MANGAUNG
METRO MUNICIPALITY
METRO MUNISIPALITEIT
LEKGOTLA LA MOTSE

DIRECTORATE
OFFICE OF THE
CITY MANAGER

Our Ref:	*Your Ref:*
Email: luvuyo.ntoyi@mangaung.co.za	Date: 5 March 2015

The Director General
Department of Water and Sanitation
Pretoria

Attention: Mr T. Ntili

AUGMENTATION OF BULK WATER SUPPLY FOR MANGAUNG METRO MUNICIPALITY

Mangaung Metro Municipality (MMM) has in consultation with DWS commenced with a pre-feasibility study to investigate the augmentation of the future bulk water supply to MMM from the Gariep Dam. In this study three water supply options were considered and it was clearly demonstrated that a direct route between Gariep Dam and Bloemfontein is the most cost effective and sustainable water supply option as indicated in the attached report.

MMM as Water Service Authority is responsible in terms of the Constitution of the Republic of South Africa, the Municipal Structures Act and the Water Services Act to ensure that water supply services are provided in an efficient, affordable, economical and sustained manner to its consumers. Clause 11 of the Water Services Act (108 of 1997) requires that “Every water services authority has a duty to all consumers or potential consumers in its area of jurisdiction to progressively ensure efficient, affordable, economical and sustainable access to water services”.

MMM is indeed prepared to honor its authority and responsibility to ensure that efficient, affordable, economical and sustainable access to water services to all consumers or potential consumers in its area of jurisdiction is provided. MMM has the necessary technical resources and administrative and political support to take a dedicated lead in ensuring that the required augmentation is done in the most efficient, affordable, economical and sustainable manner. However, we do not have the necessary direct control over the current bulk supply provided via the the Welbedacht Scheme and you are therefore kindly requested to ensure that Bloem Water is able to provide the necessary similarly efficient, affordable, economical and sustainable supply from the Welbedacht Scheme. Especially during the expected bulk supply shortfalls that are anticipated between now and until a proper augmentation scheme has been put in place.

Growing Need for Bulk Water

MMM has over the past few years experienced significant growth and as a result the ageing raw and potable water infrastructure were put under increased pressure. Subsequently we are effortlessly busy to address our water conservation and demand management program (WCDM) and addressing the re-use of a significant part of our our waste water outflow – all in accordance with the latest DWS Greater Bloemfontein Reconciliation Study.

Unfortunately both these programmes are going to take time. In the mean time we are going to be heavily dependent on a dedicated and continuous supply from Bloem Water. It is therefor of utmost importance that

Bloem Water must provide us with a complete plan as to how a a dedicated and continuous supply is going to be ensured.

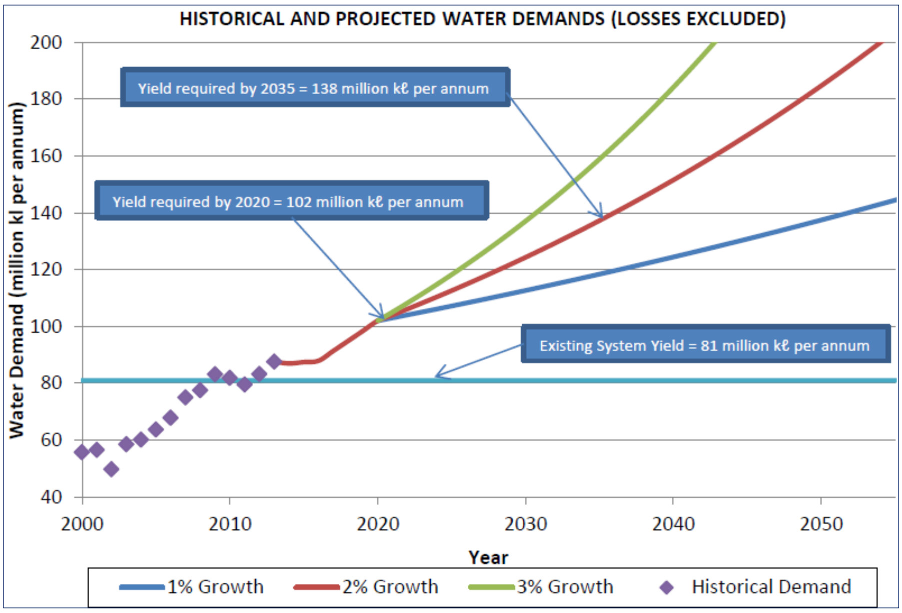

Figure 1: Historical and Projected Water Demand (Gariep Pre-Feasibility Study, 2014)

Figure 1 illustrates the demand growth which includes inter alia an active and successful Water Conservation and Demand Management (WCDM) program, increased demand as a result of the current housing developments to the south of Bloemfontein (Kaleb Motsabi, Hillside View and Vista Park) as well as additional resources required to eradicate all VIP systems in the Metro (including Thaba Nchu and Botshabelo).

