water affairs

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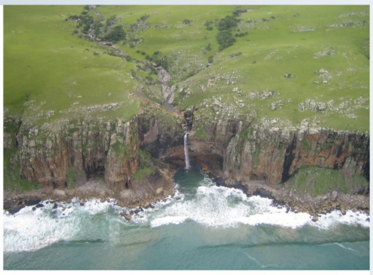
Water Affairs
REPUBLIC OF SOUTH AFRICA

DWA REPORT NO: P WMA 12/T60/00/4911

Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme (WP 10317)



MAIN STUDY REPORT

FEBRUARY 2014

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Project name:	***Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme***
Report Title:	***Main Study Report***
Author:	***HS Pieterse and E van Niekerk***
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* *BKS (Pty) Ltd was acquired by AECOM Technology Corporation on 1 November 2012*

LIST OF STUDY REPORTS

This report forms part of the series of reports, prepared for the Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme. All reports for the Study are listed below.

Report Name	DWA Report Number
Water Resources Assessment	P WMA 12/T60/00/3711
Assessment of Augmentation from Groundwater	P WMA 12/T60/00/3811
Intermediate Reserve Determination	P WMA 12/T60/00/3911
Legal, Institutional and Financial Arrangements	P WMA 12/T60/00/4011
Domestic Water Requirements	P WMA 12/T60/00/4111
Irrigation Potential Assessment	P WMA 12/T60/00/4211
Water Distribution Infrastructure	P WMA 12/T60/00/4311
Materials and Geotechnical Investigations	P WMA 12/T60/00/4411
Zalu Dam Feasibility Design	P WMA 12/T60/00/4511
Regional Economics	P WMA 12/T60/00/4611
Environmental Screening	P WMA 12/T60/00/4711
Record of Implementation Decisions	P WMA 12/T60/00/4811
Main Study Report	***P WMA 12/T60/00/4911***

This report is to be referred to in bibliographies as:

Department of Water Affairs, 2014. FEASIBILITY STUDY FOR AUGMENTATION OF THE LUSIKISKI REGIONAL WATER SUPPLY SCHEME: MAIN STUDY REPORT, P WMA 12/T60/00/4911

Prepared by:

AECOM SA (Pty) Ltd

In association with:

Executive summary

*The Department of Water Affairs (DWA) appointed **AECOM SA (Pty) Ltd** to undertake the **Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme (LRWSS)**, a project that was identified in the early 1970s to provide water to Lusikisiki area. The identified project was based on a dam on the Xura River, a tributary of the Msikaba River, and potable water supply infrastructure.*

WATER REQUIREMENTS

DOMESTIC WATER REQUIREMENTS

Estimates of future domestic water requirements were based on approximately 2% of the population consuming 25 ℓ/c/d; 13% consuming 60 ℓ/c/d; 59% consuming 90 ℓ/c/d; and 26% using 200 ℓ/c/d. The most probable water requirement scenario indicates that approximately 14.7 Mℓ/d or 5.4 million m^3/a will be required for domestic use in the LRWSS Supply Area in 2040. The average per capita consumption of water in the Study Area is almost 114 ℓ/c/d.

Increasing the basic level of services from 25 ℓ/c/d to 60 ℓ/c/d, as recommended in the National Water Resource Strategy, 2nd Edition, has minimal impact and can still be provided by the resource.

IRRIGATION WATER REQUIREMENTS

An assessment of the irrigation potential downstream of the proposed Zalu Dam, identified 5.4 ha area as highly suitable land in terms of irrigable soils, but its limited extent and high-lying position in the landscape means that large-scale irrigation development would not be viable. Further land was identified as moderately suitable, but the specialist recommended a detail soil survey before irrigation development is considered in the area. Lastly, marginally suitable land covers several isolated areas along the terraces and, in places, lower footslope sites adjacent to the Xura River. This land is not recommended for formal irrigation development, but limited areas could be used for garden purposes with technical and managerial inputs.

The estimated annual irrigation water-use required, amounts to 1.317 x 10^6 m^3 per annum and this corresponds to 4 878 m^3/ha/annum for the 270 ha development block.

WATER RESOURCES

HYDROLOGY AND CLIMATE

The mean annual precipitation (MAP) over the Msikaba River catchment ranges from 1 500 mm at the coast to 800 mm inland at the headwaters of the river system. The natural Mean Annual Runoff (MAR) of the Msikaba River is 221 million m³ from a total catchment area of 1 022 km². The MAR of the catchment upstream of the proposed Zalu Dam on the Xura River is 13.1 million m³ from a catchment area of 71 km².

RESERVE – ECOLOGICAL WATER REQUIREMENTS

The potential development of the Zalu Dam required an Intermediate Reserve to assess and mitigate the impact of a large dam on the Xura River. Two EWR sites were selected, one on the Xura River and the other on the Msikaba River. The Instream Index of Habitat Integrity (IHI) at EWR 1 was found to be in a Category A/B with a required maintenance flow of 3.2 million m³/a. The Instream IHI at EWR 2 was found to be a Category B with a required maintenance flow of 23.7 million m³/a. Drought and high flows, as well as the long term mean were also estimated for these sites.

SURFACE WATER RESOURCES

The main future potential surface water resource for the area is the proposed Zalu Dam on the Xura River. However, the available supply from Zalu Dam can be augmented with groundwater resources from seventeen identified potential production boreholes.

The Intermediate Reserve Study confirmed that the low flow Ecological Water Requirements downstream of the proposed Zalu Dam at EWR 1 will be satisfied through river releases to the abstraction point at T6H004. Furthermore, the high flow EWR is also satisfied by spills from an optimised dam and run-off from the incremental catchment. Therefore, the location of water abstraction is critical to optimise the yield from the proposed Zalu Dam as the domestic water requirements for 2040 are more than the low flow EWR.

It was found that the HFY and 1:100 year yield of a 60% MAR Zalu Dam (FSL of 612 masl) is 6.0 million m³/a and 6.75 million m³/a respectively. This yield will be sufficient to supply the maximum future demands of 2040, i.e. 6.85 million m³/a. The 1:100 year yield for a 1.5 MAR Zalu Dam, that can be used for an extended supply area, is 10.3 million m³/a.

GROUNDWATER RESOURCES

There is more than adequate groundwater recharge to meet the planned water supply volumes. Not all water can however be abstracted as a result of factors such as terrain inaccessibility. Groundwater sources were identified to augment the Lusikisiki RWSS and to supply areas further away from Lusikisiki Town.

The groundwater abstraction network was optimised, since some of the proposed boreholes are close to each other and will have to be utilised at reduced rates to minimise the influence between neighbouring boreholes.

The recommendation is to equip 9 boreholes, previously drilled, and to drill and equip an additional 8 boreholes to abstract 2 553 m³/day (0.93 million m³/a) from the Regional Well-field Area (RWA). This water is intended for supplying the domestic water needs in conjunction with surface water supplies from a new dam at the Zalu site on the Xura River. By using these water sources conjunctively a limited degree of flexibility is introduced in the bulk water distribution system and the storage capacity required in the proposed new dam can be minimized with significant savings in capital costs.

Numerous communities/villages fall outside of the RWA. These communities need to be served by stand-alone schemes that will either serve single communities or small clusters of communities depending on local groundwater conditions. Water sources will also involve springs as well as new boreholes that need to be developed.

DEVELOPMENT OF SURFACE WATER RESOURCES

The preferred dam site on the Xura River can be developed as a reliable source for meeting the expected needs for domestic use and for stimulating socio-economic development in the region, inter alia by making water available for new irrigation. This dam site is about 0.5 km northeast of the Ndimbaneni village.

The proposed Zalu Dam was sized for the following variables:

- *Abstraction of water for domestic use at the downstream gauging station T6H004, below the Ecological Water Requirements monitoring point EWR 1.*
- *The intention to provide for new irrigation development as a strategic stimulus of economic development in the region.*

- *The conjunctive use of groundwater with surface water supplies from the proposed dam.*

*URV calculations (refer to **Table 4.1**) indicates that Zalu Dam augmented with groundwater is the most favourable economic option. In consultation and with guidance by DWA, recognising the **strategic importance of irrigation development**, an allowance for an irrigation allocation was also included in the decision-making process.*

The water resource for the LRWSS is the proposed Zalu Dam with a full supply level of 612 masl on the Xura River, which can support the 5.4 million m³/a 2040 domestic demand plus the 1.45 million m³/a irrigation demand, augmented with groundwater development of seventeen production boreholes with a yield of 0.93 million m³/a, was selected for feasibility design.

However, it was estimated that the yield potential of the Xura River at the Zalu site is considerably more than that required for meeting domestic water needs up to 2040 and for providing for new irrigation development. It may be practical to create storage at the Zalu Dam site at least equal to 1.5 MAR which will deliver a yield of approximately 10.3 million m³/a. This is far more than is required in the foreseeable future but, depending on the engineering design approach and affordability, it may be justifiable to develop the larger capacity in order to make maximum use of the storage capability at the site. The final dam size needs to be confirmed before final design.

The feasibility design focused on the 0.6 MAR dam with a full supply level of 612 masl and conceptual design for a 1.5 MAR dam with a full supply level of 622.6 masl.

MATERIALS AND GEOTECHNICAL INVESTIGATIONS

Materials and geotechnical investigations confirm that suitable founding conditions and sufficient construction materials are available for a rockfill or a concrete gravity dam built using Roller Compacted Concrete (RCC) methods.

Sufficient material is available for an Earth Core Rockfill Dam (ECRD) in a borrow area downstream of the dam, where weathered dolerite clay material can be obtained. The localities of two possible rockfill quarries for unweathered dolerite upstream of the centreline have been identified; both are below the full supply level of the dam.

A horizontal layer of unweathered dolerite was encountered at the centreline of the dam; this can be used for an approach channel floor for a side channel spillway.

No natural sand was identified on site during the geotechnical investigation, and must be imported from a commercial source.

DAM TYPE SELECTION

*Two dam types and three dam sizes were investigated and pre-feasibility level estimates of construction costs of each were made to inform the dam type selection. Cost estimates were used to determine the most cost effective dam type (refer to **Table 4.2**). An Earth Core Rockfill Dam (ECRD) is significantly more cost-effective and was selected for the feasibility-level design.*

FEASIBILITY DESIGN FOR ZALU DAM

The preferred general arrangement of the Earth Core Rockfill Dam is a side channel spillway on the right bank and an intake tower with a bottom outlet next to the river on the left.

River diversion for construction of the dam is planned in three stages:

- *Stage 1: No cofferdam is required for the period when the bottom section of the intake tower and outlet conduit is constructed.*
- *Stage 2: Diversion through the outlet conduit with a cofferdam.*
- *Stage 3: Plug the opening to the conduit with concrete after the dam is completed.*

The outlet works consist of a dual pipe system comprising multi-level intakes with butterfly valves to enable water to be drawn from storage at different levels, and sleeve valves downstream for controlling releases. The outlet pipes are 900 mm diameter each with 900 mm and 300 mm sleeve valves. The 300 mm sleeve valves are for the supply of water for domestic use. The draw-off levels required should be confirmed by findings of the Environmental Impact Assessment.

*Feasibility level design and cost estimates were made for two dams sizes, namely capacity 8.0 million m^3 (FSL 612 masl) and capacity 19.8 million m^3 (FSL 622.6 masl) as shown in **Table i**.*

Table i: Cost estimates

Activity	0.6 MAR dam (FSL = 612 masl) Amount (R'000)	1.5 MAR dam (FSL = 622.6 masl) Amount (R'000)
Section		
Main Embankment	*78 406*	*118 366*
Spillway	*58 201*	*111 237*
Outlet works	*65 596*	*70 797*
Subtotal A	***202 203***	***300 400***
Landscaping (5% of Subtotal A)	*10 110*	*15 020*
Miscellaneous (15% of Subtotal A)	*30 330*	*45 060*
Subtotal B	***242 643***	***360 480***
Preliminary & General (40 % of Subtotal B)	*97 057*	*114 192*
Preliminary works	*4 500*	*4 500*
Accommodation	*8 640*	*8 640*
Subtotal C	***352 840***	***517 812***
Contingencies (20% of Subtotal C)	*70 568*	*103 562*
Subtotal D	***423 408***	***621 374***
Design and supervision (15% of Subtotal D)	*63 511*	*93 206*
Subtotal E	***486 919***	***714 581***
VAT (14% of Subtotal E)	*68 169*	*100 041*
Total Dam Cost	***555 088***	***814 622***

The implementation programmes show that construction can commence in the second half of 2017, with impoundment in August 2020 and April 2021.

HYDROPOWER POTENTIAL

Provision for installing hydropower generating equipment has been made in the conceptual design of the outlet works of the dam. Since water will be released from storage with a significant but variable head, the potential for using this situation for generating hydroelectric power was estimated for the future domestic use of 5.4 million m^3 per year in 2040 and with an average head of 13.34 m available at the 0.6 MAR dam or 20.7 m available at the 1.5 MAR dam.

*This simplified approach indicates that the potential for generating hydropower at the dam on a continuous basis, i.e. suitable for supplying a base load, is **19 kW** for the smaller dam and **29.5 kW** for the larger dam.*

WATER SERVICES INFRASTRUCTURE

EXISTING BULK SUPPLY RESERVOIRS

The existing bulk supply and village reservoirs are in a poor state. The total storage capacity of the existing reservoirs is unsure due to the lack of "as built" data, but the estimated total storage capacity of the existing reservoirs is approximately 5 335 m^3. The estimated total capacity of the existing storage reservoirs is about twice the daily capacity of the existing pipeline system.

PUMPING

The existing raw water and clear water pumping stations each have a capacity of 32 ℓ/s for 24 hours of pumping per day.

LUSIKISIKI WATER TREATMENT WORKS

The existing water treatment works (WTW) was found to be in a well maintained condition, with the dosing system and sludge handling components that require attention.

The existing WTW was constructed in modular units for future extension requirements. However, future extensions to the plant are subjected to land availability, future domestic water demands and hydraulic requirements.

The raw water from the Xura River is currently treated adequately, except for colour, turbidity and alkalinity. For the new and/or upgraded WTW it is expected that an optimally designed, operated and maintained sand filter will be sufficient to remove the colour and turbidity below the required limits. Corrosion and concrete aggression in the network could be a potential problem due to low alkalinity of the water, the alkalinity could however be increased through dosing of a hydroxide. Alternatively concrete tanks and reservoirs can be constructed with water retaining concrete or other surface coats in order to resist the aggression of the water.

Iron and Chloride are the key water quality concerns of the groundwater, although Bacteria and Coliforms are also concerns at some of the boreholes. Treatment of the borehole water at the central WTW was considered, but due to the sparse distribution of the boreholes this will not be feasible and therefore on-site treatment is recommended at each one of the boreholes where treatment is required.

Water Quality

The quality of intake water from the Xura River Weir is generally of good quality, but parameters such as Total Iron and total Coliform may be too high. For the purposes of this Study water samples were also tested and it was found that constituents of concern are colour, turbidity, iron and low alkalinity.

A multi-level dam outlet will however allow for flexibility to select water from various levels, depending on the water quality in the dam.

The quality of the surface water could however deteriorate in future due to increased population densities and agricultural/industrial growth in the Xura River catchment.

FUTURE DEVELOPMENT OPTIONS

Proposed Zalu Dam

The water resource for the LRWSS is the proposed Zalu Dam with a full supply level of 612 masl on the Xura River, which can support the 5.4 million m^3/a 2040 domestic demand for the Planning Area plus the 1.45 million m^3/a irrigation demand, augmented with groundwater development of 17 production boreholes with an yield of 0.95 million m^3/a.

Future Bulk Supply Infrastructure

Distribution Pipelines

Due to these uncertainties, the assessment of the recommended bulk supply options was performed for two scenarios:

The required capacities of the proposed new distribution infrastructure are as follows:

- ***Scenario 1**: a supply of 17.40 Mℓ/day if the proposed irrigation is implemented, for yields of 5.4 million m^3/a, and 0.95 million m^3/a from Zalu Dam and groundwater sources respectively. The required WTW capacity will be **14.7 Mℓ/day** to treat the raw water that is supplied from Zalu Dam (5.4 million m^3/a).*

- ***Scenario 2:** a supply of 22.33 Mℓ/day if the proposed irrigation is not implemented, for yields of 7.2 million m^3/a, and 0.95 million m^3/a from Zalu Dam and groundwater sources respectively. The required WTW capacity will be **19.7 Mℓ/day** to treat the raw water that is supplied from Zalu Dam (7.2 million m^3/a).*

It was found that a new bulk supply system that runs parallel to the existing bulk supply pipelines, and beyond will not be feasible.

It is recommended that new bulk supply pipelines be constructed and that the existing AC bulk supply pipes be decommissioned.

The total required storage volumes for the proposed new bulk supply system are 78 521 m³ and 106 575 m³ for Scenario 1 and 2 respectively.

Pumping

The existing raw water and clear water pumping stations each have a capacity of 32 ℓ/s for 24 hours of pumping per day. These pumping stations will have to be upgraded to capacities of 171 ℓ/s and 228 ℓ/s for abstractions of 5.4 and 7.2 million m³/a respectively, from Zalu Dam. The total daily energy requirements for pumping of the supplies from Zalu Dam, and groundwater sources, in 2040 and 2060 respectively, are 14 652 kWh/day for both the pumping rates analysed.

The existing abstraction weir on the Xura River will not require any modifications, provided that the depth of the raw water pumping station's sump is adequate to provide for sufficient suction head for the pumps.

Water Treatment Works

Out of the 17 identified potential production boreholes for future augmentation, the water from four of the boreholes is Class 1 and will not require any treatment. The water from the remaining 13 boreholes will however require some on-site treatment, as treatment of the borehole water at the central WTW will not be feasible.

Treatment must ensure that the Iron, Chloride, Bacteria and Coliform concentrations comply with the maximum permissible concentrations.

Although marginally, the URVs show that a combination of refurbishment of the existing 2.76 Mℓ/day WTW at Xura, and the construction of a new 12.03 Mℓ/day WTW at Xura was preferable to a complete new 14.7 Mℓ/day WTW at Xura.

The estimated capital cost for the proposed bulk distribution infrastructure is R 565.3 million (incl. VAT).

ENVIRONMENTAL IMPACT ASSESSMENT

No fatal flaws were identified during the risk assessment. However, the environment is sensitive and requires proper assessment and management. A detail Environmental Impact Assessment will follow the feasibility study.

The public participation process (PPP), as part of the Environmental Screening, has shown that there is a poor perception and negative attitude towards groundwater. Also, there is a lack of sustainable and safe drinking water sources in the area.

REGIONAL ECONOMIC IMPACT ASSESSMENT

The proposed LRWSS is expected to increase the size of the economy of the local area. It will have significant macro-economic impacts due to the fact that it will increase the level of production, GDP, employment and worker income at a local, provincial and national level, as well as stimulate business and human capital development and assist in raising living standards.

Through the employment opportunities created it is estimated that a total of 23 860 people will benefit from the construction phase of a 5.4 million m^3/a system. A 7.2 million m^3/a system will benefit a total of 26 100 people during the construction phase. This is the result of an increase in worker income within each household affected. The operational phase combined with the two refurbishment phases will positively affect between 23 411 and 30 580 people over a 46 year time period (depending on the chosen system).

The income profile indicated that there is a significant portion of the population that is at risk of not being able to afford the water that will be provided through the LRWSS. With time, increased economic activity through the LRWSS investments will lead to an increase in worker income and, as a result, more people will be able to afford water. It can therefore be said that to make water available and affordable grant funding will be required.

LEGAL, INSTITUTIONAL AND FINANCING ARRANGEMENTS

There are various institutions that can play a role regarding the institutional arrangements and the funding of the Zalu Dam as well as the associated water treatment works and regional water supply works. These institutions are National Treasury, the Department of Water Affairs (DWA), OR Tambo District Municipality (DM) (the Water Services Authority) and a water board, being either Amatola Water or Umgeni Water.

The works will need to be subsidised through grant funding, either Regional Bulk Infrastructure Grant (RBIG) or a dedicated grant on the DWA budget. The responsibility for applying for the required grant funding should be aligned to ownership. If for example it was decided that DWA should own the dam and that a water board or OR Tambo DM should own the water treatment works and pipelines then there would be two separate applications for grant funding, and these applications would need to be aligned.

It is recommended that the DWA, OR Tambo DM, and a water board (either Amatola Water or Umgeni Water) should negotiate and agree on ownership and contractual arrangements for the development and the operation of the water treatment works and bulk distribution works.

It is further recommended that the agreed owner of the water treatment works should be directed to apply for an RBIG Grant for the funding of the water treatment works and bulk distribution works.

It is recommended that consultation should be held with National Treasury, within DWA Regional and Head Office, with OR Tambo DM's Water Portfolio Committee, and with either Amatola Water Board or Umgeni Water Board to confirm that the above recommendations are acceptable to all parties and formal contracts should be concluded.

National Treasury has confirmed that ownership of infrastructure and responsibility for funding are generally inseparable. A commercial funder and/or the RBIG adjudication committee would expect the application for grant funding to be lodged by the proposed owner of the proposed infrastructure.

If it is decided that DWA should take ownership of the Zalu Dam and that a water board should take ownership of the Water Treatment Works then the link between funding and ownership should be clearly communicated so that the two separate applications for funding are properly co-ordinated.

A Land Affairs Board needs to be established to determine compensation, purchase prices or rents in respect of immovable property expropriated, purchased or leased by the Department of Public Works and Land Affairs for public purposes; and the giving of advice with regard to the value of land, rights in respect of land and purchase prices or rents in respect of certain immovable property. The Board may also advise the Minister of DWA on the amount of compensation to pay for land that it wishes to expropriate in the dam basin.

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List of abbreviations

AC	Asbestos Cement
AECOM	AECOM SA (Pty) Ltd
BKS	Legacy BKS (Pty) Ltd
CCPP	Calcium Carbonate Precipitation Potential
CCT	Chlorine Contact Tank
D:NWRP	Directorate: National Water Resource Planning
DOC	Dissolved Organic Carbon
DWA	Department of Water Affairs
EPBS	Eastern Pondoland Basin Study
EWR	Ecological Water Requirements (Reserve)
FSL	Full Supply Level
LRWSS	Lusikisiki Regional Water Supply Scheme
ND	Nominal Diameter
MAR	Mean Annual Runoff
OD	Outside Diameter
O&M	Operation and Maintenance
PAC	Powdered Activated Carbon
PPP	Public Participation Process
RGSF	Rapid Gravity Sand Filter
RSA	Republic of South Africa
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
VAPS	Vaal Augmentation Planning Study
URV	Unit Reference Value
WQ	Water Quality
WRC	Water Research Commission
WTW	Water Treatment Works

List of units

a	annum
ha	hectare
hrs	hours
km	kilometre
km^2	square kilometre
ℓ	litre
ℓ/cap/day	litre per capita per day
M	metre
m/s	metre per second
m^3/s	cubic metre per second
masl	metres above sea level
million m^3	million cubic metres
million m^3/a	million cubic metres per annum
Mℓ/day	megalitre per day
mm	millimetre
MW	megawatt
Ø	diameter in millimetres
s	second

1 INTRODUCTION

The Department of Water Affairs (DWA) appointed **BKS (Pty) Ltd** in association with four sub-consultants (**Africa Geo-Environmental Services, KARIWA Project Engineers & Associates, Scherman Colloty & Associates and Urban-Econ**) to undertake the **Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme (LRWSS)**. This assignment commenced on 1 September 2010

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. The new entity is a fully-fledged going concern with the same company registration number as that for BKS. As a result of the change in name and ownership of the company during the study period, all the final study reports will be published under the AECOM name.

