new command reservoirs. Two existing regional supply reservoirs, namely the 5 Mℓ reservoir at Serolorolo (Command Reservoir A) and the 7 Mℓ reservoir at Babanana (Command Reservoir B) should be utilised as command reservoirs. The proposed two new command reservoirs are situated at an elevation high enough to feed the supply area under gravity. For this reason the command reservoirs are capable of supplying villages outside their respective supply areas which adds redundancy, and also reliability, to the system.

9.3.2 Pipelines and Pump Stations

Existing pipelines from the Nkambako WTW were designed to cater for the Letaba system only. Linking of the three systems will require the installation of additional bulk water pipeline capacity and the upgrading of clear water pumps. It is proposed that two new bulk pipelines be constructed, one from Nkambako WTW to the existing Babanana Command Reservoir (Command Reservoir B) and the other from Nkambako WTW to the existing Serolorolo Command Reservoir (Command Reservoir A). A pipeline with a booster pump station is proposed to link the Babanana command reservoir and the proposed Mohlakong regional reservoir in Thapane. The existing 300 mm diameter pumping main from the Nkambako WTW will be dedicated to supply the regional reservoir at Runnymede.

The Worcester/Molototsi system (including parts of the Giyani supply area) has to be linked by new pipelines from Serolorolo command reservoir to the proposed command reservoirs, C and D. These reservoirs will then feed into Worcester-Molototsi through Worcester-Mothobeki and the Giyani supply systems.

The existing clear water pumps at Nkambako WTW cannot supply the combined system and it is therefore proposed that new pumping capacity be provided to serve the Babanana Command Reservoir and another for the Serolorolo Command reservoir, and that the existing pumps be used to serve the Runnymede regional reservoir. There is also a need for a rising main with pump station to supply the proposed Command Reservoir C north-west of the village of Hlohlokwe from the command reservoir at Serolorolo. Command Reservoir D, situated to the north-east of Gamokgwathi, can be fed by the bulk water gravity main from the existing command reservoir at Serolorolo.

9.3.3 Water Treatment Works

In order to satisfy the anticipated growth in future peak week water requirements, the Nkambako WTW will ultimately have to be expanded to a capacity of approximately 45 Mℓ/d. This will enable the WTW to meet the peak week water demand in 2027. It is important for Mopani District Municipality to meter and monitor the actual water usage to enable them to plan for the timely expansion of the Nkambako WTW in a modular fashion.

9.4 PRELIMINARY DESIGN OF BULK INFRASTRUCTURE

The analysis of the existing networks was undertaken with reference to the current DWA guidelines. The DWA technical guidelines were also checked against the recommendations made in the definitive publication on urban planning and infrastructure standards, popularly known as the "Red Book" (CSIR, 2000).

9.4.1 Command Reservoirs

An analysis was undertaken to determine the available storage in hours, based on the standard and high water requirement for 2007 and 2027. It is proposed that the two new Command Reservoirs C and D be sized at 5 Mℓ. This would ensure compliance with the requirement to provide approximately 48 hours of storage in the reticulation system in the case of a pumped supply with one source and approximately 36 hours of storage in the reticulation system in the case of a pumped supply with two sources. This capacity is also comparable to the existing 5 Mℓ Reservoir at Serolorolo and the existing 7 Mℓ Reservoir at Babanana.

9.4.2 Pipelines and Pump Stations

Various pipeline routes to each of the command reservoirs were identified and evaluated to determine the most economical options, taking factors such as capital costs (mainly a function of pipeline length), operating costs (influenced by pumping head and pipe friction), maintenance costs, and operational aspects (e.g. access to pipeline route) into account.

Peak week factors of 1,5 and 2,0 were applied to the AADD for the bulk water rising and gravity mains respectively. The peak week factor of 1,5 used for the rising mains includes provision for pumping 20 hours per day.