By establishing water balance of the regional water supply and demand it is clear that the current peak water demand already exceeds the total treatment capacity available. Urgent steps therefore need to be made to conserve and expand the water and sanitation systems.

Water Conservation and Water Demand Management

WCDM is considered as an absolute priority to ensure the sustainability of any water and sanitation system. To this end a 10 year WCDM strategy was developed. A number of opportunities were identified where MMM can reduce the system input volume, real losses and unaccounted for water. These initiatives are being implemented through various leak repair programs, old pipeline replacement program, pressure zoning and associated leak reduction, totaling approximately R152 million worth investment per year over the next 6 years.

Water Re-Use Initiatives from Local Resources

MMM operates a number of effluent treatment plants into which most of the effluent drains into the Renoster Spruit. MMM has identified significant water re-use potential by diverting the effluent from the Renoster Spruit to the Modder River upstream of Mockes Dam. This can in the short to medium term reduce the transfers required from Rustfontein dam by as much as 40Ml/d. MMM is currently in the process to implement a water re-use transfer systems and the upgrading of the Maselspoort Water Treatment Works to allow for such re-use.

Integrated Water Resource Planning and Reconciliation Study

The current Greater Bloemfontein Reconciliation Study, done by DWS indicates water re-use as a last resort to augment the bulk water systems to MMM. MMM took the initiative to utilize the local resources first because of economic advantages and later augmented by external bulk sources. At a meeting between MMM and DWS officials on 18 November 2014, DWS agreed to this principle and agreed to update the Greater Bloemfontein Reconciliation Study to reflect this principle.

Apart from the renewed focus on water re-use, integrated water resource planning can only commence once all the water resources have been identified on a regional basis. It came to our attention that Bloem Water is planning to implement certain bulk infrastructure in the near future that could have a direct negative impact on the Gariep augmentation project.

In Conclusion

Based on the background provided and the recent actions by Bloem Water and DWS we again wish to express our concerns:

- That the responsibilities and authority of MMM as a Water Services Authority is not acknowledged by allowing the Water Services Provider to continue with uncoordinated bulk water studies and upgrades, like the duplication in work on the Gariep pipeline while a complete plan as to how a dedicated and continuous bulk water supply to MMM is going to be ensured, is not properly attended to
- That the upgrading of Rustfontein WTW and replacement of the pipeline between Rustfontein and Bloemfontein receives priority from Bloem Water and DWS while this very expensive projects could proof to be unnecessary expenditures should Gariep materialize.
- DWS is therefore kindly requested to inform Bloem Water that all planned capacity upgrade programs associated with construction activities be halted until the Gariep feasibility study has been concluded, in order to establish the most appropriate option for the consumers in MMM. The feasibility study is estimated to be completed by end of May 2015.
- You are further kindly requested to instruct Bloem Water to engage with MMM on all aspects of planning that could potentially impact on the additional cost to the consumer. All options must be fairly evaluated based on acceptable costing models to allow informed and cost effective decisions. We therefore respectively request that Bloem Water refrain from such unilateral decisions until sufficient consultation and information is made available to MMM to assess its merit and necessity thereof.
- The Greater Bloemfontein Reconciliation Study study needs to be updated to recognize local water re-use as a higher priority source than what is currently the position as agreed at a meeting held between MMM and DWS on 18 November 2014. MMM can assist DWS in revising the Reconciliation Study with appropriate information on water re-use potential and cost.
- The Services Agreement between MMM and Bloem Water needs urgent revision to allow maximum water re-use. DWS assistance is required by MMM in re-negotiating the Bloem Water supply agreement.