1.1 BACKGROUND TO THE PROJECT

In the 1970s O'Connell Manthé and Partners and Hill Kaplan Scott, both Consulting Engineers, recommended that a regional water supply scheme, based on a dam on the Xura River and a main bulk supply reservoir close to Lusikisiki (located within the then defined "administration area" of the Zalu Dam), be developed to provide a potable water supply for the entire region between Lusikisiki and the coast, extending from the Mzimvubu River in the south west to the Msikaba River in the north east. Some areas up to 15 km inland of Lusikisiki would also be supplied. A **White Paper** describing the scheme was tabled by the Transkei Government in 1979. It was envisaged that the scheme would be constructed in phases as described in the report *Lusikisiki Regional Water Supply: Preliminary Report* (Hill Kaplan Scott, 1986).

After the reincorporation of the Transkei Homeland into the Republic of South Africa (RSA) in 1994, the DWA took over responsibility for further development of the scheme. The Directorate: Water Resources Planning commissioned the *Eastern Pondoland Basin Study* (EPBS) in 1999 to further investigate the water supply situation in the area, with the intention of developing the Lusikisiki Regional Water Supply Scheme (LRWSS) in the area. This detailed investigation of surface and groundwater sources confirmed that the Zalu Dam in the Xura River was the preferred source of surface water and recommended that further investigation of the groundwater sources to augment water supply to the area be undertaken.

In 2007, SRK Consulting undertook the *Lusikisiki Groundwater Feasibility Study* to investigate the groundwater potential in the area. This study reported that there is a relatively strong possibility of high yielding boreholes being developed and that a combination of surface water (from Zalu Dam) and groundwater would be the most attractive combination of sources for the LRWSS.

1.2 STUDY AREA

The Study Area comprises the region between Lusikisiki (up to about 15 km inland) and the coast, extending from the Mzimvubu River in the south-west to the Msikaba River in the north-east, as shown on **Figure 1.1**. This area includes the Zalu Dam site and its catchment in the Xura River, conveyance routes between the dam and control reservoirs, as well as borehole sites that could be developed for augmentation of water supplies from groundwater and the routes of the main pipelines from the boreholes to the control reservoirs.

In the south-western part of the study area the preferred option is to develop local water supplies from groundwater for supplying directly to the smaller surrounding communities. The broken topography, deep river valleys and the distance from reservoirs in the bulk regional scheme, render supplies to these areas from Zalu Dam very costly.

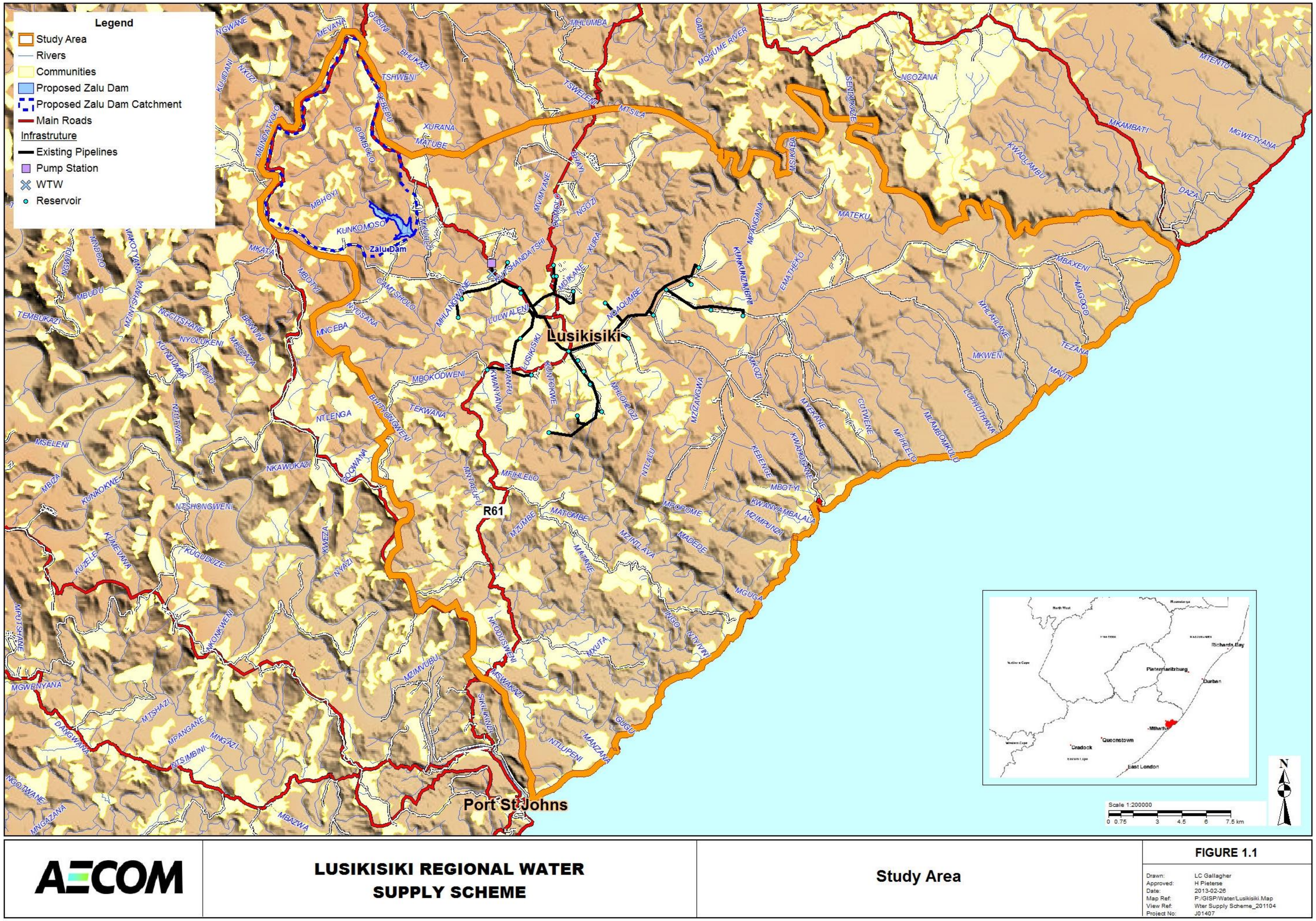


Figure 1.1 Study area

1.3 OBJECTIVE AND SCOPE OF THE STUDY

The objective of this study was to undertake a comprehensive engineering investigation, at feasibility level, of the proposed LRWSS with the proposed Zalu Dam in the Xura River being the main element, and to recommend the most attractive bulk water supply infrastructure for augmenting water supplies to the whole supply area. The options available include the development of local groundwater resources for domestic supplies for smaller communities where this provides the most cost-effective option.

Development of a major dam in the Xura River offers a unique opportunity to provide a stimulus for socio-economic development in this economically depressed region of the Eastern Cape. Poverty is rife in this region, unemployment rates are high and the level of socio-economic activity with a prospect of generating more work opportunities is very low.

In addition to the short term injection of capital investments into the economy, a significant number of short-term, meaningful job opportunities would become available during the construction period of about three years. There would be a relatively small number of permanent work opportunities created in the operation and maintenance of the new infrastructure. However, perhaps more significant and of longer lasting value, could be the allocation of water from the project for use in irrigated agriculture and perhaps in associated agro-industries.

This Feasibility Study includes the assessment of all aspects that impact on the viability of utilising a combination of surface water from the Zalu Dam on the Xura River and groundwater for augmentation of the existing domestic water supplies to all water users in the study area. Sufficient water supplies of good quality and reliability must be accessible to all, at an appropriate level of service and affordable cost to the users. It was therefore necessary to:

- Identify the technical issues likely to affect implementation, and to define and evaluate the actions required to address these issues;
- Provide an estimate of cost, at a feasibility level of accuracy and reliability, to ensure that management decisions can be made with confidence;
- Investigate the viability of new irrigation development; and to
- Provide sufficient information to enable design and implementation to proceed without much further investigation.

The activities in this feasibility study were grouped into 14 modules as shown below:

- Module 1: PROJECT MANAGEMENT: Inception Report
    - 1.1 Study initiation and inception
    - 1.2 Project management and administration
- Module 2: WATER RESOURCES
    - 2.1 Hydrology
    - 2.2 Yield analysis
    - 2.3 Reservoir sedimentation
- Module 3: GROUNDWATER AUGMENTATION
- Module 4: RESERVE: ECOLOGICAL WATER REQUIREMENTS
- Module 5: WATER REQUIREMENTS
    - 5.1 Domestic water requirements
    - 5.2 Agriculture / Irrigation potential
- Module 6: WATER SERVICES INFRASTRUCTURE
    - 6.1 Bulk water distribution infrastructure
    - 6.2 Water quality
- Module 7: PROPOSED ZALU DAM
    - 7.1 Materials and geotechnical investigations
    - 7.2 Technical details of the Dam
- Module 8: COST ESTIMATE AND COMPARISON (included in Modules 6 and 7 reports)
- Module 9: REGIONAL ECONOMICS
- Module 10: ENVIRONMENTAL SCREENING
- Module 11: PUBLIC PARTICIPATION (included in Environmental Screening Report)
- Module 12: LEGAL, INSTITUTIONAL AND FINANCIAL ARRANGEMENTS
- Module 13: RECORD OF IMPLEMENTATION DECISIONS
- Module 14: MAIN REPORT AND REVIEWS

1.4 SCOPE OF THIS REPORT

The purpose of this **Main Study Report** is to provide an overview of the specialist studies that were conducted in *the Feasibility Study for Augmentation of the Lusikisiki Regional Water Supply Scheme* (LRWSS) and to present the findings and recommendations.

2 WATER REQUIREMENTS

2.1 DOMESTIC WATER REQUIREMENTS

Water requirements for domestic use were estimated for all settlements in the Study Area shown on **Figure 1.1.** The area intended to be supplied from the proposed Zalu Dam is referred to as the LRWSS supply area. In view of the opportunity presented by development of the water resources of the Xura River to stimulate socio-economic development in the region, the possibility of in future extending the area of supply to include other towns and settlements is not discounted.

2.1.1 Demographics

The Study Area has a relatively high population density of over 110 people per square kilometre and a demographic structure typical of rural South Africa. The population of the study area is growing and is expected to continue growing in future. The absence of socio-economic development to support this population growth implies an inevitable reduction in standards of living.

The demographic analyses in this study confirmed previous estimates of the population size. Estimated population growth rates which rely strongly on historical trends are found to be unreliable. Factors such as HIV and AIDS and migration away from the rural Eastern Cape have a considerable influence on population growth expectations. Based on the latest Stats SA mid-year estimates, the national population growth rate decreased significantly from 1.45% in 2001/02 to 0.82% in 2007/08. During the same period the Eastern Cape's contribution to the total national population declined from 14.4% to 13.5%, which indicates a growth rate lower than the national average.

Four population growth scenarios (low, medium, high and a most probable scenario) were used to estimate domestic water requirements in the LRWSS Supply Area and in the Study Area. These population growth scenarios are shown in **Table 2.1**.

Table 2.1: Population growth scenarios, 2010 - 2040

Area	LRWSS Supply Area*				Study Area[#]			
Scenario	Low growth scenario	Medium growth scenario	High growth scenario	Most probable scenario	Low growth scenario	Medium growth scenario	High growth scenario	Most probable scenario
Average Annual Growth Rate	0.3%	1.1%	2.1%	1.6%	0.3%	0.9%	1.5%	1.2%
2010	78 700	78 700	78 700	78 700	162 800	162 800	162 800	162 800
2015	81 600	82 900	85 200	84 100	168 600	170 600	173 600	172 100
2020	83 600	87 800	94 000	90 900	172 000	178 900	188 400	183 650
2025	84 400	92 600	104 600	98 600	173 700	187 500	206 500	197 000
2040	85 700	107 800	147 200	127 500	179 000	211 300	258 200	234 750

* *LRWSS area: the area that will be directly influenced by the proposed Zalu Dam*

\# ***Study area:** the entire region that is being investigated in this study, defined in **Section 1.2**, includes the area that will be serviced by groundwater*

The most probable scenario, the scenario intermediate to medium and high growth, is based on historic growth rates and envisages future economic progress being stimulated *inter alia* by infrastructure development. The most probable population growth rates for the LRWSS Supply Area and the Study Area are expected to be 1.6% per annum and 1.2% per annum respectively.

2.1.2 Socio-Economic Profile

The potentially economically active portion of the population, i.e. those between the ages 15 and 64 years, comprises a small percentage of the total population. This reflects a weak labour force profile. The unemployment rate in the area is above the national average at 35% according to Census 2011 data. There is therefore a pressing need for employment opportunities in the region.

Nearly a quarter of the population of the study area has had no schooling and a further quarter has had only some level of primary education. The region is characterised by residents with a mean of only 6.5 years of schooling, far below the provincial and national averages.

A large portion of the population (40.5%) earns income below the poverty line. This indicates that there is a significant portion of the population that is at risk of not being able to afford having to pay for water provided through the LRWSS. According to the

Human Development Index (HDI) the study area scored 0.4 which indicates low levels of development.

The majority of households in the study area do not have access to piped water. This in turn affects household access to water-borne sanitation services and creates backlogs for the respective local municipal authorities in creating sustainable human settlements. At present only 17% of households receive water through a regional or local water scheme operated by their municipality or another water services provider. At present the majority of households acquire raw water from rivers or streams.

The study area has a relatively low level of social infrastructure, predominantly located near Lusikisiki and along transportation route spines. The non-provision or reduction of services has a detrimental impact on the efficiency of a region's economy and on the wellbeing of a community.

The community and social services sector, including Government and the public sector as a whole, makes the largest contribution (41.7%) to the economy of the Study Area. Construction is also a fairly large contributor to local value addition, largely a result of building activity linked to public sector programmes and projects. Formal agricultural output reflected in the regional statistics is low, but it must be noted that the official statistics do not reflect the production of subsistence farming on which the majority of the rural villages in the Study Area rely.

The Study Area output is comparatively low, particularly from the portion within the Port St Johns Local Municipal boundary. This is a consequence of historical apartheid policies that led to underdevelopment in the economies of regions in the former Transkei.

2.1.3 Projections of Domestic Water Requirements

The average per capita water consumption in the Study Area for 2013 is estimated at **114 ℓ/c/d** with 59% of the population using 90 ℓ/c/d and 26% using 200 ℓ/c/d. Only 15% of the population in the Study Area use 60 ℓ/c/d or less at present. See *Domestic Water Requirements Report (P WMA 12/T60/00/4111)*. The existing water supply system is supplied from a run-of-river abstraction in the Xura River near flow gauging station T6H004. This water source is not secure since there is no upstream storage and shortages occur during periods of low flow.

Domestic water requirements in the study area for the period 2010 to 2040 were estimated using the four population growth scenarios with the most likely scenario being adopted for planning purposes. The following service levels were used:

- Category 1: rural villages with a basic level of service: 25 ℓ/c/d[1] (population < 500);
- Category 2: rural villages with stand connections: 60 ℓ/c/d (500 < population < 1 500);
- Category 3: rural villages with provision for schools, clinics and hospitals: 90 ℓ/c/d (1 500 < population < 5 000); and
- Category 4: dense rural towns with some economic development and water-borne sewerage: 150 to 250 ℓ/c/d (population > 5 000).

> **Note**: *According to the recent National Water Policy Review (NWPR) the previous norm for the basic level of service of 25 ℓ/c/d is the minimum required for "direct consumption, for food preparation and for personal hygiene", and is inadequate for a "full, healthy and productive life." The policy takes the following position: "A basic water supply facility is defined as the infrastructure necessary to supply potable water to a formal connection at the boundary of a stand"* (South Africa, 2013). ***Based on this position, the basic water supply norm is 60 ℓ/c/d.***

The water demand projections for the Study Area and LRWSS Supply Area are given in **Table 2.2** and **Table 2.3**, respectively.

Table 2.2: Water demand projections for the Study Area (Mℓ/d and *[million m³/a]*)

Scenario	2010	2015	2020	2025	2040
LOW	18.5 *[6.75]*	19.2 *[7.01]*	19.5 *[7.12]*	19.7 *[7.19]*	20.3 *[7.41]*
MEDIUM	18.5 *[6.75]*	19.4 *[7.08]*	20.3 *[7.41]*	21.3 *[7.77]*	24.3 *[8.87]*
HIGH	18.5 *[6.75]*	19.7 *[7.19]*	21.4 *[7.81]*	23.5 *[8.58]*	29.8 *[10.88]*
MOST PROBABLE	**18.5** ***[6.75]***	**19.5** ***[7.124]***	**20.85** ***[7.61]***	**22.4** ***[8.18]***	**27.05** ***[9.87]***

[1] *The water supply for a basic level of service of 25 ℓ/c/d was set in the 1994 White paper on Water Supply and Sanitation Policy, which is based on international guidelines.*

The domestic water requirements based on the most probable scenario for the Study Area will be approximately 27.05 Mℓ/d (9.87 million m^3/a) by 2040.

Table 2.3: Water demand projections for the Supply Area (Mℓ/d and *[million m³/a]*)

Scenario	2010	2015	2020	2025	2040
LOW	8.9 *[3.3]*	9.3 *[3.4]*	9.5 *[3.5]*	9.6 *[3.5]*	9.7 *[3.6]*
MEDIUM	8.9 *[3.3]*	9.4 *[3.4]*	10 *[3.6]*	10.5 *[3.8]*	12.4 *[4.5]*
HIGH	8.9 *[3.3]*	9.7 *[3.5]*	10.7 *[3.9]*	12 *[4.3]*	17 *[6.2]*
MOST PROBABLE	**8.9** ***[3.3]***	**9.6** ***[3.5]***	**10.3** ***[3.8]***	**11.2** ***[4.1]***	**14.7** ***[5.4]***

Based on the most probable scenario it is estimated that the domestic water requirements for the LRWSS Supply Area will be approximately 14.7 Mℓ/d (5.4 million m^3/a) by 2040.

2.2 IRRIGATION WATER REQUIREMENTS

No formal irrigation has so far developed along the Xura River and no background regarding successful crop patterns and farming practices is available in the Study Area. Provision for the development of irrigated agriculture is therefore a strategic initiative to address the urgent need to stimulate socio-economic development in the region as a basis for rural development and agrarian reform. It was therefore necessary to confirm the existence of irrigable soils on which agricultural projects could be developed.

This investigation did not assess the other vital factors necessary for successful development of an irrigation scheme such as:

- Candidate farmers willing and able to participate in such a new enterprise with success.
- Cropping patterns that may be successful in this region.
- Marketing links for the sale and distribution of products.
- The most desirable size of irrigation water allocation and farm size to ensure success.

- Financial and technical advisory support available to new farmers to get going and continue into the future.
- Financing needed and available to new farmers.

Attention was focused on identifying and assessing the locality and potential of irrigable soils downstream of the proposed Zalu Dam. This study provided an overview of the soil potential for agriculture and of the present agricultural activities in the area. The irrigation potential assessment considered factors such as soil characteristics, agricultural-economic factors, and engineering considerations. See *Irrigation Potential Assessment (P WMA 12/T60/00/4211)*.

2.2.1 Irrigation Potential Assessment

A **soil-landform** survey was undertaken to:

- Identify and classify the soil-landform resources and to map them at a detailed reconnaissance level; and
- Evaluate these landforms in terms of suitability for irrigation.

Table 2.4: Physical suitability classes for irrigation development

Map Unit	Physical Irrigation Suitability Class	Gross Area (ha)	Profile Description	Recommendations for Irrigation Development
LB1	1 (Highly suitable)	5.4	Deep to very deep (100-150+ cm), well-drained, dark red, structured, clayey soil, associated with dolerite occurrences in the landscape. Water permeability is rapid to moderate throughout the profile and the sustained infiltration rate is moderate.	Due to very limited extent and height above river level – probably not viable.
LC1	2 (Moderately suitable)	25.5	Mainly deep (>100 cm), moderately well-drained, reddish, weakly structured, loam to clay loam overlying unspecified material with signs of wetness in the deep subsoil. Water permeability is rapid through topsoil and subsoil, but moderate through the deep subsoil, whereas the sustained infiltration rate is moderate.	Limited extent – probably not viable. However, if development is considered, a detailed soil survey needs to be undertaken.
LD1	3 (Marginally suitable)	244.4	Poorly drained, very dark greyish brown, weakly structured, loam to silt clay loam topsoil on dark greyish, weakly structured, cutanic, clay loam to silt clay. Water permeability is moderate to rapid through the topsoil and subsoil, but moderate through the deep subsoil, whereas the sustained infiltration rate is moderate to slow.	Not recommended for formal development. Limited areas could be used for garden purposes with technical and managerial support.

Map Unit	Physical Irrigation Suitability Class	Gross Area (ha)	Profile Description	Recommendations for Irrigation Development
LA1	5 (Not suitable)	1 629.0	Shallow effective rooting depths (<40 cm), most forms show temporary wetness in the subsoil during and after the wet season. Because they had largely developed in parent materials derived from shale, they have loam to silty clay textures, i.e. with high silt contents	Not recommended.
LF1		3 225.8		
LE1		122.9	Poorly drained, dark coloured, weakly structured, loam to clay loam topsoil on greyish, gleyed, clay loam to silt clay.	

The soil-landform map of the study area in **Figure 2.1** shows the spatial distribution of six map units, LA1 to LE1, and describes the dominant soil and associated features, as well as the positions (landform and slope) that they occupy in the landscape. The legend of **Figure 2.1** is explained in **Table 2.4**.

In the assessment of **land suitability** for irrigation the soil-landforms were subdivided into classes of physical suitability, qualified by attributes limiting their suitability. The extent and recommendations of these physical suitability classes are summarised in **Table 2.4** and **Figure 2.1**.

Only 5.4 ha labelled as LB1, i.e. 0.1% of the land surveyed, is **highly suitable land** for irrigation **(Class 1).** The smallness in area and elevated position in the landscape (60-70 m above the river level) probably renders this piece of land not economically viable for irrigation development. Similarly, the land identified as being **moderately suitable** for irrigation **(Class 2)** and shown as map unit LC1 has a gross area of only 25.5 ha (0.6% of the land surveyed). This land is 15-30 m above the river level. A detailed soil survey is required to confirm the suitability of LC1 for irrigation development. The **marginally suitable land** in **Class 3** labelled as LD1 (5% of the land surveyed) is not recommended for formal irrigation development but limited areas could be utilised for garden plots.

Approximately 94% of the land is in **Class 5** which is not at all suitable for irrigation because of serious limitations.