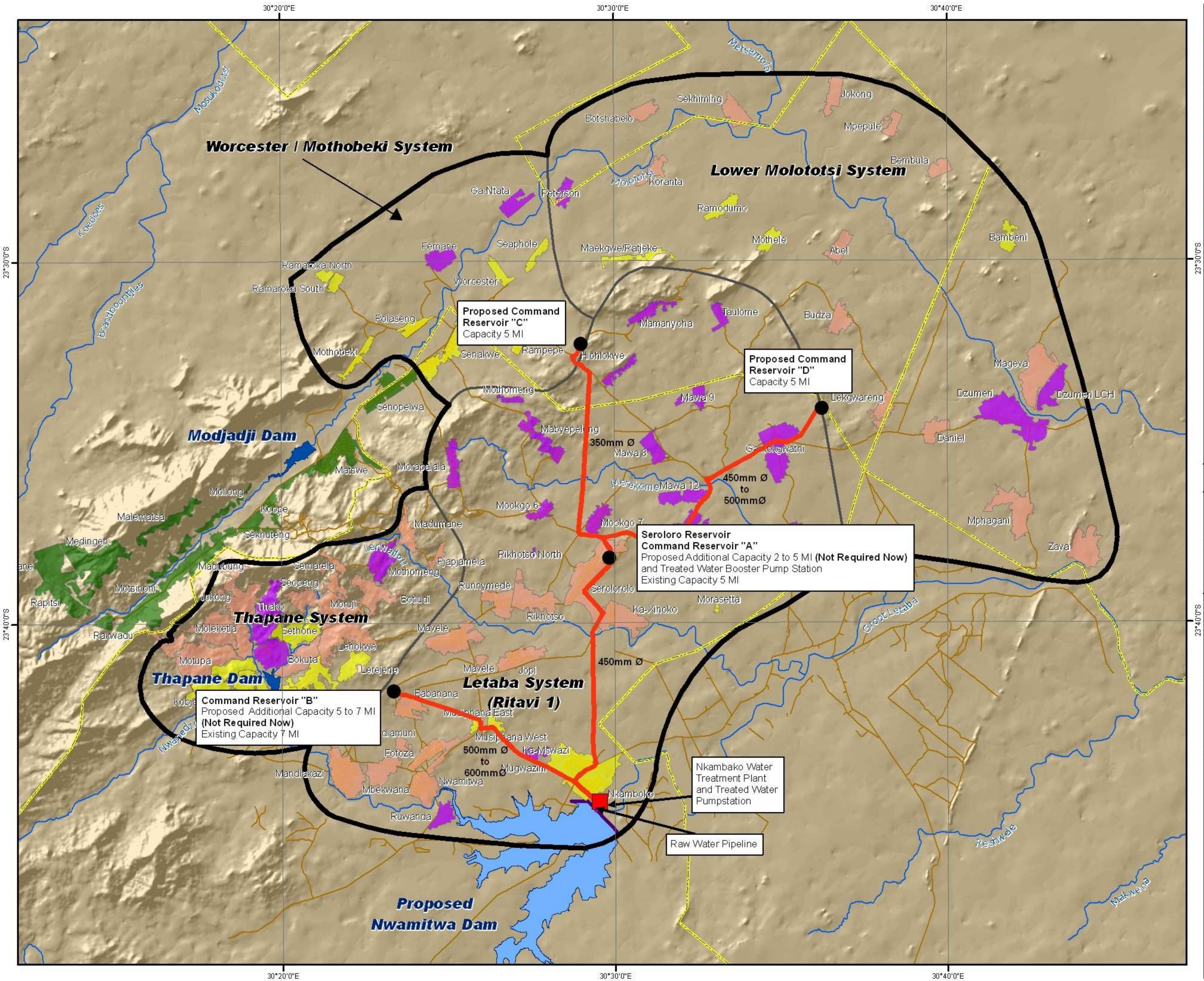
Pumping systems were optimised on the basis of the present value of capital, operating and maintenance costs for each pipeline for different pipeline diameters for the 2027 demand scenarios.

A preferred pipeline route was selected to each of the command reservoirs, based on the optimisation for the 2027 demand scenario. The optimisation process was then repeated for the 2008 demand scenario to determine the optimum pipeline diameter required in the short-term. This was used as a basis for evaluating the possibility of phasing the construction of infrastructure. The cost functions used for calculating the capital cost of the pumps and associated mechanical and electrical equipment were based on multi-stage centrifugal pumps.