Mr L Ntoyi
Head: Engineering Services

05/03/2015
Date

Ms S Mazibuko
City Manager

05/03/15
Date

Mangaung Metro Municipality

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WATER SUPPLY AUGMENTATION TO THE GREATER BLOEMFONTEIN AREA FROM THE ORANGE RIVER

ASSESSMENT OF POTENTIAL BULK WATER SUPPLY SCHEMES

MARCH 2015

DRAFT

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ABBREVIATIONS AND ACRONYMS

AADD	Average Annual Daily Demand
BEPP	Built Environment Performance Plan
dia	diameter
DWA	Department of Water Affairs
FSL	Full supply level
h	hours
kℓ	kilolitres
km	kilometre
ℓ/s	litres per second
Mℓ	Megalitres
MMM	Mangaung Metropolitan Municipality
m	meter
a.s.l.	above sea level
NB	Nominal Bore
NPV	Net Present Value
O&M	Operation and Maintenance
VIP	Ventilated Improved Pit Latrine
WC&WDM	Water Conservation and Water Demand Management
WRSS	Water Reconciliation Strategy Study
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

1. INTRODUCTION AND BACKGROUND

1.1 Purpose of the Study and Report

The Mangaung Metropolitan Municipality (MMM) water distribution area includes the Bloemfontein, Botshabelo and Thaba Nchu main centers. Severe water shortages have been experienced in the MMM water supply areas during recent years, especially during summer months.

The purpose of this assessment study is to establish the most attractive of three potential bulk water supply schemes from the Gariep Dam to augment water supply to the Greater Bloemfontein Area from the Orange River. As Water Service Authority, MMM is responsible in terms of the Constitution of the Republic of South Africa, the Municipal Structures Act and the Water Services Act to ensure water supply services are provided in an efficient, affordable and sustained manner to its consumers. MMM's objective is therefore

1.2 Scope of Study

This assessment study has been undertaken on a desk top basis with information and data that could readily be obtained. The study includes the following:

- Summary of available water resources (system yield determined previously)
- Summary of water demand projections with proposed capacity for infrastructure extensions (determined previously)
- Conceptual design of three alternative augmentation schemes with capital cost estimates.
- Comparison of alternative augmentation schemes

The study is focused on the Gariep Dam as a surface water source to supplement supply to the Greater Bloemfontein Area.

1.3 Related Reports and Studies

The following studies and reports have been reviewed during the preparation of this report:

- Water Reconciliation Strategy Study (WRSS) for the Large Bulk Water Supply Systems: Greater Bloemfontein Area by DWS dated June 2012. Two of the five study reports have been reviewed during the preparation of this assessment report.
- Bulk Water Supply to the Greater Bloemfontein Area from Gariep Dam: Pre-Feasibility Study by MMM dated July 2014.
- Accelerated Action Plan to Augment Bloemfontein's Water Supply by DWS dated August 2014.
- Pre-Feasibility Investigation: Investigation for a Pipeline from Gariep Dam to Knellpoort Dam, including Alternative Options by Bloem Water. Report not dated.

Various potential water sources to supplement water supply to the Greater Bloemfontein Area have been considered in the above reports. This assessment report is focused on augmentation of bulk water supply to the Greater Bloemfontein Area from the Gariep Dam. The options that are assessed have been identified from the above reports.

2. WATER RESOURCES

2.1 Historical Yield of Existing Surface Water Sources

The WRSS Report prepared by DWA includes detail on the availability and scarcity of raw water in the region and further exploitation of sources that could be pursued. Based on information provided in the WRSS Report, an assessment of the adequacy of the existing raw water sources for the Greater Bloemfontein area was provided in the pre-feasibility study report (Bulk Water Supply to the Greater Bloemfontein Area from Gariep Dam) dated July 2014. Information from the pre-feasibility study report is summarized in the following paragraphs.

The yield of the system supplying the Greater Bloemfontein area and small towns along the route of the Welbedacht-Bloemfontein pipeline is indicated as 84 million kℓ per annum (230 Mℓ per day). The yield is made up as follows:

- Groothoek Dam 3 million kℓ per annum (8,2 Mℓ per day)
- Rustfontein-Mockes Dam subsystem 8 million kℓ per annum (21,9 Mℓ per day)
- Caledon transfer system 89 million kℓ per annum (243,8 Mℓ per day)
- Adjustment to system[1] -16 million kℓ per annum (-43,8 Mℓ per day)
- **Combined yield 84 million kℓ per annum (230 Mℓ per day)**

[1] Referred to in WRSS as adjustment of the system to incorporate recent operating information and hydrology.