Map unit	Landform and dominant slope class	Brief description of dominant soil	Soil form		Generalised irrigation suitability class	Dominant limitations	Size (ha)
			Dominant	Other			
LA1	Level to gently sloping crest, mid- and foot slope, foot slope of limited extend in places, 1 - 5% slope	Very shallow to shallow (20-60 cm), somewhat poorly drained, dark greyish, weakly structured, loam to silt loam overlaying hard and non-hard weathered shale	Cartef 1100 Glenrosa 1121, 1221	Longlands 1000 Wasbank 1000 Klapmuts 1120 Shortlands 1110 Katspruit 1000	5 (not suitable)	Restricted soil depth; temporary soil wetness	1629
LB1	Level to gently sloping crest and mid slope, 1 - 5% slope	Deep to very deep (100-10 cm), well drained, dark red, fine sub-angular blocky structured, clay associated with dolerite occurrences	Shortlands 1110		1 (highly suitable)	Mainly higher laying land	5.4
LC1	Gently sloping mid slope, 2 - 5% slope	Mainly deep (>100 cm), moderately well drained, red, weakly structured, loam to clay loam overlaying unspecified material with signs of wetness	Tukulu 1210	Hutton 1100	2 (moderately)	Temporary soil wetness in deep subsoil	25.5
LD1	Mainly level to gently sloping river terrace (valley bottom) and lower foot slope, 0 - 3% slope	Mainly deep (>100 cm), somewhat poorly to moderately well drained, dark coloured, weakly to strong fine blocky structured, loam to silt clay overlaying unspecified material signs of wetness, in places with layers of rounded stones in profile	Tukulu 1110, 2110 Bonheim 1110	Westleigh 1000 Katspruit 1000 Dundee 1210	3 (marginally suitable)	Temporary soil wetness ; flooding	244.4
LE1	Level to gently sloping river terrace, river banks with incised streambeds, bank and gully erosion evident, < 3% slope	Association of deep, dark grey, weakly structured, clay loam to clay with subsoil wetness, development from alluvium	Katspruit 1000 Dundee 1210	Tukulu 1110	5 (not suitable)	Temporary soil wetness; flooding; riparian land	122.9
LF1	Moderately sloping to very steep crest, scarp, mid- and foot slope, > 6 - 45% slope	Association of very shallow, dark grey, loam to silt clay soils, in places with rock outcrops	Glenrosa 1121 Cartef 1100 Mispah 1100	Shortlands 1110	5 (not suitable)	Steepness of land; restricted soil depth	3225.8
						TOTAL SIZE	5253

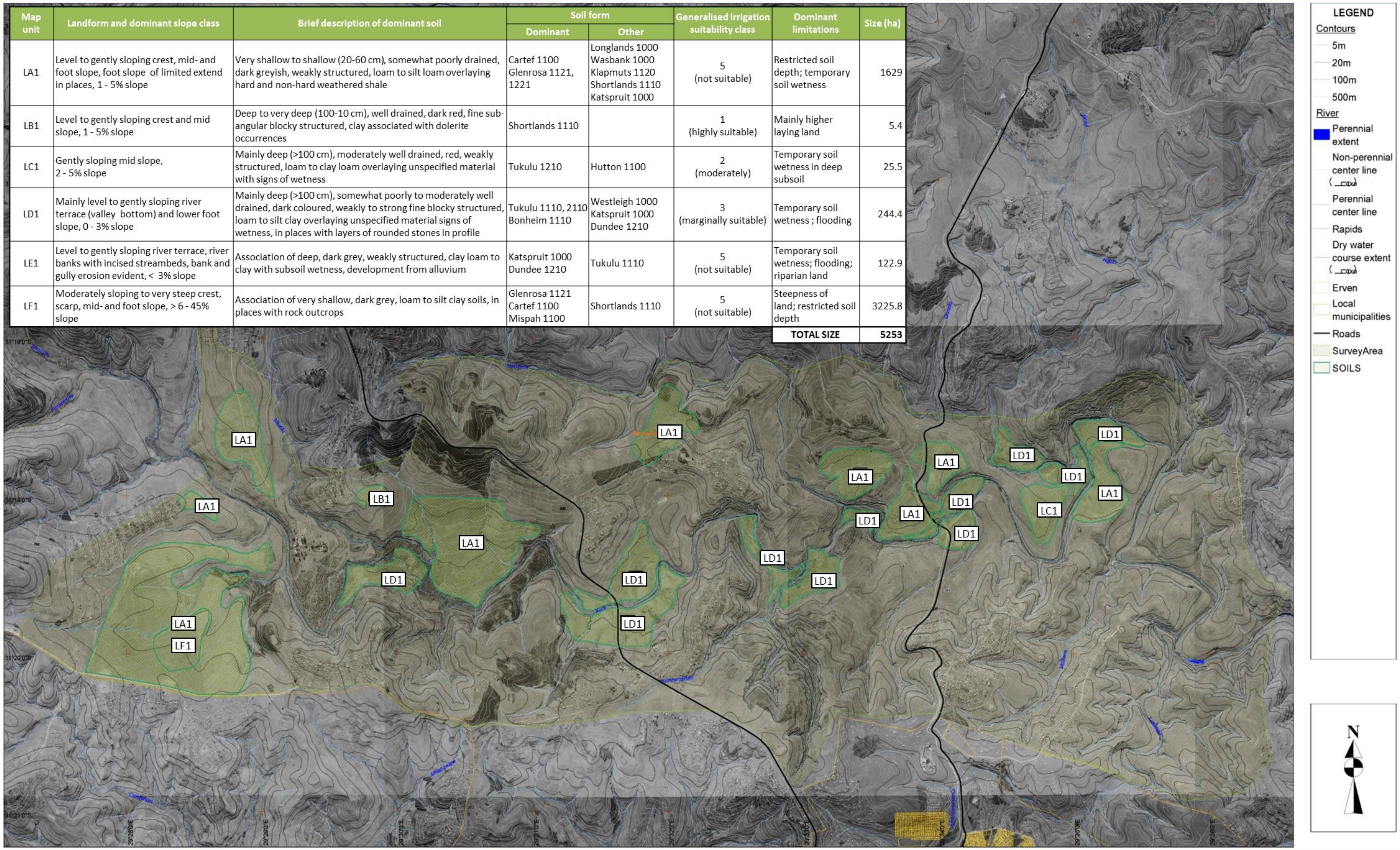


Figure 2.1: Detailed reconnaissance soil-landform map of the study area

Development of new irrigation schemes in economically deprived rural areas is viewed as a key strategic objective by the National Government in order to stimulate socio-economic development. Consequently provision is made for allocating water from the planned yield of Zalu Dam for irrigation, based on the areas of land in LB1, LC1 and LD1 that can be used effectively. *However, the suitability of these marginal soils for irrigation development must be verified by a more detailed soil survey.*

2.2.2 Irrigation water requirements

The irrigation water requirements for a variety of crops, namely beans, beetroot, pumpkin, tomato, spinach, carrot, mango and citrus, were estimated using SAPWAT 3. This is a model based on the universally recognised Penman-Monteith method of estimating reference evapotranspiration (ETo), the FAO method of linking reference evapotranspiration to any given crop by way of a crop factor (kc), and a series of efficiency factors, including irrigation method and effective rainfall.

The estimated annual irrigation water requirement at field edge amounts to 1.32 million m^3 per annum for the 275.3 ha of land that could possibly be developed. This corresponds to an annual allocation of 4 795 m^3/ha/annum.

If the new irrigation area is supplied from Zalu Dam, the allocation of ***water for irrigation*** will be 1.45 million m^3/a to accommodate a 10% provision for transmission losses. It is recommended that the irrigation development be subjected to the following conditions:

- A detailed soil survey is required to confirm suitability of LC1 for irrigation development; and
- The Class 3 (marginally suitable land) is not developed for formal irrigation development; however, limited areas could be utilised for garden plots.

2.2.3 Other agricultural water uses

Other existing water uses associated with agricultural development are:

- Livestock water use which is estimated at 6 200 m^3/day or 2 263 000 m^3/annum.
- Current poultry and broiler production will require about 1 650 m^3/annum and is not expected to grow by much more than 20% to about 2 000 m^3/annum.
- A red meat abattoir with an estimated water use at 25 000 m^3/annum.
- An area of 2 100 ha which is already under afforestation.

These water uses are assumed to continue unabated. Since they consume a relatively small quantity of water their impact on the surface water resource and the estimated yield of a new dam is not significant.

2.2.4 Agro-economic activities

A survey of the agricultural and agro-industrial activities in the study area indicates that there was a decline in this economic sector since 2001, when the previous baseline study was carried out. The following was noted:

- The Lambasi Cooperative, established in 1982, was closed in 2006.
- The Lambasi Dairy Project and Calf Raising Unit was established in 1982 and closed down in 2006.
- Dry-land sugar cane farming ceased, mainly due to a lack of finance.
- The planned expansion of the Magwa Enterprise Tea (Pty) Ltd estate did not materialise.
- Dairy, cattle, maize and chicken production projects for the communities in the region which were promoted by Magwa Enterprise Tea (Pty) Ltd have ceased, mainly due to a lack of finance.

The socio-economy must be stimulated in this rural area, and agricultural activities may be revived through the development of the Zalu Dam.

3 WATER RESOURCES

3.1 HYDROLOGY AND CLIMATE

The hydrology of the catchment of the Msikaba River was updated in this study in order to assess the impact of current and future developments on the surface water run-off. The natural Mean Annual Runoff (MAR) of the Msikaba River is 221 million m³. The major tributaries of the Msikaba River are the Xura, Kwadlambu and Mateku rivers as shown in **Figure 3.1**.

The mean annual precipitation (MAP) over the Msikaba River catchment decreases from 1 500 mm at the coast to 800 mm inland at the headwaters of the river system.

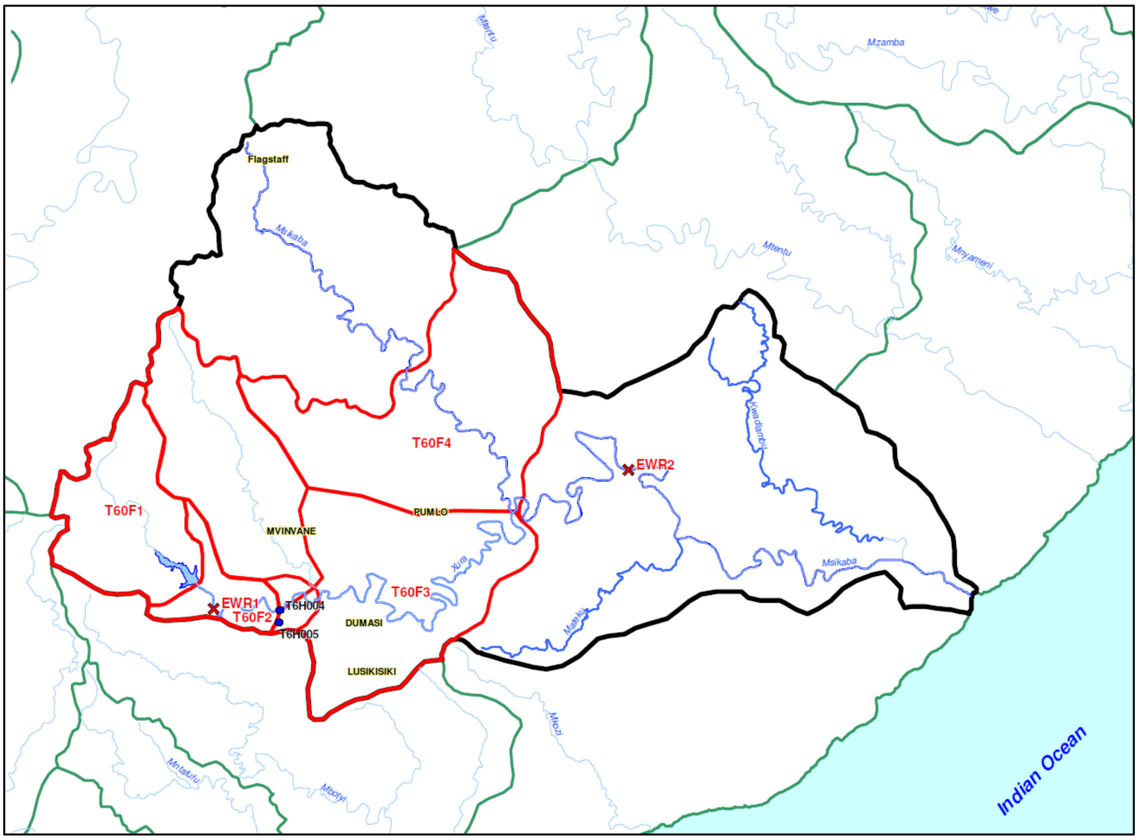


Figure 3.1: Msikaba River catchment

Land use throughout the study area consists predominantly of small-scale and subsistence agriculture comprising the cultivation of cash crops (mainly maize and vegetables) and a variety of livestock. The total present-day water use in the Msikaba River catchment for domestic purposes and irrigation, and by afforestation and invasive alien plants (IAPs) is very low. An estimate of these uses in 2007 is summarised in **Table 3.1**. For more detail refer to the *Domestic Requirements (P WMA 12/T60/00/4111)* and *Irrigation Potential Assessment (P WMA 12/T60/00/4211)* reports.

Table 3.1: Present day water usage

Quaternary catchment	Catchment area (km²)	Afforestation usage (million m³/a)	Alien vegetation usage (million m³/a)	Domestic usage (million m³/a)
T60E	198.0	0.3	0.2	0.0
T60F1	71.3	0.0	0.6	0.0
T60F2	21.6	0.0	0.0	1.0
T60F3	271.1	0.0	0.0	0.0
T60F4	99.9	0.0	0.0	0.0
T60G	360.0	0.0	0.0	0.0
Total T60E, F & G	**1 021.9**	**0.3**	**0.8**	**1.0**

Table 3.2: Present day flow generated in the Msikaba River catchment

Catchment	Catchment area (km²)	Natural incremental MAR (million m³/a)	Present day incremental MAR (million m³/a)
Msikaba River upstream of confluence with Xura River	297.9	48.0	47.5
Xura River upstream of Zalu Dam	71.3	13.1	12.5
Xura River downstream of Zalu Dam	292.7	54.2	53.1
Msikaba River downstream of the confluence with the Xura River	360.0	105.7	105.7
Total T60E,F&G	**1 021.9**	**221.0**	**218.8**

Estimates of present day streamflow are based on the development level in the hydrological year 2007 which has an insignificant influence on the quantity of water available in the Msikaba River catchment.

Table 3.2 gives a comparison of the natural vs. present day MAR for the Msikaba quaternary and quinary catchments.

3.2 Ecological Water Requirements

3.2.1 Background

The potentially large impact of development of the Zalu Dam in the Xura River, an important tributary of the undeveloped Msikaba River which has a high conservation status, necessitated an Intermediate Reserve assessment to provide an estimate of the Ecological Water Requirements (EWR) in the river system to a high degree of reliability.

The locality of the two EWR sites identified for this study is provided in **Table 3.3.** EWR 1 is located downstream of the proposed Zalu Dam in the Xura River while EWR 2 is in the Msikaba River downstream of its confluence with the Xura River.

Table 3.3: Locality and characteristics of EWR sites

EWR site	River	Co-ordinates		EcoRegion (Level II)	Geozone[1]	Altitude (masl)	Management Resource Unit	Quaternary[2]	Gauge
		Latitude	Longitude						
EWR 1	Xura	*-31.327°*	*29.487°*	16.03	Lower Foothills	586	MRU 1: From source to T6H004	T60F	T6H004
EWR 2	Msikaba	-31.252°	29.749°	17.01	Lower Foothills	208	MRU 2: Represented by T60G_06145	T60G	none

[1] *Geomorphological zone*
[2] *Quaternary catchment*

The objectives of the Reserve determination were to determine the EWR for different ecological states at the two EWR sites, namely the Present Ecological State (PES), Recommended Ecological Category (REC) and Attainable Ecological Category (AEC).

3.2.2 Methodology

EWRs were determined by applying the Intermediate Ecological Reserve Methodology (DWAF, 1999) which comprises the following two main steps:

- EcoClassification; and
- EWR quantification for different ecological states.

The EcoClassification process followed is according to the methods of Kleynhans and Louw (2007) to determine and categorise the Present Ecological State (health or integrity) of various biophysical attributes of a river compared to the natural (or close to natural) reference condition. The state of the river is then expressed in terms of the following biophysical components:

- Drivers (physio-chemical, geomorphology, hydrology) which provide a particular habitat template; and
- Biological responses (fish, riparian vegetation and macro-invertebrates).

Different processes were followed to categorize each component (A = Natural to F = critically modified). Ecological evaluation in terms of expected reference conditions, followed by integration of these components, represents the Ecological Status or EcoStatus of a river.

3.2.3 EcoClassification results

The Instream Index of Habitat Integrity (IHI) and the Riparian IHI at EWR 1 were found to be in Category A/B and B, respectively. The IHI and RHI at EWR 2 were found to be in Category B and B/C, respectively. The results of the EcoClassification process are summarised in **Table 3.4**.

Table 3.4: Summary of EcoClassification outcomes

EWR 1

EIS: MODERATE
Highest scoring metrics were unique instream species, diversity of instream and riparian habitat types, presence of critical instream refuges and important riparian migration corridors.

PES: B
Trampling and limited erosion (cattle).
Increased nutrient levels (cattle, human waste and clothes washing).
Alien vegetation.

REC: B
EIS was MODERATE and the REC was therefore to maintain the PES.

AEC: C
A hypothetical deteriorated situation was characterised by decreased flows and the resulting responses to this situation.

table continued on the next page

Driver Components	PES & REC	Trend	AEC ↓
IHI HYDROLOGY	A/B		
WATER QUALITY	A/B		B/C
GEOMORPHOLOGY	A/B		C
Response Components	**PES**	**Trend**	**AEC↑**
FISH	A/B	0	B/C
MACRO INVERTEBRATES	A/B	0	B/C
INSTREAM	A/B	0	B/C
RIPARIAN VEGETATION	B/C	0	C
ECOSTATUS	B		C
INSTREAM IHI	A/B		
RIPARIAN IHI	B		
EIS	MODERATE		

EWR 2

EIS: MODERATE
Highest scoring metrics were unique instream species, presence of critical instream refuges and important instream and riparian migration corridors.

PES: B/C
Trampling and limited erosion (cattle).
Increased nutrient levels (cattle, discharges from upstream Water Treatment Works and Holycross Hospital).
Alien vegetation.

REC: B/C
EIS was MODERATE and the REC was therefore set to maintain the PES.

AEC: C/D
A hypothetical deteriorated situation was characterised by decreased flows and the resulting response to this situation.

Driver Components	PES & REC	Trend	AEC↓
IHI HYDROLOGY	A/B		
WATER QUALITY	B		C
GEOMORPHOLOGY	A		B
Response Components	**PES**	**Trend**	**AEC↓**
FISH	A/B	0	B/C
MACRO INVERTEBRATES	B	0	C
INSTREAM	B	0	C
RIPARIAN VEGETATION	C	0	C/D
ECOSTATUS	B/C		C
INSTREAM IHI	B		
RIPARIAN IHI	B/C		
EIS	MODERATE		

Confidence in the EcoClassification process is largely based on data availability. EcoClassification can be defined as follows:

- Data availability: Evaluation based on the adequacy of any available data for assessing Present Ecological State (PES).
- EcoClassification: Evaluation based on the confidence in the outcome and probable accuracy in defining the Present Ecological State (PES).

Confidence in the EcoClassification of the two EWR sites:

- While limitations in the data available for the assessment led to a moderate confidence in the EcoClassification process at EWR 1, confidence in the outcome of the EcoClassification process was found to be high since it is highly probable that the defined PES describes the present state of the system.
- Confidence in the data available for the EcoClassification process and in the outcome of the process at EWR 2 was moderate.

The higher confidence in setting the present Ecological State (PES) at EWR 1 is related to the flow gauging weir with observed flow data, and also the availability of water quality data.

3.2.4 Ecological Water Requirements for different Ecological States

A summary of the estimated EWRs, expressed as a percentage of the natural MAR and as an annual volume of runoff, for the PES, REC and AEC are given in **Table 3.5**.

Table 3.5: Summary of EWRs for the PES, REC and AEC

EWR[1] site	EC	Low Flow EWR				Maintenance high flow EWR		Long term mean EWR	
		Maintenance Low		Drought Low					
		(%Natural MAR)	million m^3	(%Natural MAR)	million m^3	(%Natural MAR)	million m^3	(% Natural MAR)	million m^3
EWR 1	PES[2] and REC[3]: A/B	22.49	3.186	5.70	0.807	20.21	2.863	36.79	5.212
	AEC[4]: B/C	16.19	2.294	4.75	0.673	14.19	2.009	28.71	4.067
EWR 2	PES and REC: B	18.37	23.684	9.96	12.837	12.98	16.687	30.08	38.792
	AEC: C	13.25	17.09	8.34	10.751	7.42	9.565	22.88	29.457

[1] Ecological water requirements
[2] Present ecological state
[3] Recommended ecological category
[4] Alternative ecological category

3.3 Surface Water Resources

An analysis of the surface water resources was undertaken to determine the preferred dam size at the Zalu site on the Xura River, upstream of the town of Lusikisiki, to meet the water requirements for various future development scenarios, after taking into account the contribution that can best be made from groundwater sources.

The expected 2040 water requirements to be met from both surface and groundwater resources are given in **Table 3.6.** The Ecological Water Requirements are derived from the Intermediate Reserve Assessment.

Table 3.6: Expected 2040 water requirements

Domestic	Irrigation[1]	Total maintenance EWR at EWR 1 (EC=A/B)[2]	Maintenance low flow EWR at EWR 1 (EC=A/B)[2]
5.40 million m^3/a	1.45 million m^3/a	6.05 million m^3/a	3.19 million m^3/a

[1] Including 10% allowance for losses
[2] EWRs are non-consumptive

The historic firm yield (HFY) and yields associated with a range of degrees of reliability derived from stochastic analyses of the hydrological data were estimated for a range of storage capacities from 0.5 MAR to 1.5 MAR at the proposed Zalu Dam site. The estimated 50-year sediment accumulation in the reservoir of 2.52 million m³ was taken into consideration, see *Water Resources Report (P WMA 12/T60/00/3711)*, and account was taken of evaporation loss from the surface of water in storage with the aid of the stage-area-capacity curves in **Figure 4.2**.

The options of abstracting water for treatment and domestic use directly from the dam or placing the abstraction point at gauging station T6H004, while simultaneously satisfying the EWRs, were examined in detail to determine the impact on the estimated yield available from the dam. Consideration was given to river losses when the river is used as a conveyance, to minor tributary inflows between the Zalu dam site, EWR 1, and gauging station T6H004, and to unregulated inflows from the next major tributary, the Xurana River. The outcome of these analyses is reported in the *Water Resources Report*. It was found that the most effective arrangement is to locate an abstraction point for domestic water supplies at flow gauging weir T6H004 in the Xura River.

With this arrangement no special high flow EWR releases will be necessary from Zalu Dam because the combination of spillages from the dam and unregulated runoff in tributaries downstream of the dam are sufficient for this purpose. From the date of commissioning of the proposed dam till 2040, releases from the dam to provide the non-consumptive low flow EWR's will satisfy water requirements for domestic use.

Results of historic and stochastic yield analyses of the proposed Zalu Dam, with abstractions for domestic use at T6H004, are shown in **Table 3.7** and **Figure 3.2**.