The preliminary design of new works takes account of the capacity of existing infrastructure, such as pumps and pipelines. Based on the good working condition of existing pumps, it is preferable to utilise the existing infrastructure as far as possible. The proposed pipeline routes are shown in **Figure 9.3**

9.4.3 Water Treatment Works

The Nkambako WTW has a capacity of 12 Mℓ/d (including the recently constructed 6 Mℓ/d extension). In view of the uncertainty associated with the current and future water requirements it is proposed that any future upgrading be undertaken in increments of 12 Mℓ/d. The High Level service water requirement scenario indicates that the capacity of the WTW (based on peak week water requirements) should be 45 Mℓ/d in 2027. This water requirement assumes that all the settlements in the logical supply area of the proposed Nwamitwa Dam have installed reticulation networks down to village level.



LEGEND

- Water Treatment Works
- Proposed Reservoirs
- Rivers
- Secondary Roads
- Proposed Dam Wall
- Raw Water Pipe
- Recommended Pipeline Route
- Dams
- Proposed Supply Areas of Nwamitwa Dam
- Municipality Boundaries

Villages

- Access to water
- Critical
- Villages outside study area
- Poor

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GROOT LETABA RIVER WATER DEVELOPMENT PROJECT

Recommended Pipeline Routes

FIGURE NO.:
9.3

The treated water must comply with the SANS Class I specification. It is noted that some limited urban development exists within the catchment of the proposed dam and is close to the high water mark. It can therefore be expected that raw water quality will decline over time, particularly as regards orthophosphate and nitrate, and that a degree of eutrophication may occur in the future. It is recommended that adequate sanitation be provided by the Water Services Authority in order to limit the danger of bacteriological contamination of the water source.

The following long-term water quality changes may occur in the proposed Nwamitwa Dam: slightly lower pH, increase in dissolved metals, (Fe and Mn in bottom water), increase in organic carbon associated with algae, possible increase in turbidity and TDS, and possible increase in e-coli. It is therefore important that the water treatment process be designed for the possible long term water quality that can be expected. The required water treatment process is described in more detail in the report entitled *Bulk Water Distribution Infrastructure (DWA, 2010 k).*

9.4.4 Raw Water Pipeline and Pump Station

The existing raw water balancing dam at the WTW has a full supply level of approximately 474 m, whereas the operating level in the Nwamitwa Dam is likely to fluctuate from 470 m (i.e. 15% full) to 479,5 m (i.e. full supply level). It is therefore necessary to design the system to allow the filling of the balancing dam under gravity when the water level in the Nwamitwa Dam is high enough. Pumping is necessary when the water level in Nwamitwa Dam is lower than that in the balancing dam.

It would not be possible to locate the pump station at the Nwamitwa Dam, as the fluctuating water level makes it impossible to cover the complete operating range in flows (even when equipping the pumps with variable speed drives). The control of the switching from gravity to pumping mode, and vice versa, would also be complicated.

The preferred method of operation would be a hydraulically controlled system whereby the existing balancing dam would be filled under gravity when the water level in the Nwamitwa Dam is above 474 m, and a new balancing dam with a full supply level at 465 m to 467 m is filled when the water level in Nwamitwa Dam drops below 474 m. Water would then be pumped from the lower balancing dam to the existing balancing dam against a fixed head. This option would be suitable for fixed speed motors and would simplify the stopping and starting of the pumps, which would be regulated by the water level in the existing balancing dam.

The main criterion for selecting a suitable pipeline route is that the invert level of the pipeline must remain below a level of 464 m to enable flow to gravitate to the proposed second balancing dam.

It is recommended that a 600 mm diameter pipeline be installed from the Nwamitwa Dam to the existing and the proposed balancing dams.

It is proposed that the new balancing dam be sized for 2 hours balancing capacity to prevent frequent stopping and starting of the pumps. A balancing capacity of 3 780 m^3 would thus be required for a peak demand of 525 ℓ/s. Based on a depth of 2 m, the surface area would be approximately 45 m x 45 m.

9.5 GROUNDWATER

A large number of villages in the supply area are reliant on groundwater. Many of the boreholes, however, deliver water of poor quality and require treatment before use. Blending poor quality borehole water with good quality water from surface sources to dilute the high concentrations of solutes is one method of utilising the existing and potential groundwater supply. A number of alternative ground water usage scenarios were investigated and are described in more detail in the Bulk Water Distribution Infrastructure Report (DWA, 2010 k).

