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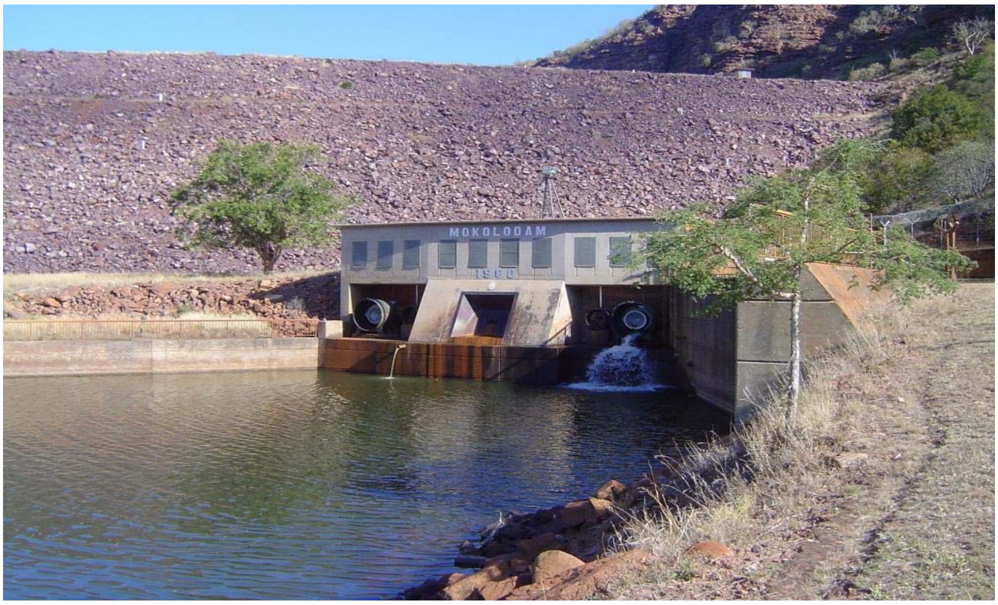
Department of Water and Environmental Affairs

Chief Directorate: Integrated Water Resource Planning
Directorate: Options Analysis

MOKOLO AND CROCODILE RIVER (WEST) WATER AUGMENTATION PROJECT (MCWAP) FEASIBILITY STUDY: TECHNICAL MODULE

Project No. WP9528



SUPPORTING REPORT NO. 11
PHASE 1
FEASIBILITY STAGE

FINAL

Lead Consultant: Africon

In association with: KV3, VELA VKE

LIST OF REPORTS

REPORT NO	DESCRIPTION	REPORT NAME
FEASIBILITY STAGE		
P RSA A000/00/8109	Main Report	MCWAP FEASIBILITY STUDY TECHNICAL MODULE SUMMARY REPORT
P RSA A000/00/8409	Supporting Report 8A	GEOTECHNICAL INVESTIGATIONS PHASE 1
P RSA A000/00/8709	Supporting Report 8B	GEOTECHNICAL INVESTIGATIONS PHASE 2
P RSA A000/008509	Supporting Report 9	TOPOGRAPHICAL SURVEYS
P RSA A000/00/8609	Supporting Report 10	REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER
P RSA A000/00/8209	**Supporting Report 11**	**PHASE 1 FEASIBILITY STAGE**
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P RSA A000/00/8809	Supporting Report 1	WATER REQUIREMENTS
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P RSA A000/00/9309	Supporting Report 6	WATER TRANSFER SCHEME OPTIONS
P RSA A000/00/9409	Supporting Report 7	SOCIAL AND ENVIRONMENTAL SCREENING
INCEPTION STAGE		
P RSA A000/00/9609	Inception	INCEPTION REPORT

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REPORT DETAILS PAGE

Project name:	***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)***
Report Title:	**Report 11 – Phase 1 Feasibility Stage Report**
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PSP

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PREFACE

The Mokolo (Mogol) River catchment is part of the Limpopo Water Management Area (WMA). The Mokolo River originates close to Modimolle (Nylstroom) and then drains to the north into the Limpopo River. The Mokolo Dam (formerly known as the Hans Strijdom Dam) is the largest dam in the catchment. The dam was constructed in the late 1970s and completed in July 1980, to supply water to Matimba Power Station, Grootegeluk Mine, Lephalale (Ellisras) Municipality and for irrigation downstream of the dam. Based on the water infrastructure, the current water availability and water use allows only limited spare yield existing for future allocations for the anticipated surge in economic development in the area.

There are a number of planned and anticipated consequential developments in the Lephalale area associated with the rich coal reserves in the Waterberg coal field for which additional water will be required. These developments include inter alia the development of further power stations by Eskom, the potential development of coal to liquid fuel facilities by Sasol and the associated growth in mining activities and residential development.

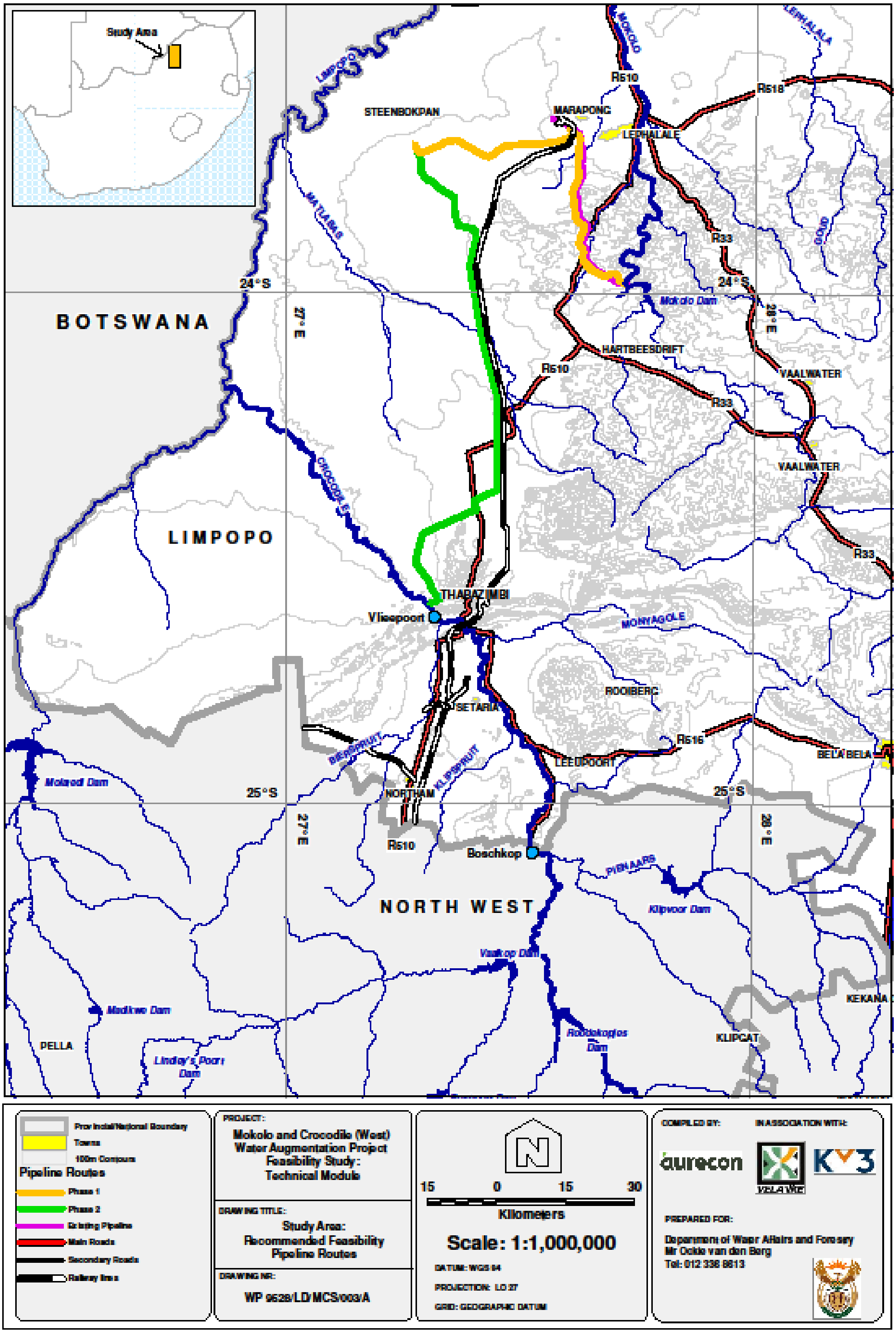
The development of new power stations is of high strategic importance with tight timeframes. Commissioning of the first generation unit will start in September 2010 and additional water needs to be available by mid-2011 according to the expected water requirements. A solution addressing the water needs of the Lephalale area must be pursued. The options to augment existing water supplies include transferring surplus effluent return flows from the Crocodile River (West) / Marico WMA to Lephalale and the area around Steenbokpan shown on the map indicating the study area on the following page.

The Department of Water Affairs (DWA) commissioned the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) to analyse the options for transferring water from the Crocodile River (West). In April 2008, the Technical Module of this study was awarded to Africon in association with Kwezi V3, Vela VKE and specialists. The focus of the Technical Module is to investigate the feasibility of options to:

- Phase 1: Augment the supply from Mokolo Dam to supply in the growing water requirement for the interim period until a transfer pipeline from the Crocodile River (West) can be implemented. The solution must over the long term, optimally utilise the full yield from Mokolo Dam.
- Phase 2: Transfer water from the Crocodile River (West) to the Lephalale area. Options to phase the capacity of the transfer pipeline (Phase 2A and 2B) must be investigated.

The Technical Module has been programmed to be executed at a Pre-feasibility level of investigation to identify different options and recommend the preferred schemes, which was followed by a Feasibility level investigation of the preferred water schemes. Recommendation on the preferred options for Phase 1 and Phase 2 Schemes were presented to DWA during October 2008 and draft reports were submitted during December 2008. The Feasibility Stage of the project commenced in January 2009 and considered numerous water requirement scenarios, project phasing and optimisation of pipeline routes. The study team submitted a draft Feasibility report during October 2009 to the MCWAP Main Report in November 2009.

This report (Report 11 – Feasibility Stage, Phase 1, P RSA A000/00/8209) cover the Feasibility Stage Investigation for the Mokolo Transfer Scheme.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STEENBOKPAN
MARAPONG
R510
R518
LEPHALALE
MOKOLO
MATLABAS
R33
24° S
27° E
28° E
Mokolo Dam
BOTSWANA
HARTBEESDRIFT
VAALWATER
CROCODILE
LIMPOPO
THABAZIMBI
Vlieepoort
MONYAGOLE
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Mokolo and Crocodile (West) Water Augmentation Project Feasibility Study: Technical Module
DRAWING TITLE:
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DATUM: WGS 84
PROJECTION: LO 27
GRID: GEOGRAPHIC DATUM
COMPILED BY:
IN ASSOCIATION WITH:
aurecon
VELA VKE
KV3
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MOKOLO AND CROCODILE RIVER (WEST) WATER AUGMENTATION PROJECT FEASIBILITY STUDY:

PHASE 1

FEASIBILITY STAGE

EXECUTIVE SUMMARY

INTRODUCTION

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long-term industrial, commercial and domestic use.

The Mokolo Dam is considered to be the only viable source of water that can supply in the water requirements of the interim period until the Crocodile River (West) Transfer Scheme has been constructed. The Mokolo Dam has a yield of 39.1 Million m^3/annum at a recurrence interval of 1:200 years of which 10.4 Million m^3/annum is allocated for irrigation. The remaining 28.7 Million m^3/annum is available to supply and augment the water supplies of the Lephalale and Steenbokpan areas.

Scheme Description

The existing water transfer scheme from the Mokolo Dam consist of a pump station at the Mokolo Dam, pumping water to Wolvenfontein Reservoir from where it gravitates to a T-off point at Zeeland and further to Matimba.

A new pump station will be constructed at the Mokolo Dam. This will include the construction of a new bulk power supply line, as well as a new sub-station. From the new pump station, water will be pumped via a new rising main to Wolvenfontein Reservoirs from where it will gravitate via new gravity mains to the end users at Zeeland, Matimba, Medupi, CF 3&4 mining and Steenbokpan. New terminal reservoirs with 18 day storage capacities will be required at each end user to ensure the prescribed reliability for the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP).

Transfer Capacity

The baseline figures to be used for planning and sizing the Phase 1 delivery from Mokolo Dam have been established, using the water requirement figures presented by the users in February 2009. The Phase 1 Mokolo Dam Transfer Scheme Average Annual Demand (AAD) delivering from Mokolo Dam was calculated as follows:

- *53.4 (Total volume of water transferred during 2014) – 14.7 (capacity of the existing pipeline system from the Mokolo Dam) = 38.7 Million m³/annum (2014)*

The strategic importance of the users that will account for the bulk of the water consumption requires that the risk of failure in the supply of water is kept to a minimum. Sufficient reliability and redundancy must therefore be provided in the water supply system.

The Terms of Reference (TOR) requires the transfer systems to be designed for 95% reliability, which is 18 days maximum downtime per annum for whatever reason. As a consequence of this, constraint storage capacity must be designed into the system to ensure that strategic customers will not have a high risk of a water supply shortage for the long term condition (i.e. 99.5% assurance of supply or hydrologic reliability).

Considering the reliability requirements the design flow was calculated with due allowance for a down time period of maximum 18 days continuous per year for planned and unplanned closures. To cater for this, the pipeline capacities have been increased to 120% of the annual average requirements. This will enable the storage dams to be re-filled in 90 days following an 18-day continuous supply interruption. The Steenbokpan link from the Steenbokpan T-off to Steenbokpan was optimised, taking into account the long-term flow requirements via the Phase 2 Crocodile River (West) Transfer Scheme.

Existing Mokolo Dam Transfer Scheme

The infrastructure of the existing Mokolo Dam Transfer Scheme is generally in a good condition with some minor repair works proposed on sections of the pipeline. The scheme comprises the following infrastructure:

- *Pump station at Mokolo Dam - 3 duty pumps with total combined capacity of 820 ℓ/s;*
- *Pump main to Wolvenfontein Reservoirs - 700 mm diameter steel pipeline;*
- *Gravity main from Wolvenfontein Reservoirs to Zeeland Water Treatment Works (WTW) – 700 mm diameter steel pipeline; and*
- *Gravity main from Zeeland Water Treatment Works to Matimba - 600 mm diameter steel pipeline.*

The free flow capacity of gravity main between Wolvenfontein and Zeeland Water Treatment Works - 570 ℓ/s converting to a capacity of 14.7 Million m³ per annum. The friction coefficient of the pipelines was calculated as 0.5.

It is envisaged that the entire existing pipeline will be refurbished in 2015 after commissioning of the Crocodile River (West) Transfer Scheme, i.e. Phase 2A.

Geotechnical Aspects

Rock occurs at shallow depths (generally less than 1 m) at the position where the construction of the new Mokolo Dam pump station is proposed and the structure will be founded entirely on rock.

The expected geotechnical conditions along the pipeline routes have been assessed by way of a visual appraisal of the routes.

The major constraint relating to the pipeline from Mokolo Dam to Matimba Power Station is the paucity of soft material in the mountainous sections south of Zeeland and haul distances may be significant (particularly in the vicinity Rietspruitnek). Rates of excavation will be low (particularly in the mountainous part) due to the large amount of rock present.

No significant constraints are anticipated on the pipeline route extending westwards from the Matimba Manifold towards Steenbokpan. Soft material should be readily available and haul distances will then be reasonable. Rates of excavation should be significantly higher than on the Mokolo Dam - Matimba route.

Proposed Mokolo Dam Transfer Scheme

The philosophy employed in aligning the new pipelines of the proposed Mokolo Dam Transfer Scheme was to stay parallel to existing infrastructure such as roads, power lines and the existing pipeline belonging to Exxaro as far as possible in order to minimise negative social and environmental impacts.

- ***Pump Station***

  The new pump station at Mokolo Dam will be required to transfer the following quantities of water from the dam to the balancing reservoir at Wolvenfontein from where it will gravitate to the consumers:

  - *The maximum interim requirement from Mokolo Dam: 53.4 (Total volume of water transferred during 2014) – 14.7 (capacity of the existing pump station) = 38.7 Million m³/annum (2014) + 2% losses + 20% refill peak = 47,4 Million m^3/annum = 1 502,1 ℓ/s.*
  - *The long-term requirement from Mokolo Dam: 28,7 Million m^3/annum + 20% refill peak = 34.4 Million m^3/annum = 1 092 ℓ/s.*

  Due to the highly strategic importance of this project the top of the pump well, as well as electrical infrastructure (switchgear, gantry crane, access road, etc.) of the pump station will be sited above the maximum tail water level directly downstream of the dam, so as to have no probable risk of natural flooding for the Probable Maximum Flood.

- ***Rising Main***

  A new 900 mm diameter steel rising main with 8.0 mm standard wall thickness (Grade X42) will be constructed from the new Mokolo Dam pump station to Wolvenfontein Reservoirs, following the route of the existing access road. The combined capacity of the existing and proposed rising mains should be 53,4 Million m^3/annum (maximum interim water requirement, 2014) + 2% losses + 20% refill peak = 2 072 ℓ/s. The existing and new rising mains will be interconnected near the pump station to allow for the option to operate the two pipelines separately or as 'n system.