Table 3.7: Yield results in million m^3/a with the abstraction point at T6H004

Contour	Area	Gross Capacity		Net Cap	HFY (no EWR)[1]	HFY with low flow EWR (AB)[1]	Stochastic yield with low flow A/B EWR			
							Return Period (year)			
masl	km^2	million m^3	as proportion of MAR	million m^3	million m^3/a	million m^3/a	1:20	1:50	1:100	1:200
622.6	**1.8**	**19.8**	**1.5**	**17.3**	**9.8**	**9.8**	**12.1**	**10.9**	**10.3**	**9.8**
614.9	1.0	10.6	0.8	8.0	7.4	7.4	9.4	8.4	7.9	7.5
612.0	**0.8**	**7.6**	**0.6**	**5.1**	**6.0**	**6.0**	**7.9**	**7.2**	**6.8**	**6.5**
610.3	0.7	6.6	0.5	4.1	5.2	5.2	7.2	6.6	6.2	5.9
607.5	0.6	5.1	0.4	2.8	4.1	4.1	5.6	5.3	5.1	4.9

[1] *EWRs have an insignificant impact for scenario with abstraction at the weir*

Figure 3.2 shows rather weak typical inflection points in the yield curves corresponding to net storage capacities of about 6.5 million m^3 and 10.5 million m^3. These inflection points often correspond with optimized storage capacities when the unit cost of water stored or the unit cost of the yield available (URV) is adopted as an objective function. In this case **the objective is to supply a target quantity of water at an appropriate degree of assurance which requires a specific storage capacity**. A dam with this capacity can be designed to make optimum use of the site and provide for possible later enlargement by raising when this is justified by the increase in water requirements. The determination of the storage capacity required to meet the target water supplies and the selection of the preferred dam type for this site is discussed in Section 4 below.

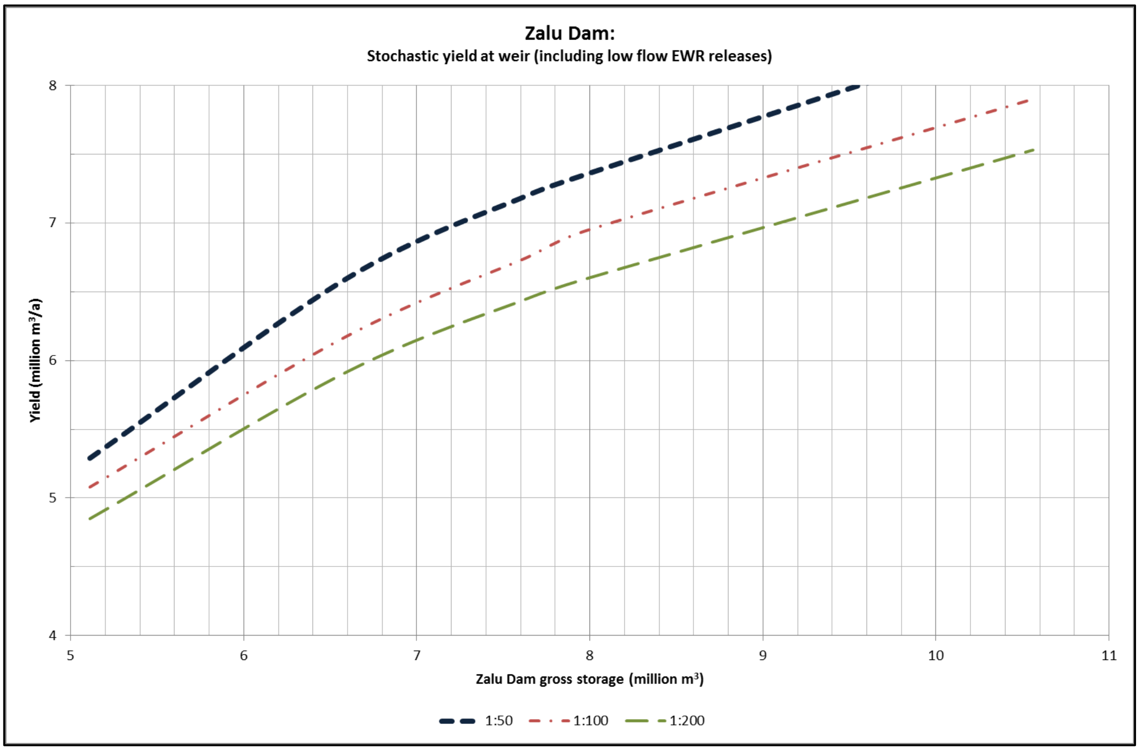


Figure 3.2: Stochastic yield results for various Zalu Dam gross storages

3.4 Groundwater Resources

The groundwater resources in the Study Area were assessed to determine the locality and extent of this water source that could be developed to provide a sustainable, cost-effective and reliable water supply to augment the surface water supplies from the proposed Zalu Dam. Groundwater is also envisaged as the most appropriate sole source of sustainable water supplies in remote areas where the cost of supplies from the proposed Zalu Dam becomes excessive because of (i) the cost of long distribution pipelines, (ii) the unfavourable topography, and (iii) the very high energy costs of pumping water against high heads.

3.4.1 Hydrogeological review

A review of information on groundwater resources from previous investigations is summarised in **Table 3.8**.

Table 3.8: Geo-hydrological sites in study area

Description	Total
Total boreholes known in study area	**235**
Boreholes reflected on NGDB database	152
Additional boreholes sourced from GRIP survey	17
Boreholes identified during SRK Hydrocensus	36
New boreholes drilled during SRK study	30
Total springs in study area	**119**
Springs reflected on NGDB database	49
Additional springs sourced from GRIP survey	22
Springs identified during SRK Hydro-census	48

The Study Area is predominantly underlain by sedimentary rocks of the Karoo Supergroup sequence of rocks in the inland and southwest coast, with hypabyssal dolerite intrusions in the form of sills (sub-horizontal and horizontal structures) and dykes (sub-vertical to vertical linear structures). The brittle Natal Group sandstone (NGS), which Woodford (1999) described as the Msikaba Formation, dominates the south-eastern and eastern quadrant of the Study Area (see **Figure 3.3**). This formation has a number of faults and is highly incised creating dramatic landscapes. The groundwater potential of the geology is assessed in the detailed *Groundwater Report (P WMA 12/T60/00/3811)*.

3.4.2 Numerical groundwater flow modelling and sustainability

A numerical groundwater flow model was constructed to simulate the consequences of abstraction from high yielding boreholes in the study area. It was also possible to demonstrate the effect of future abstractions on regional groundwater levels and so determine the sustainability of planned abstractions. It must be noted that no account was taken in the numerical flow modelling of the reliance of Ecological Water Requirements (EWR) on groundwater as a source of low flows in rivers and streams.

3.4.3 Groundwater resource in the Study Area

The Groundwater Yield Model for the Reserve (GYMR) was used to estimate the likely groundwater flow balances on an annual basis for various development scenarios. The groundwater flow balances, and numerical flow modelling in selected areas, were used to determine the sustainable yield of the resource for groundwater reserve definition purposes. These analyses demonstrate that groundwater recharge is sufficient to sustain the envisioned abstraction and use of groundwater for purposes of domestic use.

Following are the most important outcomes demonstrated by the numerical model:

- An estimated 2 553 m^3/d (0.95 million m^3/a) can be abstracted on a sustainable basis from the nine Feasibility Study boreholes which are still to be equipped and an additional eight proposed boreholes to be drilled and equipped.
- During dry periods or droughts baseflow in rivers and streams and the flow of springs will be affected if excessive abstractions continue unabated.
- The model indicates an annual recharge less than that estimated in the GYMR scenario.
- An average drop of 7.2 m in all observation borehole water levels is forecast when a one in twenty year drought is simulated.
- The numerical model indicates that the sustainable abstraction from groundwater is less than that indicated by the GYMR scenarios.
- The abstraction from boreholes proposed for inclusion in the LRWSS is only about 2% of the estimated total safe yield of groundwater resources in the Study Area.

Monitoring of groundwater levels at the proposed LRWSS abstraction boreholes is strongly recommended.

It is recommended when the groundwater EWR has been determined, another modelling scenario should be performed to determine whether groundwater levels are drawn down below river channels as well as to determine the amount of baseflow available to the EWR.

3.4.4 Groundwater awareness

A groundwater-community interdependence survey, comprising of a desktop study and questionnaires completed by 360 participants in the Study Area, was undertaken to identify community dependencies and attitudes towards groundwater, to obtain information on and assess regional groundwater use and infrastructure, and to determine water source preferences based on perceptions.

It was concluded that the community has a preference for groundwater and spring water for drinking purposes, probably due to the fact that they have in the past relied on groundwater as a source through springs and also because the existing surface water scheme could not always satisfy their water requirements. The highest preference for surface water was noted at the Zalu dam site.

Figure 3.4 summarises the attitudes and perceptions regarding groundwater.

Water awareness initiatives were conducted in four wards to increase project sustainability through creating awareness around ground- and surface water and to stimulate the sensitivity of participants to the importance of conserving water.

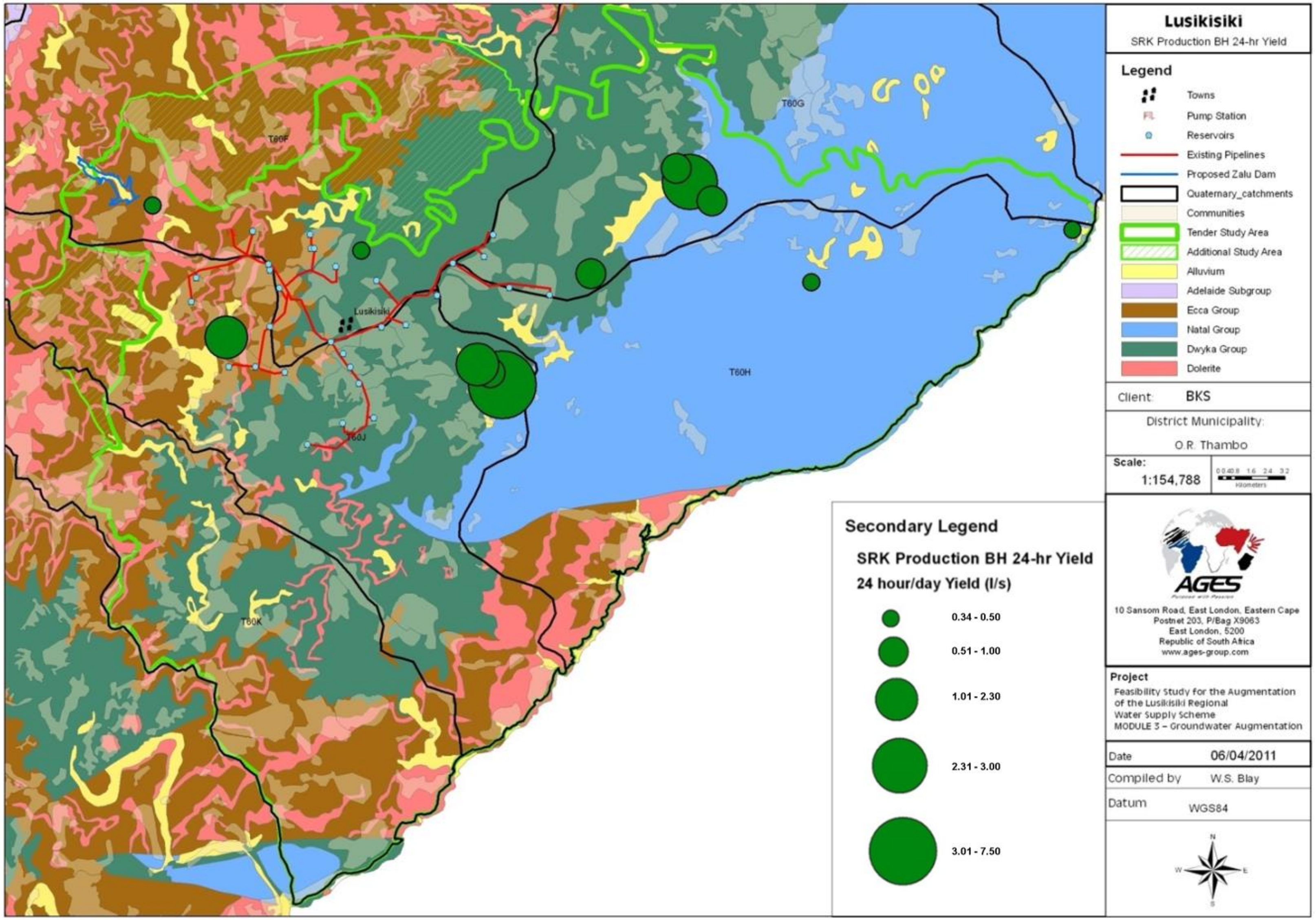


Figure 3.3: Lusikisiki RWSS study area geology and previous SRK feasibility study boreholes with yields

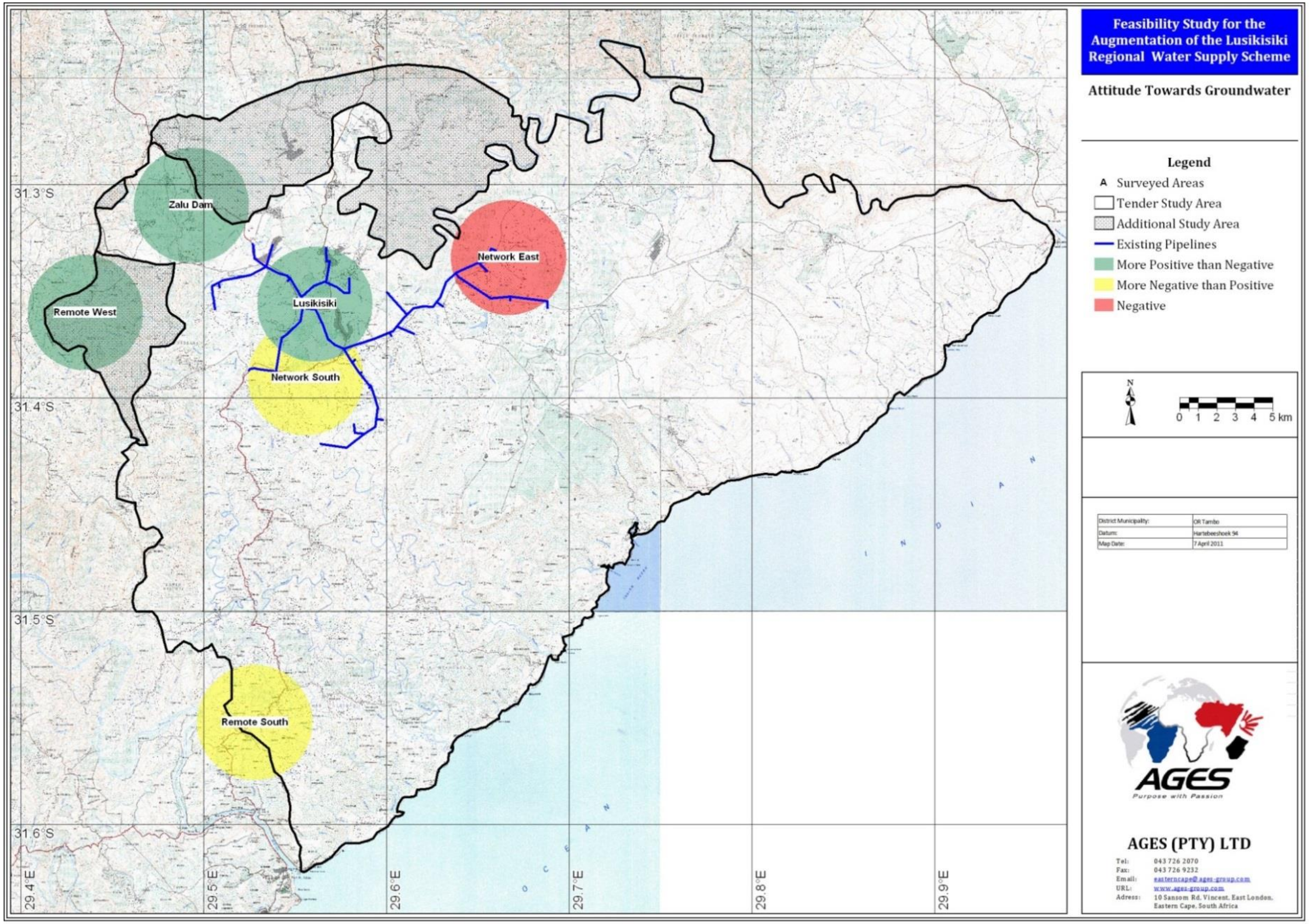


Figure 3.4: Attitude towards groundwater

3.4.5 Regional well-field abstraction network

Information on the yields and positions of proposed new boreholes as well as existing boreholes was examined to locate the recommended production boreholes within the Regional Well-field Area, also known as the (RWA). It was found that some boreholes are too close to each other and will have to be utilised at reduced rates to avoid the influence of one on another. An analysis of abstractions at the 14 Feasibility Study boreholes in the RWA as well as the nine proposed additional boreholes showed that groundwater level drawdowns at production boreholes may affect springs and wetlands if water is abstracted at a rate associated with the 95% assured recharge conditions. The recommended abstraction rate from the well-field area is therefore decreased from 3 081 m^3/d to 2 553 m^3/d. This abstraction rate can be achieved by equipping and using only nine Feasibility Study boreholes and by drilling and equipping an additional eight boreholes in the Regional Well-field Area.

The 2 553 m^3/d, or 0.93 million m^3/a, made available in this way can be used to augment the surface water supply made available from the proposed Zalu Dam for the LRWSS.

In view of the groundwater quality, particularly elevated iron concentrations, it will be desirable for groundwater from the regional well-field to be blended with surface water as far as possible. The surface water and groundwater quality will determine suitable blending ratios and this will probably change from time to time.

Several zones of higher groundwater potential were identified outside the RWA, as indicated in **Figure 3.5**. Numerous small communities in the Study Area but outside of the RWA should be served by stand-alone groundwater supply schemes based on these zones. These communities were grouped in six clusters, each associated geographically with a zone or zones of high groundwater yield. These envisaged local stand-alone water supply schemes will not be connected to the LRWSS.

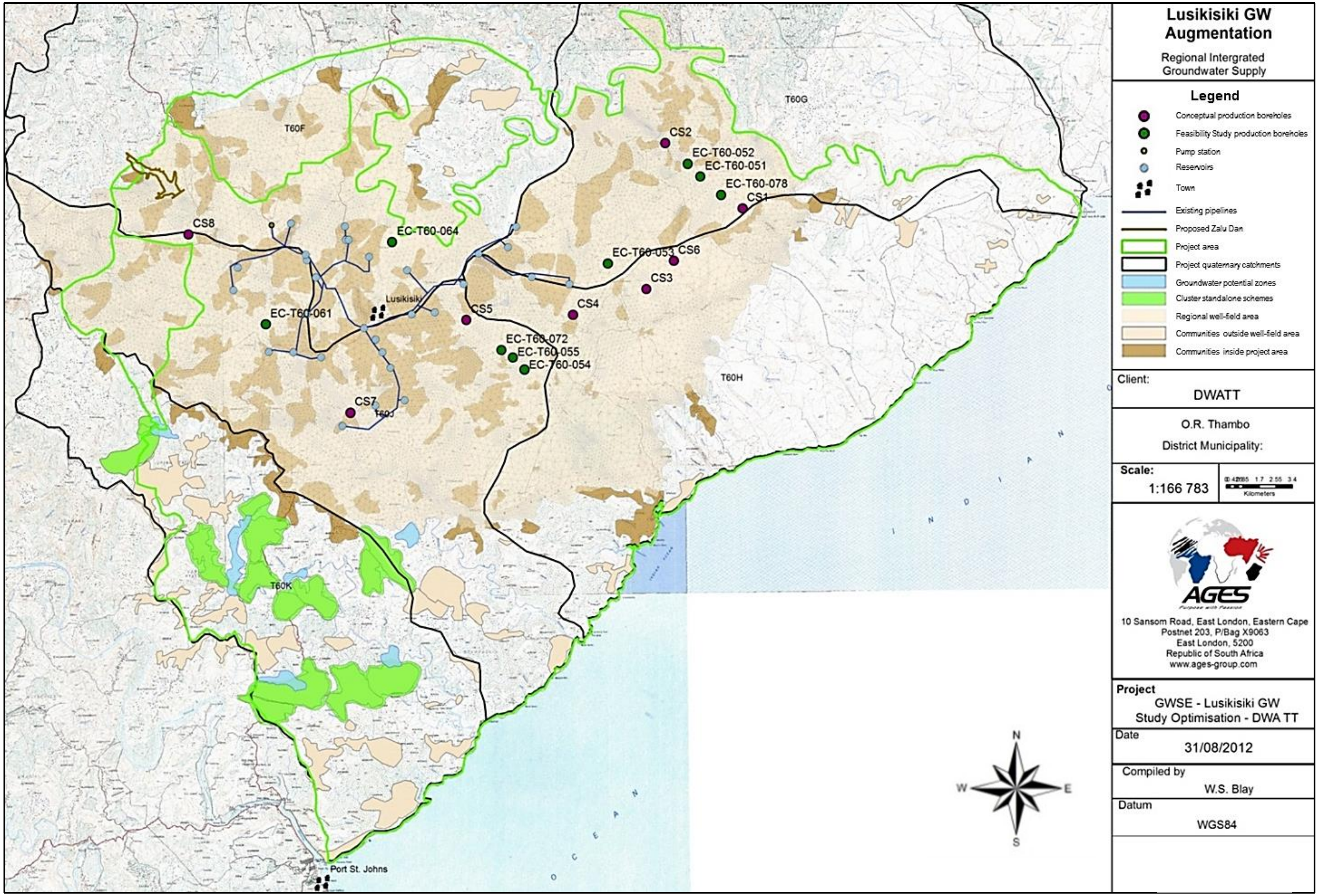


Figure 3.5: Regional integrated groundwater supply

4 DEVELOPMENT OF SURFACE WATER RESOURCES

In previous investigations a preferred dam site was identified where the water resources of the Xura River could be developed as a reliable source for meeting the expected needs for domestic use in Lusikisiki and surrounding settlements and for stimulating socio-economic development in the region, *inter alia* by making water available for new irrigation. This dam site is about 0.5 km northeast of the Ndimbaneni village. **An official name for the dam has not yet been selected and the name Zalu Dam was used in previous investigations based on a local place called Zalu Heights.** The coordinates of the point where the centreline of the envisaged dam intersects the river are:

31° 18' 55.4" S, 29° 28' 37.3"E

Various dam types were considered for development, taking into account the yield that is required to satisfy the estimated water requirements, the hydrological characteristics of the Xura River, the topographical characteristics of the preferred dam site and basin (with particular attention to the siting of a spillway for accommodating floods), the founding conditions at the site, and the materials available for constructing a dam.

4.1 WATER REQUIREMENTS

In **Section 2** above it is noted that the LRWSS is intended to supply the expected water requirements for domestic use up to the planning horizon of 2040, i.e. 5.4 million m^3/a, and to provide for an allocation of 1.45 million m^3/a water for new irrigation development on about 273.5 ha of suitable soil located downstream of the proposed Zalu Dam. Cognisance is taken of the fact that these water user sectors call for supplies with different risks of shortfalls. Up to a total of about 6.85 million m^3/a will be required for distribution through the LRWSS and water for domestic use must be treated to potable standards.