The combined yield needs to be reduced with 1 million kℓ per annum and 2 million kℓ per annum to respectively accommodate the impact of the Metolong Dam and Environmental Water Requirements. The remaining yield is therefore 81 million kℓ per annum (222 Mℓ per day).

As indicated in the WRSS Report, smaller towns account for approximately 4% of water supplied by Bloem Water which leaves 78 million kℓ per annum (213,7 Mℓ per day) for the Greater Bloemfontein area.

The total volume of water supplied to Bloemfontein, Botshabelo and Thaba Nchu by Bloem Water during the 2013 calendar year amounted to 88 million kℓ (241 Mℓ per day) which exceeds the yield available to the Greater Bloemfontein area by approximately 13%. Severe water shortages were experienced in the Bloemfontein supply area during 2013 and had shortages not been encountered, the volume supplied during 2013 would have been more than 88 million kℓ (241 Mℓ per day) and would thus have resulted in a shortfall in excess of 13%. The following should however also be borne in mind:

- The Groothoek Dam is virtually empty and currently provides no or little yield towards the system.
- Environmental Water Requirements may not have been implemented yet
- Although sold by Bloem Water as raw water supplied to Maselspoort, a portion of the water treated at Maselspoort is from indirect reuse (treated sewage effluent from Botshabelo and Thaba Nchu) and therefore does not impact on the available yield from the Caledon and Modder sub-systems.

Based on the above assessment it is concluded that insufficient yield is available from existing surface water sources to meet the current and future water demand of the Greater Bloemfontein Area.

3. WATER DEMAND

Historic and projected future water consumption in the Greater Bloemfontein Area have been considered in the pre-feasibility study report (Bulk Water Supply to the Greater Bloemfontein Area from Gariep Dam) dated July 2014. The impact of water conservation and water demand management initiatives, new developments and the eradication of VIP's on water demand in the Bloemfontein area was taken into consideration in the pre-feasibility study report. Information from the pre-feasibility study report is summarized in the following paragraphs.

Projected average daily and 7-day peak demands are reflected in **Figure 3**. Average daily demand includes for 8% bulk supply system losses so as to reflect the volume of water to be supplied to the water distribution systems. Water treatment plant losses were not taken into consideration.

A peak factor of 1.5 was adopted for 7-day sustained peak demands.