- ***Power Supply***
  The existing 33 kV line feeding from Waterberg sub-station will be upgraded to 132 kV, while a new 132 kV line will be constructed from Bulge River sub-station to Mokolo Dam to ensure a reliable redundant supply to Mokolo Dam with adequate capacity. It is also proposed that a new switch yard be constructed at the Mokolo Dam.

- ***Gravity Main***
  A new 1 100 mm diameter steel pipeline with 7.0 mm standard wall thickness (Grade X42) will be constructed from Wolvenfontein Reservoirs to Rietspruitnek and a 1 000 mm diameter steel pipeline with 7.8 mm standard wall thickness (Grade X42) from Rietspruitnek to the Steenbokpan T-off. This new gravity main will follow the alignment of the existing Exxaro pipeline. The capacity of the proposed gravity main should be 53,4 (maximum interim water requirement, 2014) – 14.7 (capacity of existing gravity main) = 38,7 Million m³/annum + 2% losses + 20% refill peak = 1 502 ℓ/s.

  A new pipeline will also be constructed from the Steenbokpan T-off point to Steenbokpan. This section of pipeline was sized to provide in the Phase 1 water requirements of the Steenbokpan area users, but was optimised to form part of the delivery line of the Crocodile River (West) Transfer Scheme.
  - *Steenbokpan T-off to Medupi off take - 900 mm diameter steel pipeline with 6.3 mm standard wall thickness (Grade X42);*
  - *Medupi T-off to CF3&4 mining T-off - 900 mm diameter steel pipeline with 6.3 mm standard wall thickness (Grade X42);*
  - *CF3&4 mining T-off to Crocodile River (West) Transfer Scheme connection – 1 100 mm diameter steel pipeline with 6.1 mm standard wall thickness (Grade X42); and*
  - *Crocodile River (West) Transfer Scheme connection to Steenbokpan – 1 900 mm diameter steel pipeline with 12.1 mm standard wall thickness (Grade X42).*

- ***Delivery Points***
  Water will be supplied to the delivery points at Matimba, Medupi, CF 3&4 mining and Zeeland Water Treatment Works. Due to the uncertainty regarding the exact location of the Exxaro, Eskom and possibly Sasol users in the Steenbokpan area, only one other delivery point has been allowed for at this stage at Steenbokpan.

  An 18-day storage capacity Terminal Reservoir will have to be provided by the users at each delivery point of Exxaro, Eskom and Sasol to ensure the prescribed reliability for those users.

- ***System Operation***
  The water from the Mokolo Dam is of a much better quality than that from the Crocodile River (West). It is therefore necessary to design and operate the Mokolo and Crocodile

River (West) Water Augmentation Project system in such a way that the water from the two sources does not mix during normal operation.

As agreed by the stakeholders, the design philosophy of the scheme is that the Crocodile River (West) will not provide redundancy to users at Zeeland Water Treatment Works and that the Mokolo Dam will not provide redundancy to users at Steenbokpan.

Environmental Aspects

A desktop investigation and a brief site visit were carried out to identify major fatal flaws, if any should exist. The conclusion of this investigation was that the pipeline does traverse some sensitive areas where particular care should be taken, but that with mitigation measures the construction of the pipeline will have a minimal lasting effect on the surrounding area.

The construction of a new pump station at Mokolo Dam is also not foreseen to have a significant impact due to the fact that it will be located close to the existing facility. Precautionary measures regarding possible erosion will, however, have to be taken due to the fact that it is situated on steep slopes. It is proposed that the site for the pump station must be identified in conjunction with faunal and floral specialists.

A detailed Environmental Impact Assessment will be carried out as part of the detail design phase.

Social Aspects

A socio-economic impacts analysis was carried out based on all available satellite and aerial photography. The assessment of Phase 1 of the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) has revealed that the development will have a minimal socio-economic impact on the affected and surrounding areas.

Cost Estimates and Economic Analysis

Capital cost estimates were calculated in accordance with Supporting Report No. 3 for this study, Guidelines for Feasibility Stage Sizing and Costing, which are based on the Vaal Augmentation Planning Study (VAPS) model accepted for this study. The construction cost rates in this report have a common base date of April 2008.

The capital and operational costs for the Mokolo Dam Transfer Scheme were calculated and discounted, using rates of 6%, 8% and 10% to determine the present values of costs as summarised in the following table.

Discount Rate	*Capital (R)*	*Operation & Maintenance (R)*	*Total (R)*
6%	*1 407 195 000*	*1 096 257 000*	*2 503 452 000*
8%	*1 340 098 000*	*818 483 000*	*2 158 581 000*
10%	*1 277 789 000*	*635 838 000*	*1 913 627 000*

The unit reference values (URVs) of water was determined for a discount rate of 6%, 8% and 10% and was based on water transferred to the demand centres for a 45-year period.

Discount Rate	*Discounted Present Value of Water @ R1/m^3*	*Discounted Present Value (R)*	*Unit Reference Value (R/m^3)*
6%	*389.34*	*2 503 452 000*	*6.430*
8%	*291.18*	*2 158 582 000*	*7.413*
10%	*266.57*	*1 913 627 000*	*8.446*

Programme of Implementation

The prospective beneficiaries of the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) provided key dates indicating their water requirement timeframes. From these key dates, water should be available at Medupi not later than 1 September 2010 and at Steenbokpan not later than 30 November 2011. The design and construction of the Phase 1 Mokolo Dam Transfer Scheme must therefore be programmed in order to meet these requirements.

The capacity of the existing infrastructure from the Wolvenfontein Reservoirs to Matimba T-Off will be sufficient until approximately February 2011, while the proposed completion date of the entire Phase 1 Mokolo Dam Transfer Scheme is only December 2011. Construction of the new pipeline from Mokolo Dam will therefore be programmed with interconnections to the existing pipeline to increase the flow capacity and allow sufficient time to construct the pump station and the rest of the Phase 1 infrastructure. The first 9 km section of the new 1 100 mm diameter pipeline from the Wolvenfontein Reservoirs towards Rietspruitnek will be installed first in order to be able to supply in the projected peak water requirement for December 2011.

Conclusions and Recommendations

The maximum short-term interim water requirement to be supplied from the Mokolo Dam in 2014 is 53.4 Million m³/annum. The capacity of the existing infrastructure supplying water from the Mokolo Dam to Matimba is 14.7 Million m³/annum which means that infrastructure is required to supply the additional 38.7 Million m³/annum for the interim maximum water requirement from the Mokolo Dam.

The first date that water is required at the new Medupi Power Station is 1 September 2010, while Steenbokpan requires water not later than 30 November 2011. In order to meet the water requirements of the prospective users, the following should be implemented:

- *Construct a new pump station at the Mokolo Dam to transfer the required quantities of water from the dam to the balancing reservoir at Wolvenfontein from where it will gravitate to the consumers.*
- *Upgrade the existing 33 kV line feeding from Waterberg sub-station to a 132 kV line and construct a new 132 kV line from Bulge River sub-station to Mokolo Dam to ensure a reliable redundant supply to Mokolo Dam with adequate capacity.*
- *Construct a new 900 mm diameter steel rising main with 8.0 mm standard wall thickness (Grade X42) from the Mokolo Dam pump station to the Wolvenfontein Reservoirs.*
- *Construct a new 1 100 mm diameter steel pipeline with 7.0 mm standard wall thickness (Grade X42) from the Wolvenfontein Reservoirs to Rietspruitnek and a 1 000 mm diameter steel pipeline with 7.8 mm standard wall thickness (Grade X42) from Rietspruitnek to the Steenbokpan T-off.*
- *Construct a new steel pipeline (Grade X42) from the Steenbokpan T-off point to Steenbokpan. This pipeline will comprise a combination of 900 mm, 1 100 mm and 1 900 mm diameter pipe sections.*
- *The construction sequence of the new pipeline will be programmed to first increase the capacity of the existing gravity section from Wolvenfontein Reservoir with interconnections to the new pipeline to Rietspruitnek. This will increase the capacity of the existing pipeline and allow more time to construct the entire Phase 1 Mokolo Dam Transfer Scheme.*
- *Water will be supplied to the delivery points at Matimba, Medupi, CF 3&4, Zeeland Water Treatment Works and one other delivery point at Steenbokpan.*
- *An 18-day storage capacity Terminal Reservoir will have to be provided by the users at each delivery point of Exxaro, Eskom and Sasol to ensure the prescribed reliability for the Mokolo and Crocodile River (West) Water Augmentation Project.*
- *Operating rules for the Mokolo and Crocodile River (West) Water Augmentation Project system should be developed during the detail design stage of the project. The water from the Mokolo Dam is of a much better quality than that from the Crocodile River (West). It is therefore necessary to design and operate the Mokolo and Crocodile River (West) Water Augmentation Project system in such a way that the water from the two sources does not mix during normal operation.*
- *The design philosophy of the scheme is that the Crocodile River (West) will not provide redundancy to users at Zeeland Water Treatment Works and that the Mokolo Dam will not provide redundancy to users at Steenbokpan.*
- *It is envisaged that the entire existing pipeline will be refurbished in 2015 after commissioning of the Crocodile River (West) Transfer Scheme.*
- *It is recommended that Phase 1 Mokolo Dam Transfer Scheme be implemented as a matter of urgency.*

MOKOLO AND CROCODILE RIVER (WEST) WATER AUGMENTATION PROJECT FEASIBILITY STUDY:

PHASE 1: FEASIBILITY STAGE

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LIST OF ABBREVIATIONS

AAD	Average Annual Demand
CP	Cathodic Protection
CRA	Concept Release Approval
CTL	Coal to Liquid
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
FBC	Fluidised Bed Combustion
FGD	Flue Gas Desulphurisation
GUL	Guided Ultrasonic Testing
MCWAP	Mokolo and Crocodile River (West) Water Augmentation Project
M&E	Mechanical and Engineering
NKP	National Key Point
O&M	Operation and Maintenance
PMF	Probable Maximum Flood
PSP	Professional Service Provider
TOR	Terms of Reference
URV	Unit Reference Value
VAPS	Vaal Augmentation Planning Study
VSD	Variable Speed Drive
WMA	Water Management Area
WTW	Water Treatment Works

1. INTRODUCTION

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long-term industrial, commercial and domestic use.

The Mokolo Dam is considered to be the only viable source of water that can supply in the water requirements of the interim period until the Crocodile River (West) Transfer Scheme has been constructed. The Mokolo Dam has a yield of 39.1 Million m^3/a at a recurrence interval of 1:200 years of which 10.4 Million m^3/a is allocated for irrigation. The remaining 28.7 Million m^3/a is available to supply and augment the water supplies of the Lephalale and Steenbokpan areas.

During the Pre-Feasibility stage, the following options of transferring water from the Mokolo Dam to the consumers as a first phase were identified and investigated:

a) Construct a pump station and new pipeline from Mokolo Dam to Zeeland Water Treatment Works (WTW), Matimba and Medupi Power Stations, as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities). This pipeline will be constructed parallel (or close) to the existing pipeline for much of the route.
b) Construct a weir, abstraction works and a high lift pump station downstream of Mokolo Dam, as well as a pipeline to deliver water to Zeeland WTW, Matimba and Medupi Power Stations, as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities).

The investigation concluded that the weir option be discarded and that the option to construct a pipeline from Mokolo Dam be further investigated at Feasibility level as part of this study. Refer to Report No P RSA A000/00/9109 for the Pre-Feasibility Investigation.

The objective of this report is to refine the work done at the Pre-Feasibility stage and to incorporate all identified and investigated changes since the Pre-feasibility investigation. Also to develop this option to a sufficient level of detail to confirm the technical feasibility and environmental acceptability, as well as compiling a revised project cost estimate.

It should be noted that due to the emergency requirement to provide water by September 2010, the level of detail in this report was not carried out to full Feasibility level. The topographical survey and Geotechnical Investigations will be carried out by others only during 2009 and was not available as input for this study as would normally be required for a Feasibility Study. This must be incorporated in the Detail Design phase.

2. SCHEME DESCRIPTION

The existing water transfer scheme from the Mokolo Dam consist of a pump station at the Mokolo Dam pumping water along a 700 mm diameter steel rising main to Wolvenfontein Reservoir from where it gravitates along a 700 mm diameter steel pipeline to a T-off point at Zeeland. At the T-off point, the pipeline reduces to a 600 mm diameter pipeline which gravitates further to Matimba. Refer to Section 4 of this report for details of the existing transfer scheme.

A new pump station will be constructed at the Mokolo Dam adjacent to the existing pump station, but at a higher level to ensure that the pump station is not flooded under a Probable Maximum Flood (PMF) event. This will also require the construction of a new bulk power supply line, as well as a new sub-station.

The pipeline will follow a route parallel to that of the existing pipeline except for the rising main section from Mokolo Dam to Wolvenfontein Reservoir where the pipeline will follow the existing access road. A total length of approximately 84 km (including the rising main from the Mokolo Dam and the gravity main to the end consumers) will be required; including the extension to Steenbokpan. The new gravity main from Wolvenfontein Reservoir to Matimba will be interconnected with the existing pipeline at Zeeland to increase the reliability of the new transfer scheme.

The end users will be responsible for the development of infrastructure from a central delivery point at Steenbokpan. This will include a section of the pipeline, as well as a Terminal Reservoir which will be constructed as part of Phase 2. Blasting in close proximity to the existing pipeline may be problematic and this needs to be mitigated. The existing servitude of 15 m wide will have to be widened to a temporary construction width of 30 m and a permanent width of 20 m. Refer to **Appendix A** for a layout and locality plan.

Options to programme the construction sequence of the new pipeline to first increase the capacity of the existing gravity section from Wolvenfontein Reservoir with interconnections to the new pipeline to Rietspruitnek will allow more time to construct the full scheme. By utilising the existing pump station at Mokolo Dam, water could then be delivered at a rate higher than the capacity of the existing pipeline.

After the construction of the Phase 2 infrastructure, the flow in a section of the pipelines between Steenbokpan and Matimba constructed during Phase 1 of the project will be reversed as shown on the schematic layouts in **Appendix C**.

Details of the scheme will be provided in more detail in the relevant sections to follow.

2.1 Summary of Major Scheme Components

Table 2-1 summarises the proposed additional major scheme components which was sized for the maximum flow requirements during Phases 1 and 2 (including losses and Terminal Reservoir re-fill peak factor as discussed in Section 3.3.3), as indicated on sheets 2 and 3 of the schematic layouts in **Appendix C**. The pipeline section between Steenbokpan and the Steenbokpan T-off point was optimised taking into account the long-term flow requirements via the Phase 2 Crocodile River (West) Scheme.

Table 2-1: Pipeline from Mokolo Dam – Phases 1 & 2 Design Flows

Component		Description
High-lift pump station:		Static head 220 m Total head pumped (peak) = 260 m Design Flow = 1 502 ℓ/s
900 mm	Rising main (Mokolo Dam pump station to Wolvenfontein operating reservoir	5 700 m (Design Flow = 1 502 ℓ/s, V = 2.25 m/s)
1 100 mm	Gravity main (Wolvenfontein operating reservoirs to Rietspruitnek)	15 860 m (Design Flow = 1 502 ℓ/s, V = 1.58 m/s)
1 000 mm	Gravity main (Rietspruitnek to Steenbokpan T-off)	19 970 m (Design Flow = 1 502 ℓ/s, V = 1.91 m/s)
800 mm	Gravity main (Steenbokpan T-off to Matimba)	1 940 m (Design Flow = 757 ℓ/s, V = 1.50 m/s)
900 mm	Gravity main (Steenbokpan T-off to Medupi T-off)	8 180 m (Design Flow = 865 ℓ/s, V = 1.36 m/s)
900 m	Gravity main (Medupi T-off to CF3&4 mining T-off)	3 590 m (Design Flow = 1 044 ℓ/s, V = 1.63 m/s)
1 100 mm	Gravity main (CF3&4 mining T-off to Crocodile River (West) Transfer Scheme connection point)	27 090 m (Design Flow = 1 432 ℓ/s, V = 1.5 m/s)
1 900 mm	Gravity main (Crocodile River (West) Transfer Scheme connection point to Steenbokpan)	1 400 m (Design Flow = 5 138 ℓ/s, V = 1.8 m/s)

* Refer to Sheets 1 to 3 in Appendix C for schematic layouts of the above components

3. TRANSFER CAPACITY

3.1 Projected Water Requirements

Two water requirement scenarios (based on the water requirement estimates provided by the users in July 2008) were compiled for the period up to 2030, i.e.:

- Scenario 4 – Matimba Power Station (Fluidised Bed Combustion (FBC)), Medupi Power Station (Flue Gas Desulphurisation (FGD)), 3 new power stations (FGD), coal supply to five (5) power stations, Exxaro project, the associated construction activities and the associated growth in Lephalale and Steenbokpan. Average Annual Demand (AAD) for Scenario 4 = 40.3 Million m^3/a.
- Scenario 8 – Scenario 4 + Sasol development of two Coal to Liquid fuel (CTL) plants, the associated construction activities and the associated growth in Steenbokpan. AAD for Scenario 8 = 50.4 Million m^3/a.

Due to the relatively small difference in augmentation required in 2014 between Scenarios 8 and 4, excluding the irrigation (50.4 – 40.3 = 10.1 Million m^3/a) Phase 1 was originally investigated and reported on utilising the Scenario 8 water requirements.