In devising such a multi-purpose regional water supply scheme cognisance is taken of the fact that the present water supply for domestic use is drawn from unregulated flow in the Xura River at flow gauging station T6H004, downstream of the proposed Zalu Dam site. This arrangement offers no security against seasonal low flows in the river falling short of the increasing water needs for domestic use. The dam will regulate the flow in the Xura

River and significantly increase the reliable yield available for domestic users and make water available for envisaged new irrigation development.

While the increasing need for water for domestic use is well documented, the development of irrigated agriculture will be a new economic activity along the Xura River. Water resource development is intended to be a strategic government intervention to stimulate and facilitate socio-economic development and agrarian reform in this relatively depressed rural environment. As a consequence there are many uncertainties regarding the implementation of the irrigation development and associated activities.

The main uncertainties mentioned above relate to the timing of new irrigation development and to the actual quantity of water that will be used beneficially for this purpose. If, in the worst case, none or only a portion of the water intended for irrigation is taken up for that purpose, increasing amounts can be reallocated for domestic use and for other possible economic activities, such as industrial development, which are not yet envisaged.

4.2 Opportunities for Conjunctive Use

In **Section 3.4** it is reported that up to 0.93 million m^3/a can be made available from groundwater sources. This water is intended for supplying the domestic water needs in conjunction with surface water supplies from a new dam at the Zalu site in the Xura River. By using these water sources conjunctively a limited degree of flexibility is introduced into the bulk water distribution system and the yield from the proposed new dam can be used more effectively.

4.3 Sizing of the Proposed Zalu Dam

In order to determine the storage capacity that must be provided in the Zalu Dam consideration is given, *inter alia*, to the following factors which affect the operation of the dam and which are discussed elsewhere in this report:

- Water for domestic use should be abstracted at the site of the existing works for domestic supplies downstream of the dam at gauging station T6H004, below the Ecological Water Requirements monitoring point EWR1 (see **Section 3.3** above).

- Provision for supplying water for irrigation, to be abstracted at convenient points directly from the river downstream of the dam, as a strategic stimulus of economic development in the region.
- The conjunctive use of groundwater with surface water supplies from the proposed dam.

Four development scenarios were considered based on the primary function of supplying water from Zalu Dam for domestic use. The factors considered in defining each scenario are (a) whether or not groundwater is developed in conjunction with surface water supplies for domestic use and (b) whether or not provision is made for development of the irrigation potential.

Following are the four scenarios considered:

Scenario 1: Zalu Dam yield used conjunctively with groundwater and no irrigation development. This scenario assumes that groundwater has been exploited to its full potential with a yield of 0.93 million m³/a for use in the LRWSS. The remaining domestic water requirement, increasing to 4.47 million m³/a by 2040, is supplied from Zalu Dam. No provision is made for irrigation development.

Scenario 2: **Zalu Dam supplies only the full domestic use, i.e. no groundwater development and irrigation is not stimulated**. The total water requirement for domestic use, i.e. 5.4 million m³/a, is supplied from Zalu Dam and no provision is made for irrigation demands.

Scenario 3: **The yield from Zalu Dam is used conjunctively with groundwater for supplying domestic users and provision is made for new irrigation development.** Same as for Scenario 1 plus irrigation development requiring 1.45 million m^3/a, including 10% conveyance losses. The total water requirement to be supplied from Zalu Dam is 5.92 million m³/a.

Scenario 4: **The yield of Zalu Dam is not augmented by groundwater supplies and provision is made for supplying new irrigation development.** This is Scenario 2 plus irrigation development. The total water requirement from Zalu Dam is 6.85 million m³/a.

URVs calculated for these scenarios are shown in **Table 4.1** to demonstrate the relative merits of each scenario.

Table 4.1: Scenario analysis for Zalu Dam

Scenario	Yield (million m³/a)	FSL of Zalu Dam (m)	Description	URVs (R/m³)
1	4.5 Zalu 0.9 GW	607.5	Supply only domestic demand Groundwater augmentation	R 6.62
2	5.4 Zalu	610.0	Supply only domestic demand No groundwater augmentation	R 8.39
3	**6.0 Zalu 0.9 GW**	**612.0**	**Supply total domestic demand Supply irrigation + 10% losses Groundwater augmentation**	**R 6.44 (R 8.08)***
4	6.9 Zalu	615.0	Supply total domestic demand Supply irrigation + 10% losses No groundwater augmentation	R 7.90 (R 10.12)*

** URVs when the implementation of irrigation fails*
Zalu = yield supplied by the proposed Zalu Dam
GW = yield supplied from groundwater development

The URVs in **Table 4.1** indicate that augmentation of the yield of Zalu Dam with groundwater for supplying domestic users is an attractive option when judged against the criterion of unit cost of making water available. In view of the **strategic importance of stimulating socio-economic development through new irrigation development, Scenario 3** was adopted as the basis for determining the dam capacity required for meeting the estimated water requirements.

The domestic water requirements in the LRWSS Supply Area are estimated to be 5.4 million m^3/a in 2040. When the envisaged new irrigation development is also supplied the dam will be called upon to deliver 6.85 million m^3/a, not all at the same security of supply. **Figure 3.2** shows that for a yield of 6.85 million m^3/a a dam with gross capacity of 7.6 million m^3 at the Zalu site will be required. The security of supply of this yield is such that the risk of shortages in any one year will be between 1% and 2%. This is a realistic security of supply for the combination of user sectors to be supplied from the dam.

This indicative capacity equates to 0.6 MAR and the Full Supply Level (FSL) will be 612.0 masl, or 35 m above the river bed level. The indicative gross storage capacity makes provision for the accumulation of 2.52 million m^3 of sediment over the effective life of the dam.

Figure 3.2 indicates that the yield potential of the Xura River at the Zalu site is considerably more than that required for meeting domestic water needs up to 2040 and for providing for new irrigation development on the soils found to be suitable for this purpose. It is practical to create storage at the Zalu Dam site at least equal to 1.5 MAR which will deliver a yield of approximately 10.3 million m^3/a. This is far more than is required in the foreseeable future but, depending on the engineering design approach and affordability; it may be justifiable to develop the larger capacity in order to make maximum use of the storage capability at the site. Where dam capacities on east-flowing rivers in South Africa have been optimized on hydro-economic criteria, capacities in excess of 1.5 MAR are seldom, if ever, justified.

4.4 MATERIALS AND GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations confirm that suitable founding conditions exist to accommodate a rockfill or a concrete gravity dam at the Zalu site.

Sufficient weathered dolerite clay material is available in a potential borrow area downstream of the dam, on the right bank of the river, for an Earth Core Rockfill Dam (ECRD). No natural sand was identified on site during the geotechnical investigation, and must probably be imported from a commercial source.

The localities of two possible rockfill quarries of unweathered dolerite have been identified, one on the right bank and the other on the left bank, 1 km upstream of the centreline of the proposed dam. These quarry sites are located below the full supply level of the dam and are covered with moderately to completely weathered shales. The moderately weathered shales can possibly be used in the shell of a rockfill dam.

At the centreline of the dam, on the right bank, a horizontal layer of unweathered dolerite was encountered at a level of approximately 611 masl. This material can be used for an approach channel floor for a side channel spillway. Some of the excavated materials could be used for the shell of a rockfill dam.

4.5 DAM TYPE SELECTION

Two dam types, namely an Earth Core Rockfill Dam (ECRD) and a Concrete Gravity Dam, for three dam sizes covering the range of storage capacities likely to be required were investigated. Feasibility level estimates of construction costs of each were made to inform a dam type selection. The guideline for the preliminary sizing and costing of planning options for water resource development developed in the Vaal Augmentation Planning Study (VAPS) was used to determine the quantities and construction costs for the options investigated. These cost estimates are shown in **Table 4.2.**

Table 4.2: Summary of cost estimates for various dam types and sizes

Type of Dam	Cost per Size of dam (excl. VAT)* (2012)		
	FSL = 615 masl	FSL = 619 masl	FSL = 622 masl
Roller Compacted Concrete	R 600 641 134	R 720 492 184	R 827 958 639
Earth Core Rockfill	R 365 477 607	R 434 856 268	R 495 349 034

** Costs include Preliminary and General, Preliminary works, Contingencies, Planning, Design and Supervision*

For the three dam sizes examined an Earth Core Rockfill Dam (ECRD) is significantly more cost-effective than a Concrete Gravity Dam and this type was selected for feasibility-level design. A typical cross section of an ECRD is illustrated in **Figure 4.1**.

4.6 FEASIBILITY DESIGN FOR ZALU DAM

4.6.1 Dam characteristics

The relationships between elevation and (a) gross storage capacity and (b) water surface area at FSL as measured from the available contour plans are shown in **Figure 4.2**.

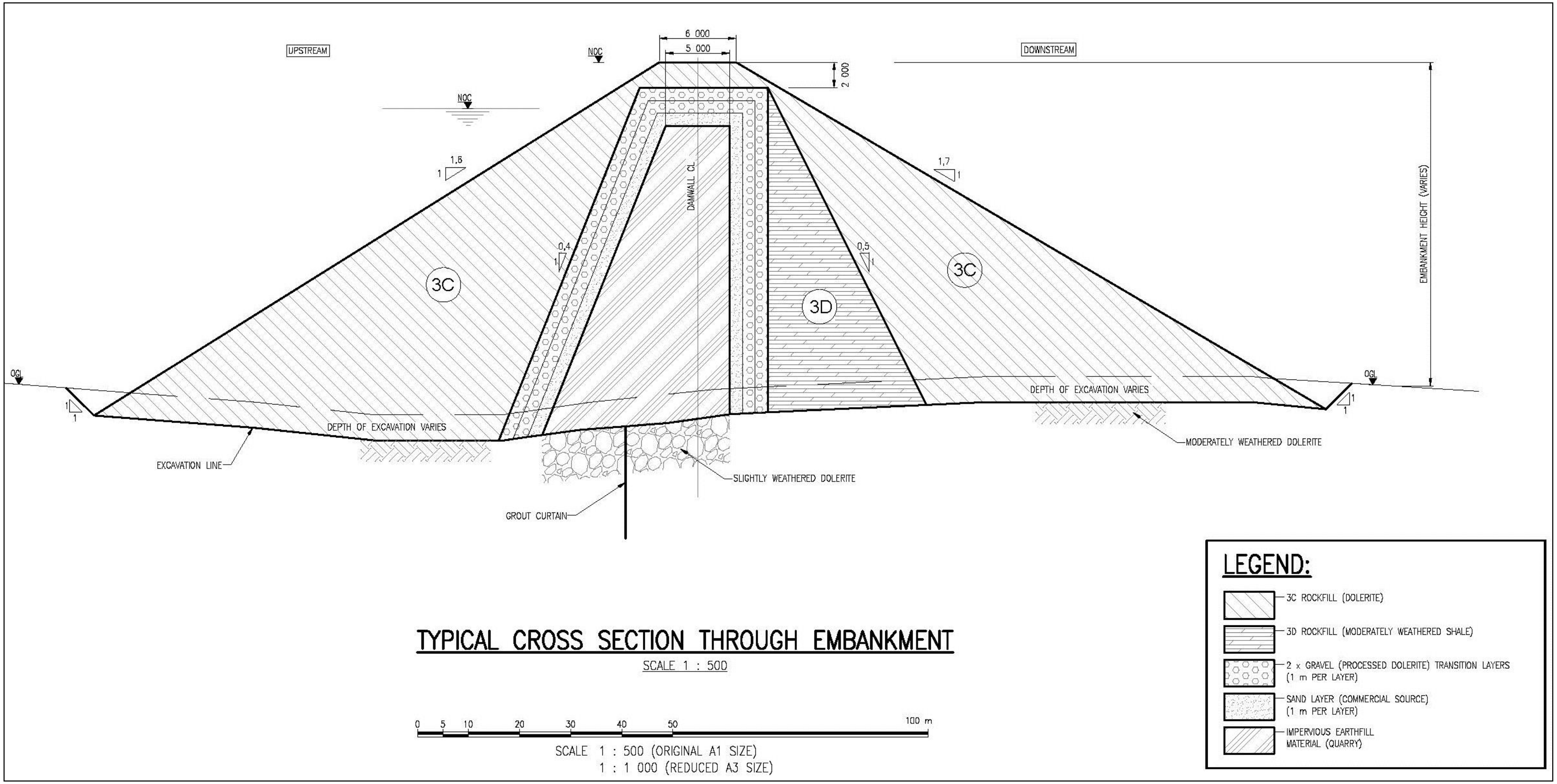


Figure 4.1: Proposed Zalu dam main embankment cross section

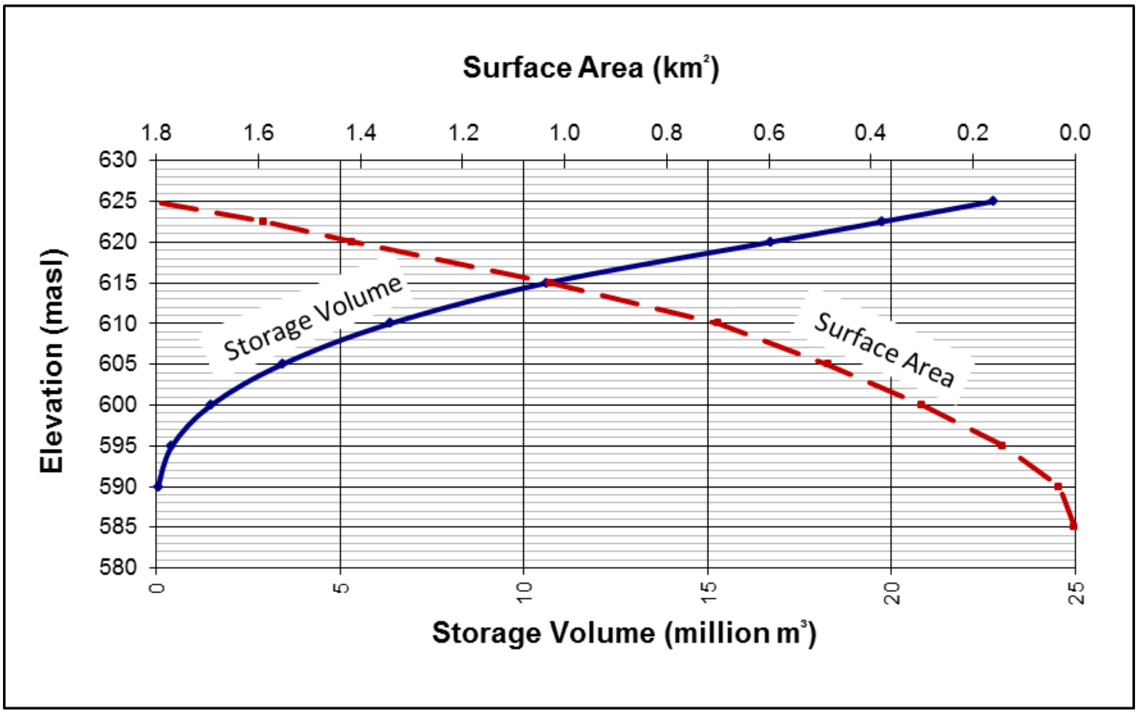


Figure 4.2: Storage volume and surface area curves for the proposed Zalu dam

The estimated sediment accumulation in the dam over a 50-year period is 2.52 million m^3. This lower portion of the dam basin is not available as effective storage for regulating the runoff.

4.6.2 Flood Hydrology

Design flood peaks at the dam site were estimated by the Department of Water Affairs in 2001 and reviewed by SRK's *Investigating the potential to supplement the Lusikisiki Rural Water Supply Scheme (LRWSS)* in May 2009. The estimated Flood Frequency Distribution, Regional Maximum Flood (RMF) and Safety Evaluation Flood (SEF) are shown in **Table 4.3** and were used for preparing the feasibility level design of the dam and spillway.

Table 4.3: Design flood peaks (m^3/s) for the proposed Zalu Dam

Return period (years)	2	5	10	20	50	100	200	RMF	SEF
Flood peak (m^3/s)	81	132	182	246	386	548	625	1090	1405

4.6.3 General arrangement of an Earth Core Rockfill Dam at the Zalu site

The preferred general arrangement of Earth Core Rockfill Dams at this site in the size range from a gross storage capacity of 6.6 million m^3 (0.5 MAR) to 19.8 million m^3 (1.5 MAR) is similar, with a side channel spillway on the right bank and an intake tower with a bottom outlet next to the river on the left bank. Detail of a typical dam layout is shown in **Figure 4.3**.

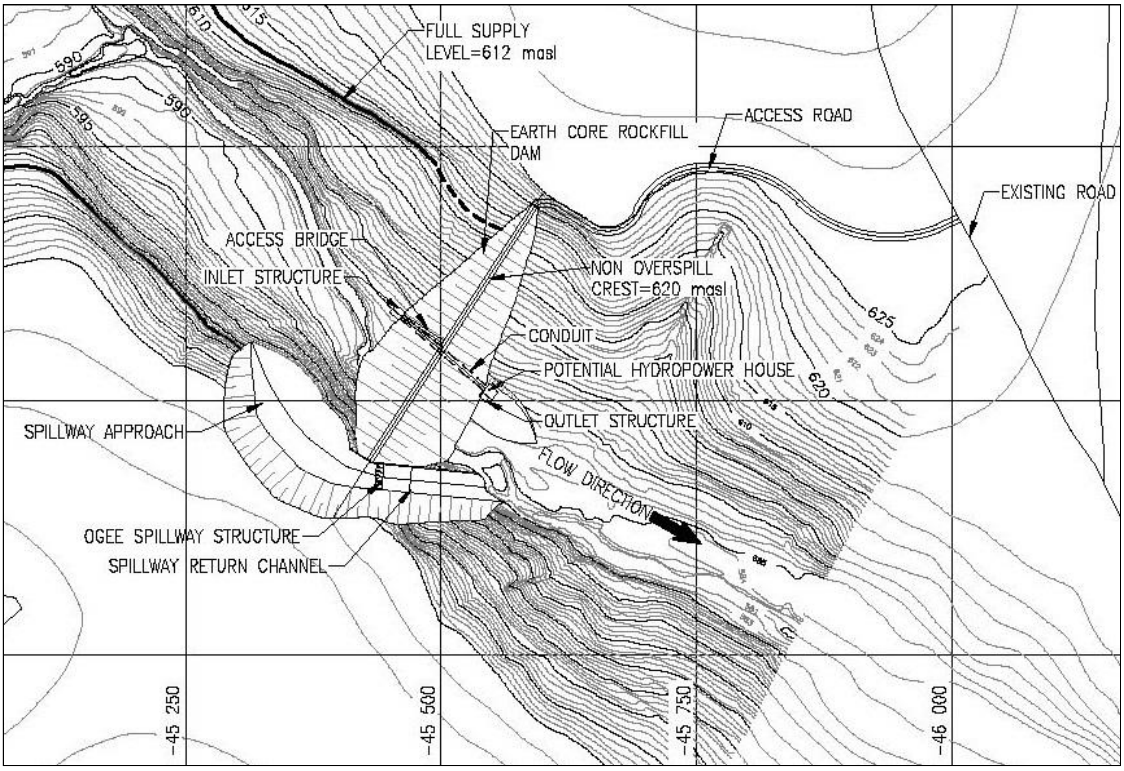


Figure 4.3: Detail layout of Zalu Dam

For this size range there are different optimized spillway lengths and associated overspill depths to accommodate the design flood. The dam heights from river bed level to Non-Overspill Crest (NOC) range from 35 m to 44 m.

4.6.4 River Diversion

River diversion for construction of the dam is planned in three stages:

- Stage 1: No cofferdam is required for the period when the bottom section of the intake tower and outlet conduit is constructed.
- Stage 2: Diversion through the outlet conduit with a cofferdam.
- Stage 3: Plug the opening to the conduit with concrete after the dam is completed.

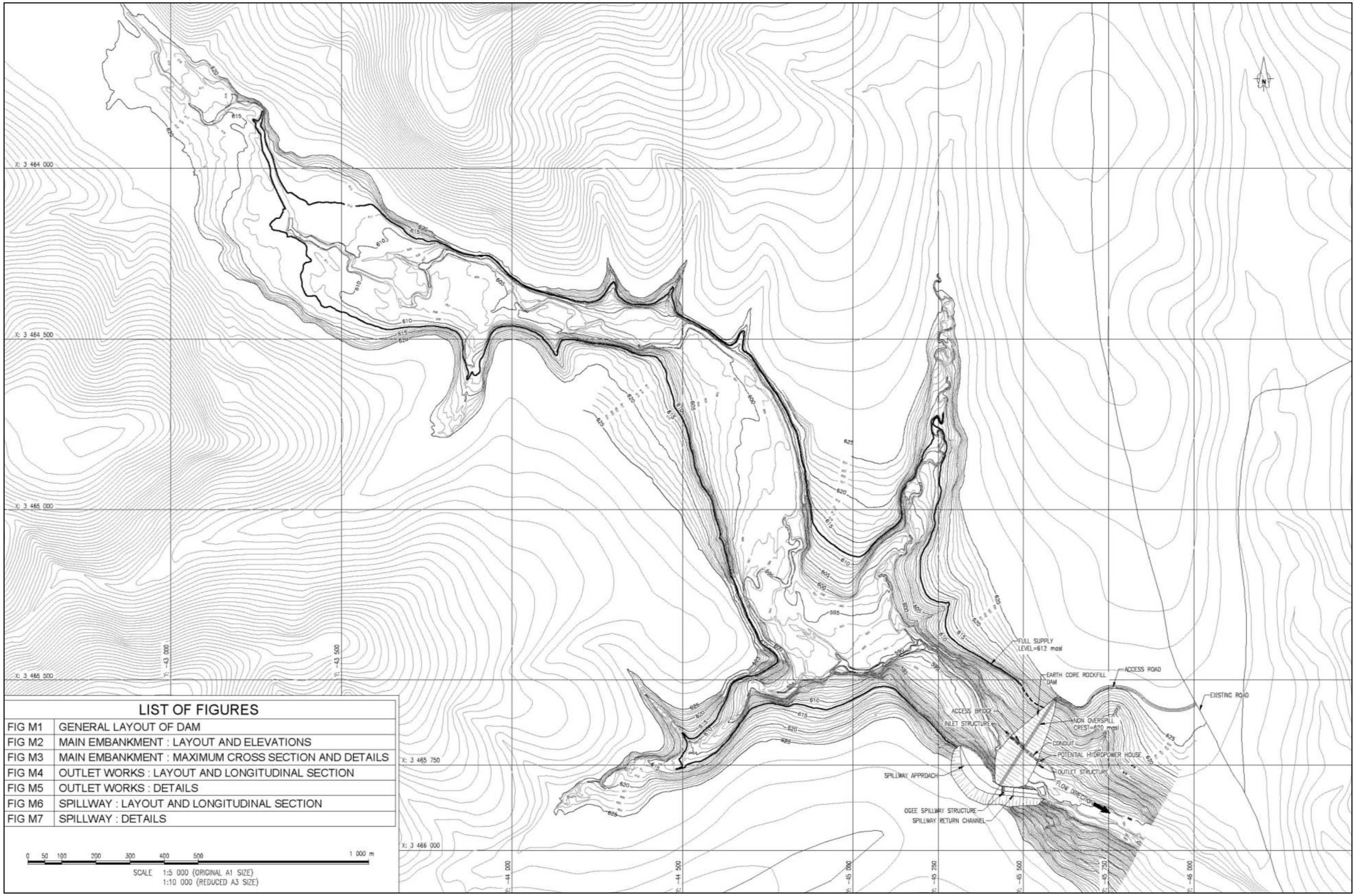


Figure 4.4: Proposed Zalu Dam general layout

4.6.5 Outlet Works

The outlet works consist of a dual pipe system with multi-level intakes, controlled with butterfly valves, to enable water to be drawn from storage at different levels. The rate of releases from the dam is controlled by sleeve valves at the discharge point. The outlet pipes are 900 mm diameter, each fitted with 900 mm and 300 mm sleeve valves. The 300 mm sleeve valves are for the supply of water for domestic use. The draw-off levels should be determined from a limnological study in the detailed design phase.