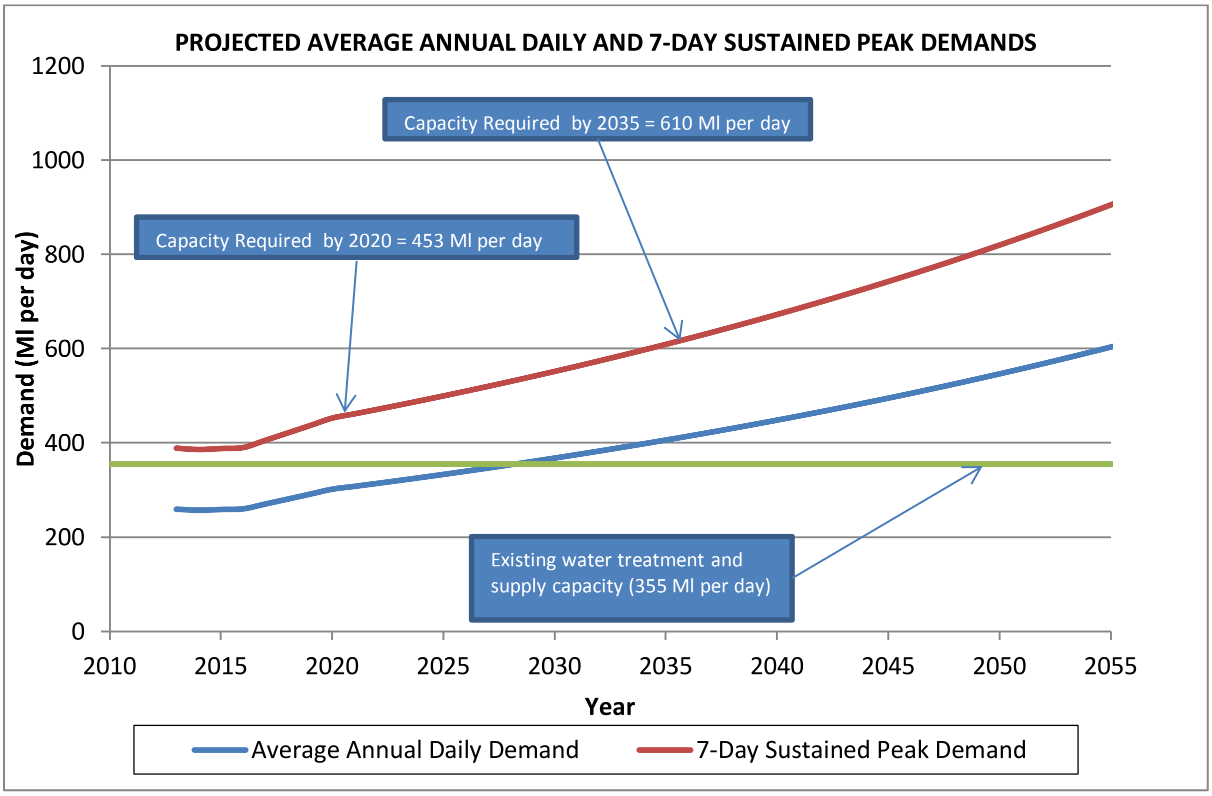

Figure 3: Projected Average Annual Daily and 7-Day Sustained Peak Demands for the Greater Bloemfontein Area

Projected water demands, resource yield requirements and bulk water infrastructure capacity requirements are summarized in **Table 3** below. The extent to which current and projected future water demand exceed the resource yield is summarized and the shortfall in water treatment and supply infrastructure capacity to meet 7-day sustained peak demands are also illustrated in **Table 3**.

Table 3: Summary of Projected Water Demands, Resource Yield Requirements and Bulk Water Infrastructure Capacity Requirements

Year	Projected Water Demand (million kℓ per annum)	Shortfall in Existing Resource Yield (million kℓ per annum)	Shortfall in Existing Resource Yield (Mℓ per day)	7-Day Sustained Peak Demand (Mℓ per day)	Shortfall in Infrastructure Capacity to Meet 7-Day Sustained Peak Demand (Mℓ per day)
2014	87	6	16,4	386	31
2020	102	21	57,5	453	98
2035	138	57	156	610	255

The current available yield is 81 million kl per annum (refer to **Section 3**). Existing water treatment plant and bulk supply system capacities for the Greater Bloemfontein Area amounts to 355 Mℓ per day (Groothoek excluded).

2035 was adopted as design horizon and based on the data included in **Table 3**, water supply augmentation from the Orange River to the Greater Bloemfontein area should cater for average annual daily demand of 170 Mℓ per day and peak demand of 255 Mℓ per day.

4. AUGMENTATION SCHEMES PROPOSED PREVIOUSLY

Section will be completed in future when the report is finalized.

5. ASSESSMENT OF POTENTIAL BULK WATER SUPPLY SCHEMES

Three potential bulk water supply schemes, to augment water supply from the Gariep Dam to Bloemfontein, are considered in the report i.e.:

- From the Gariep Dam to Bloemfontein, via the Knellpoort and Rustfontein Dams.
- From the Gariep Dam to Bloemfontein, via the Novo Outfall, Rustfontein Dam, Mockes Dam and Maselspoort Dam.
- From the Gariep Dam directly to Bloemfontein.

Refer to **Figure 5** for layouts of the three schemes.

The criteria applied with the conceptual designs and assessments are provided in **Section 6**. The conceptual designs and cost estimates for the three schemes are provided in **Section 7** to **Section 9**. Various parameters are compared in **Section 10** for each of the schemes.