However, in February 2009, updated water requirement figures were provided and Scenario 8 was updated to Scenario 9 with an AAD of 53.4 Million m^3/a, which was used for the Feasibility stage. The water requirement table Scenario 9 (submission date 20 February 2009) is attached to this report in **Annexure B**. The table indicates the requirements of each user including the annual totals. The table further indicates the split in water requirements between Lephalale and Steenbokpan.

Figure 3-1 illustrates water requirement Scenarios 4, 8 and 9 for the water requirement estimates received in July 2008 (for Scenarios 4 and 8) and in February 2009 (for Scenario 9) for the period up until implementation of Phase 2 (main transfer scheme from Crocodile River (West)). The graph shows the total volume of water transferred per year (January to December of each year), excluding the irrigation water allocation downstream of the Mokolo Dam of 10.4 Million m^3/a.

At the time of the compilation of this report, the water requirements had not been revised any further. It is assumed that the detail design Professional Service Provider (PSP) will review the above water requirements to take into account any changes made by the users since February 2009.

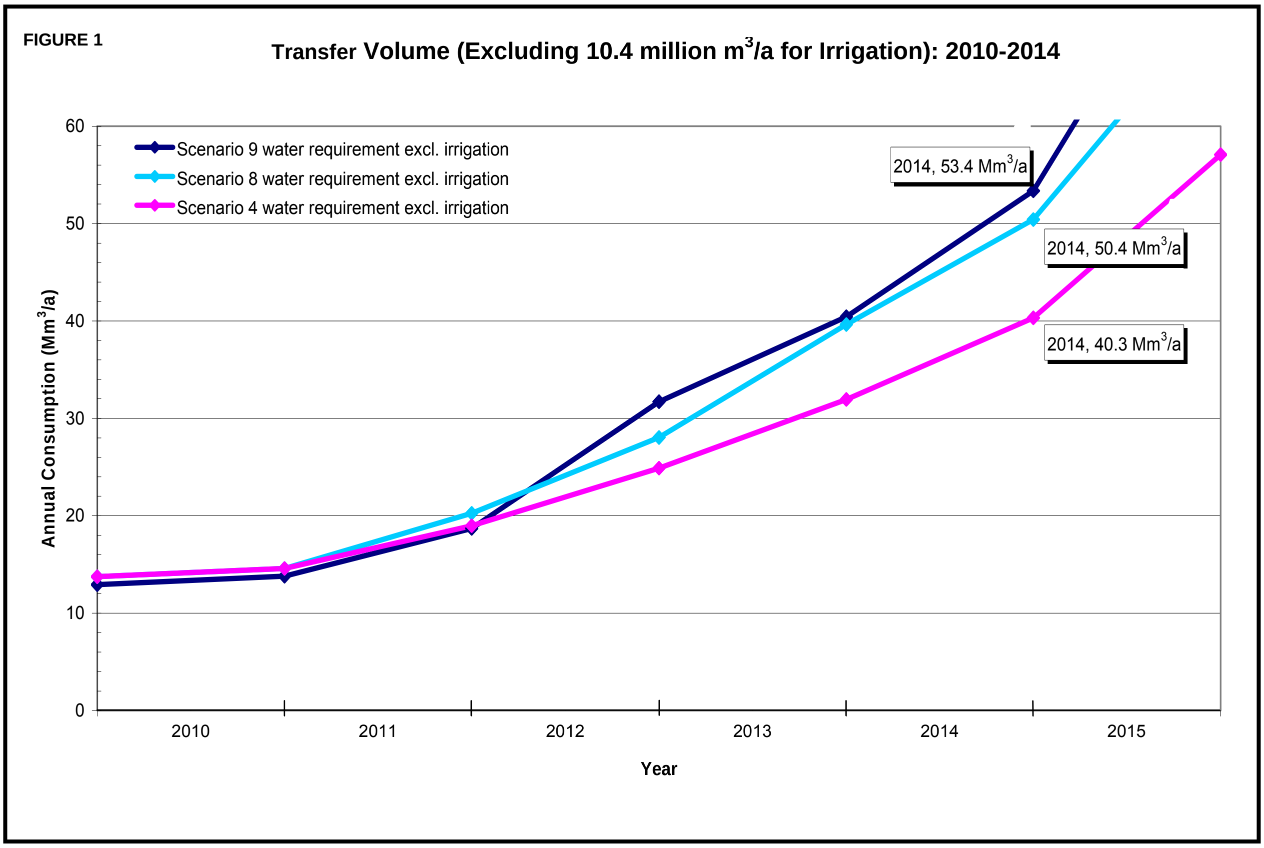

Figure 0-1: Transfer Volume (Excluding 10.4 Million m^3/a for Irrigation): 2010 – 2014

3.2 Transfer Volume

The baseline figures to be used for planning and sizing the Phase 1 delivery from Mokolo Dam was established using the water requirement figures presented.

- Phase 1: Scheme AAD delivering from Mokolo Dam:
  - 53.4 (Total volume of water transferred during 2014) – 14.7 (capacity of the existing pipeline system from the Mokolo Dam – refer to Section 4.2.1 of this report) = 38.7 Million m³/a (2014)

The average annual volumes to be transferred in each year and scheme implementation dates are indicated in **Figure 3-2** (February 2009 estimates and excluding the irrigation water requirement). Annual water requirements are shown as year-end values.

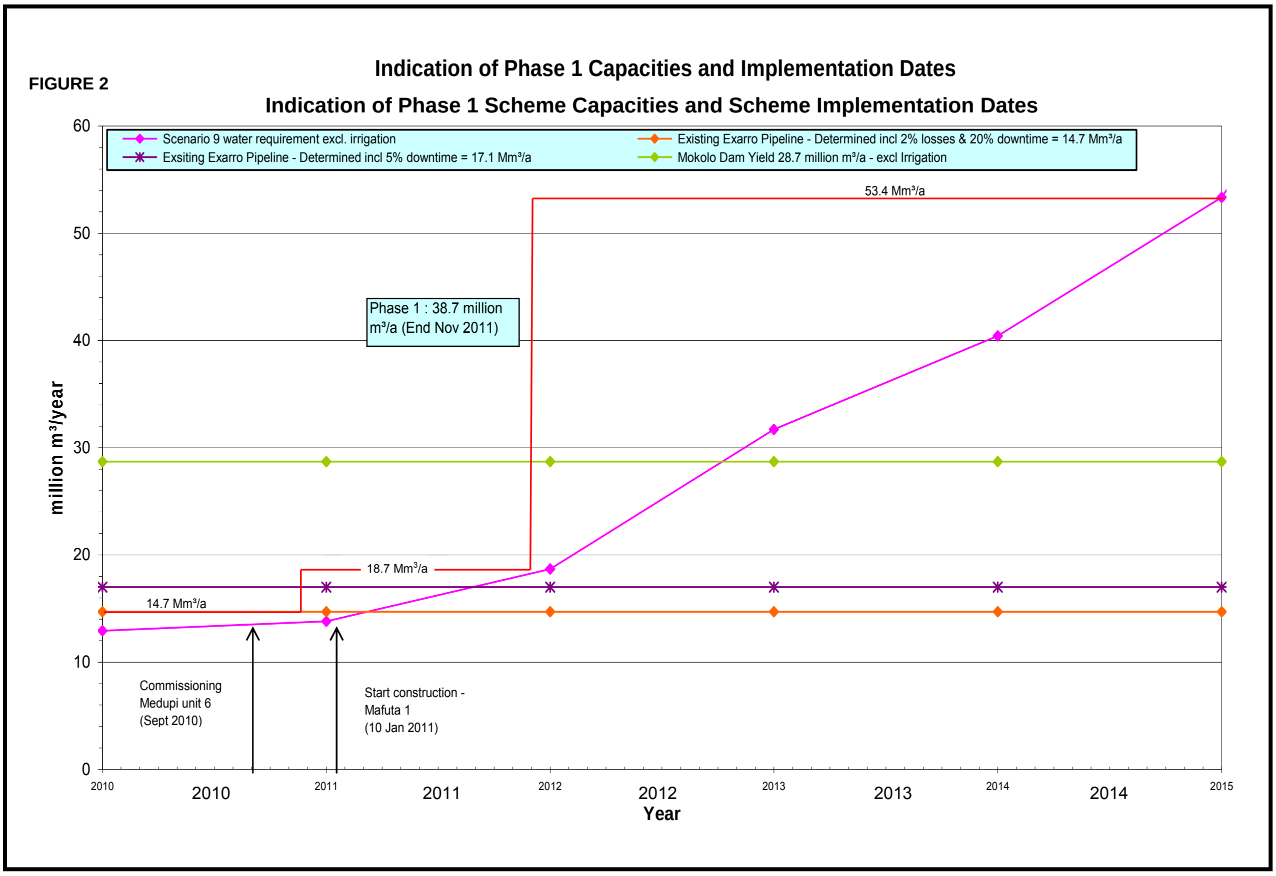

Figure 0-2: Indication of Transfer Volumes (excluding Irrigation) and Scheme Implementation Dates

3.3 Aspects of Reliability and Redundancy

3.3.1 Introduction

The strategic importance of the users that will account for the bulk of the water consumption requires that the risk of failure in the supply of water is kept to a minimum. Sufficient reliability and redundancy must therefore be provided in the water supply system.

The TOR requires the transfer systems to be designed for 95% reliability, which is 18 days maximum downtime per annum for whatever reason. To achieve this, the system must be designed to include sufficient storage, to minimise the risk of strategic customers suffering supply shortages. They require 99.5% assurance of supply.

3.3.2 General Criteria

The following general criteria were applied when designing for reliability and redundancy:

- The transfer systems shall be designed for 95% system availability, implying that the scheme shall have 100% reliability if it is inoperative for up to 18 days of any one year, and the scheme capacity adjusted to allow the full annual requirements to be supplied in 347 days.
- No storage exists at Zeeland WTW and this will have to be provided to ensure the prescribed reliability for those users.
- No allowance was made in the cost estimate for the cost of storage facilities at the end users. It is recommended that these facilities be investigated, funded and implemented by the users.

Allowing for a scheme to be inoperative continuously for 5% of the time during any one year (18 days) will be sufficient to cater for the following situations:

- Pump station failures if there had been severe damage such as flooding of the electrical equipment;
- Constructing temporary by-passes to repair pipeline linings and joints; and
- The time required to restore power supplies after major interruptions resulting from bushfires, flooding, lightning, etc.

3.3.3 Design Flow

Considering the reliability requirements the design flow was calculated with due allowance for a down time period of maximum 18 days continuous per year for planned and unplanned closures. To cater for this, the pipeline capacities have been increased to 120% of the annual average requirements. This will enable the storage dams to be re-filled in 90 days, following an 18-day continuous supply interruption. The Steenbokpan link from the Steenbokpan T-off to Steenbokpan was optimised, taking into account the long-term flow requirements via the Phase 2 Crocodile River (West) Transfer Scheme.

No additional allowance was made for seasonal peak factors on domestic requirements for the calculation of the design flows since these peaks will be absorbed by the Terminal Reservoir re-fill peak factor. The highest summer peak factor calculated for 2014 is approximately 19% which is less than the Terminal Reservoir re-filling peak of 20% which was accepted by the major stakeholders. This was calculated as follows:

- Total volume transferred during 2014 = 53.4 Million m^3/a.
- Average water transfer rate per month during 2014 = 53.4 / 12 = 4.45 Million m^3.
- Maximum monthly water requirement during 2014 = 5.3 Million m^3 (December 2014).
- Peak factor = 5.3 / 4.45 = 19%.

It should be noted that the pipelines from Mokolo Dam will only operate at its design flow capacity for the last few months of 2014. After this, the Phase 2 pipelines should be operational, resulting in the water requirement from the Mokolo Dam only being 28.7 Million m³/a (long term firm yield of the Mokolo Dam).

In the unlikely event of the maximum 18-day down time period occurring in 2014 in the month with the maximum summer peak requirement, it will merely requires a refill period of no more than 90 days. No additional allowance has therefore been made for seasonal peak factors in the capacity of the Mokolo Dam Transfer Scheme.

Refer to **Appendix C** for a schematic layout indicating design flows required for Phase 1 (2014), as well as the for the long-term flows via the Crocodile River (West) Transfer Scheme.

3.3.4 On Site Terminal Storage Requirements

Unless at least 18 days storage is provided on site, the users could be without water if the supply from the Phase 1 Scheme is interrupted for up to 18 days continuously. Redundancy will also not be available if the onsite storage does not exceed 18 days of the water requirements at the time.

It should be noted that the Crocodile River (West) Augmentation will not provide supply or redundancy to Zeeland WTW. The existing treatment works are equipped only to purify water from the Mokolo Dam, which is of much better quality than water from the Crocodile River (West). The treatment works will not be upgraded in the foreseeable future to purify Crocodile River (West) water.

4. EXISTING MOKOLO DAM TRANSFER SCHEME

4.1. Condition of Existing System

The following section contains extracts from a report compiled by Exxaro in November 2007:

4.1.1. Main Pump Station at Mokolo Dam

4.1.1.1 Electric Motor Control Switchgear

The upgrading/replacement project of the pump station motor control switchgear has been completed and successfully commissioned in 2006. The objectives of the project were firstly to avoid premature failures of the 855 kW motors by upgrading the starting and protection technology in order to protect the motors against overheating due to over-current caused by prolonged starting time, and secondly to replace the old and dangerous oil breaker switchgear with new high technology vacuum breaker switchgear in order to improve the safety of switching operations.

Up to this point, no motor failures or downtime due to overheating or over-current have occurred.

4.1.1.2 Electric Motors

Three 855 kW Siemens motors are installed and two motors are in stock. No motor failures have occurred since installation and commissioning of the new motor control switchgear. The roller bearings of the motors are protected against overheating and vibration impacts by a continuous heat and vibration monitoring system. Scheduled maintenance is planned and done by means of the Exarro SAP maintenance system.

4.1.1.3 Pumps

Three Sulzer horizontal drive barrel pumps model HPL 45/30 are installed and two pumps are in stock. No pump failures have occurred during the past six years. The bearings of the pumps are also as in the case of the motors, protected against overheating and vibration impacts by a continuous heat and vibration monitoring system. Scheduled maintenance includes oil analysing in order to ensure preventative maintenance.

4.1.1.4 Lime Dosing System

One lime dosing unit was replaced. Replacement became necessary due to normal wear and the limited availability of spare parts. The unit was in service for more than ten years and has now been replaced with a latest model unit.

4.1.1.5 Pipework and Manifolds

All pipework and manifolds are in a good condition. One non-return valve and one gate valve were replaced due to normal wear. Replacement items are in stock and available for installation when necessary. Downtime due to failures on these items does not have any significant impact on water supply as such.

4.1.1.6 Power Supply Line, Eskom to Pump Station

One cable failure occurred between the Eskom substation and the pump station. The failure was caused by a weak cable connection which overheated and subsequently flashed. The cable was replaced in minimum time without any prolonged interruption of raw water supply to the Wolvenfontein Reservoirs.

4.1.1.7 Pump Station Building and Environment

The pump station building is still in a good condition. The interior of the switchgear room was upgraded and repainted in 2006. No pollution occurred in the area and the environment is well protected and maintained.

4.1.2. Main Pipeline from Pump Station to Wolvenfontein (Rising Main)

4.1.2.1 Internal Inspections

- <u>Visual internal inspection</u>
  Two visual internal inspections were conducted on the rising main. The first inspection was done during February 2007 and the second during August 2007.

  In previous reports and correspondence it was stated that damage to the bitumen lining, mostly along the crown and at the field welded joints, have taken place due to cavitation. It was also reported that these damaged areas were rectified by application of epoxy putty to the affected areas which at this stage seems to be successful along the crown. The epoxy putty on some of the affected field welded joints has however come loose and needs to be rectified.

- <u>Guided wave ultrasonic testing (GUL)</u>
  Limited NDT inspection, using the GUL testing technique, to determine the extent of internal corrosion in the last 400 m of the rising main was undertaken at the end of 2006. Metal losses along the crown were detected in this section. These are the specific areas which were previously addressed by the internal epoxy repairs as reported.

4.1.2.2 External Inspection, Rising Main

Several excavations to expose the pipeline for GUL testing were done on the rising main. None of these exposed areas showed any indication of corrosion or any other damage to the pipeline as such or the external lining in particular.

4.1.2.3 Air Valves

All the old air valves on the rising main were replaced with new and more effective valves during 2004/2005. The fact that no further cavitation has taken place in the last 400 m section of the pipeline proves that the new valves operate effectively.

4.1.2.4 Shut-Off Valves and Non-Return Valves

All valves are still in a good condition.

4.1.3. Wolvenfontein Dams

One shut-off valve was replaced due to normal wear. A three meter piece of outlet pipe was removed and replaced. The dams are otherwise in a good and clean condition. No major maintenance or expenditures are foreseen in the near future.

4.1.4. Gravity Pipeline from Wolvenfontein Reservoirs up to Zeeland WTW

4.1.4.1 Internal Inspections

- <u>Visual internal inspections</u>
  No visual internal inspections were done on the section of the pipeline. Inspections on four positions of the line have been planned.