It is envisaged that groundwater obtained from a wellfield in the Worcester/ Molototsi system could be either taken to Command Reservoir C or D, or to a regional bulk water supply reservoir where the groundwater can be blended with better quality water from other sources. Supplies from a wellfield in the Letaba/Ritavi supply area should be conveyed to either Command Reservoir A or B or to Runnymede regional bulk water supply Reservoir.

Groundwater sources can meet a portion of the Average Annual Daily Demand (AADD). The proposed regional bulk water supply system would then supply the balance of the AADD, as well as the peak week water requirements. By utilising groundwater conjunctively with water from the proposed Nwamitwa Dam, it would be possible to :

- delay future extensions to the Nkambako WTW
- delay the need for increased conveyance capacity to the proposed Command Reservoirs from Nkambako WTW (provided the yield of proposed Nwamitwa Dam is sufficient to allow for this possibility), and

- delay supplying water outside the logical supply area, such as to meet the future shortfall in the Mojadji system.

9.6 NWAMITWA RWS: CONCEPTUAL MASTERPLAN

In parallel with the GLeWaP Bridging Study, DWA appointed EVN Africa (EVN) to undertake a bulk water supply planning assignment for the area surrounding the proposed Nwamitwa Dam. In order to ensure integration between the two studies, EVN utilised the services of Aurecon to develop a conceptual master plan for the bulk reticulation system. The conceptual master plan integrated the planning of the GLeWaP Regional Bulk Water Supply Infrastructure with the planning of the "Connector" Bulk Water Supply Infrastructure. The “connector” bulk water supply infrastructure links the Command Reservoirs identified in the GLeWaP Study with the water reticulation infrastructure in each settlement area. The Nwamitwa RWS Conceptual Master Plan Report is presented in Appendix J of the Bulk Water Distribution Infrastructure Report (DWA, 2010 k).

9.7 TIMING AND PHASING OF THE PROPOSED INFRASTRUCTURE

It is evident that all three water supply systems in the area currently receive an inadequate supply of water. All the proposed infrastructure components will be required to satisfy the specified level of service at the planning horizon of 2027. Because of the lack of usage metering and effective water conservation and demand management, there is uncertainty regarding current and projected future water requirements. Therefore the implementation of the bulk connector infrastructure should proceed with caution. It is believed that there is an immediate need to implement certain components of new bulk regional infrastructure as proposed in this report.

The proposed timing and phasing of the bulk water supply infrastructure (both Regional and Connector Infrastructure) is based on the following considerations:

1) The need to utilise existing unutilised bulk water supply infrastructure.

2) The need to provide reliable water services to areas which currently receive no potable water.

3) The need to augment water supplies to areas which currently experience water shortages and water rationing.

4) The need to expand the water reticulation network to all settlements and villages.

9.8 COST OF REGIONAL BULK WATER SUPPLY INFRASTRUCTURE

The cost estimate of the various components of the Regional Bulk Water Supply Infrastructure are described in detail in Section 6 of this report and are summarised in **Table 9.3.**

Table 9.3 Cost estimate of the various components of the Regional Bulk Water Supply Infrastructure

Scheme	Component	Cost Estimate (excluding VAT) (Note 1)
Nkambako WTW to Serolorolo Reservoir (Command Reservoir A)	Pump station, 450 mm diameter pipeline and upgrading of existing 315 m diameter Xihoko pipeline	R 37 million
Nkambako WTW to Babanana Reservoir (Command Reservoir B)	Pump station and 450 mm diameter pipeline	R 27 million
Serolorolo Reservoir to Command Reservoir C	Pump Station and 350 mm diameter pipeline	R 17 million
Command Reservoir C	5 Mℓ Reservoir	R 5 million
Serolorolo Reservoir to Command Reservoir D	450 mm diameter pipeline	R 24 million
Command Reservoir D	5 Mℓ Reservoir	R 5 million
Nkambako WTW	For an increase in capacity from 12 Mℓ/d to 45 Mℓ/d.	R 198 million
	TOTAL	**R 313 million**

Note 1: Costs include contingencies and professional fees. Costs have been escalated to reflect 2009 prices.

It is estimated at the total cost to implement the proposed Regional Bulk Water Supply Infrastructure is approximately R313 million in 2009 terms.