4.6.6 Costs Estimates

Feasibility level cost estimates were made for two dams sizes, namely capacity 8.0 million m^3 (FSL 612 masl) and capacity 19.8 million m^3 (FSL 622.6 masl) as shown in **Table 4.4**.

Table 4.4: Cost estimates

Activity	0.6 MAR (FSL = 612 masl) Amount (R'000)	1.5 MAR dam (FSL = 622.6 masl) Amount (R'000)
Main Embankment	78 405	118 366
Spillway	58 20	111 237
Outlet works	65 597	70 797
Subtotal A	**202 202**	**300 400**
Landscaping (5% of Subtotal A)	10 110	15 020
Miscellaneous (15% of Subtotal A)	30 330	45 060
Subtotal B	**242 642**	**360 480**
Preliminary & General (40 % of Subtotal B)	97 058	114 192
Preliminary works	4 500	4 500
Accommodation	8 640	8 640
Subtotal C	**352 840**	**517 812**
Contingencies (20% of Subtotal C)	70 568	103 562
Subtotal D	**423 408**	**621 374**
Design and supervision (15% of Subtotal D)	63 511	93 207
Subtotal E	**486 919**	**714 581**
VAT (14% of Subtotal E)	68 169	100 041
Total Dam Cost	**555 088**	**814 622**

4.6.7 Implementation Programme

The implementation programmes show that construction can commence in the second half of 2017, with impoundment in August 2020 and April 2021 for the 0.6 MAR and 1.5 MAR dams respectively (refer to **Appendix A**). The implementation programmes are based on the feasibility design and conceptual designs of the 0.6 MAR and 1.5 MAR dams respectively.

4.6.8 Hydropower Potential

Water will be released from storage under heads that vary significantly as the level of water in storage changes from the FSL to the lowest draw down level; this is not conducive to the generation of hydro-electric power. However, the available potential was estimated using a simplified approach represented by the following equation:

$$P = \rho \times g \times \eta \times Q \times H$$

where

- P = Power in Watt
- ρ = Density of water = 1000 kg/m^3
- g = Gravitational acceleration = 9.8 m^2/s
- η = Total entrance and mechanical efficiency = 0.85 (assumed)
- Q = Flow rate = 0.171 m^3/s
- H = Head = 13.34 m or 20.7 m

The following assumptions are made regarding the various parameters:

- Water for domestic use of about 5.4 million m^3 per year, which is the estimated requirement in 2040, is assumed to be released at a constant rate of 0.171 m^3/s;
- The average head available at a dam with capacity 8.0 million m^3 will be 13.34 m and 20.7 m at a dam with capacity 19.8 million m^3; and
- Total efficiency is assumed to be 0.85.

This simplified approach indicates that the potential for generating hydropower at the dam **on a continuous basis**, i.e. suitable for supplying a base load, is **19 kW** for the smaller dam and **29.5 kW** for the larger dam. When supplies for full development of the envisaged new irrigation is included, and the seasonal pattern of supplying water for irrigation is taken into account, the additional power potential which **is not available on a continuous basis is 24.1kW** for the small dam and **37.4kW** for the larger dam.

The need and justification for developing the hydropower potential at Zalu Dam has not been investigated but provision has been made in the feasibility design of the outlet works of the dam for installing hydropower generating equipment.

4.6.9 Considerations during detailed design

The feasibility investigations indicate that careful consideration should be given to the following aspects during detailed design of a dam at the Zalu site:

- The necessity for lining the spillway channel in the dolerite rock with concrete. This may only be possible once rock on the floor of the spillway channel has been fully exposed in the excavation.
- The Minimum Operating Level (MOL) of the dam must be confirmed after consideration of the impact mitigation measures specified in the Environmental Impact Assessment (EIA).
- The hydraulic conditions in the side channel spillway and the energy dissipation conditions on the apron downstream of the dam. A physical hydraulic model may be necessary to confirm certain requirements such as the height of the retaining wall next to the return channel. Such a model may be necessary to also confirm that the flow conditions in the discharged water returning to the river are acceptable.
- The freeboard height and spillway width which must be optimised for least cost.
- The market for and economic viability of developing the hydropower potential.
- Optimization of the design of the dam at the preferred size, with provision being made for the future raising when necessary to fully develop the potential of the dam site.

4.7 KEY FACTORS FOR THE DEVELOPMENT OF WATER RESOURCES AND INFRASTRUCTURE

The key factors which were identified with particular relevance to the scenarios that may be anticipated are:

- Growth in water requirements;
- Water quality and sedimentation;
- Possible development of irrigation;
- Ecological water releases for the interim period until the full demand from the proposed Zalu Dam is released;
- Development of operational rules for the proposed Zalu Dam;
- Maintenance and operation of infrastructure;
- Ongoing monitoring of flow at T6H004, water abstraction at T6H005; and
- New monitoring to calculate inflows into the proposed Zalu Dam, i.e. water levels, abstractions, releases, rainfall and evaporation.

5 BULK WATER SERVICES INFRASTRUCTURE

The existing bulk water supply infrastructure consists of the following:

- Bulk supply pipelines;
- Bulk supply and village reservoirs;
- Pumping stations;
- Equipped boreholes, and
- Water Treatment Works (WTW).

In the Feasibility Study of water resource development, account was also taken of conveying bulk water supplies to users. Water reticulation networks and the retail supplies to users, were not assessed. The existing bulk water supply infrastructure was found to be in need of maintenance, repair and even of refurbishment in some instances. A Feasibility level estimate was made of the scope and cost of bringing the existing works up to an acceptable standard, and of expanding these works to meet the future water supply needs.

These future water supply needs are 2040 domestic water supply requirements, estimated to be 6.35 million m^3/a in the LRWSS Supply Area, and water supplies for irrigation of 1.45 million m^3/a.

Since the development of new irrigation is subject to further detailed planning and to the establishment of the necessary institutional arrangements, development of the Bulk Water Distribution Infrastructure for domestic use will most likely precede that for irrigation use. The following two scenarios were envisaged for Bulk Water Supplies for domestic use:

- **Scenario 1**: A supply of 5.4 million m^3/a from Zalu Dam and 0.95 million m^3/a from groundwater sources.
- **Scenario 2**: The full yield of a 0.6 MAR from Zalu Dam, i.e. 7.2 million m^3/a, supplemented by 0.95 million m^3/a from groundwater sources if the proposed irrigation is not developed. The full yield of the dam is more than the estimated domestic water requirements in 2040 but groundwater would still be utilized to augment the system especially to supply settlements which are far from the network supply points. Supplying the distant villages from the bulk supply network

would be unaffordable, and these villages can most economically be supplied from a safe, reliable local source.

5.1 LUSIKISIKI WATER TREATMENT WORKS

5.1.1 Current Status of the Water Treatment Works

Water is at present abstracted from the Xura River at the pool formed by the weir of flow gauging station T6H004 at the road bridge carrying the R61 Road. Water is pumped from the river over a distance of approximately 800 m directly into the Water Treatment Works' (WTW) inlet structure. From there water gravitates through the works which are in a well maintained condition and capable of producing 2.76 Mℓ/d. The potable water produced by these works is of acceptable quality except for periodic non-compliance with colour, turbidity and alkalinity standards. Attention to the dosing systems and the sludge handling facility at the WTW would address these issues.

The non-availability of as-built information hampered full understanding of the operation of the WTW. However, the existing works were designed and built as modular units and can be modified and extended to satisfy the estimated future water requirements in the LRWSS Supply Area. Sufficient space for future extensions to the works seems to be available.

It is understood that the flow in the Xura River has always been sufficient to meet the abstraction capacity of the existing pumps feeding the WTW. Water shortages in the past in the Lusikisiki reticulation system were most probably a consequence of the limited treatment capacity of the WTW or of operation and maintenance issues in the system which led to water losses and to other inefficiencies. Last-mentioned reasons are the most likely.

5.1.2 Expanded Water Treatment Works

The proven capacity of the existing WTW at Xura is 2.76 Mℓ/day which is on the threshold of being insufficient to meet existing realistic needs for potable water for domestic use. This capacity should be increased as soon as possible by attending to the few process shortcomings in the works. The growing needs for potable water in the LRWSS should then be met by constructing additional modules to the works as the need arises, starting immediately with the first such new module.

In order to meet the estimated water requirements in 2040 a treatment capacity of 14.7 Mℓ/day will be required at Xura. This means that that the existing works plus about four additional modules of the same capacity would be required by 2040. This presents considerable flexibility in expanding the WTW capacity and enables the actual growth in water requirements to be closely tracked in future.

The option of decommissioning the existing works and developing a totally new works up to a capacity of 14.7 Mℓ/day was examined. There is a small but meaningful cost advantage to retaining the existing works, refurbished as suggested above.

It is expected that an optimally designed, operated and maintained sand filter system will be suitable, in conjunction with the other existing processes, to treat the raw water from the Xura River to satisfy the prescribed standards for Class 1 potable water. This includes removing the colour and turbidity in the water which is a problem at the existing works. Corrosion and concrete aggression in the network could be a potential problem due to low alkalinity of the water. Alkalinity could be increased through dosing of a hydroxide. Alternatively concrete tanks and reservoirs can be constructed with water retaining concrete and surface coats in order to resist the aggression of the water.

5.1.3 Treatment of Groundwater

Iron and Chloride concentrations in the groundwater are the key concerns. Bacteria are present in some of the boreholes with Coliforms detected in one borehole. Of the 17 potential production boreholes identified for future development to augment the LRWSS the water from four of the boreholes is Class 1 and will not require any treatment. The water from the remaining 13 boreholes will however require some limited treatment before introducing it into the supply system. In view of the dispersed locality of the borehole sites it is recommended that a package treatment plant be provided at each production hole.

Depending on the raw water quality at each site, provision should be made for aeration, filtration and disinfection which, it is envisaged, will be sufficient to produce Class 1 potable water.

The treatment requirements at the boreholes are summarised in **Table 5.1**.

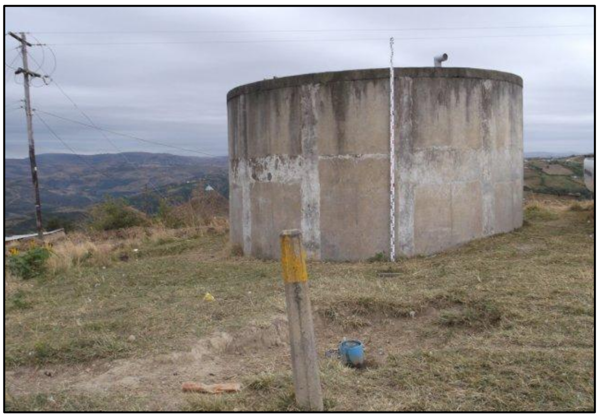
Table 5.1: Summary of on-site treatment requirements at the boreholes

Treatment Required	Number of Boreholes where Treatment is Required	Annual Supply from these Boreholes (m^3)	Capacity required per day (Mℓ/day)
No Treatment Required	4	320 000	0.88
Class 2 Iron to Class 1 Iron	4	240 000	0.66
Class 2 Bacteria to Class 1 Bacteria	9	420 000	1.15
Class 2 Chloride to Class 1 Chloride	3	130 000	0.36
Class 4 Iron to Class 1 Iron*	1	20 000	0.06
Class 4 Bacteria to Class 1 Bacteria*	1	20 000	0.06
Class 4 Coliforms to Class 1 Coliforms*	1	50 000	0.14

** These boreholes may not be worthwhile developing, and require more detailed assessments at design stage.*

In view of the localities of the borehole sites in relation to the rural communities and to the bulk water supply infrastructure of the LRWSS, it is expected that some borehole water could best be supplied directly to these communities and not be blended with water from the proposed Zalu Dam. Integration of boreholes into the regional scheme should therefore be based on detailed evaluations of the individual merits and costs of developing each borehole.

5.2 Bulk Water Supply Infrastructure



5.2.1 Current Status of the Bulk Distribution Infrastructure

a) Bulk distribution pipelines

The existing bulk water supply system comprises mainly Asbestos Cement (AC) Pipes for which no record of maintenance and repairs or of recent breakages could be located. This type of pipeline is no longer used for water supply due to the risk it poses to public health. The bulk distribution system was designed to handle 2.76 Mℓ/day, i.e. 1.01 million m^3/a, which is abstracted from the Xura River.

The bulk distribution pipeline system will have to be reviewed to serve the current geographical distribution of water users and their estimated water requirements, now and in future. It is anticipated that as the pipeline system is upgraded and expanded in future, the AC pipes will be replaced. This could be a progressive process leading to total replacement in the foreseeable future.

b) *Bulk Supply Reservoirs*

Village service reservoirs, which are all fed from bulk supply reservoirs, that were inspected were found to be in a state of neglect and are vandalised. Some reservoirs were completely dry while others were overflowing.

The existing bulk supply reservoirs were inspected and were found to be in a better condition than the village service reservoirs. The total storage capacity of the existing reservoirs is estimated to be 5 335 m^3. This estimate could not be confirmed because of the lack of as-built plans and other information. The estimated total reservoir storage capacity is about twice the daily supply capacity of the existing pipelines.

c) *Pumping stations*

The existing raw water pumping station at the abstraction point in the Xura River and the potable water pumping station at the WTW each have a capacity of 32 ℓ/s.

5.2.2 Expanded Bulk Water Distribution Infrastructure

It is envisaged that the Bulk Water Distribution Infrastructure will be expanded to provide for the estimated domestic water requirements in 2040, i.e. for a supply of 5.4 million m^3/a (14.7 Mℓ/day) from Zalu Dam and 0.95 million m^3/a (3.06 Ml/d) from groundwater sources. The layout of the proposed bulk water distribution infrastructure, relative to the proposed dam and to water users, is shown in **Figure 5.1**.

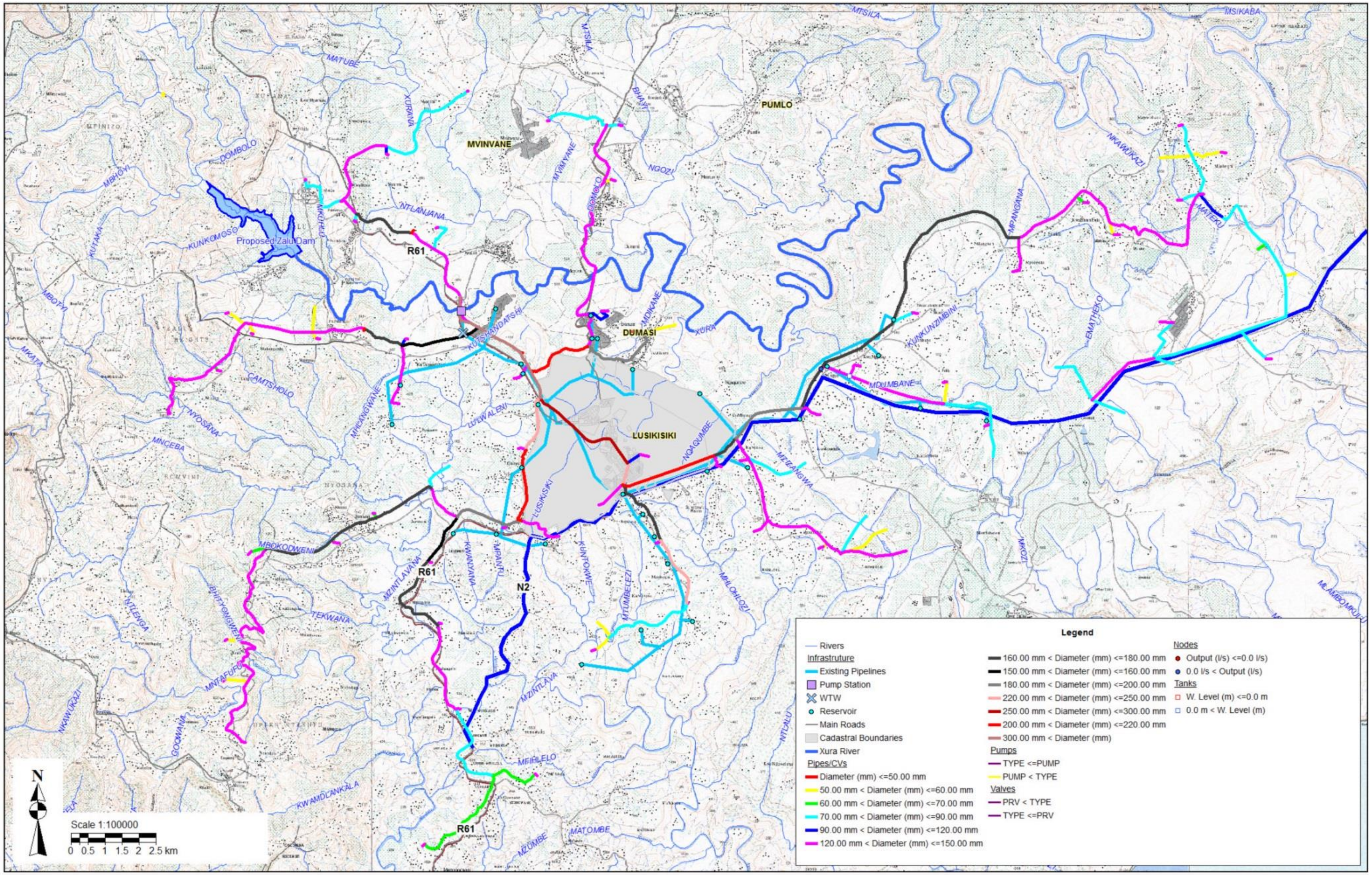


Figure 5.1: Proposed water distribution infrastructure

a) Bulk Water Distribution Pipelines

In view of the fact that the existing bulk water distribution pipelines comprise predominantly AC pipes which have apparently not been maintained and repaired to normal minimum standards, it is recommended that a new bulk distribution system be built to meet the estimated water requirements up to 2040. The existing AC bulk water supply pipes should be decommissioned as the new system is commissioned. Further background and motivation for this recommendation is given in the *Water Distribution Infrastructure Report*. The lengths of pipelines required for the proposed new bulk water distribution system to meet the estimated 2040 water requirements are summarised in **Table 5.2**.

Table 5.2: Pipeline lengths required for a new bulk distribution system

Pipe Description	Required Total Pipe Lengths (m)	
	Scenario 1	Scenario 2
Class 16 uPVC Pipe: 63 mm to 315 mm OD	178 271	174 875
Steel Pipe: 400 mm to 450 mm OD	4 137	7 541

Additional, larger diameter, steel pipelines will probably be required to serve water requirements beyond 2040.

b) Bulk Supply Reservoirs

For the proposed new bulk water distribution scheme the storage volume required in reservoirs will be twice the daily water demand on the scheme, plus some additional backup storage, i.e. twice 14.7 Mℓ plus a margin for flexibility. The total storage capacity in the bulk water distribution reservoirs should therefore be 30 Mℓ. Provision should also be made for storage in the village service reservoirs to be increased to approximately the same as the storage in the bulk water distribution reservoirs, i.e. 30 Mℓ. The total capacity of all reservoirs in the system should therefore be increased to 60 Mℓ.

It is recommended that due diligence be exercised on the structural integrity of the existing reservoirs with a total capacity of about 5.3 Mℓ in order to establish which can be retained and refurbished and which should be replaced. It is estimated that about R 7.5 million (2012 prices) in capital costs can be saved if the exiting storage reservoirs are retained and refurbished.

c) Pumping stations

The existing raw water and clear water pumping stations, each with a capacity of 32 ℓ/s, will have to be expanded from time to time up to a capacity of 171 ℓ/s to meet the expected increase in domestic water requirements by 2040. The total daily energy requirements for pumping water from Zalu Dam, through the WTW and to the reservoirs in the distribution system, plus that required for pumping groundwater, will be about 14 700 kWh/day in 2040.

The existing abstraction weir on the Xura River may not require any modifications, provided that sufficient suction head for the new pumps is available in the pool at the weir.

5.2.3 Estimated Capital Costs for the Bulk Water Distribution System

The estimated capital costs of the proposed bulk water distribution system are summarised in **Table 4.6**.

Table 4.6: Estimated capital costs of the preferred bulk supply system

Bulk Supply Infrastructure Component	Rand (million)
Bulk Supply Pipelines	160.6
Bulk Supply and Village Reservoirs	162.9
Pumping Stations	25.3
Borehole Development	9.1
Water Treatment Works	55.3
Sub Total	413.2
Preliminary and General (20% of Sub Total)	82.6
Total (excl. VAT)	R 495.8
VAT (14% of Total)	R 69.4
Total (incl. VAT)	**R 565.2**

The annual Operating and Maintenance Costs are estimated as being 2.5% of the capital cost of a new scheme as recommended in the Vaal Augmentation Planning Study (VAPS) Guidelines.

The following assumptions were made for estimating future refurbishment costs of the bulk water distribution infrastructure:

- The WTW will be refurbished every 15 years at a cost of 50% of the cost of a new works.
- Each borehole will be refurbished every 10 years at a cost of 50% of the borehole development cost.
- Pumping stations will be refurbished every 10 years at a cost of 50% of the cost of a new pumping station.

The average weighted energy cost, based on the 2012/13 Eskom Ruraflex Tariffs, is estimated to be R 0.64 per kWh. The URV calculations based upon this energy cost for water from the abstraction point in the Xura River to the village service reservoirs is R 3.06 per m^3.

5.3 WATER QUALITY

The quality of water abstracted from the Xura River is generally good, but the SRK Study (2009) found that the total Iron and total Coliform concentrations could be too high at times. Water samples were tested and it was found that colour, turbidity, iron and low alkalinity are of concern. These constituents do however not present any direct risks to public health but do influence the aesthetic quality of the water. Bacteria, Iron and Chloride concentrations are concerns in regard to the ground water sources.

The physical, chemical and biological properties of water in the Xura River will change when impounded in the proposed Zalu Dam. Provision of a multi-level outlet facility will allow flexibility in selecting water from various levels in the dam so as to abstract the best quality water for treatment and supply via the LRWSS. Aeration of the water that is released into the Xura River for abstraction downstream at the weir will also improve the quality of the water that is released from the dam.