- <u>Guided NDT inspection (GUL)</u>
  Limited NDT inspections were also done on sections of this pipeline. Results show that there were only minor patches of corrosion with the exception of some field welding joints where the bitumen lining has separated. The corrosion found is, however, not severe.

4.1.4.2 External Inspections

Several excavations to expose the pipeline for GUL testing were done on the rising main. None of these exposed areas showed any indication of corrosion or any other damage to the pipeline itself or the external lining in particular.

4.1.4.3 Air Valves and Shutoff Valves

All air valves and shutoff valves are still in a good condition.

4.1.5. Gravity Pipeline from Zeeland WTW to Grootegeluk Mine

4.1.5.1 Internal Inspections

- Visual internal inspections
  Limited visual internal inspections were done at 100 m outside Grootegeluk Mine's main gate. It was found that the pipeline in this area is still in a very good condition with the internal lining and external coating in a good and smooth state with no signs of corrosion.

  The pipe section in the vicinity of the Eskom waste dumps, where external wrapping was done five years ago, is still an area of concern. Visual internal inspection needs to be done in this area.

- Guided NDT inspection (GUL)
  Guided NDT (GUL) testing was done in different locations of this section of pipeline. Results of these inspections show minor corrosion in the pipeline with the exception of the location in the vicinity of the Matimba ash dumps. This location requires further detail inspection and investigation.

4.1.5.2 External Inspections

A 300 m length of pipeline, located near the Matimba ash dumps, was damaged externally by chemically aggressive run-off water originating from the ash dumps a couple of years ago. The external bitumen coating separated from the metal, exposing the bare metal surfaces to the said water, causing extensive corrosion to the pipeline. All run-off water has since been stopped and five shallow boreholes were drilled to monitor the situation. Currently, the entire area is still dry.

The damaged areas on the steel surface were repaired and the bitumen coating was replaced with bitumen wrapping. Inspections done on this location over the last five years showed that no further damage to the outside of the pipeline has occurred and that the coating is still effective and in a good condition. Several excavations to expose the pipeline for GUL testing were done on this section of pipeline. None of these exposed areas proved any damage to the external coating or the pipeline as such. An internal inspection on the 300 m length of concern is planned by Exxaro.

It is envisaged that the entire existing pipeline will be refurbishment in 2015 after commissioning of the Crocodile River (West) Transfer Scheme. The capacity of the new pipeline will be sufficient to meet the demand should the existing pipeline be out of commission.

4.1.5.3 Air Valves and Shut-Off Valves

All air valves are in a good working condition. Two roll seal flow control valves were replaced at the Matimba take-off manifolds.

4.1.6. Sacrificial Cathodic Protection (CP)

The redundant sacrificial CP system was replaced with a new system in 2002. Annual effectiveness measurements that were taken by mine personnel show the system is effective.

4.2. Capacity of Existing System

The capacity of the existing system from Mokolo Dam was analysed in order to determine for how long this system could still provide for the projected water requirement and what measures could be implemented to extend this period. This was done to determine the critical date when the infrastructure of Phase 1 should be commissioned in its totality.

The following information was available:

- Pump station at Mokolo Dam - 3 duty pumps with total capacity of 820 ℓ/s;
- Pump main to Wolvenfontein Reservoirs - 700 mm diameter steel pipe. Taking into account the condition of the existing pipeline, a maximum acceptable velocity of 2 m/s was accepted which calculates to a maximum flow rate through the existing rising main of approximately 770 ℓ/s (which equates to 24.3 x 10^6 m^3/a);
- Gravity main from Wolvenfontein Reservoirs to Zeeland WTW - 700 mm diameter steel pipe;
- Gravity main from Zeeland WTW to Matimba - 600 mm diameter steel pipe;
- Free flow capacity of gravity main between Wolvenfontein and Zeeland WTW - 570 ℓ/s converting to a capacity of 14.7 Million m^3/a as discussed below; and
- Age of pipeline is approximately 25 years.

4.2.1. Capacity of Existing Pipeline

This is dictated by the free flow capacity of the existing gravity main between the Wolvenfontein Reservoirs and Zeeland WTW which was recently tested and accepted as 570 ℓ/s. The peak capacity of the existing pipeline is therefore accepted as 570 ℓ/s (17.98 Million m^3/a) under minimum static operating head, converting to 14.7 Million m^3/a if the 20% reliability allowance is made for re-filling of the storage reservoirs, as well as accounting for 2% losses.

4.2.2. Determination of the Friction Coefficient of the Existing Gravity Main

The existing pipeline between the Wolvenfontein Reservoirs and Zeeland WTW was analysed with a discharge of 570 ℓ/s at Zeeland assuming various k-values (friction coefficient). With a k-value of 0.5, the maximum velocity of the water through the pipeline was approximately 1.5 m/s and the hydraulic head above the Rietspruitnek was 9 m. See **Appendix A** for locality map and Figure 1 in **Appendix D** for the hydraulic grade line.

A friction coefficient of 0.5 was therefore accepted for the existing pipelines and used in further calculations.

4.2.3. Maximum Supply Horizon of Existing System and Modifications

From **Figure 3-2** in Section 3.2, it can be seen that the capacity of the existing infrastructure from the Wolvenfontein Reservoirs to Matimba T-Off will be sufficient until approximately July 2011 by which time the capacity of the existing system of 17.1×10^6 m^3/a (17.98×10^6 m^3/a - 5% normal downtime with no allowance being made for re-filling of storage dams) would have been reached. The maximum water requirement taken from the demand curve for July 2011 is 1.4×10^6 m^3 (x 12 = 16.8×10^6 m^3/a < 17.1×10^6 m^3/a). For August 2011, the water requirement is 1.5×10^6 m^3/a (x 12 = 18×10^6 m^3/a > 17.1×10^6 m^3/a). The proposed completion date of the entire Phase 1 Scheme, however, is only December 2011. Figure 2 in **Appendix D** shows that the projected peak water requirement for December 2011 will not be able to gravitate over Rietspruitnek through the existing pipeline and all the way to the users at Steenbokpan.

Options were therefore investigated using Scenario 9 water requirements (maximum interim water requirement during 2014 of 53.4 Million m^3/a) to establish if the construction of the new pipeline from Mokolo Dam can be programmed in phases with interconnections to the existing pipeline to increase the flow capacity and allow sufficient time to construct the pump station and the rest of the Phase 1 infrastructure.

The analyses showed that the projected total water requirement for 2011 of 18.8×10^6 m^3/a plus the 2% losses and the 20% reservoir re-fill peak factor (when converted equals 729.68 ℓ/s) will be able to gravitate over Rietspruitnek and all the way to the end users at Steenbokpan if the first 9 km section of the new 1 100 mm diameter pipeline from the Wolvenfontein Reservoirs is installed. This total water requirement is less than the acceptable rising main delivery of 770 ℓ/s and at 1.90 m/s the maximum velocity of the water through the existing gravity main is less than the accepted safe velocity of 2 m/s. See Figure 3 in **Appendix D**.

The maximum monthly water requirement during 2011 is 1.8 x 10^6 m^3 which converts to an annual requirement of 21.6 x 10^6 m^3/a (1.8 x 12) which is more than 18.8 x 10^6 m^3/a. If the dam refill peak is, however, not allowed for in the peak month of 2011, then the safe capacity of the existing Scheme with the first 9 km section of the new 1 100 mm diameter pipeline will be 22.6 x 10^6 m^3/a > 21.6 x 10^6 m^3/a. In the unlikely event of the maximum 18-day down time period occurring in the last three months of 2011, it will merely requires a refill period of more than 90 days.

Two other options were considered:

1. Construct a pump station at the Wolvenfontein Reservoir to boost the water over the high point at Rietspruitnek and provide sufficient head for the water to gravitate all the way to the end users at Steenbokpan. This option will not be viable since the ordering and delivery of electrical and mechanical equipment for such a pump station requires long lead times (approximately 18 months) and the pump station will therefore not be completed by the time that additional capacity is required.

2. Tunnel through the high point at Rietspruitnek. Approximately 1 140 m of tunnelling and the installation of an equal length of new pipeline will be required to enable water to gravitate from Wolvenfontein Reservoirs through Rietspruitnek. A booster pump station will then, however, also be required to boost the water over the high point on the Steenbokpan link.

Neither of the above mentioned alternatives will meet the projected deadline of July 2011 and were therefore not investigated further.

5. GEOTECHNICAL INVESTIGATIONS

5.1. Geotechnical Overview

The pipeline route from the Mokolo Dam to Lephalale and on to Steenbokpan can, for geotechnical purposes, be split into two as follows:

- Southern Section:
  This comprises the first 30 km northwards from Mokolo Dam up to about 3.5 km south of Zeeland WTW. The topography comprises rugged mountains and the route is underlain by coarse sediments of the Waterberg Group, Mogalakwena Formation (purplish brown sandstones and conglomerates). Numerous outcrops occur and soils are shallow and generally sandy and gravelly. As a result of the shallow soils present, vegetation is sparse and consists mainly of shrubs and small trees.

- Northern Section:
  This area is relatively flat and stretches northwards from the mountains towards the townlands of Lephalale and westwards on to Steenbokpan. The southern part is underlain by Waterberg sediments, but these are mostly covered by aeolian sands, though scattered outcrops and isolated tors of hard rock occur as inselbergs poking up through the sand cover. In the north, sediments of the Ecca Group (Swartrand and Grootegeluk Formations - sandstone, shale, mudrock and coal) occur, but these are often overlain by sands, gravels and calcrete. The deeper soil cover means that more grass and larger trees are present.

5.2. Mining Areas

A map showing the existing and proposed mining areas in the project area is given in Drawing No. WP 9528/LD/CTS/004/A in **Appendix E**. On the map, the Eenzaamheid Fault can clearly be seen. It is this fault that forms the southern boundary of the Waterberg coalfield and places the Ecca Group rocks into contact with the Waterberg sandstone.

5.3. Geotechnical Evaluation of the Pipeline from Mokolo Dam to Matimba Power Station

The expected geotechnical conditions along the route have been assessed by way of a visual appraisal of the route.

A summary of the evaluation carried out is given in **Table 5-1**, and sections where specific problems are foreseen, are then discussed separately. The detailed evaluation is given in **Appendix E**.

Table 5-1: First Geotechnical Evaluation

Pipeline Section*	km		Geology	m to Hard	% Soft Reusable	Side Slope (1:H)	Haul (km)	Comments
	Start	End						
Nodes 30 to 31	0	5.2	Msm	0 - 1	0 - 100	0 - 1	1 - 3	Paucity of soft material
Nodes 31 to 32	0	20.3	Msm	0 - 2	0 - 100	0.5 - 1	1 - 7	Crosses small vlei areas (wetlands)
Nodes 32 to 33	0	6.5	Msm	0 - 2	0 - 100	0 - 1	1 - 1.5	
Nodes 33 to 34	0	1.3	Msm	0.5 - 2	0 - 100	0 - 1	1	Zeeland
Nodes 34 to 35	0	1	Msm	0.5 - 2	100	0 - 1	1	
Nodes 35 to 36	0	3.5	Msm	2	100	1	1	
Nodes 36 to 37	0	3.9	Msm	2	100	1	1	Eskom ash dump (seepage/corrosion)
Nodes 37 to 38	0	7.8	Ecca	2	100	1	1	Matimba RWR
Total km		49.5						

* Shown on Drawing No. WP9528/LD/MTS/001/B in Appendix A

Msm = Mogalakwena Formation Ecca = Ecca Group

The headings used in the table are defined as follows:

m to Hard. This is a prediction of the depth to which excavation using an excavator should be possible, without recourse to blasting. This assumes a maximum depth of excavation of 4m for the pipeline.

% Soft Re-usable. This is a prediction of the percentage of the soft material (i.e. which could be excavated), that is suitable for re-use as bedding, selected backfill or general soft backfill around or over the pipe. This percentage does not consider the hard material.

Side Slope. This is a prediction of the safe side slope that may be employed in soft material during construction, without having to install shoring. Note that this is indicative only and the safe side slope will have to be determined by the contractor during construction. The slope is reflected as a ratio of vertical to horizontal (with the vertical expressed as 1 –i.e. 1:2 is flatter than 1:1).

Haul (km). This is a prediction of the likely distance over which additional soft material for use as bedding, selected or general soft backfill will have to be hauled for each pipe section. This takes no account of social, financial or practical considerations that may be experienced in having to source the material.

In regard to the material classified as "soft" and suitable for bedding, selected backfill and general backfill around the pipe, the characteristics of the material are a PI less than 12 and a maximum particle size of 10 mm.

5.3.1. Pump Station

A new pump station will be constructed just north and slightly upslope of the existing pump station. Rock occurs at shallow depth (generally less than 1 m) and the structure will be founded entirely on rock.

5.3.2. Rising Main from Mokolo Dam to Wolvenfontein Reservoir

Most of the new pipeline to Matimba follows the alignment of the existing pipeline feeding the Zeeland WTW and on to the Matimba Manifold. A significant amount of geotechnical information was obtained through inspection of the spoil from the excavations for this line.

Along the rising main pipe section (node 30 to 31) from the Mokolo Dam pump station to the Wolvenfontein Reservoir, the route does not follow the existing alignment, but follows the existing access road from the dam to Wolvenfontein. The reasons for adopting this slightly longer route are discussed in Section 5.2 with the main reasons being as follows:

- To follow the existing route will require extensive blasting right next to the existing pipeline; and
- The production rate along the alternative route (along the access road) is estimated to be about three times that achievable along the existing pipe route.

Excavation along this section of the route will be almost exclusively in rock and bedding and soft backfill will have to be hauled into this part of the route. Extensive blasting will be necessary and care will have to be exercised to avoid damage to the surroundings by flyrock. The blasted rock will bulk significantly and the excess material will have to be spoiled in an environmentally acceptable manner.

5.3.3. Gravity Main from Wolvenfontein Reservoir to Matimba

The route follows the existing pipeline, passing the Zeeland WTW and on to the Matimba Manifold.

Near the northern end, the route runs to the west of the Matimba ash dump which is approximately 2 km south of the Steenbokpan road. At this point, there is evidence of seepage from the paddock dams at the foot of the dump, which are designed to retain runoff from the dump. It is reported that severe corrosion of the pipeline has occurred in this area and this is probably due to the acidic nature of the runoff.

This section of the route exhibits far more favourable geotechnical conditions, with much less rock present and adequate sources of bedding and soft backfill material available. In the north excavation depths are expected to be of the order of 2 m or more. An exception to these conditions is the part of the route where it crosses over Rietspruitnek on the farm Fancy 556LQ, where almost continuous rock outcrop occurs and soft material will have to be hauled in.

5.3.4. Zeeland Water Treatment Works

Foundation conditions at this site are favourable, with frequent Waterberg sandstone outcrops occurring. Footings at shallow depth are thus expected.

5.3.5. Constraints

The major constraint relating to the pipeline from Mokolo Dam to Matimba Power Station is the paucity of soft material in the mountainous Southern Section and haul distances may be significant (particularly in the vicinity Rietspruitnek). Excavation rates will be low (particularly in the mountainous part) due to the large amount of rock present.

5.4. Geotechnical Evaluation of the Steenbokpan Link

The pipeline route extends westwards from the Matimba Manifold towards Steenbokpan and follows a new alignment. The information available from an existing pipe line is thus not available for this part of the route and the level of confidence in the information is thus less than that for the pipeline from Mokolo Dam to Matimba.

In general, conditions along this section of the route are favourable with excavation possible to about 3 m and extensive availability of sand for use as bedding and backfill. A summary of the evaluation carried out is given in **Table 5-2** and the detailed evaluation is given in **Appendix E** and then discussed thereafter.

Table 5-2: First Geotechnical Evaluation

Pipeline Section*	km		Geology	m to Hard	% Soft Reusable	Side Slope (1:H)	Haul (km)	Comments
	Start	End						
Nodes 37 to 39	0	7.8	Ecca	2	75	1	2	
Nodes 39 to 45	0	14.9	Ecca	2	75	1	2	
Nodes 45 to 53	0	8.7	Ecca	2	100	1	2	
Nodes 53 to 55	0	4.9	Ecca	2	100	1	2	Steenbokpan
Total km		36.3						

* Shown on Drawing No. WP9528/LD/MTS/001/B in Appendix A

The different characteristics are those discussed for Table 5-1 and are not repeated.

5.4.1. Constraints

No significant constraints are anticipated on the route. Soft material should be readily available and haul distances should be reasonable. Rates of excavation should be significantly higher than on the Mokolo Dam - Matimba route.

5.5. Future Investigations

Detailed investigations will need to be carried out along the pipeline routes as follows:

- Centreline soil survey. This will entail pitting at a nominal 5 test pits per km to refusal or a maximum depth of 4m along the centreline of the route. An excavator will be used to dig the test pits as this will help to "calibrate" the hardness (and particularly the depth to refusal) of the materials encountered, and should provide valuable information to tenderers. The extent of rock outcrops along the route must be mapped. Representative samples of material to be used as bedding and selected backfill material must be recovered and laboratory tested to characterise the materials encountered. The tests will include Road Indicators (sieve gradings and Atterberg Limits), compactability tests and various chemical tests for deleterious materials such as nitrates and chlorides.
- Borrow pit investigations. Borrow pits should be located at a nominal 5 km spacing and aimed at proving 50,000 m^3 of "soft" material suitable for use as bedding, surround and selected backfill. These borrow pits will, out of necessity, have to be located on private property and it is important that land owners along the route are notified timeously of this investigation. The teams

carrying out the investigation will not be in a position to negotiate with these land owners to extract the material.