10. IMPLEMENTATION PROGRAMME

For the purpose of establishing a timeline for the implementation programme, it was assumed that the tender design phase of the project would start in July 2010 (i.e. design PSP would be appointed by this date). Should the milestone be later than July 2010, then the whole programme can be adjusted accordingly. It is assumed that quite a tight timeline would be established for the design and tender period and one year was according allocated for this task. The construction of Nwamitwa Dam would take approximately 3.5 years to complete from mobilisation to demobilisation of the contractors' staff. Under this scenario the proposed dam would be completed by February 2015.

Re-alignment of the roads 529 and P43-3 and the construction of the two bridges across the Hlangana and Nwanedzi Rivers could commence by August 2011. It is anticipated that all construction activities associated with the re-alignment of the two roads could be completed by June 2013.

The Regional Bulk Water Supply Infrastructure should be phased in in accordance with the budgetary constraints and service delivery need of Mopani District Municipality. A more detailed description of the proposed timing and phasing of the proposed bulk water supply infrastructure is given in the Bulk Water Distribution Infrastructure Report (DWA, 2010g).

Figure 10.1 shows anticipated construction timelines.

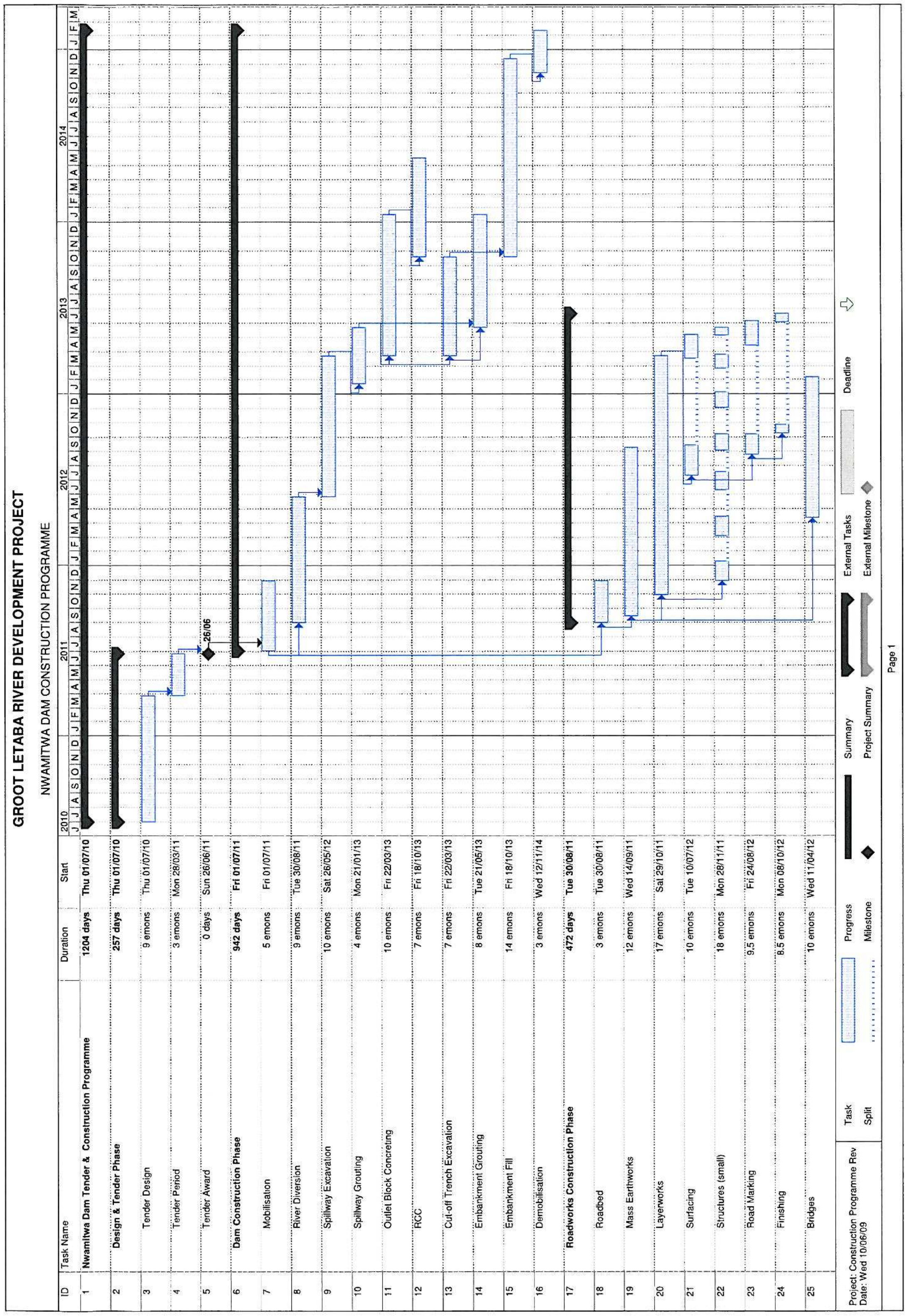

Figure 10.1 Implementation Programme

11. CONCLUSIONS

Review of water requirements:

- Detailed information about existing and future population and water use is not readily available. Estimates were based on available information with reasonable assumptions regarding population growth and socio-economic development.

- Based on a medium growth scenario it is anticipated that the primary water requirements for the Groot Letaba Catchment will increase from a 2007 base of 23.5 Mm^3/a to approximately 52.11 Mm^3/a in 2030.

- Estimates of future population growth rates in the supply area were used to project water requirements for the catchment up to 2030. It is estimated that the growth in water requirements from Tzaneen Dam will increase from a 2009 level of 13.9 Mm^3/a to an estimated 19.58 Mm^3/a in 2030. It is estimated that the water requirement from the proposed Nwamitwa Dam will be approximately 13 Mm^3/a in 2027. It must be noted that the estimate of 13 Mm^3/a is based on a high level of service for the areas of Ritavi 1 (Letaba) and Bolobedu, including Modjadji, Thapane and the Worcester-Molototsi areas.

- The safe yield of most of the significant surface water sources is already over-allocated. As a result, the supply of water to the irrigation sector is curtailed to about 50% of their allocations on an ongoing basis. The recent determination of the Environmental Water Requirement (EWR) has introduced an additional factor which has increased the pressure on the available surface water supplies.

- In view of the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important to undertake verification and validation of water use in the Groot Letaba Catchment.

Groundwater:

- Based on a desktop evaluation, it is estimated that the groundwater potential in the Study Area is 91 Mm^3/a. It is estimated that the current groundwater use is approximately 40 Mm^3/a. This would leave approximately 51 Mm^3/a (without accounting for groundwater losses) available for development. Groundwater is therefore a significant potential water resource for the area. Development on a regional scale is envisaged as an important option for the area.

Updating of Hydrology:

- The scope of this Study included an extension of the catchment modelling time period by 12 years to end in hydrological year 2004 from 1992, giving a total modelling period of 80 hydrological years (from 1995 to 2004). The scope of work specifically excluded the re-calibration of the Pitman rainfall-runoff model.

- The decision not to re-calibrate has led to some uncertainties regarding the extension of the hydrology.

- There is a lack of both rainfall and evaporation data for this area, particularly in the eastern part of the catchment. Only six evaporation stations are located in or near the catchment. Out of the possible 194 rainfall stations in and near the catchment, only 12 passed the screening criteria and were used as input to the rainfall-runoff model. This is a very low number for such a large catchment, and combined with the poor distribution of the stations, is cause for concern.

Water Resource Analysis:

- One of the major conclusions from the water resource analysis was that the extended hydrology did not adequately reflect the low flows in the system. If the extended hydrology was used unmodified, the proposed Nwamitwa Dam would have zero yield, mainly because of the obligation to meet the EWR. Once the additional freshets (a series of low flow events based on observed flow records, with a MAR of 34 Mm^3/a) were added to the simulated streamflows, the yield of the proposed Nwamitwa Dam increased to 14 Mm^3/a.

- The increase in system yield was found to be extremely sensitive to the way in which the EWR was implemented in the WRYM. This is a concern because of the preliminary nature of the EWR and the lack of detail regarding exactly how it needs to be implemented. Considerable further work is required to refine the EWR with particular attention to how it can be modelled within the WRYM.

- The Reserve Determination Study did not consider the modification in flows caused by the Nwamitwa Dam and the possible impact of channel losses along the Groot Letaba River.

- The historical firm yield at Nwamitwa decreases from 18 to 6 Mm3/a, depending on the factor applied to the losses, i.e. 100%, 50% or 0%, downstream of the Letaba Ranch. If a 50% loss factor is assumed, the historical firm yield of Nwamitwa Dam would be 14 Mm3/a (scenario ct77H). This yield assumes that the environmental water requirements at EWR Site 3 are fully met by the proposed Nwamitwa Dam.