The quality of the surface water could however deteriorate in future due to increased population densities and agricultural and industrial growth in the Xura River catchment.

6 ENVIRONMENTAL IMPACT ASSESSMENT

It is a statutory requirement that new infrastructure developments be authorized in terms of the National Environmental Management Act. An Environmental Impact Assessment (EIA), undertaken by an independent Environmental Assessment Practitioner (EAP), must be submitted to the Department of Environmental Affairs in support of an application for authorization. The EIA must include a draft Environmental Management Plan (EMP) which offers direction on how to implement mitigation measures when the project is constructed. The EIA must be undertaken in a separate assignment according to Terms of Reference which are informed by the development proposals emanating from this Feasibility Study. Compilation of these Terms of Reference was facilitated by an Environmental Screening which was undertaken in the Feasibility Study.

6.1 ENVIRONMENTAL SCREENING

An environmental screening was carried out to identify and evaluate the possible environmental consequences of the various options available for development. In this way environmental "red flags" and possible "fatal flaws" in relation to the biophysical, social and economic environment could be identified and used to eliminate, as early as possible, those options which are not viable. Attention was also given to risks of non-compliance with environmental legislation that could render an option unsuitable or not worth further investigation.

Environmental screening was a useful aid in arriving at the preferred and most attractive development proposals for the LWRSS. A detailed Environmental Impact Assessment (EIA) of the development proposals will follow in a separate assignment with a view to obtaining full environmental authorisation for the project.

The project area is located in the Pondoland centre of plant endemism and previous studies have indicated that better conservation of this natural resource is highly desirable. Previous investigations also found no special ecological sensitivities at the proposed dam site, but the abstraction of more water from the river system may have significant impacts of on the estuary of the Msikaba River.

No human settlements are located in the dam basin so the negative impacts on local communities are expected to be relatively small. Health and safety risks to local communities arising from construction activities include (a) the increased spreading of HIV/Aids and (b) potential safety hazards associated with having access to water bodies. The risk of accidents on local roads used for access to work areas involving construction vehicles and traffic from surrounding communities will be significant. The construction of new roads will increase the potential for soil erosion and other ecological impacts.

Plants with various medicinal and commercial uses as well as grazing land will be destroyed in the area to be inundated by the dam. This will result in a loss of income for the local communities. Construction of the dam and other components of the proposed scheme will provide short-term employment opportunities and training in technical skills for local people.

In view of the high level of investigation involved in the environmental screening it is noted that uncertainties exist regarding the following issues:

- The presence of flora and fauna species of conservation value.
- The presence of heritage resources.
- The number of people to be displaced.
- The environmental impacts of access roads.

Risks associated with each environmental issue identified in the screening were rated on a scale of 1 to 5, with 1 indicating a Fatal Flaw and 5 indicating a Positive Impact. The average rating score of the risk associated with each issue in respect of each environmental dimension is given in **Table 6.1**. An interpretation is also given of the score assigned to each issue to provide guidance on the probable focus required in undertaking the EIA.

Table 6.1: Risk assessment summary

Environmental issue	Average score	Interpretation of average score
Biophysical		
Geology	3.5	Uncertain - favourable
Soil	3	Uncertain
Fauna/Flora	2.75	Less favourable – Uncertain
Riverine ecosystem	2.4	Uncertain - less favourable
Water quality	3.3	Uncertain – favourable
Hydrology	4	Favourable

Environmental issue	Average score	Interpretation of average score
Social		
Agricultural	3	Uncertain
Heritage	3	Uncertain
Displacement of persons	3.3	Uncertain – favourable
Health and safety	2.6	Uncertain – less favourable
Access route	2.3	Less favourable - Uncertain
Visual	4	Favourable
Infrastructural development	4.3	Favourable
Public Participation	3.5	Uncertain –favourable
Economic		
Loss of local income due to project	3	Uncertain
Employment creation	3.3	Uncertain -favourable
Enviro-legal		
Enviro-legal	3	Uncertain

6.2 PUBLIC PARTICIPATION

A limited stakeholder participation process was undertaken in support of the Environmental Screening during the Feasibility Study. Key stakeholders and decision makers were included in a Stakeholder Committee in order to:

- Implement the DWA policy of engaging with stakeholders at a local, provincial and national level, as well as with institutions and other bodies with a direct interest in the LRWSS;
- Inform stakeholders about the intention to develop the LRWSS and to provide them with information on the project, including the nature and scope of technical investigations being undertaken and the process to be followed in the planning and implementation phases;
- Gain the perspectives (perceptions, impressions, concerns, needs, ideas, suggestions) of stakeholders on issues that may be relevant to the project; and
- Pave the way for a more thorough Public Involvement Process in support of the EIA which will follow as a separate assignment.

The outcome of the Public Participation was (a) better informed decisions with respect to the selection of the best options and configuration for the project and (b) clarity on the need for and scope of further investigations. Two issues which were made very clear by the stakeholders in their participation in the Feasibility Study are:

- There is a lack of sustainable and safe potable water supplies in the area; and
- There is a poor perception of and a negative attitude towards groundwater.

An awareness campaign was undertaken to improve the knowledge among stakeholders about groundwater and to better inform their perceptions of this important source of water. Communication with the stakeholders and the communities in the project area should continue to ensure informed participation, decision-making and a transparency in the following phases of the project cycle.

The Stakeholder Committee met four times during the Environmental Screening and prepared the stakeholders for more detailed participation in the Environmental Impact Assessment which will follow in a separate assignment.

7 REGIONAL ECONOMICS ASSESSMENT

The purpose of the Regional Economics Assessment was to provide a strategic economic overview of the potential impacts of the proposed LRWSS, including major developmental opportunities and spinoff benefits for the regional and national economy.

Economic impacts are assessed in terms of their duration and the stage of the project lifecycle in which they occur, namely the development phase when construction takes place and the operational phase when, in this case, water can be suppied. Economic impacts during the construction phase are usually of short duration and therefore have a temporary effect. On the other hand, the operational phase of the project is expected to continue indefinitely. Economic impacts during operation are designed to be positive and sustainable.

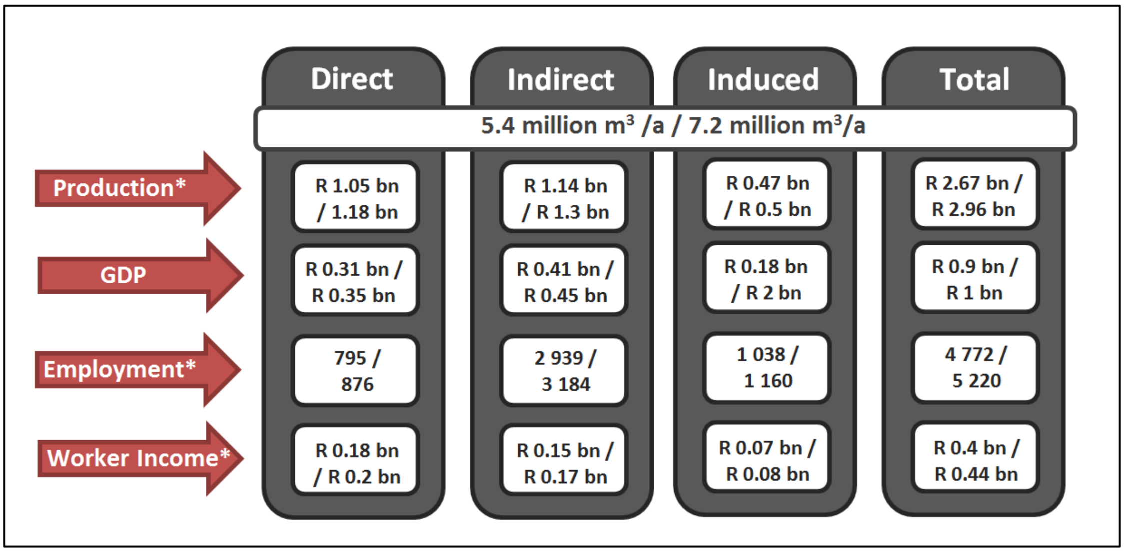
Development of the LRWSS is viewed as comprising two construction phases, the first being construction of the Zalu Dam and the second including the water treatment works and bulk water distribution infrastructure. Periodic refurbishment of the pumping stations, the water treatment works (WTW), and borehole equipment is envisaged during the operational phase of the LRWSS.

All components of the LRWSS except the Zalu Dam were assessed for a system that can supply 5.4 million m^3/a to domestic users and 1.45 million m^3/a for use in new irrigation development. The alternative scenario where no water is taken up for irrigation and the full yield of the proposed Zalu Dam, i.e. up to 7.2 million m^3/a, is supplied only for domestic use was investigated. For the 5.4 million m^3/a supply a 0.6 MAR (8.1 million m^3 storage) dam will be developed whereas the 7.2 million m^3/a supply will be supplied by a 0.6 MAR or 1.5 MAR dam (19.8 million m^3 storage). It should be noted that in the base case scenario mentioned above the cost of developing bulk water distribution infrastructure to supply irrigation areas and on-farm irrigation systems is not taken into account while in the alternative scenario the capital cost of distributing the full 7.2 million m^3/a yield of the dam for domestic use is taken into account. This affects the rational interpretation of the Regional Economic Assessments.

The economic implications of maximizing the utility of the Zalu dam site in the Xura River for making reliable water supplies available as a stimulus for regional economic development was also assessed as a strategic development option.

7.1 Economic Impact Assessment

The economic impact assessment showed that development of the LRWSS will have a significant impact on the regional and local economies during the construction, operational and refurbishment phases. It is expected that the proposed LRWSS will stimulate job creation and long-term economic development. The economic impact expected during the implementation phase when construction takes place is illustrated in **Figure 7.1**.



Source: Urban-Econ Development Economists calculations (2013)

**Impact calculated in billions (2012 prices)*

Figure 7.1: Macro-economic effect of the implementation phase

Figure 7.1 indicates that the total expenditure on capital works during the construction phase of the LRWSS will amount to approximately R 1.05 billion for a system that makes 5.4 million m^3/a available for domestic use, *without any provision for the development of irrigation infrastructure*. The direct investment in the domestic manufacturing industry will cause increased productivity in other sectors of the economy. In total, the construction phase in this scenario will raise the level of production by approximately R 2.67 billion. The total impact on production during the construction phase for the scenario in which irrigation development does not materialise and the full

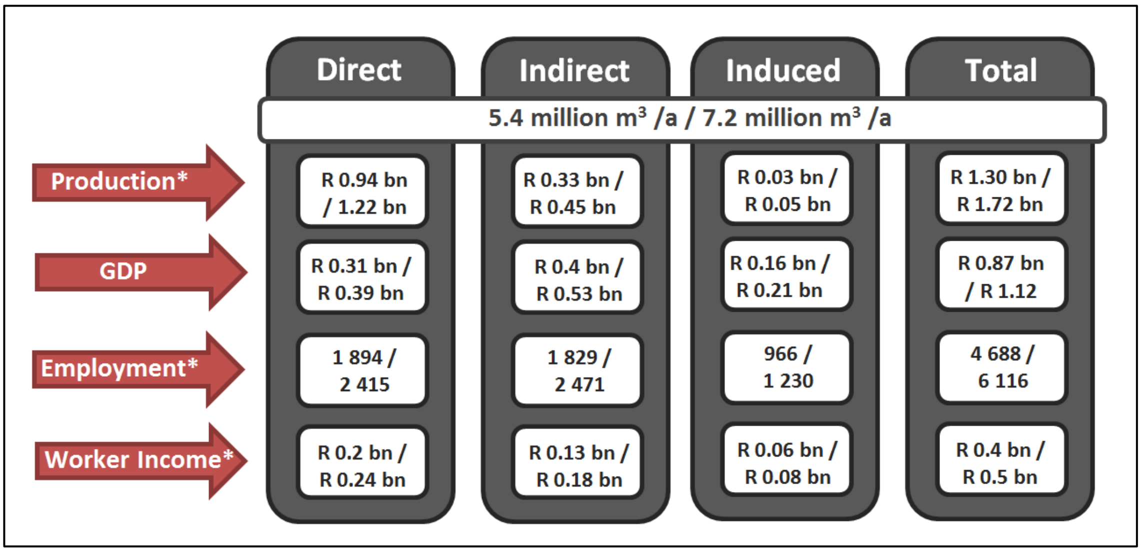
7.2 million m^3/a yield of the dam is distributed in bulk for domestic use will be higher at an estimated R 2.96 billion.

Raised production levels are accompanied by increased GDP. The direct GDP impact of the construction phase is an increase of R 0.31 billion for the base case and R 0.35 billion for the scenario in which irrigation development does not materialise. The total GDP is expected to grow by between R 0.9 billion and R 1 billion.

The construction phase of a system to supply 5.4 million m^3/a for domestic use and provide for irrigation development, without accounting for the infrastructure for this irrigation, will generate the employment of approximately 795 persons for a period of 36 months. Employment opportunities will also follow from increased production in industries supplying construction materials and consumer goods. The indirect impact on the economy through these industries will be in the form of approximately 2 939 employment opportunities, while the induced impact on industries supplying consumer goods and services will be the creation of approximately 1 038 employment opportunities. In total, construction of the base case scenario will generate approximately 4 772 employment opportunities. A total of approximately 5 220 employment opportunities will be created by construction of the alternative scenario of not reserving water for irrigation but providing for the distribution of 7.2 million m^3/a for domestic use.

In return for providing a service, employees naturally receive an income. It is estimated that a cumulative employee income of R 0.4 billion will be generated through the construction phase of the base case scenario and R 0.44 billion for the alternative scenario.

Figure 7.2 illustrates the estimated macro-economic impact of the operational phase of the LRWSS over a long period of 46 years. This period includes three stages of refurbishment of hydro-mechanical and electrical equipment.



Source: Urban-Econ Development Economists calculations (2013)

**Impact calculated in billions (2012 prices)*

Figure 7.2: Macro-economic effect of the operational phase

From **Figure 7.2** it can be seen that direct expenditure during the operational phase of the LRWSS, including periodic refurbishment, will amount to approximately R 0.94 million for the base case scenario, resulting in production in other sectors of the economy. In total, the operational phase of the base case scenario will raise the level of production by approximately R 1.30 billion, and by approximately R 1.72 billion for the alternative scenario.

Raised production levels are accompanied by increased GDP. The direct impact of the operational and refurbishment phases is an increase in GDP of R 0.31 billion for the base case scenario. In total the GDP is estimated to increase by approximately R 0.87 billion for this case. The estimated equivalent contributions to GDP by the alternative scenario are R 0.39 billion and R 1.12 billion.

The operational phase of the base case will generate employment for an estimated 1 894 persons over a period of 46 years. Increased production in industries supplying operation materials and associated consumer goods will in turn generate employment opportunities in these industries. The indirect impact of the operational phase on employment in industries supplying materials will be the creation of approximately 1 829 jobs while the induced impact in industries supplying consumer goods and services will be the creation of approximately 966 jobs. In total, the operational (including refurbishment) phase of the base case scenario will generate approximately 4 688 employment opportunities.

The alternative scenario is estimated to create a total of 6 116 new employment opportunities.

In return for providing a service during the operational phase of the base case, employees will receive a cumulative income (over 46 years) of an estimated R 0.4 billion. The estimated income earned during operation of the alternative scenario is R 0.5 billion.

Due to the higher expenditure associated with the construction and operational phases of a 1.5 MAR dam the associated impact will be larger. During the construction phase a 7.2 million m^3/a capacity system supplied by a 1.5 MAR dam will make a total contribution of R 3.218 billion to production, R 1.074 billion towards GDP and 5 449 employment opportunities will be created which will result in worker income of R 0.464 billion. The operational phase of a 1.5 MAR dam for a 7.2 million m^3/a capacity system will contribute a total R 3.257 billion to production and R 1.240 billion towards GDP while creating a total of 6 679 million employment opportunities.

The economic impact during construction is considerable but occurs only for a short period. On the other hand, operation of the project is intended to last indefinitely and will make a more sustainable contribution to the domestic economy. The positive impacts on the estimated increase will be higher for the construction and operation of a 7.2 million m^3/a capacity system. Both sized systems will result in no irrigation costs.

7.2 AFFORDABILITY

In **Section 2.1.2**, it is reported that a large portion of the population (40.5%) lives below the poverty line and is probably not able to afford to pay even a highly subsidised price of the water that will be provided through the LRWSS. With time, increased economic activity which is expected to result from investments in the LRWSS will lead to an increase in household income. This will result in more people being able to afford to pay for water at subsidised prices. In order to make safe and reliable supplies of potable water accessible and affordable through the proposed LRWSS it will be necessary to finance the construction cost through grant funding. Such investment would not be recovered through income from the sale of water to consumers.

7.3 CONCLUSION

Implementation and operation of the proposed LRWSS is expected to increase the size of the economy in the project area. Significant macro-economic impacts can be expected, including an increase in the level of production, GDP, employment and household income at a local, provincial and national level. Business activity will be stimulated and human capital development will result from training and skills acquisition. An improvement in living standards can be expected.

The current economic profile was established as a point of departure to evaluate the anticipated effects. The effect of changes in the economic performance resulting from the proposed development was assessed and found to be positive. Through the employment opportunities created it is estimated that a total of 23 860 people will benefit from the construction phase of a 5.4 million m^3/a system, *but maybe more if the irrigation infrastructure is developed*. A 7.2 million m^3/a system will benefit a total of 26 100 people during the construction phase. This is the result of an increase in worker income within each household affected. The operational phase combined with the three refurbishment phases will positively impact between 23 411 and 30 580 people over a 46-year period (depending on the chosen system).

8 LEGAL, INSTITUTIONAL AND FINANCING ARRANGEMENTS

8.1 OVERVIEW

Various development options have been considered but for purposes of estimating the funding requirements and the most appropriate sources of these funds, it is assumed that a new bulk water distribution system for domestic use with the capacity to utilise the full yield of Zalu Dam will be constructed. This assumption is conservative and implies that existing works such as the WTW serving Lusikisiki and the old AC pipelines will be replaced.

The development of groundwater has been identified as the most appropriate source for serving some sparsely populated areas furthest from the dam.

The initial investment required is approximately R 1 100 million in 2012 Rands. These costs do not include relocation and compensation costs; at the time of investigation the land within the proposed bam basin did not contain any settlements or dwellings. A breakdown of these costs is displayed in **Table 8.1**.

Table 8.1: Initial investment

Scheme components	Capital cost in R million (2012 Rands)	
	0.6 MAR Zalu Dam	1.5 MAR Zalu Dam
Zalu Dam (including Preliminary and General and Contingencies)	R 486, 919	R 714, 581
New Water Treatment Works	R 75, 602	R 75, 602
Bulk Water Pipelines	R 167, 055	R 167, 055
Pumping stations	R 33, 071	R 33, 071
Bulk Supply and Village Reservoirs	R 221, 143	R 221, 143
Borehole Development	R 9, 147	R 9, 147
Preliminary and General for Bulk water components	R 102, 341	R 102, 341
Total development cost in 2013 Rands (excl. interest and VAT)	**R 1 095, 278**	**R 1 322, 940**
Total (incl. VAT)	**R 1 248, 617**	**R 1 508, 152**

** Inflation and interest charges should be added to these amounts*

 # Investment cost was taken for 7.2 million m³/a bulk supply infrastructure scenario

The cost of energy for pumping surface and groundwater is estimated to be about R 3.4 million per annum in 2040 and R 4.7 million per annum in 2060.

Inflation and interest charges, where applicable, should be added to these amounts.

8.2 LEGAL ARRANGEMENTS

The *National Water Act, Act 36 of 1998* stipulates that the onus for making applications for the necessary Water Use Licences, and for appointing the Approved Professional Person to take responsibility for engineering tasks on the dam, rests with the owner of the dam. It is therefore necessary that responsibility for ownership of the dam be assigned to an appropriate institution or entity early in the implementation phase of the project.

Early confirmation of which institution will be the owner of the dam is also necessary to ensure that timeous application can be made for Regional Bulk Infrastructure Grant (RBIG) funding.

It is recommended that either a water board or OR Tambo DM takes early ownership of the dam and, with the assistance of DWA, makes the necessary water use licence applications and appoints the Approved Professional Person to take responsibility for dam design and construction supervision tasks in accordance with the Dam Safety Regulations. Section 19 of the *Water Services Act, Act 108 of 1997* gives preference to water boards as water services providers over private sector providers.

Chapter 5 of the *National Environmental Management Act, Act 107 of 1998* (NEMA) provides for Integrated Environmental Management. Regulations published in terms of the NEMA in 2010 require that the owner of a listed activity, which includes an institution which wishes to construct a dam, must undertake an environmental impact assessment (EIA) of the proposed dam. An EIA must be undertaken in accordance with procedures laid down by the Minister or MEC, as the case may be. The EIA must be submitted in support of an application for environmental authorisation by the Minister or MEC and such authorisation must be obtained before proceeding with the construction of the dam.

The *Land Affairs Act, Act 101 of 1987* provides for the establishment of a Land Affairs Board to determine amounts of compensation payable, purchase prices or rents in respect of immovable property expropriated, purchased or leased by the Department of

Public Works for public purposes such as the construction of government water works envisaged for the LRWSS. The Land Affairs Board is also empowered to give advice with regard to the value of land, rights on or in respect of land, and purchase prices or rents in respect of certain immovable property.

The Board may also advise the Minister of Water Affairs on the amount of compensation to pay for land that it wishes to expropriate in the dam basin.

8.3 INSTITUTIONAL ARRANGEMENTS

There are various entities that can play a role in the institutional arrangements and funding of the Zalu Dam and associated regional bulk water distribution system, including the water treatment works, distribution pipelines and reservoirs. These institutions are National Treasury, the Department of Water Affairs (DWA), OR Tambo District Municipality (DM) which is the Water Services Authority, and a water board, being either Amatola Water or Umgeni Water.

The proposed dam is not within the definition of National Water Infrastructure given in the NWRS but will be in the category of Regional Water Infrastructure. There may however be strategic reasons why DWA, as the custodian of water resources in South Africa, may wish to own regional dams. Such a reason could be that the water made available from the dam would in large measure be allocated for domestic use in situations where full cost recovery will not be possible. Allocations for new irrigated agriculture, such as is envisaged along the Xura River below the proposed Zalu Dam, can be expected to generate tariff incomes that would barely cover Operation and Maintenance costs. There are no industrial or other commercial users in the project area that could make capital contributions to the development costs or bear the full unit cost of water that could be made available.

The decision regarding ownership of the dam rests with the Minister, acting on advice from the DWA. Ownership of the dam by the DWA would enable the Minister to more directly regulate and control water allocations and deal with dam safety.

In the event that the proposed dam is owned by the DWA the department could itself implement the dam using departmental design and construction resources, or direct either the Trans-Caledon Tunnel Authority (TCTA), Amatola Water or Umgeni Water (last-mentioned both being existing Water Boards with regional responsibilities) to implement the dam as Implementing Agent on its behalf.

Ownership of the water treatment works and bulk water distribution pipelines could reside with OR Tambo DM or with a water board. Given the intention expressed in the NWRS for water boards to be consolidated into Regional Water Utilities (RWUs), and given the future role that is intended for these utilities, there is a strong motivation to direct a water board to own, implement and to operate the water treatment works and bulk water distribution infrastructure.