During the borrow pit investigation, data must also be collected regarding the availability and quality of sources of commercially utilisable materials (concrete sand, concrete stone, etc.).

- Foundation Investigations. Core drilling will be carried out at the Mokolo pump station to define the foundation conditions at this site. Where refusal occurs at shallow depth, cores will be drilled to investigate the quality of the in-situ materials so that an assessment can be made of the excavatability of the hard material. It is anticipated that such drilling will be carried out in the north on the Steenbokpan Link where sands blanket the bedrock and prevent an assessment of its excavatability, quality and extent (as is possible on the pipeline route from Mokolo Dam to Matimba).

Tenders must be sought from drilling and geotechnical contractors and soils testing laboratories to carry out the investigations. The work must be carried out under the direction of a professional geotechnical team.

6. PROPOSED MOKOLO DAM TRANSFER SCHEME

6.1. Pump Station

The new pump station at Mokolo Dam will be required to transfer the following quantities of water from the dam to the balancing reservoir at Wolvenfontein from where it will gravitate to the consumers:

- *The maximum interim requirement from Mokolo Dam:* 53.4 (Total volume of water transferred during 2014) – 14.7 (capacity of the existing pump station) = 38.7 Million m³/a (2014) + 2% losses + 20% refill peak = 47,4 Million m^3/a = 1 502,1 ℓ/s. No additional allowance has been made for the consumer peak, as discussed in Section 3.3.
- *The long term requirement from Mokolo Dam*: 28,7 Million m^3/a + 20% refill peak = 34.4 Million m^3/a = 1 092 ℓ/s. No additional allowance has been made for the consumer peaks, as discussed in Section 3.3.

6.1.1. Suction Pipe to Pump Station

The unused pipe of the present outlet pair (1 200 mm diameter) from the dam has adequate capacity to supply the new pump station. If required the maximum delivery requirement can in the interim be provided through one pipe, thus allowing for 100% standby. This also provides for reliability requirements. This maximum delivery requirement is:

> (53,4 Million m^3/a + 2% losses + 20% refill peak) = 65.4 Million m^3/a = 2 072.6 ℓ/s.
> N.B. This does not include a likely 10,4 Million m^3/a (330 ℓ/s) release for irrigation purposes that will pass through a sleeve valve discharging to the river at the end of the outlet pipe.

This maximum flow results in a flow velocity of 1.83 m/s through one 1 200 mm diameter pipe, and 2.12 m/s if the irrigation flow is added. Both flow rates are within acceptable design norms.

The report of "Dam Safety Inspection of Mokolo Dam" dated October 2002 (as well as an apparently more recent inspection), refers to numerous mechanical, electrical and civil defects which should all be attended to. The suction piping system for the pump stations in particular needs repairs for internal pipe lining and may require an upgrade to its structural capability in the event of a sudden power failure and the subsequent water hammer. In the event of both pump stations being in full operation and supplied through one pipe, there could be a flow of 1.83 m^3/s if the crossover valve is not opened. In accordance with the Design Report (November 1980), the maximum design discharge of each outlet pipe at lowest draw down level of the dam (LDDL) is 2,66 m^3/s.

Observations have caused doubt as to whether the outlet pipes are adequately anchored. It is therefore recommended that a water hammer analysis be done and the design be reviewed for the maximum outlet capacity of 2.66 m^3/s.

As shown on the layout drawing (Drawing no WP9528/LO/MTS/001/B – **Appendix H**), and also dealt with under Paragraph 6.2.2 below, it is proposed that the outlet pipe supplying the existing pump station, ultimately be connected to the new pump station manifold once the existing pump station is decommissioned or mothballed.

6.1.2. Pump Station Position

The recommendation of transferring water directly from Mokolo Dam to the consumers, i.e. having the new pump station at Mokolo Dam instead of from a downstream weir near Lephalale was accepted by the Client.

The most suitable way of abstracting water from Mokolo Dam is to have the transfer pump station on the left bank of the river, directly downstream of the existing pump station, and supplied with water from the existing outlet pipes. This is the only viable locality for a pump station downstream of Mokolo Dam.

As shown on the layout drawing WP9528/LO/MTS/001/B – **Appendix H**, the new pump station has been positioned so as to cause least interference to the operation of the existing pump station. The supply pipe to the suction manifold of the new pump station has been routed around the back of the existing pump station (against the hillside) and, although more expensive, it is intended to minimise the impact on the operation of the existing pump station.

Furthermore, as Mokolo Dam will eliminate sedimentation impacts, no de-siltation will be required upstream of the pump station.

The foundation conditions where the new pump station will be built seem sound with rock close to the surface as the site is against the hillside downstream of the existing station.

Due to the highly strategic importance of this project the following will apply:

Flood levels:

The top of the pump well, as well as electrical infrastructure (switchgear, gantry crane, access road, etc.) of the pump station, is sited at RL 881,0 m which is above the maximum tailwater level directly downstream of the dam. The maximum tailwater level at a flood of 14 300 m^3/s is 879.5 m (DWAF Drawing Registration No. 62130/76 and Design Report, November 1980). More recent estimates propose a PMF between 8 030 m^3/s and 10 000 m^3/s. The spillway channel will have to be repaired and the rubble removed as it may cause the tailwater level to rise above the indicated levels since this was not accounted for in the tailwater analysis.

High-lift pumps' station:

The High-lift pumps are sited at RL 881,0 m, above the PMF tailwater level directly downstream of the dam and will have no probable risk of natural flooding.

Booster pumps associated with High-lift pumps:

Protective measures such as having sealed motors and cabling, and positioning the switchgear above the PMF level, will protect these pumps against external flooding and accidental flooding caused by a leaking pipe or valve.

6.1.3. Pump Station Development Options and Design

When doing the basic design, three options were considered namely:

Option 1: Retaining the existing pump station and constructing a new pump station. The two to-be operated in parallel. Because of having to operate and maintain two entirely separate pump stations, virtually doubling the workload, and the age of the existing pumping equipment (approximately 28 years) irrespective of the pump sets and spares still being in good condition, together with the danger of the entire pumping equipment being flooded, this option was not considered any further.

Option 2: Constructing a new pump station containing both the old and new pump stations as separate functioning units. This option was also not considered any further because of the age of the present pumping equipment and spares, having two systems to operate and maintain, having to extend the pump station building by approximately 30 m - and pump well (width 10 m by 15 m deep) - to accommodate the existing pumps and motors, and having the existing pumps and motors still prone to flooding due to internal pipe and valve leaks. Furthermore, it is most likely that two Eskom switchyards supplying power at different voltages (3,3 kV and 11 kV for old and new equipment) would have to be replaced, etc. All these factors will increase the cost of this pump station option substantially.

Option 3: Constructing one new pump station which in addition to the existing pump station, will cater for the full requirements of the Phase 1 Mokolo Dam Scheme until 2014 when Phase 2 Crocodile River (West) Transfer Scheme comes into operation.

This will be in the three duty pump sets. Hereafter, the existing pump station will become unnecessary and it can be decommissioned and mothballed since the new pump station will have a built-in surplus capacity of close to 35% (38,7 - 28,7) ÷ 28,7 million m^3/a = 34,8%; which is approximately 15% more than the refill pumping rate) in excess of its long-term requirement. It appears that the existing pump station pump selection was not made with the dam LDL in mind, and the effect of moving these pumps to the lower level will have an effect on the duty curves.

Furthermore, three pump arrangement options have been considered, namely:

Option A: A level controlled well with submersible or vertical spindle booster pumps, or similar arrangement feeding in-line High-lift pumps. Because of the head lost in the well and the resulting higher pump energy requirement, this option was not considered any further.

Option B: Multistage pumps with low NPSH requirement and no boosters (similar to the existing pump station). This option was also not considered any further because of the DWA stated requirements for horizontal split casing pumps for their greater reliability and ease of maintenance. These pumps will, similar to Option C below, require a pump well of approximately 14 m below the lowest operating level of the dam, but have a larger pump well, increasing the cost. It will also pose a greater risk of flooding due to internal valve or pipe leaks.

Option C: The third and preferred option comprises low lift booster pumps which will cope with the lower operational draw down levels in the dam together with in-line high lift pumps installed at RL 881,0 m, which is well above the PMF tailwater level downstream of the dam. Due to the relatively high delivery head the booster pumps will be used continuously even when the dam is full. As shown on the concept drawing (WP9528/LO/MTS/002/B – **Appendix H**), the booster pumps will be in a 14 m deep pump well with an available manometric suction head of 8.0 m below the minimum available manometric head in the suction manifold (i.e. RL 875,5 m).

While the LDL at the inlet pipe in the dam is RL 879.0 m (see DWA Dwg. Reg. No. 62130/62), the safe LDL, without forming vortexes, is estimated to be RL 881.5 m. The static suction head of 14.0 m (i.e. 881.5 - 867.5 m), thus available at the pump inlet manifold, is therefore adequate. The in-line booster pumps will not be flooded by natural flood waters.

The maximum duty rating of the new pump station will be:

Interim requirement from Mokolo Dam of 53.4 – 14.7 = 38.7 Million m^3/a + 2% losses + 20% refill peak = 47,4 Million m^3/a = 1 502,1 ℓ/s.

This will be at a total manometric pumping head of 263 m, pipe line friction losses included, measured above RL 875.5 m and an energy requirement in the order of:

$$P = \frac{Q \times 9{,}81 \times H}{0{,}70} = 5{,}534 \text{ MVA}$$

ASSUME : 5,5 MVA

*The long term average **duty** of the new pump station will be:*

The long term demand from Mokolo Dam of 28,7 Million m^3/a = 910 ℓ/s.

The pump system will, however, be able to provide up to 38.7 x 1.2 x 1.02 Million m^3/a if needed.

Generally, the number of pumps in a pump station are selected to suit the delivery rates required, plus adequate standby units/capacity in the order of one for every 3 to 4 duty rating units, with no less than two units for each duty rating. The conventional layout of 4 pump sets; 3 duty and one live standby was chosen. It is presently envisaged that variable speed drive (VSD) units may be required to adequately provide the total variation in consumer requirements.

6.1.4. Operation

The Mokolo Dam Transfer Scheme will be integrated with the greater MCWAP system.

However, at present the existing pump station system is largely operated by telecontrol from a manned control room at Zeeland WTW. Nonetheless, interim operation of the new Mokolo pump station, using the present control room locality and the existing tele-control system, appears to be the easiest and cheapest option to be investigated.

It is proposed that the present high maintenance arrangements will be maintained until the institutional arrangements for the MCWAP are established.

6.1.5. Security

It is believed that the security of the Mokolo pumping system will be classified (if not already) as an Important Works and required to be hardened to National Key Point (NKP) Standards. The present security arrangements should be evaluated and upgraded as required during design of the new pump station.

6.1.6. Tenders

It is strongly recommended that when tenders for the pump station are called for the civil construction and the supply and installation of the mechanical-electrical equipment be split into separate tenders. The advantages in having two separate tenders include:

- A contractually stronger and more direct hold on especially the Mechanical and Engineering (M&E) part of the pump station (that actually forms the heart of the system) with respect to aspects such as quality and delivery. The same will also apply to the civil structure. Although the basic pump station dimensions will only become available when the M&E tenders are awarded, there will still be ample time available in which to design and construct the pump station due to the long delivery time of the M&E equipment;
- The best and most suitable M&E, as well as civil tender can be selected;
- Experience has shown that it invariably results in a lower total cost; and
- It is not more difficult and costly to manage two contracts as opposed to one.

6.2. Rising Main

Refer to **Appendices A** and **C** for the schematic layout of the proposed rising mains and gravity mains to be constructed as part of the Phase 1 Mokolo Dam Transfer Scheme.

The proposed Mokolo Dam rising main is depicted on Drawing No. WP9528/LS/MTS/001/B included in **Appendix H**.

6.2.1. Routing

The philosophy employed in aligning the rising main was to make as much use as possible of the servitude of the existing Mokolo Dam rising main.

After a site visit to the existing pipeline route, it became apparent that it would be very difficult to fit in a second pipeline next to the existing pipeline and it is proposed that the new rising main follows the route of the existing access road from the pump station to the Wolvenfontein Reservoirs. Negative features of the existing pipeline route include the following:

- The existing route:
  - traverses very rugged terrain;
  - has very steep crossfall slope which will make it difficult to accommodate a second pipeline next to existing pipeline;
  - has rock outcrops over about 90% of its length;
  - is often on a bench blasted into the side slope;

- has no soft material for bedding/backfill; and
- limits the number of working fronts to two (i.e. from either end).

- To follow the existing route would:
  - require extensive blasting right next to the existing pipe;
  - result in a very low production rate, due to having to limit blast loadings;
  - impose a very real risk of damage to the existing pipe;
  - result in risk of erosion and damage if the pipe was placed on the downslope side of existing pipe and the existing pipe leaked; and
  - means that all pipes and backfill material would have to be hauled in along the pipe route. The cover to the existing pipe is insufficient for heavy equipment and there is insufficient space to trench for the new pipe and haul along the route.

In particular, the production rate along the alternative route (along the access road) is estimated to be about three times that achievable along the existing pipe route. Conditions along the access road are similar, with extensive outcrops present, but crossfalls are generally less steep and access is possible along the whole route (allowing work on multiple fronts). A “normal” production rate should be possible along this route (which will be about three times that of when the route followed the existing line).

The existing road section will have to be widened to allow for the installation of the pipeline adjacent to the road. Access to and from the pump station will have to be maintained at all times during construction.

The existing and new rising mains will be interconnected near the pump station to allow for the option to operate the two pipelines separately or conjunctively.

Typical servitude cross sections are included in **Appendix H**. Cross sections and servitudes for sections with steep crossfalls will be dealt with in the detail design phase when detailed survey information is available.

6.2.2. Pipeline Design

The following parameters were adopted for the design of the rising main:

- Pipeline material = Grade X42 Steel with yield stress of 290 MPa;
- Maximum allowable design stress = 50% of yield stress of steel;
- Corrosion protection = Sintakote coating and epoxy lining;
- Roughness coefficient = 0.5;
- Maximum flow velocity = 2.5 m/s;

- Maximum allowable pump head = 350 m; and
- Minimum head at Wolvenfontein Reservoirs = 15 m.

The primary issue concerned the determination of the pipeline diameter. A range of pipe diameters and associated wall thickness were subjected to an engineering economic analysis based on April 2008 rates and discounted over a 45-year period, the results of which are listed in **Table 6-1**.

Table 6-1: Analysis of Optimum Rising Main Diameter

Rising Main Diameter (mm)	Grade Steel	Wall Thickness (mm)	Velocity (m/s)	Capital Cost (R) (excl. VAT)	Present Value of Cost @ 8% Discount Rate (R) (excl. VAT)	URV for new Phase 1 Rising Main @ 8% Discount Rate (R/m³)
800	X42	8	3,01	295 176 222	430 105 321	**1,394**
900	X42	8	2,37	298 659 627	421 239 370	**1,372**
1000	X42	9	1,92	309 539 257	424 657 619	**1,386**

The analyses were based on the assumption that all the water from the Mokolo Dam to the Wolvenfontein Reservoirs will be conveyed via the new rising main, up to its design capacity of (38,7 Million m³/a + losses) x 1,2 = 1 502 ℓ/s until 2014. After 2014, when the Crocodile River (West) Transfer Scheme comes into operation, the new rising main will operate at 28,7 Million m³/a on average (957 ℓ/s) in the long term which is the sustainable yield of the Mokolo Dam, excluding the irrigation requirements of 10,4 Million m³/a. This assumption was made only in order to do the engineering economic analyses. The operating rules regarding the long term use of the existing rising main are yet to be confirmed. Whether the existing rising main is used in the long term or not, is however not expected to influence the optimum diameter Unit Reference Value (URV) sequence as indicated in **Table 6-1** above.

The Present Value allows for electricity costs and operation and maintenance costs.

The results of the analyses showed that the most economical size is a 900 mm diameter pipe. The resulting velocity is 2.25 m/s for the peak flow of 1 502 ℓ/s. The long-term requirement of 28,7 Million m³/s will result in a velocity of 1.76 m/s. A sensitivity analysis using discount rates of 6% and 10% was carried out and showed the same order of economical preference as shown in **Table 6-1**.

The vertical alignment and hydraulic grade line shows that the pipeline is well below the hydraulic grade throughout the length of the rising main. A detail hydraulic analysis for the positioning of the air valves, isolation valves and reflux valves will be carried out as part of the detail design. Refer to Drawing No. WP9528/LS/MTS/001/B included in **Appendix H**.

During the final design of the pump station and rising main, the sizing of this pipe should be revisited to ensure that the above sizing remains valid.

6.2.3. Water Hammer Analyses

A preliminary water hammer analysis was not performed on the rising main due to time constraints and should be carried out in the detail design phase of the pipeline. Some flexibility was, however, allowed by using a design stress of only 50% of the yield stress (while 60% is commonly accepted).