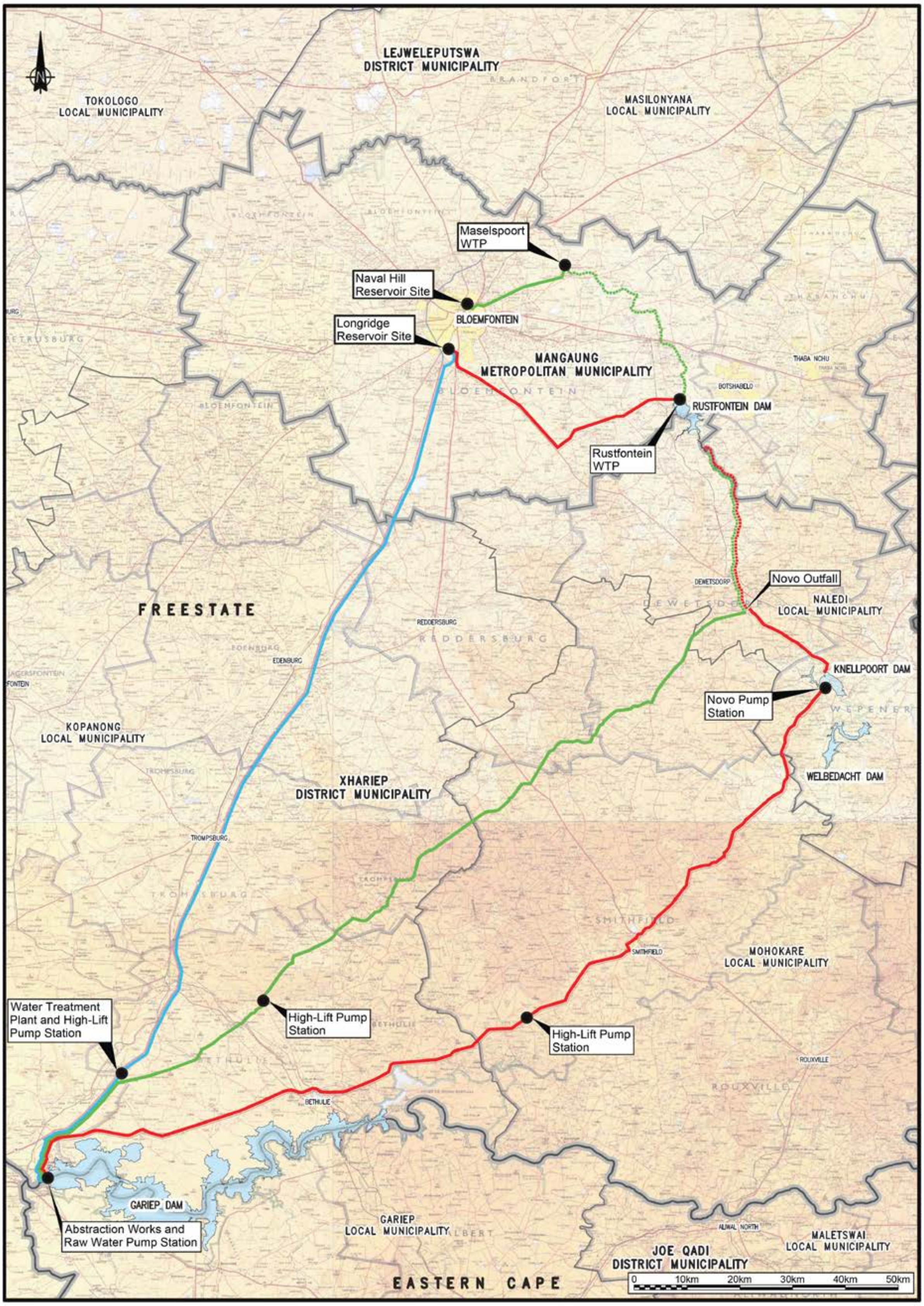

Figure 5: Layout of Potential Bulk Water Supply Schemes

6. CRITERIA APPLIED WITH CONCEPTUAL DESIGN AND ASSESSMENTS

The objective with implementing any of the three bulk water supply schemes is to augment water supply to Bloemfontein. All components required from water source to Bloemfontein are therefore included in the assessment toachieve a realistic comparison.

The following criteria have been applied during the assessment:

- Each of the assessed schemes is sized for average annual daily demand of 170 Mℓ per day and peak demand of 255 Mℓ per day.

- A 22 hour supply period per day was adopted to make allowance for down time due to maintenance requirements and power supply interruptions that may occur from time to time.

- The following flow velocities have been adopted:
  - Rising mains – 1,1 m/s at average flow (dictated by energy costs)
  - Gravity mains – maximum of 3 m/s

- The following hydraulic design parameters have been adopted:
  - Colebrook White roughness of 0,2 mm
  - Secondary losses in pipelines of k=0,5 per kilometre of pipeline

- Pipeline route selection was based on 1:50 000 topographical maps with contour lines at 20 m height intervals.