8.4 FINANCING ARRANGEMENTS

Approximately 40% of the population in the supply area lives below the poverty line (see **Section 7.2** above) and will not be able to afford to pay for water at a tariff that can recover at least a significant portion of the cost of the water. Further, there is no possibility that a portion of the project could be funded off-budget by an entity in the private sector. The cost of the works will accordingly have to be financed through grant funding, either through a Regional Bulk Infrastructure Grant (RBIG) or a dedicated grant on the DWA budget.

The responsibility for applying for grant funding should be aligned to ownership. If, for example, it was decided that DWA should own the dam and that a water board or OR Tambo DM should own the water treatment works and bulk distribution infrastructure, then two separate applications for grant funding would be necessary and these applications would have to be aligned.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 WATER REQUIREMENTS

Water for domestic use in the LRWSS supply area is at present abstracted from a run-of-river scheme in the Xura River, treated and then distributed to the users. The existing bulk water distribution infrastructure is not well maintained and, while the availability of water at the abstraction point in the river seldom falls short of requirements, users regularly experience shortages and interruptions in supply.

The expected realistic water requirements for the LRWSS is estimated to be 14.7 Mℓ/d (5.4 million m^3/a) by 2040, allowing for a steady increase in the level of water services provided.

No significant irrigation takes place along the Xura River at present, and the study reveals that only a limited area of about 275.3 ha of soil is classified as being moderately suitable for successful irrigation development along the river. In view of the low level of economic activity in the project area, the provision of water for new irrigation development offers an opportunity to stimulate economic activity. The cropping patterns likely to be sustainable in this environment will require an estimated 4 878 m^3/ha/a for irrigation, or 1.45 million m^3/a when an allowance is made for transmission losses. The assurance of supply of this water will be less than that provided for domestic use and for the Reserve.

It is recommended that a storage dam be built in the Xura River at Zalu, to supply the expected water requirements for domestic use and to provide water for new irrigation. Furthermore, the following is recommended:

- Before irrigation development is considered in the area identified as being <u>moderately suitable</u> land, a detailed soil survey needs to be undertaken.
- <u>Marginally suitable</u> land could be used for gardening purposes with technical and managerial inputs.
- The reasons for the failure of agricultural development projects in the study area need to be further researched.

9.2 Water Resources

The proposed Zalu dam in the Xura River, a tributary of the Msikaba River near the town of Lusikisiki, was previously identified as resource to supply the requirements for the LRWSS.

9.2.1 Hydrology and Climate

The Mean Annual Runoff (MAR) in the Xura River at the Zalu Dam site is estimated to be 13.1 million m^3 from a catchment area of 71 km^2. The MAR of the Msikaba River is 221 million m^3 from a total catchment area of 1 022 km^2.

The following is recommended:

- A climate station, measuring at least evaporation and rainfall, must be established at the proposed Zalu Dam.
- Continued accurate gauging at the gauging stations T6H004 and T6H005 is essential for future studies.
- Only after a reasonable overlapping period of data is gathered at the dam and at T6H004, can flow measurement at T6H004 be discontinued on condition that a reliable dam balance is possible.
- Flow gauging is required at high water levels in the Xura River to extend the rating curve at T6H004 so that the number of times that the rating curve is exceeded can be reduced. The rating curve can also be extended if the high flows and spills at Zalu Dam are accurately measured.

9.2.2 Ecological Water Requirements

The Msikaba River is one of the few rivers in South Africa that has not yet been regulated; therefore the protection of the ecological functioning of this river is regarded as critical. An Intermediate Reserve Determination was undertaken with the selection of two Environmental Water Requirements (EWR) sites, EWR 1 on the Xura River and EWR 2 on the Msikaba River. The Index of Habitat Integrity (IHI) at EWR 1 is Category A/B with a required maintenance flow of 3.2 million m^3/a, and Category B at EWR 2 with a required maintenance flow of 23.7 million m^3/a. Drought and high flows, as well as the long term mean, were also estimated for these sites.

The Reserve, which includes water for basic human needs, is assigned the highest priority in the allocation of water between user sectors. The seasonal flow regime of the Reserve was determined for use in estimating the yield of a dam at the Zalu site that could be allocated to other economic user sectors.

The following is recommended:

- Regular review as well as constant monitoring and enforcement of water use licenses;
- Compliance with the Reserve requirements;
- Protection of water resources against pollution;
- Development and implementation of operation rules for the proposed Zalu Dam;
- Allocation and management of water resources to meet user quality objectives; and
- Efficient management of the water resources for sustainability in the Study Area.

9.2.3 Surface Water Resources

The historic firm yield (HFY) and 1:100 year yield for a 60% MAR Zalu Dam (FSL of 612 masl) are 6.0 million m^3/a and 6.75 million m^3/a respectively. This yield will be sufficient to supply the maximum future demands up to 2040, i.e. 6.85 million m^3/a. The 1:100 year yield for a 1.5 MAR Zalu Dam is 10.3 million m^3/a.

The Intermediate Reserve Study confirmed that the low flow Ecological Water Requirements downstream of the proposed Zalu Dam at EWR 1 will be satisfied through river releases to the abstraction point at T6H004. Furthermore, the high flow EWR is also satisfied by spills from an optimised dam and run-off from the incremental catchment. Therefore, the location of water abstraction is critical to optimise the yield from the proposed Zalu Dam as the domestic water requirements in 2040 are more than the low flow EWR.

The following is recommended:

- Domestic water must be abstracted at T6H004.
- Seasonality of releases from Zalu Dam should be addressed according to recommendations in the Intermediate Reserve Determination Report. Also, whilst the full 2040 water requirements are not released, provision should be made to comply with the low flow ecological reserve.
- The 60% MAR Zalu Dam (FSL of 612 masl) is recommended for future analyses.
- No land development should be allowed without studying the impact on the Reserve and the impact on the yield of Zalu Dam.

- A monthly dam balance is required at Zalu Dam – but continuous measurement of spills and releases is necessary.

9.2.4 Groundwater Resources

There is sufficient information available to conclude that sufficient groundwater resources of adequate quality are available to (a) supply some remote rural settlements where the cost of linking with the LRWSS is prohibitive and (b) provide a significant source for conjunctive use in the regional scheme with water supplied from a dam at the Zalu site in the Xura River.

It is recommended that seventeen boreholes, nine previously drilled and eight still to be drilled, be fully developed and equipped to augment the supplies from a dam at the Zalu site. These boreholes will be capable of supplying 2 553 m^3/day (0.93 million m^3/a) from the Regional Well-field Area (RWA).

The following is recommended:

- Groundwater level monitoring should be conducted at strategically located sites.
- Social trends that indicate "water use from groundwater is negatively perceived" should be considered and mitigated before borehole schemes are implemented.
- Equip only nine boreholes identified during the Feasibility Study, and drill and equip an additional eight boreholes to finally abstract 2 553 m^3/day (0.93 million m^3/a) from the Regional Well-field Area (RWA).
- Smaller communities outside the RWA need to be served by stand-alone groundwater schemes which will either serve single communities or small clusters of communities depending on local groundwater conditions.
- Groundwater sources should involve springs as well as new boreholes that need to be developed.

9.3 FUTURE DEVELOPMENT OF THE PROPOSED ZALU DAM

The proposed Zalu Dam can support the 5.4 million m^3/a 2040 domestic requirements plus the 1.45 million m^3/a irrigation requirements. However, the yield potential of the Xura River at the Zalu site is considerably more, thus a 1.5 MAR dam was also considered.

Recommendations regarding the development of the proposed Zalu Dam are as follows:

- Develop the proposed Zalu Dam on the Xura River with a full supply level of 612 masl; however, confirm the final dam size before final design.
- The available supply from Zalu Dam should be augmented with groundwater resources from seventeen identified potential production boreholes with a yield of 0.95 million m^3/a.

9.4 BULK WATER INFRASTRUCTURE

The existing bulk supply and village reservoirs are in a poor state. The total storage capacity of the existing reservoirs is unknown due to the lack of "as built" data, but is estimated at approximately 5 335 m^3. The existing raw water and clear water pumping stations each have a capacity of 32 ℓ/s for 24 hours of pumping per day.

The existing WTW was found to be in a well maintained condition, but the dosing and sludge handling systems require attention. The existing WTW can be modified and extended for future requirements of the upgraded scheme.

The raw water from the Xura River is currently adequately treated, except for colour, turbidity and alkalinity. For the new and/or upgraded WTW it is expected that an optimally designed, operated and maintained sand filter will be sufficient to remove the colour and turbidity to within the required limits.

The disconcerting concentrations of Iron and Chloride are the key groundwater quality concerns, and to a lesser extent, the presence of Bacteria and Coliforms at certain boreholes.

The following is recommended:

- Urgent confirmation from decision makers on the development of an irrigation scheme, before the bulk supply infrastructure can be developed for either 5.4 or 7.2 million m^3/a.
- Confirmation that the depth of the raw water pumping station's sump is able to provide sufficient suction head for the pumps, based on the design of the existing abstraction weir.

- Construction of a new raw water pumping station and utilization of the existing structure if possible. Both the raw and clear water pumping stations will have to be upgraded to capacities of 171 ℓ/s and 228 ℓ/s respectively.
- Refurbishment of the existing WTW and the construction of a new WTW for the treatment of water supplied from Zalu Dam.
- Treatment must ensure that the Iron, Chloride, Bacteria and Coliform concentrations comply with the maximum permissible concentrations.
- Decommissioning of the existing bulk supply system's AC pipes, and construction of a new bulk supply pipe network, along the same routes of the existing pipelines and beyond.
- Construction of new storage reservoirs and the refurbishment of the existing reservoirs, where and if possible. The total required storage volumes are 78 521 m^3 and 106 575 m^3 for Scenario 1 and 2 respectively.
- Conjunctive use of surface water from Zalu Dam and groundwater from the seventeen identified potential production boreholes.
- On-site treatment of the groundwater at the boreholes at which it is required.

9.5 Environmental Impacts Assessment

No fatal flaws were identified during the risk assessment. However, the environment is sensitive and requires an in-depth assessment and management.

The public participation process during the Screening process has shown that there is a poor perception and negative attitude towards groundwater. Also, there is a lack of sustainable and safe drinking water sources in the area.

An EIA of the proposed dam and associated infrastructure is required before proceeding with construction.

9.6 Regional Economic Impact Assessment

The proposed LRWSS is expected to increase the size of the economy of the local area. It will have significant macro-economic impacts due to the fact that it will increase the level of production, GDP, employment and worker income at a local, provincial and national level, as well as stimulate business and human capital development and assist in raising living standards.

Through the employment opportunities created it is estimated that a total of 23 860 people will benefit from the construction phase of a 5.4 million m^3/a system. A 7.2 million m^3/a system will benefit a total of 26 100 people during the construction phase. This is the result of an increase in worker income within each household affected. The operational phase combined with the refurbishment phases will positively affect between 23 411 and 30 580 people over a 46-year time period (depending on the chosen system).

The income profile indicated that there is a significant portion of the population that is at risk of not being able to afford the water that will be provided through the LRWSS. With time, increased economic activity through the LRWSS investments will lead to an increase in worker income and, as a result, more people will be able to afford water. It is therefore recommended that to make water available and affordable grant funding will be required.

9.7 Legal, Institutional and Financing Arrangements

There are various institutions that can play a role regarding the institutional arrangements and the funding of the Zalu Dam and the associated water treatment works and regional water supply works. These institutions are National Treasury, the Department of Water Affairs (DWA), OR Tambo District Municipality (DM) (the Water Services Authority) and a water board, being either Amatola Water or Umgeni Water.

The following is recommended:

- The owner of the proposed Zalu Dam must be **confirmed early** in the implementation process.
- Either a water board or OR Tambo DM must take early ownership of the Zalu Dam and, with the assistance of DWA, make the necessary water use licence applications and the appointment of the Approved Professional Person.
- There may however be strategic reasons why DWA, the custodian of water resources in South Africa, may wish to own regional dams.
- DWA would also need to decide who should implement the dam. DWA could implement the dam itself, or direct either the Trans-Caledon Tunnel Authority (TCTA) or a water board (Amatola Water or Umgeni Water) to implement the dam as implementing agent on its behalf.
- Determining the amounts of compensation, purchase prices or rents with respect to immovable property expropriated, purchased or leased by the Department of Public

Works for public purposes; a Land Affairs Board should be appointed to advise on this aspect.

- The ownership of the water treatment works and bulk distribution infrastructure could reside with either OR Tambo DM or with a water board. Given the intention expressed in the NWRS for water boards to be consolidated into Regional Water Utilities (RWUs), and given the future role that is intended for these utilities, there is a strong motivation to direct a water board to own, implement and operate the water treatment works and bulk distribution pipelines.
- The works should be subsidised through grant funding, either Regional Bulk Infrastructure Grant (RBIG) or a dedicated grant on the DWA budget. Because of the low affordability of the users the portion of the project that can be funded off-budget, i.e. through the private sector, is very limited.
- The responsibility for applying for the required grant funding should be aligned to ownership. If for example it was decided that DWA should own the dam and that a water board or OR Tambo DM should own the water treatment works and bulk distribution infrastructure then there would be two separate applications for grant funding, and these applications would need to be aligned.

10 REFERENCES

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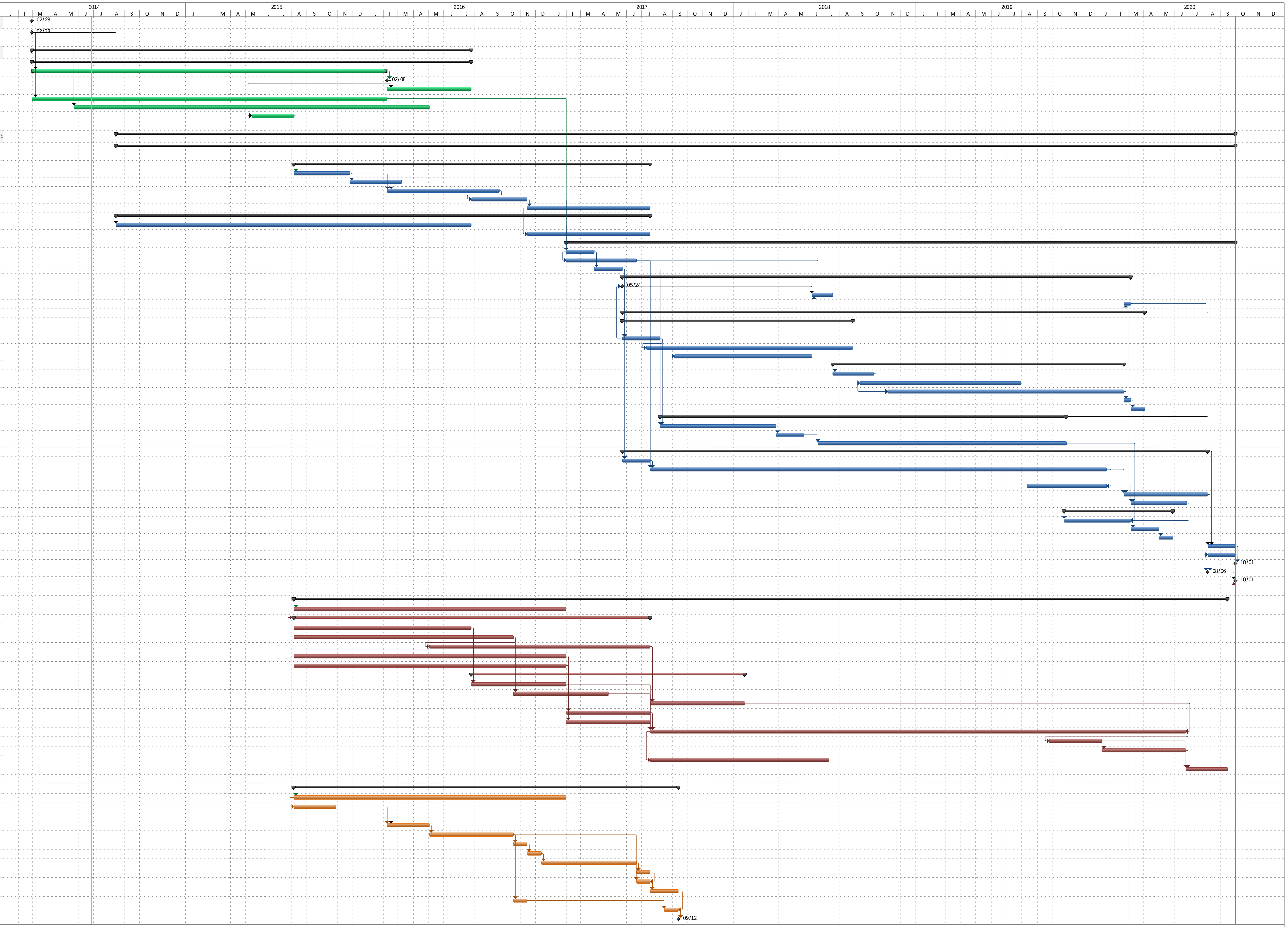
Investigating the Potential to Supplement the Lusikisiki Rural Water Supply Scheme – Final Report, 2009.

Appendix A

Implementation Programme

ID	Task Name	Duration
1	A. Feasibility Study	0 days
2	End of Lusikisiki Feasibility Study: technical component	0 days
3		
4	B. Decision support phase	600 days
5	ENVIRONMENTAL AUTHORISATION	600 days
6	Environmental Impact Assessment (including decision making phase	24 mons
7	Environmental authorisation	0 days
8	Appeal period	6 mons
9	INSTITUTIONAL AND FINANCIAL ARRANGEMENTS	24 mons
10	DECISION SUPPORT STAGE	24 mons
11	MINISTERIAL APPROVAL	60 days
12		
13	C. Implementation programme	1512 days
14	1. IMPLEMENTATION PROGRAMME FOR THE PROPOSED ZALU DAM (FSL = 621.2 masl)	1512 days
15	1.1 DETAIL TENDER AND DESIGN PHASE	480 days
16	1.1.1 Procurement of Design PSP	4 mons
17	1.1.2 Additional geotechnical investigations	3 mons
18	1.1.3 Tender design	8 mons
19	1.1.4 Tender documents and procurement	4 mons
20	1.1.5 Detail design	8 mons
21	1.2 PRELIMINARY WORKS	720 days
22	1.2.1 Electrical supply to site (ESKOM)	24 mons
23	1.2.2 Heritage assessment and Land acquisition	8 mons
24	1.3 CONSTRUCTION PHASE	912 days
25	1.3.1 Site establishment	8 wks
26	1.3.2 Mobilisation and erection of crusher and batching plant	5 mons
27	1.3.3 Site clearing	2 mons
28	1.3.4 River diversion	682 days
29	1.3.4.1 Stage 1 (no coffer dam)	0 mons
30	1.3.4.2 Stage 2 (upstream coffer dam)	1.5 mons
31	1.3.4.3 Stage 3 (Plug of intake tower)	2 wks
32	1.3.5 Main embankment	702 days
33	1.3.5.1 Stage 1 (Left and right flank, excl. river section, from 595masl up to NOC)	314 days
34	1.3.5.1.1 Excavation	2.7 mons
35	1.3.5.1.2 Curtain grouting	14 mons
36	1.3.5.1.3 Embankment fill	9.1 mons
37	1.3.5.2 Stage 2 (River section up to 595masl))	386 days
38	1.3.5.2.1 Excavation	2.9 mons
39	1.3.5.2.2 Curtain grouting	10.8 mons
40	1.3.5.2.3 Embankment fill	15.4 mons
41	1.3.5.3 Crest road construction	2 wks
42	1.3.5.4 Finishing (guardrails etc.)	1 mon
43	1.3.6 Spillway, chute and stilling basin	550 days
44	1.3.6.1 Spillway excavation (approach and return channel)	7.5 mons
45	1.3.6.2 Spillway grouting	2 mons
46	1.3.6.3 Formwork, reinforcing and structural concrete placeme	17 mons
47	1.3.7 Outlet works (incl. conduit)	792 days
48	1.3.7.1 Excavation and foundation preparation	2 mons
49	1.3.7.2 Reinforcement, formwork, concrete and unformed surfaces	30.4 mons
50	1.3.7.3 Hydro-mechanical items (stage 1)	5 mons
51	1.3.7.4 Access bridge to intake tower	6 mons
52	1.3.7.5 Hydro-mechanical items (stage 2)	4 mons
53	1.3.8 Access roads	140 days
54	1.3.8.1 Roadbed & mass earthworks	4 mons
55	1.3.8.2 Layer works	2 mons
56	1.3.8.3 Surfacing	1 mon
57	1.3.9 Fencing	2 mons
58	1.3.10 Landscaping	2 mons
59	1.3.11 Commissioning and handover	0 days
60	1.4 RESERVOIR IMPOUNDMENT	0 days
61	1.5 EARLIEST WATER DELIVERY FROM DAM	0 days
62		
63	2. WATER SERVICES INFRASTRUCTURE	1260 days
64	2.1 Obtain Water Use Licences from DWA	18 mons
65	2.2 Detail design and specifications:	480 days
66	2.2.1 Bulk supply pipelines and appurtenant works	12 mons
67	2.2.2 Refurbishment WTW	15 mons
68	2.2.3 New WTW	15 mons
69	2.2.4 Pumping stations	18 mons
70	2.2.5 New bulk supply and village reservoirs	18 mons
71	2.3 Tendering	360 days
72	2.3.1 Bulk supply pipelines and appurtenant works	6 mons
73	2.3.2 Refurbishment WTW	6 mons
74	2.3.3 New WTW	6 mons
75	2.3.4 Pumping stations	6 mons
76	2.3.5 New bulk supply and village reservoirs	6 mons
77	2.4 Construction	36 mons
78	2.5 Install telemetry	3 mons
79	2.6 Train operators	6 mons
80	2.7 Security and projection of boreholes	12 mons
81	2.8 Final testing and commissioning	3 mons
82		
83	3. IMPLEMENTATION PROGRAMME FOR GROUNDWATER SCHEM	520 days
84	3.1 Obtain Water Use Licences from DWA	18 mons
85	3.2 Detail design and specifications: boreholes and appurtenant works	3 mons
86	3.3 Tender	3 mons
87	3.4 Equip boreholes	6 mons
88	3.5 Pump tests	1 mon
89	3.6 Water quality tests	1 mon
90	3.7 Sourcing of appropriate water treatment package plant	6 mons
91	3.8 Connect boreholes to bulk supply system	1 mon
92	3.9 Install telemetry	1 mon
93	3.10 Train operators	2 mons
94	3.11 Security and projection of boreholes	1 mon
95	3.12 Final testing and commissioning	1 mon
96	3.13 Delivery of water from boreholes	0 days



P WMA 12/T60/00/4811: RID
Implementation programme

Task	Milestone	Project Summary	External Milestone	Inactive Milestone	Manual Task	Manual Summary Rollup	Start-only
Split	Summary	External Tasks	Inactive Task	Inactive Summary	Duration-only	Manual Summary	Finish-only

Deadline
Progress

FEASIBILITY STUDY FOR AUGMENTATION OF THE LUSIKISIKI REGIONAL WATER SUPPLY SCHEME