6.2.4. Cathodic Protection

Due to time constraints, an assessment to determine the required CP and AC mitigation measures that will be required to protect the proposed rising main was not carried out and should be carried out in the detail design phase of the pipeline. A first order cost estimate for CP and AC mitigation was, however, based on the assessment that was done for the Crocodile River (West) Transfer Scheme and was incorporated into the financial analyses of the Mokolo Dam Transfer Scheme.

6.3. Power Supply

6.3.1. Bulk Power Supply

Mokolo Dam: Additional 4.3 (5) MVA sub-station - Full Redundancy (Existing pump station load: 3.2 MVA)

The existing 33 kV line feeding from Waterberg sub-station will be upgraded to a 132 kV line, but utilized as a 33 kV line until the new voltage level is required. The existing pump station is a 3.3 kV station, and the new pump station will be utilised at 11 kV. This upgrade will have a major influence on utilizing the existing 3.3 kV pump station in the future. The sub-station will be converted to either a 132/33/3.3 kV or a 132/3.3 kV sub-station. This is applicable to both the upgrading of the new sub-station, and/or to building a new sub-station. The capacity of this line after the upgrade will be more than 100 MVA, and will form part of Eskom’s network upgrade.

A new 132 kV line is planned from Bulge River sub-station to Mokolo Dam. Both the sub-station and line is in Eskom’s CRA (Concept Release Approval) stage. The line route is not finalized due to land owner disputes.

The planned upgrade of the existing Waterberg line and the planned new Bulge River line will ensure a reliable redundant supply to Mokolo Dam with adequate capacity.

Capital Connection costs have been calculated after consultation with Eskom. The following inputs were used:

- 132 kV line construction costs calculated at R 950 000/km.
- Costs for similar completed substations and MV switching stations were used.
- Where exact line route details were not available, line lengths were increased by 30% for budget purposes.
- A 10% contingency has been added.
- Prices exclude Eskom connection charges. (Connection charges are insignificant in relationship to the project costs)
- Provision has been made at Mokolo Dam for both 132/11 kV and 132/33 kV sub-stations to service the new and existing pump stations.
- These are only provisional costs due to the fact that Eskom is unable to provide accurate feasibility quotations to date.

Table 6-2: Preliminary Connection Costs for Mokolo Dam Sub-station

Connection Description	Transformer (MVA)	Line Lengths	Connection Cost (Capital)		TOTAL	
			Line Cost - Eskom	Sub-station Cost - Eskom	MV Switching Station (Owner)	(Excl. VAT) + 10%
Mokolo Dam: Additional 4.3 MVA (Full redundancy)	5	58	R 55,100,000.00	R 14,382,000.00	R1,920,000.00	**R 71,594,000.00**

6.3.1.1 Tariff

From previous studies it was evident that the Megaflex tariff should be used. Nightsave is a little more economical to use during high demand periods. The saving is, however, only in the region of 1.5%, and the high demand season period is only for 3 months. Megaflex is about 8% cheaper than Nightsave in the 9-month off peak season.

Megaflex also has several financial advantages over Nightsave whenever demand side management is implemented. Further, to use Nightsave, one needs to increase pipeline and pump station capacities, which overrides the small difference between Nightsave and Megaflex.

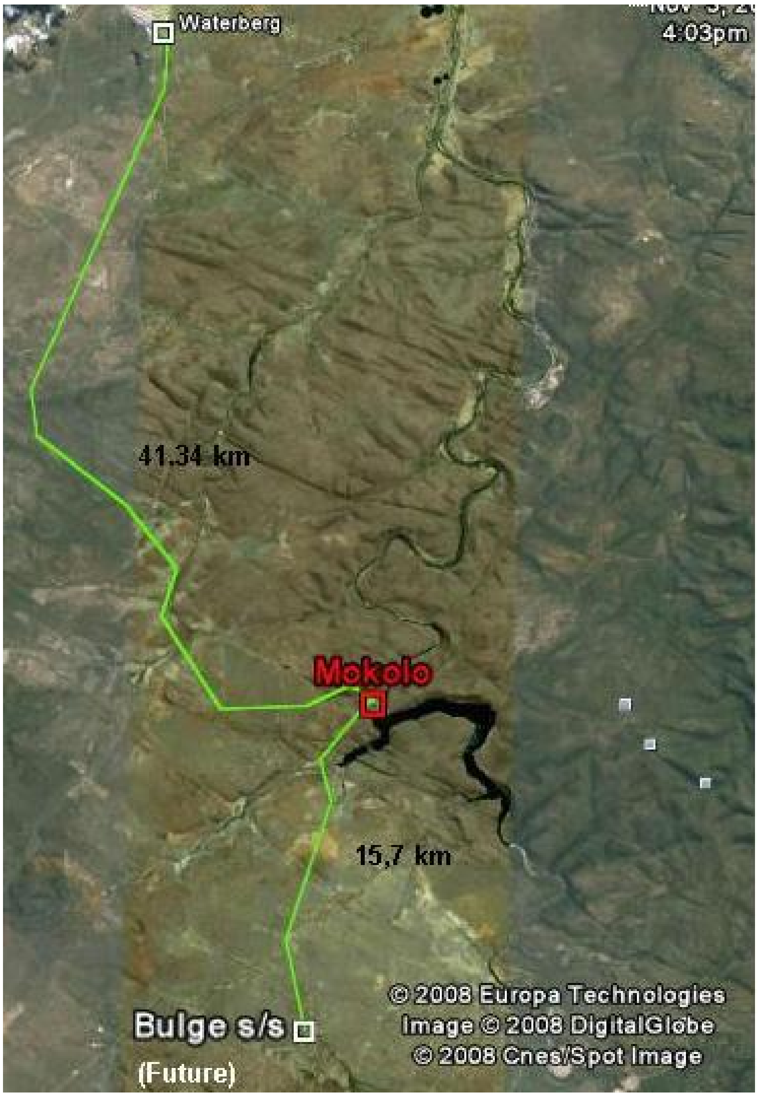

Figure 6-1: Aerial Photograph of the Proposed Power Line Routes and Mokolo Dam Pump Station Location

6.3.2. New Eskom Switch Yard Supply Route from Yard to Pump Station

In accordance with information received from Exxaro, the capacity of the existing incoming power supply (33 kV) seems adequate for the existing, as well as the new pump station at Mokolo Dam.

The present switch yard is unsuitable for extension for the following reasons:

- The switch yard will be fully submerged by the tailwater level at PMF (depth of submergence approximately 1.0 m).
- New transformers will be installed for the new pump station. The existing transformers are at 3,3 kV which is unlikely to be chosen for the new motors. An

extension to the yard will therefore be required which is not advisable during operation.

It is therefore proposed that an entirely new switch yard be constructed.

Furthermore, because of the history of unreliability of the existing power line due to lightning strikes and bush fires (as well as the lines being supported on wooden poles), an additional new power supply is strongly recommended. This is supported by Exxaro who in fact has already recommended that a new power line be constructed.

Two alternative positions for the Eskom switch yard, Options 1 and 2 are shown on Drawing no WP9528/LO/MTS/001/B included in **Appendix H**:

- *Option 1* is on higher ground close to the existing yard; and
- *Option 2* is just behind the proposed new pump station.

Option 2 is preferred because it is the most suitable for supply to the pump station switch rooms because of its closeness. It will, however, be more expensive since the yard terrace will have to be benched into the hillside behind the pump station.

Option 1, although the terrain is fairly level, has the disadvantage of:

- Being about 200 m away; and
- This option poses a greater risk because of the route and the longer length of cabling required, which involves duplicated M.V. and signal cables in a lidded-cable-culvert between the switch yard and the pump station.

The ultimate decision will in the end rest with Eskom. An early decision is therefore required since the preparation of the switch yard terrace is generally done by the civil contractor on site.

6.4. Inlet Structure to Wolvenfontein Reservoirs

The existing inlet structure at Wolvenfontein is currently functioning well and refurbishment to a pipe section was recently carried out.

No detail analyses as to how the second rising main should tie into the existing inlet works was carried out and should be carried out in the final detail design stage of the project.

The capacity of the two reservoirs combined is approximately 52,000 m^3 which will result in approximately 8.5 hours of storage under the peak 2014 requirements of 53.4 Million m^3/a. It should, however, be noted that the Wolvenfontein Reservoirs will only act as balancing reservoirs and will not contribute to the storage capacity required to ensure the prescribed reliability at each of the users.

6.5. Gravity Pipeline

Refer to Appendixes A and C for the schematic layout of the proposed rising mains and gravity mains to be constructed as part of the Phase 1 Mokolo Dam scheme.

The Mokolo Dam gravity main is supplied from the Wolvenfontein Reservoirs and is depicted on drawings No. WP9528/LS/MTS/002/B and WP9528/LS/MTS/003/B included in **Appendix H**.

6.5.1. Routing

- **Wolvenfontein to Steenbokpan T-off:**
  An alternative alignment considered was to follow Road R510 to Lephalale. This was investigated to eliminate passing through the high point at Rietspruitnek. During the site visit it became clear that this alternative would not be possible due to the steep rocky slopes on the north-eastern side of the road and the spruit on the south-eastern side which leaves no space for the gravity pipeline.

  It was therefore concluded that the existing alignment be followed. The existing servitude is 15 m wide with the existing pipeline constructed 5 m from the boundary. It may be required that the servitude be widened in places to 20 m to accommodate the second gravity pipeline. The use of the existing servitude has obvious advantages. Typical servitude cross sections are included in **Appendix H**. Cross sections and servitudes for sections with steep crossfalls will be dealt with in the detail design phase when detail survey information is available.

  The new pipeline will be interconnected to the existing pipeline for the first 9 km from Wolvenfontein Reservoirs towards Rietspruitnek to increase the flow capacity and allow sufficient time to construct the pump station and the rest of the Phase 1 infrastructure, as discussed in Section 4.2 of this report.

  The new pipeline will also be interconnected to the existing pipeline at the Zeeland WTW to ensure sustained water supply to the treatment works from the Mokolo Dam while the existing pipeline is taken out of operation during refurbishment.

- **Steenbokpan Link:**
  This section of the gravity pipeline tees off from the Wolvenfontein-Matimba gravity pipeline at the Steenbokpan/Lephalale Road T-junction. From there it

follows the road for approximately 3.7 km where after it turns south to follow the existing railway line for approximately 13 km before it turns north again to mainly follow farm boundaries to a termination point at Steenbokpan.

CP measures will be installed for the section of the pipeline adjacent to the railway line. The exact layout of the proposed pipeline in relation to the railway line and the service road will be fixed when detail survey information becomes available during the detail design stage.

Typical servitude cross sections are included in **Appendix H**. Section-specific cross sections and servitudes will be dealt with in the detail design phase.

6.5.2. Pipeline Design

The following parameters were adopted for the design of the gravity mains:

- Pipeline material = Grade X42 Steel with yield stress of 290 MPa;
- Maximum allowable design stress = 50% of yield stress of steel;
- Corrosion protection = Sintakote coating and epoxy lining;
- Roughness coefficient = 0,5;
- Maximum flow velocity = 2,5 m/s;
- Minimum design pressure at peak flow = 15 m at any point in the system; and
- Minimum head at T-off points to end users = 25 m (15 m for hydraulic loss through valves and 10 m for change in elevation and head loss in pipeline to Terminal Reservoir), as agreed with stakeholders.

6.5.3. Hydraulic Considerations

- **Wolvenfontein to Matimba:**

  The hydraulic gradeline shown on the drawing (Drawing No. WP9528/LS/MTS/002/B), dictates the design of the gravity line with the high point at CH 15 650 (Rietspruitnek) in particular being the limiting factor.

  The proposed pipelines required to fulfil the water requirements is a 1 100 mm diameter steel pipeline with 7.0 mm standard wall thickness (Grade X42) from the Wolvenfontein Reservoirs to Rietspruitnek and a 1 000 mm diameter steel pipeline with 7.8 mm standard wall thickness (Grade X42) from Rietspruitnek to the Steenbokpan T-off. This gives maximum flow velocities of 1,58 m/s and 1,91 m/s in the two pipeline sections respectively under peak flow conditions of (38,7 Million m³/a + losses) x 1,2 = 1 502 ℓ/s.

  A link to the Zeeland WTW via the existing pipe will be provided on this section of pipeline.

A detail hydraulic analysis for the positioning of the air valves, isolation valves and reflux valves will be carried out as part of the detail design.

- **Steenbokpan Link:**
This section of pipeline was sized to provide water as Phase 1 to the Steenbokpan area users. The pipeline was then optimised to form part of the delivery line from the Crocodile River (West) Transfer Scheme.

It was assumed for the purpose of this report that the Crocodile River (West) Transfer Scheme would include a Reservoir at the so-called Node 15.

The section of pipeline constructed as Phase 1 to deliver Mokolo Dam water to the users will be operated in reverse and under gravity for the long term scheme to provide Crocodile River (West) water to some of the users in the Lephalale area. Mokolo Dam will not provide long term redundancy to the users at Steenbokpan.

For the proposed new pipeline to fulfil the hydraulic requirements for the above-mentioned scenario the following was found (pipes sized for Phase 1 (short term) and Phase 2 (long term) water requirements) (**Table 6-3**).

Table 6-3: Pipes Sized for Phase 1 (Short Term) and Phase 2 (Long Term) Water Requirements

Description	Diameter (mm)	Std Wall Thickness (mm)	Phase 1 Velocity (m/s)	Phase 2 Velocity (m/s)
• Steenbokpan T-off to Medupi T-off	900	6.3	1.28	1.36
• Medupi T-off to CF3&4 mining T-off	900	6.3	1.28	1.63
• CF3&4 mining T-off to Crocodile River (West) Transfer Scheme connection	1100	6.1	0.64	1.50
• Crocodile River (West) Transfer Scheme connection to Steenbokpan	1900	12.1	0.21	1.80

A detailed hydraulic analysis for the positioning of the air valves, isolation valves and reflux valves will be carried out as part of the detail design. Refer to Drawing No WP9528/LS/MTS/003/B in **Appendix H** for hydraulic gradeline of the selected design.

6.5.4. Water Hammer Analyses

A preliminary water hammer analyses has not been performed on the gravity pipeline due to time constraints and should be carried out in the detail design phase of the pipeline. Some flexibility was, however, allowed by using a design stress of only 50% of the yield stress (while 60% is commonly accepted).

6.5.5. Cathodic Protection

As illustrated on the layout drawing (WP 9528/LD/MTS/001/B – **Appendix A**), the proposed pipeline route of the Steenbokpan link runs parallel to and crosses the railway line to Matimba. This railway line is currently not electrified and if electrified in future, it is expected to be with AC power. Stray current interference is therefore expected on all pipelines in the area.

Due to time constraints, an assessment to determine the required CP and AC mitigation measures that will be required to protect the proposed gravity pipelines was not carried out and should be done in the detail design phase of the pipelines. A first order cost estimate for CP and AC mitigation was, however, based on the assessment that was done for the Crocodile River (West) Transfer Scheme and was incorporated into the financial analyses of the Mokolo Dam Transfer Scheme.

6.6. Delivery Points

The proposed pipeline was designed to supply water to the following delivery points taking into account the Phase 1 (short term) and Phase 2 (long term) water requirements.

6.6.1. Zeeland Water Treatment Works

An interconnection to the existing pipeline will be provided to supply water to the Zeeland WTW to deliver the following requirements (AAD):

- 2014 – 9,4 Million m³/a
- 2030 – 9,2 Million m³/a

This interconnection will also be utilised when refurbishment of the existing pipeline takes place. It is envisaged that the refurbishment will take place in 2015 after commissioning of the Crocodile River (West) Transfer Scheme. There will thus be sufficient capacity through the new pipeline to completely take out the existing pipeline for refurbishment. See Figure 4 in **Appendix C** for an indication of the flows in the existing and proposed pipelines during Phase 1, in the year of refurbishment and in the long term.

An 18-day storage capacity Terminal Reservoir will have to be provided by the users at Zeeland WTW for the users supplied from it to ensure the prescribed reliability for those users.

6.6.2. Matimba Power Station and Grootegeluk Mine

The gravity pipeline will terminate at the existing manifold west of Matimba Power Station (Node 38).

The pipeline (including existing pipeline) will deliver the following water requirements at this point (AAD):

- 2014 – 17,0 Million m³/a
- 2030 – 10,1 Million m³/a (from Mokolo Dam)
  – 22,3 Million m³/a (from Crocodile River (West) via the Steenbokpan Link)

An 18-day storage capacity Terminal Reservoir will have to be provided by the users at the Matimba Power Station, as well as at the Grootegeluk Mine to ensure the prescribed reliability for those users.

6.6.3. Medupi Power Station

It was assumed that the total requirement up to 2014 will be supplied at the Matimba termination point. Eskom is currently in the process of re-designing and constructing a 600mm pipeline that will transfer water from the existing Matimba manifold to a proposed new Reservoir to be constructed just south of Medupi power station. This Terminal Reservoir is required to have a storage capacity at least equal to 18 days of water requirement to ensure prescribed reliability for the Medupi power station.

The Steenbokpan link will thus only provide for the additional long term requirement which cannot be met by the Phase 1 Mokolo Dam Scheme and will need to be supplied from the Crocodile River (West) Transfer Scheme via the Steenbokpan Link.