- Given the modelling assumptions made regarding the freshets, the uncertainty regarding the implementation of the EWR and the coarse assumptions regarding "river losses", the yield results for the proposed Nwamitwa Dam should be viewed as preliminary and subject to confirmation once the hydrology has been recalibrated as recommended below.

- The incremental increases in the firm yield of the system from raising Ebenezer by 5 and 10 meters were 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa was constructed first, then the incremental firm yield from raising Ebenezer reduces from 4.5 to 3.9 Mm^3/a.

- There is a 50% probability that the proposed Nwamitwa Dam (FSL 479.5 masl) will fill within four years and an 80% probability that the dam will fill within eight years.

- The construction of the proposed Nwamitwa Dam and raising of Tzaneen Dam will have very limited impact on the yield of Massingir Dam (reduction of 3 Mm^3/a on 575 Mm^3/a). The development of the proposed Rooipoort Dam in the Olifants River will reduce the historical firm yield of Massingir Dam to 500 Mm^3/a.

- It is important that Nwamitwa Dam and Tzaneen Dam are operated conjunctively to maximise the yield. Nwamitwa Dam should be drawn down first, primarily to minimise evaporation losses, as the Nwamitwa Dam has a larger surface area for a given storage volume than the Tzaneen Dam and a higher evaporation rate. Under this operating rule the average nett evaporation from the Nwamitwa Dam is about 9 Mm^3/a. Were Nwamitwa Dam maintained at its full supply level the nett evaporation would exceed 20 Mm^3/a. A secondary benefit of drawing down the Nwamitwa Dam first, is that this also maximises the storage available to intercept floods from the Letsitele River.

Preliminary Design of Nwamitwa Dam:

- The valley shape factor for the Nwamitwa Dam site is in excess of 50, which is a clear indication that the most appropriate dam type would be an embankment type dam.

- A straight ogee spillway is the most economical type spillway configuration for the proposed Nwamitwa Dam

- The optimisation analysis did not point to a clearly most economical size. A dam with a FSL of 479.5 m and a historical firm yield of 14 Mm^3/a was however proposed as the preferred dam size. This size will ensure that sufficient yield is obtained in order to meet the anticipated future domestic water requirements of the area surrounding Nwamitwa Dam, limit expropriation costs and limit the amount of evaporation losses from the proposed dam.

Raising of Tzaneen Dam:

- Both the labyrinth spillway and side channel spillway options are considered to be technically feasible. A labyrinth spillway option is the most cost effective solution and also has minimum future maintenance costs.

- The fuse gate option could still be considered during the detailed design phase of the project should the raising of the NOC (associated with the labyrinth and side channel spillway options) and associated impacts on the Sybrand and Marietjie van Niekerk bridges during extreme flood events be considered unacceptable.

- The raising of the full supply level of Tzaneen Dam by 3 m to a level of 729.9 masl will increase the firm yield of the Tzaneen/Nwamitwa system by about 4 Mm^3/a.

Raising of Ebenezer and Dap Naude Dams:

- The raising of Ebenezer Dam is technically feasible. The incremental increase in firm yield of the Ebenezer/Tzaneen System for a raising of Ebenezer Dam by 5 and 10 metres is estimated to be 2.3 and 4.5 Mm^3/a respectively. If Nwamitwa Dam were constructed first, then the incremental firm yield reduces from 4.5 Mm^3/a to 3.9 Mm^3/a for the 10 meter raising option.

- During a recent dam safety inspection it was found that the Dap Naude Dam is unstable and significant upgrading works had subsequently been undertaken. A raising of the dam would therefore effectively involve a complete reconstruction of the existing dam.

Bulk Water Distribution Infrastructure:

- The study confirmed that critical shortages of treated potable water exist in the Letaba, Thapane and Worcester Molototsi systems. These water shortages can be attributed to insufficient water resources, the lack of bulk water infrastructure and incorrect pump type selection. In order to alleviate these shortages, it is imperative that the regional bulk water supply infrastructure as proposed in the recommendations of this report be implemented.