- Operating pressures in the various pipelines will be relatively high and steel piping was therefore adopted for the purposes of this study.

- Raw water losses as reflected in **Table 6** below have been allowed for.

Table 6: Raw Water Losses associated with Water Treatment Plants, various Dams and sections of the Modder River

Description of Losses	Extent of Losses
Losses at Water Treatment Plants	5% at average flow
Conveyance Losses in Knellpoort Dam	5% at average flow
Conveyance Losses from Knellpoort Dam to Rustfontein Dam	17 % at average flow
Conveyance Losses from Rustfontein Dam to Maselspoort Dam	5% at average flow

7. CONCEPTUAL DESIGN AND COST ESTIMATES FOR GARIEP – KNELLPOORT – RUSTFONTEIN - BLOEMFONTEIN SCHEME

7.1 Description of Main Project Components

A bulk water supply system to augment water supply from the Gariep Dam to Bloemfontein, via the Knellpoort and Rustfontein Dams, will require the following main project components:

- Raw water transfer system from Gariep Dam to Knellpoort Dam
  - Raw water pump station downstream from the Gariep Dam
  - Raw water pipeline and associated infrastructure to transfer raw water from the Gariep Dam to the Knellpoort Dam
  - One or more high lift pump stations located along the raw water pipeline route
- Extensions to the Novo Transfer Scheme
  - Raw water pump station at Knellpoort Dam
  - Raw water pipeline and associated infrastructure to transfer raw water from the Knellpoort Dam to the Novo Outfall in the Modder River
  - Outlet structure at the Novo Outfall
- Extensions to the water transfer and treatment systems at Rustfontein Dam to supply potable water to Bloemfontein
  - Raw water pump station at the Rustfontein Dam
  - Raw water pipeline to transfer raw water from Rustfontein Dam to the water treatment plant
  - Water treatment plant located next to the existing water treatment plant
  - High lift pump station downstream from the water treatment plant
  - Potable water pipeline and associated infrastructure to transfer potable water from Rustfontein to Bloemfontein
  - A reservoir to receive potable water at Bloemfontein

A desk top study of the above project components has been undertaken and more detail of the various components is provided in **Section 7.1** to **Section 7.10**. A preliminary scheme layout is reflected in **Figure 5**.

7.2 Raw Water Abstraction from Various Dams

7.2.1 Gariep Dam

Raw water will be abstracted through the existing multi-level outlet through the Gariep Dam wall. The existing 84 inch (approximately 2 100 mm) diameter outlet pipeline for water supply to Bloemfontein will have more than sufficient capacity to cater for the proposed design capacity.

The outlet infrastructure in the dam wall has not been in operation since 1971 and the condition of the infrastructure should be assessed during a future feasibility study to establish the extent of refurbishment work that may be required to the infrastructure. The capital cost estimates include an estimated amount of R 75 million for potential refurbishment work to the dam outlet infrastructure.

7.2.2 Knellpoort Dam

The existing Novo pump station is located on the north western bank of the Knellpoort Dam. The existing pump station design allowed for four pump sets (three duty and one standby) to achieve the design capacity of the existing Novo Transfer System. The intake to the pump station is higher than the lowest draw down level of the dam and the full capacity of the Knellpoort Dam is therefore not available for the Novo Transfer Scheme.

The exiting pump station cannot accommodate additional pump sets to transfer an additional 2 700 ℓ/s from Gariep Dam. A new pump station structure and pumping equipment will thus be required to accommodate the flow from the Gariep Dam.

Various alternatives could be considered for the abstraction of raw water from the Knellpoort Dam. A conservative approach was adopted and allowance was made for an abstraction tower to be constructed on the bank of the Knellpoort Dam in the vicinity of the existing Novo pump station. Alternative options could be considered during further studies that may follow in future.

7.2.3 Rustfontein Dam

The existing raw water pump station at Rustfontein is located on the right bank of the dam wall. The site layout of the Rustfontein Water Treatment Plant allows for a 50 Mℓ per day future extension and it was assumed that the raw water pump station would have adequate space to accommodate pumping equipment for such future extension. The intakes of the existing vertical spindle axial flow raw water pumps is higher than the lowest draw down level of the dam and the full capacity of the Rustfontein Dam is therefore not available to the Rustfontein Water Treatment Plant.