Provisions for the following water requirements were made (AAD):

- 2014 – 6,0 Million m³/a (from Matimba manifold via Eskom pipeline)
- 2030 – 9,4 Million m³/a (from Matimba manifold via Eskom pipeline)
  – 4,6 Million m³/a (from Crocodile River (West) via the Steenbokpan Link)

6.6.4. CF 3&4 Mines

A termination point for the mines to supply CF 3&4 has been allowed for on the Steenbokpan link near Medupi.

Provisions for the following water requirements were made (AAD):

- 2014 – 5,3 Million m³/a (from Mokolo Dam)
- 2030 – 10,0 Million m³/a (from Crocodile River (West) via the Steenbokpan Link)

An 18-day storage capacity Terminal Reservoir will have to be provided by the users at the CF 3&4 mines to ensure the prescribed reliability for those users.

6.6.5. Steenbokpan Area

Due to the uncertainty regarding the exact location of the Exxaro, Eskom and possibly Sasol users in the Steenbokpan area, only one other termination point has been allowed for at this stage, namely at Steenbokpan.

Provision for the following water requirement was made at the Steenbokpan terminal point (AAD):

- 2014 – 15,7 Million m³/a (from Mokolo Dam)
- 2030 – 132,4 Million m³/a (from Crocodile River (West)

For the purpose of this study it was accepted that the users will be responsible for design and construction of the respective pipelines from this central termination point at Steenbokpan or en-route at T-off points once the exact positions are fixed.

A minimum 18-day storage capacity Terminal Reservoir will have to be provided by the users at each termination point of Exxaro, Eskom and Sasol to ensure the prescribed reliability for those users.

6.7. System Operation

The Mokolo Dam Transfer Scheme will be integrated with the Crocodile River (West) Transfer Scheme to form the greater MCWAP to be operated as a system. The water from the Mokolo Dam is of a much better quality than that from the Crocodile River (West). It is therefore necessary to design and operate the MCWAP system in such a way that the water from the two sources does not mix during normal operation.

As agreed by the stakeholders, the design philosophy of the scheme is that the Crocodile River (West) will not provide redundancy to users at Zeeland WTW and that the Mokolo Dam will not provide redundancy to users at Steenbokpan.

Operating rules need to be developed during the detail design stage of the project.

7. ENVIRONMENTAL ASPECTS

7.1. Background

The development of new power stations is of high strategic importance and the construction of the first new power station, Medupi, is already underway. The first units will be commissioned by the end of 2010. The required Environmental Impact Assessments (EIA) and obtaining of an Environmental Authorisation must also take place in this time period. The Crocodile River (West) Transfer Scheme will not be completed in time to meet these dates and it will be necessary to implement interim bridging arrangements to achieve this. The interim arrangements must supply in all the requirements until the transfer scheme becomes operational.

7.2. Listed Activities

Activities identified in terms of Section 24(2)(a) and (d) of the National Environmental Management 1998 (Act 107 of 1998) (the Act), which may not commence without environmental authorisation from the competent authority and in respect of which the investigation, assessment and communication of potential impact of activities must follow the procedure as described in Regulations 22 to 26 of the Environmental Impact Assessment Regulations, 2006, promulgated in terms of Section 24(5) of the Act, are listed below.

The construction of a pipeline is a listed activity in terms of the Act. The following listed activities are included under Regulation 386 indicating a basic assessment:

1(k) The bulk transportation of sewage and water, including storm water, in pipelines with –

(i) an internal diameter of 0,36 metres or more; or
(ii) a peak throughput of 120 litres per second or more

4. The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5 cubic metres from a river, tidal lagoon, tidal river, lake, in-stream dam, floodplain or wetland.

Although indicated as a Basic Assessment, it is anticipated that several detailed specialist investigations will have to be completed such as fauna, flora and heritage assessments. The timing of the project is therefore significant as some of the studies may only be conducted during certain periods of the year. Due to the extent of the project, the relevant authority may also require that a full EIA be conducted.

A basic assessment process is the shorter process but can have an extended time due to the specialist investigations that need to be conducted. It can therefore take anything from 6 – 12 months to complete. The timeframe is also subject to the input and comments received during the Public Participation Process.

Should a Full EIA be required by the relevant authority the process can take anything from 18 – 24 months.

It is, however, anticipated that the authority will concur with the Basic Assessment Process.

7.3. Potential Environmental Impacts of Phase 1– Mokolo Dam Pipeline

The construction of a pipeline could have numerous environmental impacts, including the following:

- Destruction of vegetation;
- Faunal habitat loss;
- Soil erosion;
- Hydrocarbon pollution of soil, ground and surface water;
- Air pollution (dust during blasting and drilling); and
- Noise pollution.

The pipeline alignment especially close to the Mokolo Dam is relatively close to sensitive rocky areas and particular care should be taken to minimise the disturbance of these areas.

The pipeline to Steenbokpan also traverses areas that are not considered as specifically sensitive. There are no rocky outcrops or significant wetland areas on the proposed route. It is therefore not foreseen to have any significant impact.

Most of the potential impacts could, however, be negated or minimised through proper construction management.

7.4. Conclusion

The pipeline does traverse some sensitive areas where particular care should be taken. These will be pinpointed during a detailed investigation. Rocky areas are most sensitive due to the presence of aloe species, as well as the distinct habitat it provides for certain animal species. The construction of a new pump station at the Mokolo Dam is not foreseen to have a significant impact due to the fact that it will be located close to the existing facility. Precautionary measures regarding possible erosion will have to be taken due to the fact that it is situated on steep slopes. The area surrounding the dam has very steep slopes, as well as large areas of sensitive rocky outcrops. The construction of the pump station will in all likelihood result in the destruction of some of these areas. To minimise this impact, the site for the pump station must be identified in conjunction with faunal and floral specialists.

The fact that the pipeline alignment is adjacent to the existing pipeline and that the vegetation has recovered along the existing pipeline, it is a clear indication that the disturbance of the vegetation is of a temporary nature. With mitigation measures the construction of the pipeline will have a minimal lasting effect on the surrounding area.

The detailed investigations envisaged for the design stage will be the responsibility of the consultant responsible for the EIA. The Pre-feasibility and Feasibility stages only consisted of a desktop investigation and a brief site visit to identify major fatal flaws, if any should exist. During the Design Phase, detailed fauna and flora investigations will have to be conducted to identify specific plant communities that are sensitive, as well as sensitive habitats that will be affected by the scheme. The investigation also needs to indicate how well such communities are represented in the vicinity and elsewhere.

8. SOCIAL ASPECTS

8.1. Introduction

This section provides the socio-economic impacts that could result during the construction and operation of Phase 1 of MCWAP. The analysis is based on all available satellite and aerial photography.

8.2. Social Impacts

The most significant socio-economic impacts of the proposed pipeline are discussed below:

8.2.1. Loss of Agricultural Land

The servitude will mainly run alongside various existing roads, power lines and an existing pipeline. Along such sections of the route, the socio-economic impacts of the pipeline route are expected to be minimal.

Most of the land that will be affected by the pipeline servitude is currently natural pasture (plain land with bushes and shrubs).

During construction, the owners of the affected farms will experience a loss of either cultivated or pastural land. The land will, however, not be fenced and the owners will be able to regain use of the land soon after construction. The inconvenience to the farmer will therefore mostly only be during the construction phase.

The following is an indication of the existing farms affected by the pipeline route:

- Witbank 647-LQ
- Wolvenfontein 645-LQ
- Toulon 643-LQ
- Sterkfontein 642-LQ
- Nooitverwatch 635-LQ
- Goedgedacht 602-LQ
- Fancy 556-LQ
- Fourieskloof 557-LQ
- Goedehoop 552-LQ
- Grootgenoeg 526-LQ
- Fancy 316-LQ
- Wellington 519-L
- Zwartwater 507LQ -Q
- Hanglip 508-LQ
- Grootestyd 465-LQ
- Naauwontkomen 509-LQ
- Vergulde Helm 316 – LQ
- Buffelslagt 317-LQ
- Kringgsatspruit 318-LQ
- Taaiboschpan 320-LQ
- Zyferbult 324-LQ
- Toezicht 323-LQ
- Theunispan 293-LQ

Approximately 40 km of the pipeline, from Wolvenfontein Reservoir to Matimba is alongside the existing pipeline. The social impact of the pipeline will be less on the farms where the existing pipeline sections is present. This can be seen as an ideal or best location of the pipeline route.

It should, however, also be noted that farming activities and arable land may be negatively affected for an area larger than the servitude width especially during construction, due to vehicle movements, dust, vibrations, etc. Due to the fencing that could be erected during the construction of the pipeline, agricultural vehicles may not be able to gain access to all areas of the farm unless this is adequately provided for.

During the operation phase, the land preparation and construction of the pipeline would have removed vegetation, increased surface run-off, created erosion, etc. The necessary management practices and procedures need to be put in place and implemented so that the negative impacts can be minimised.

8.2.2. Foreign Work Force and Inflow and Outflow of Workers

Local socio-economic impacts of large-scale development projects tend to be closely associated with the location (immigration) of project workers and their families to communities near the project site.

The influx of people could be brought about by a number of factors. Through its positive economic impacts, the construction phase can attract unemployed persons in search of work (both directly and indirectly related to the pipeline construction). Squatter camps can develop and will have a number of environmental impacts, which include adverse health effects resulting from lack of facilities for handling sewage and domestic waste, poor ventilation and a potential increase in crime.

The presence of a workforce from outside the project area could lead to conflict between them and locals due to differences in culture and values, competition for employment opportunities and a perception among local residents that services are being provided for outsiders while their own needs are not addressed.

During the construction period, the inflow of temporary workers may result in socio-economic impacts, such as demographic changes, disruption of existing social networks, and Sexual Transmitted Deceases (STDs) and related illnesses. An increase in local population could indirectly trigger impacts such as local increases in crime.

8.2.3. Worker Camps and Effect on Communities in Proximity

It is proposed that workers' camps be provided for the construction of the project, since probably not all the workers will be locally recruited. Failure to provide for workers' camps may cause influx of squatters. Thus, could result in the project not being able to adequately manage the workers which lead to negative impacts.

In determining suitable sites for the workers' camps, it should be noted that while relatively close proximity to the project site is attractive, factors such as the availability of space for temporary housing, camps and adequate public and commercial services must also be considered.

The workers' camps should be within close proximity to existing towns/settlements (in this case Lephale/Onverwacht) within the vicinity of the pipeline.

The exact location for the workers' camp needs to be determined beforehand in consultation with Lephalale Municipality. The positive impacts of availing land for workers' camp outweighs the negative factors as highlighted previously and this should be clearly indicated to the applicable Municipality.

The decision to allow employees to live in accommodation separate from the workers' camp will contribute towards curtailing an increase in the incidence in STDs and AIDS. Furthermore the accommodation of staff within a single-sex workers' camp or as residents within neighbouring villages – in the absence of the family members – has the potential to result in an increased incidence of STDs.

Early efforts to provide a workers' camp and support services in the pre-construction stage should be initiated and the workers camp needs to conform to public health and safety regulations.

Other less tangible impacts that may occur to the areas as a result of the workers' camp include: reduction in social stability, loss of social support structure, decrease in safety and security, community conflicts and loss of sense of community.

8.2.4. Possible Disruption of Daily Living

Changes in the routine living, activities, movement patterns and infrastructure (to a lesser degree) of residents in the affected areas will be brought about by the alteration to the visual environment, noise, transportation route changes, etc. These impacts will be most significant during the construction phase.

Numerous gravel roads in the area will also affect the flow of pedestrians and vehicular traffic along routes in the area, as well as the creation of dust. Furthermore, construction vehicles on these roads will increase air pollution.

After careful analysis of the proposed pipeline route, no structures were identified to be within the pipeline servitude, therefore, the social impact of the route is limited. No families will need to be moved and no farmers will lose major portions of their farm as a result of the pipeline.

Although temporary, the construction phase will be responsible for the greatest amount of disruption caused during the entire implementation, operation and maintenance process.

During operation, regular inspections will be undertaken and a certain amount of maintenance will need to be carried out periodically. This will include repair to the pipeline. Access will need to be granted to inspection and maintenance teams where the servitude is not located close to the road or power line servitude, which may inconvenience farmers. Where pipeline problems occur below ground, excavation may need to be done in order to assess the problem. This will lead to further temporary disruption to address the problem. It is expected that pipeline sections alongside existing servitudes (road, existing pipelines and power lines) will be relatively easy to access and therefore to inspect and maintain.

8.2.5. Safety and Security

During the Construction phase and to a lesser degree during the Operation phase, safety and security problems are foreseen due to people having to gain access to private land. Individuals could sustain permanent physical harm during the construction period from the noise, dust and stress levels; therefore long-term psychological problems could emerge. Since few dwellings are located near the pipeline route, safety and security impacts could be expected more for the construction workers.

8.2.6. Impact on Property Values

The prices of farms in the affected areas may be affected. The uncertainty of property owners and potential new property owners will have negative impacts on the value of land and surrounding farms affected by the pipeline.

The farmers need to get compensated for the value of the land for the area on which servitude is to be registered.

8.2.7. Aesthetic Impacts

Aesthetic impacts on the surrounding landscape will be most notable during the construction phase. Factors such as the width of servitude and size of the delivery pipeline have a temporary influence on the visual quality of the landscape during the construction phase.

Other visual intrusions during the construction phase include:

- Fencing erected in and around the construction servitude area;
- Workers' camp at the proposed location;
- Prefabricated offices and vehicle storage places along the route; and

- The 20-metre wide servitude along the length of the pipeline.

Since the pipeline is below ground the visual impact is far less marked than had it been situated above ground. During operation the only visual impact will be gravel access roads and valve chambers along the pipeline. The visual impact during operation is thus relatively small.

8.2.8. Increased Government Income and Stimulation of Local Economy

The potential positive economic benefits such as increased financial spending, increased infrastructure investment, increased expenditure by employees, etc. is likely to result in increased markets for the sale of local goods for the new employment created and the direct future employment by the mines and industries such as Eskom and Sasol.

The supply of water can thus be seen as an economic injection to the area that would also lead to increased government income, through an increased tax base, and increase the capacity of the local municipality to increase and/or improve social and service support actions and local spending.

8.2.9. Employment and Decrease in Local Unemployment Level

The pipeline will provide sufficient water which will allow the mines and industries to grow at the pace desired, thus bringing an increase in employment and mining activity, as well as decreasing the local unemployment level.

8.2.10. An Increase in New Businesses Sales

The increased employment expected, will impact positively upon the regional and local economy. Increased employment is associated with increased income and consequently with increased buying powers in the area, thus leading to new business sales to accommodate the new demand for services and goods. The employees will spend more money which will be injected into the economy.

8.2.11. Increased Standards of Living

The multiplier or spin-off effects from this economic activity will improve standards of living, decrease dependence on pensions, increase disposable income and ability to purchase additional goods and/or establish other business enterprises. Apart from having the potential to create occupational opportunities, the proposed development could also stimulate economic growth in the region by attracting other commercial activities. If this is the case, indirect local benefits may accrue in the form of job opportunities in other sectors and industries. The proposed development may also serve as a catalyst for the improvement of services and infrastructure in the longer term. A stimulation of the economy is also expected in the transport sector, as more public transport will have to be made available for workers. An increase in trade, which includes retailers, wholesalers, restaurants and accommodation establishments, is also expected when large numbers of people enter an area.

8.2.12. Transfer of Skills

With an increase in employment, a definite transfer of skills will result. Skills development is a requisite for human resource development, and will have a lasting impact on the economy.

8.2.13. Summary of Impacts per Section of Pipeline

Table 8-1: Summary of Impacts per Section of Pipeline

Pipeline Sections*	Description	Impact
Nodes 30 to 31	Follows gravel road Mostly natural pastures	Low impact
Nodes 31 to 32	Adjacent to the existing pipeline Small section also adjacent to R510	Low impact
Nodes 32 to 38	Adjacent to the existing pipeline	Low impact
Nodes 37 to 39	Adjacent to a secondary road Portion on farm boundary Crosses railway line	Moderate impact
Nodes 39 to 45	Adjacent to a secondary road Small section crosses through two farms	Moderate impact
Nodes 45 to 53	Runs through farms but close to the boundaries	Moderate impact
Nodes 53 to 55	Runs through a farm Some land cultivated	Moderate impact

* Shown on Drawing No. WP9528/LD/MTS/001/B in Appendix A

8.2.14. Socio-Economic Impact Summary

The most significant socio-economic impacts of the proposed pipeline are:

- **Negative impacts:**
  - Loss of agricultural land
  - Foreign work force and inflow and outflow of workers
  - Workers' camp and effect on communities in proximity
  - Possible disruption of daily living
  - Safety and security
  - Impact on property values
  - Aesthetic impacts

- **Positive impacts:**
  - Increased government income and stimulation of local economy
  - Employment and decrease in local unemployment level
  - An increase in new businesses and in sales
  - Increased standards of living
  - Transfer of skills

Management procedures need to be put in place and implemented so that the negative impacts can be reduced and the positive impacts enhanced. Fencing used during construction should still enable farmers to have access to their land and dwellings. A workers' camp needs to be planned for well in advance to ensure that various negative social impacts are curbed.

8.3. Estimated Compensation Costs

To calculate the estimated compensation cost for the land to be acquired, a 15 m servitude has been used for pipe sections that are within the existing pipeline route and a 20 m servitude is used for the rest of the pipeline.