- There is uncertainty regarding the actual current and expected future water requirements in the area of supply of the proposed Nwamitwa Dam. It is therefore imperative that Mopani District Municipality ensure the metering and monitoring of all the proposed bulk water supply schemes. The expansion of the Nkambako WTW could be undertaken modularly as the water requirement increases in the future.

- Most of the good quality groundwater is found in the relatively wetter western part of the study area. The north-eastern part of the region, namely the villages in the Worcester-Molototsi system is being supplied from boreholes with Class III and IV, which is unacceptable for potable use. Groundwater could potentially supply a significant portion of the future water requirements in the logical supply area of the proposed Nwamitwa Dam, either through blending with potable supplies or by onsite treatment prior to conveying it to the regional bulk water supply reservoirs. More detailed investigative studies are necessary in order to determine the full potential of and develop the groundwater in the area.

12. RECOMMENDATIONS

The following recommendations are made:

Review of Water Requirements:

- Given the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important to undertake verification and validation of water use in the Groot Letaba Catchment.
- It is important that municipalities measure and monitor water use so that reliable information is available for modelling and demand management.
- The implementation of water demand and water conservation measures in the catchment is strongly recommended.

Groundwater:

- A comprehensive regional groundwater investigation should be undertaken so that the location and availability of suitable quality groundwater can be determined with greater certainty. These investigations should be focussed on developing regional groundwater supply schemes in the supply area currently envisaged for the proposed Nwamitwa Dam.
- The potential yields, costs and environmental implications associated with a regional groundwater supply scheme should be determined and compared with the yields, costs and environmental implications of the proposed Nwamitwa Dam development.

Updating of Hydrology:

- There is a paucity of good quality basic hydrological data and every effort should be made to maintain the existing evaporation and rainfall stations and to ensure that the data collected is of a quality suitable for use in rainfall-runoff modelling.
- A complete re-calibration of the rainfall – runoff model should be undertaken. The focus should be on achieving a good match in the low to medium flow range (freshets), to enable modelling of the EWR requirements in the WRYM to be done with confidence.

Water Resource Analysis:

- The EWR should be refined, with attention given to how the EWR can be applied and modelled most accurately in the WRYM.
- Further investigations should be undertaken to refine the assumptions made regarding "river losses". This will enable the yield to be estimated with a higher level of certainty.
- The historical firm yield of the proposed Nwamitwa Dam should be re-determined once the results of the abovementioned investigations are available and once the rainfall runoff model has been re-calibrated.

Preliminary Design of Nwamitwa Dam:

- An embankment type earthfill dam should be constructed with a central ogee spillway. Whilst an optimum dam size could not be established, it is proposed that a dam with a full supply level of 479.5 masl be constructed. This will ensure that sufficient yield in obtained to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, limit expropriation costs and limit the amount of evaporation from the proposed dam.

Raising of Tzaneen Dam:

- Both the labyrinth spillway and side channel spillway options are considered to be technically feasible. However, given the fact that the labyrinth spillway option is the most cost effective solution coupled with the fact that this option has minimum future maintenance costs, it is recommended that this method of raising be adopted. The fuse gate option could still be considered during the detailed design phase of the project should the impact on the Sybrand and Marietjie van Niekerk bridges during extreme flood events be considered unacceptable.

Bulk Water Distribution Infrastructure:

- The Regional Bulk Water Supply Infrastructure as proposed should be implemented.
- The proposed timing and phasing of the bulk water supply infrastructure (both Regional and Connector Infrastructure) should be based on the following considerations:
  - o The need to utilise existing bulk water supply infrastructure to maximum capacity.
  - o The need to augment water supplies to areas which currently receive little or no potable water.

- o The need to augment water supplies to areas which currently experience water shortages and water rationing.
- o The need to expand the water reticulation network to all settlements and villages.
- o The Nkambako WTW should be designed to cater for the expected changes in the raw water quality in the long term.

- The Mopani District Municipality should implement a metering and monitoring system in order to ascertain the actual water consumption for domestic purposes and to establish how the requirement changes with the implementation of the regional bulk water supply and connector bulk infrastructure.
- The capacity of the Babanana Reservoir (Command Reservoir B) and the Serelorolo Reservoir (Command Reservoir A) should be increased when the future water requirements reach the stage that there is insufficient emergency and balancing storage in the respective supply areas.
- Provision should be made for including water from a future regional groundwater supply system in the bulk infrastructure which stores and distributes treated water from surface sources.

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