The estimated compensation cost for the pipeline servitude route is shown in **Table 8-2** below. The estimated compensation costs based on 2008 market values obtained through discussions with estate agents active in the area.

Table 8-2: Estimated Compensation Costs

Pipeline sections*	Estimated compensation cost (R'000/ha)	Area (ha)	Estimated compensation (R millions)
Nodes 30 to 31	20	9.6	0.19
Nodes 31 to 32	16	28.1	0.45
Nodes 32 to 33	16	9.7	0.16
Nodes 33 to 34	16	1.9	0.03
Nodes 34 to 35	16	1.5	0.02
Nodes 35 to 36	16	5.2	0.08
Nodes 36 to 37	16	5.8	0.09
Nodes 37 to 38	16	3.2	0.05
Nodes 37 to 39	16	13.9	0.22
Nodes 39 to 45	15	30.1	0.45
Nodes 45 to 53	14	17.2	0.24
Nodes 53 to 55	14-50	12.8	0.19
Total		**138.7**	**2.17**

* Shown on Drawing No. WP9528/LD/MTS/001/B in Appendix A

No improvement such as houses, windmills, reservoirs, etc. will be lost as a result of the pipeline and no families will have to be moved.

8.4. Conclusion

The Socio-Economic Impact Assessment of Phase 1 of the MCWAP has revealed that the development will have a minimal socio-economic impact on the affected and surrounding areas and that the compensation costs for acquiring the affected servitude area will be relatively small.

9. COST ESTIMATES AND ECONOMIC ANALYSIS

9.1. Capital Cost

Capital cost estimates were calculated in accordance with Supporting Report No. 3 for this study, *Guidelines for Feasibility Stage Sizing and Costing*. These guidelines are based on the Vaal Augmentation Planning Study (VAPS) model accepted for this study. The construction cost rates in this report have a common base date of April 2008.

Table 9-1 summarises the capital cost for the proposed Phase 1 Mokolo Dam Transfer Scheme infrastructure, including landscaping, miscellaneous, P&G, contingencies and design fees, but excludes VAT.

Table 9-1: Total Capital Cost of Phase 1

Component	Total (R)
Pump Station (Peak pumping head 263 m)	
- Civil Works	64 805 000
- Mechanical & Electrical Work	70 770 000
Rising Main	
- 900mm diameter (5 700 m)	86 540 000
Gravity Mains	
- 1900mm diameter (1 400 m)	51 243 000
- 1100mm diameter (42 950 m)	692 875 000
- 1000mm diameter (19 970 m)	308 070 000
- 900mm diameter (11 770 m)	152 910 000
- 800mm diameter (1 940 m)	27 544 000
Eskom Electricity to Site	76 430 000
Compensation	2 170 000
Environmental and Socio-economic Studies	1 000 000
TOTAL	**1 534 357 000**

The residual value of the existing pump station at Mokolo Dam, as well as the existing pipeline between Mokolo Dam and Matimba was calculated as R8 million and R33 million, respectively and were added to the project capital cost in the engineering economic analysis calculations.

9.2. Operation and Maintenance Costs

Annual Operation and Maintenance (O&M) costs are based on percentages of capital cost as per Supporting Report No. 3, *Guidelines for Feasibility Stage Sizing and Costing,* and are calculated as follows:

- 0.5% of pipeline capital cost per annum.
- 4% of the electrical and mechanical installation of a pump station per annum.
- 15% of the initial capital cost of pump and motors every 15 years for major overhaul.
- 0.25% of the capital cost of civil structures, including the civil portion of pump stations per annum.
- Apart from the capital investment every 15 years on mechanical components, the cost of replacement infrastructure, land acquisition, design and supervision fees were excluded from the calculated O&M costs.
- Electricity costs were based on the Megaflex tariff structure.
- The raw water cost was based on a rate of R2.00 / m^3.

Table 9-2 summarise the annual operation and maintenance costs, when the scheme is operating at maximum capacity (2030), excluding overhaul costs of pump stations and VAT.

Table 9-2: Annual Operation and Maintenance Costs

Component	Total (R)
New Pump Station	
- Civil	141 000
- Mechanical & Electrical	2 462 000
- Electricity Cost (from 2015)	14 131 000
New Rising Main	376 000
New Gravity Mains	
- 1900mm diameter	223 000
- 1100mm diameter	3 012 000
- 1000mm diameter	1 339 000
- 900mm diameter	665 000
- 800mm diameter	120 000
Raw Water Cost (from 2015)	58 571 000
Existing Exxaro Pump Station	
- Civil	6 000
- Mechanical & Electrical	223 000
Exisiting Exxaro Pipeline	165 000
TOTAL	**81 434 000**

9.3. Present Value of Cost

The present value calculations for the proposed Phase 1 Mokolo Dam Transfer Scheme infrastructure are included in **Appendix F** and summarised in **Table 9-3** below.

A redemption period of 45 years after completion of construction of Phases was used for all components, including mechanical and electrical components. Costs were discounted to 2008.

The cash flows of expenditure and Operation and Maintenance were based on the Programme for Implementation given in **Appendix G**.

Table 9-3: Summary of Discounted Present Values of Rates

Discount Rate	Capital (R)	O & M (R)	Total (R)
6%	1 407 195 000	1 096 257 000	2 503 452 000
8%	1 340 098 000	818 483 000	2 158 581 000
10%	1 277 789 000	635 838 000	1 913 627 000

* Cost at April 2008 prices

9.4. Unit Reference Values

The URV of water is not the tariff for the water, but the value attached to the water so that the discounted present value of the water is equal to the discounted present value of the cost.

The URV of water has been determined for a discount rate of 6%, 8% and 10% and is based on water transferred to the demand centres for a 45-year period. The URVs for the proposed Phase 1 Mokolo Dam Transfer Scheme infrastructure are indicated in **Table 9-4** and exclude VAT.

Table 9-4: Unit Reference Values

Discount Rate	Discounted Present Value of Water @ R1/m^3	Discounted Present Value (R)	Unit Reference Value (R/m^3)
6%	389.34	2 503 452 000	6.430
8%	291.18	2 158 582 000	7.413
10%	266.57	1 913 627 000	8.446

* Cost at April 2008 prices

Refer to **Appendix F** for the economic analysis, as well as the cost models of each component. All discounting was done to 2008 and over a period of 45 years after completion of construction of Phase 1.

10. PROGRAMME OF IMPLEMENTATION

The prospective beneficiaries of the Mokolo and Crocodile River (West) Water Augmentation Project provided key dates indicating their water requirement timeframes.

- 1 September 2010 Start commissioning of Medupi Unit 6.
- 30 November 2011 Start construction of Mafuta 1 at Steenbokpan. Construction period approximately 3 years with full operation in 2016.
- 28 February 2011. Start commissioning of Medupi Unit 5 following 6 months after commissioning of Unit 6.
- 1 September 2011 Medupi Unit 6 is commercial, 12 months after start of commissioning.
- 28 February 2012 Medupi Unit 5 is commercial, 12 months after start of commissioning.

From the above key dates, water should be available at Medupi, not later than 1 September 2010 and at Steenbokpan, not later than 30 November 2011. The design and construction of the Phase 1 Mokolo Dam Transfer Scheme must therefore be programmed in order to meet these requirements.

The capacity of the existing infrastructure from the Wolvenfontein Reservoirs to Matimba T-Off will be sufficient until approximately February 2011 while the proposed completion date of the entire Phase 1 Mokolo Dam Transfer Scheme is only December 2011. Construction of the new pipeline from Mokolo Dam will therefore be programmed with interconnections to the existing pipeline to increase the flow capacity and allow sufficient time to construct the pump station and the rest of the Phase 1 infrastructure. The first 9 km section of the new 1 100 mm diameter pipeline from the Wolvenfontein Reservoirs towards Rietspruitnek will be installed first in order to be able to supply in the projected peak water requirement for December 2011. The capacity of the existing pump station is, however, sufficient until December 2011 as discussed in Section 4.2 of this report.

The programme attached in **Appendix G** indicates key events for the proposed project.

11. CONCLUSIONS AND RECOMMENDATION

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long-term industrial, commercial and domestic use.

The Mokolo Dam is considered to be the only viable source of water that can supply in the water requirements of the interim period until the Crocodile River (West) Transfer Scheme has been constructed, which is expected to be December 2014. The Mokolo Dam has a yield of 39.1 Million m^3/a at a recurrence interval of 1:200 years of which 10.4 Million m^3/a is allocated for irrigation. The remaining 28.7 Million m^3/a is available to supply and augment the water supplies of the Lephalale and Steenbokpan areas.

The maximum short-term interim water requirement to be supplied from the Mokolo Dam in 2014 is 53.4 Million m^3/a. The capacity of the existing infrastructure supplying water from the Mokolo Dam to Matimba is 14.7 Million m^3/a which means that infrastructure is required to supply the additional 38.7 Million m^3/a for the interim maximum water requirement from the Mokolo Dam.

The first date that water is required at the new Medupi Power Station is 1 September 2010, while Steenbokpan requires water not later than 30 November 2011. In order to meet the water requirements of the prospective users, the following should be implemented:

1. Construct a new pump station at the Mokolo Dam, which will be required to transfer 1502 ℓ/s of water from the dam to the existing balancing reservoir at Wolvenfontein from where it will gravitate to the consumers. This has been based on being able to supply the maximum of the following two sessions:

   - *The maximum interim requirement from Mokolo Dam:* 53,4 (Total volume of water transferred during 2014) – 14.7 (capacity of the existing pump station) = 38.7 Million m^3/a (2014) + 2% losses + 20% refill peak = 47,4 Million m^3/a = 1 502,1 ℓ/s.
   - *The sustainable long term requirement from Mokolo Dam*: 28,7 Million m^3/a + 20% refill peak = 34.4 Million m^3/a = 1 092 ℓ/s.

2. Upgrade the existing 33 kV power line feeding from the Waterberg sub-station to a 132 kV line and construct a new 132 kV line from Bulge River sub-station to Mokolo Dam to ensure a reliable supply to Mokolo Dam with adequate spare capacity.

3. Construct a new 900 mm diameter steel rising main with 8.0 mm standard wall thickness (Grade X42) from the Mokolo Dam pump station to the Wolvenfontein Reservoirs.

4. Construct a new 1 100 mm diameter steel pipeline with 7.0 mm standard wall thickness (Grade X42) from the Wolvenfontein Reservoirs to Rietspruitnek and a 1 000 mm diameter steel pipeline with 7.8 mm standard wall thickness (Grade X42) from Rietspruitnek to the Steenbokpan T-off. The capacity of the proposed gravity main should be 1 502 ℓ/s from Wolvenfontein Reservoirs to the Steenbokpan T-off.

5. Construct a new pipeline from the Steenbokpan T-off point to Steenbokpan. This section of pipeline has been tentatively sized to provide water for both the Phase 1 users between the Steenbokpan T-off and Steenbokpan and those that will eventually be supplied by the Crocodile River (West) Transfer Scheme on a permanent basis.

   - Steenbokpan T-off to Medupi T-off - 900 mm diameter steel pipeline (Grade X42).
   - Medupi T-off to CF 3&4 T-off - 900 mm diameter steel pipeline (Grade X42).
   - CF 3&4 T-off to Crocodile River (West) Transfer Scheme connection – 1 100 mm diameter steel pipeline (Grade X42).
   - Crocodile River (West) Transfer Scheme connection to Steenbokpan – 1 900 mm diameter steel pipeline (Grade X42).

6. The capacity of the existing pipeline from Wolvenfontein Reservoirs to Matimba will not be sufficient to supply in the water requirement until the Phase 1 Mokolo Dam Transfer Scheme is completed, with the restraining section being between Wolvenfontein Reservoirs and Rietspruitnek. The construction sequence of the new pipeline should therefore be programmed to first increase the capacity of the existing gravity section from Wolvenfontein Reservoir with interconnections to the new pipeline to Rietspruitnek. This will allow more time to construct the entire Phase 1 Mokolo Dam Transfer Scheme.

7. The philosophy employed in aligning the new pipelines was to stay as far as possible parallel to existing infrastructure such as roads, power lines and the existing pipeline belonging to Exxaro in order to minimise negative social and environmental impacts.

8. Water should be supplied to the termination points at Matimba, Medupi, CF 3&4 and Zeeland WTW. Due to the uncertainty regarding the exact location of the

Exxaro, Eskom and possibly Sasol users in the Steenbokpan area, only one other termination point has been allowed for at this stage, namely at Steenbokpan.

9. An 18-day storage capacity Terminal Reservoir will have to be provided by the users at each termination point of Exxaro, Eskom and Sasol to ensure the prescribed reliability for the MCWAP.

10. The water from the Mokolo Dam is of a much better quality than that from the Crocodile River (West). It is therefore necessary to design and operate the MCWAP system in such a way that the water from the two sources does not mix during normal operation.

11. Operating rules for the MCWAP should be developed during the detail design stage of the project.

12. As agreed by the stakeholders, the design philosophy of the scheme is that the Crocodile River (West) will not provide redundancy to users at Zeeland WTW and that the Mokolo Dam will not provide redundancy to users at Steenbokpan.

13. It is envisaged that the entire existing pipeline will be refurbishment in 2015 after commissioning of the Crocodile River (West) Transfer Scheme. There will thus be sufficient capacity through the new pipeline to completely take out the existing pipeline for refurbishment.

14. During the operation phase, the land preparation and construction of the pipeline would have removed vegetation, increased surface run-off, created erosion, etc. The necessary management procedures need to be put in place and implemented so that the negative impacts can be reduced.

15. It is recommended that the Phase 1 Mokolo Dam Transfer Scheme be implemented as a matter of urgency.

APPENDIX A

LOCALITY MAP AND LAYOUT PLAN

APPENDIX B

WATER REQUIREMENTS

APPENDIX C

SCHEMATIC OF TRANSFER SCHEME – PHASE 1

APPENDIX D

EXISTING MOKOLO DAM GRAVITY MAIN – LONGITUDINAL SECTIONS AND HYDRAULIC GRADE LINES

APPENDIX E

GEOTECHNICAL EVALUATION

MOKOLO TRANSFER ROUTE: FIRST GEOTECHNICAL EVALUATION																		
Node*	30 to 31									31 to 32								
Pipe section	1									2								
km start	0	1	4	0	2.4	3.8	4.9	5.6	6.5	7.6	8.3	10.4	10.7	13.4	16.7	17.2	18.3	19.4
km end	1	4	5.2	2.4	3.8	4.9	5.6	6.5	7.6	8.3	10.4	10.7	13.4	16.7	17.2	18.3	19.4	20.3
Geology	Msm**	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm
Depth to hard (m)	1	0	0.5	0.5	2.5	0.5	1	3	1	0	2	1	1.5	0	1	2	0	2
% of soft reusable	50	0	100	100	80	100	100	50	50	0	75	100	65	0	50	100	0	100
Sideslopes (1: H)	0.5	0	0	0	1	0	0.5	1.5	0	0	1	0.5	0.5	0	0	1	0	1
Bedding and backfill haul (km)	1	3	2	1.5	1	1.5	2	2	4	4	3	3	2	7	1	1	2	1
Comments	May locate BP near river		May locate BP near Wolve'f dams		May locate BP on this section			Vlei area, high water table				Vlei area						

* Shown on Drawing No. WP9528/LD/MTS/002/B in Appendix A

** Mogalakwena Formation

Nodes*	32 to 33			33 to 34		34 to 35			35 to 36	36 to 37	37 to 38
Pipe Section	3			4		5			6	7	8
km start	0	0.3	1.5	0	1.1	0	0.3	0.6	0	0	0
km end	0.3	1.5	6.5	1.1	1.3	0.3	0.6	1	3.5	3.9	7.8
Geology	Msm**	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Msm	Ecca
Depth to hard (m)	2	0	2	2	0.5	0.5	1	2	2	2	2
% of soft reusable	100	0	100	100	50	100	100	100	100	100	100
Sideslopes (1: H)	1	0	1	1	0	0	0	1	1	1	1
Bedding and backfill haul (km)	1	1.5	1	1	1	1	1	1	1	1	1
Comments										Passes Matimba ash dump, seepage and corrosion	

* Shown on Drawing No. WP9528/LD/MTS/002/B in Appendix A

** Mogalakwena Formation

STEENBOKPAN LINK: FIRST GEOTECHNICAL EVALUATION					
Nodes*	37 to 38	37 to 39	39 to 45	45 to 52	52 to 46
Pipe Section	8	14	24	25A	25B
km start	0	0	0	0	0
km end	7.8	7.8	14.9	8.7	4.9
Geology	Ecca	Ecca	Ecca	Ecca	Ecca
Depth to hard (m)	2	2	2	2	2
% of soft reusable	100	75	75	100	100
Sideslopes (1: H)	1	1	1	1	1
Bedding and backfill haul (km)	1	2	2	2	2
Comments			Blanketed by sands		

* Shown on Drawing No. WP9528/LD/MTS/002/B in Appendix A

APPENDIX F

COST ESTIMATES

APPENDIX G

PROGRAMME FOR IMPLEMENTATION

APPENDIX H

DRAWINGS

REPORT DETAILS PAGE

Project name:	***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)***
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