The exiting pump station cannot accommodate additional pump sets to transfer an additional 3 400 ℓ/s (at peak) to a new water treatment plant for water from Gariep Dam. A new pump station structure and pumping equipment will thus be required to accommodate the flow from the Gariep Dam.

Various alternatives could be considered for the abstraction of additional raw water from the Rustfontein Dam. A conservative approach was adopted and allowance was made for an abstraction tower to be constructed on the north eastern bank of the Rustfontein Dam in the vicinity of the existing raw water pump station. Alternative options could be considered during further studies that may follow in future.

7.3 Pipeline Routes, Vertical Alignments and Lengths

7.3.1 Gariep Dam to Knellpoort Dam

A preliminary scheme layout is reflected in **Figure 5**.

A straight line between the Gariep Dam wall and the Knellpoort Dam would approximately follow Road R701. A pipeline route along the Road R701 would be favourable from a pipeline length, mitigation of environmental and social impacts and accessibility perspectives. This pipeline route will however cross a water shed at an elevation higher than the Knellpoort Dam at approximate chainage 178 km.

An alternative pipeline route, from approximately chainage 147 km to the Knellpoort Dam, was investigated to avoid crossing the water shed at an altitude higher than the Knellpoort Dam. The route would have to deviate from Road R701 (approximately from chainage 147 km) towards the south west to follow the Caledon River valley. This route will be substantially longer than the route along Road R701. The last section of the route would have to be constructed along the Caledon River valley and the bank of the Welbedacht Dam to avoid altitudes higher than the Knellpoort Dam. Environmental and social impacts associated with this route are expected to be substantially more severe and construction costs are likely to be substantially higher.

The pipeline route along Road R701 was adopted for conceptual design purposes. The route starts at the termination point of the existing outlet pipe from the Gariep Dam and follows Road R701 for approximately 182 km. The last 7 km of the route deviates from the Road 701 though farm land towards the south western bank of the Knellpoort Dam.

The length of the selected pipeline route is approximately 189 km.

7.3.2 Knellpoort Dam to Novo Outlet

The route of the existing Novo Transfer Pipeline was adopted as pipeline route for the transfer of water from the Knellpoort Dam to the Modder River catchment. From the Knellpoort Dam a route towards the north through farm land is followed for approximately 3 km. The route then follows a provincial road for approximately 11,4 km in a north western direction. A water shed is crossed at this location (approximate chainage 14,4 km). The route then continues in a north western direction through farm land and along a provincial road for a further 6 km to the outfall in the Modder River.

The length of this pipeline is approximately 20,4 km.

A break pressure tank will be required at the water shed and an additional outlet structure will be required where the water will be discharged into the Modder River.

7.3.3 Rustfontein Dam to Bloemfontein

The routes of the existing raw and potable water pipelines were adopted for the transfer of water from Rustfontein to Bloemfontein. It was assumed that the water treatment plant will be located to the east of the Rustfontein Dam (next to the existing) and the raw water pipeline route will therefore follow a route towards the east of the dam. The potable water pipeline from Rustfontein to Bloemfontein follows a route to the south-west through farm land over a distance of approximately 25 km up to Road R702. The route then follows Road R 702 for approximately 10 km in a north western direction. The route then deviates from Road R702 in a north western direction through farm land over a distance of 11 km and run parallel to Church Street for 2,5km. At Road N6 the route deviates from the existing route and follows Road N6 in a northern direction over a distance of approximately 2,5 km. The route then deviates from Road N6 towards the north west though farm land over a distance of approximately 2,5 km up to the Longridge reservoir site.

The existing raw and potable water pipelines are respectively approximately 300 m and 53,6 km long and these lengths were adopted for conceptual design purposes.

7.4 Design Flows

As indicated in **Section 3**, the augmentation project from the Gariep Dam is based on a capacity of 255 Mℓ per day to cater for the 7-day sustained peak demand projected for 2035. A peak factor of 1,5 was adopted with demand projections in this report and the average annual daily demand will therefore be 170 Mℓ per day for 2035. The average and peak flows applicable to each of the various scheme components were calculated based on the criteria provided in **Section 6** and are summarized in **Table 7.4** below.

Table 7.4: Design Capacities

Water Treatment Plant and High Lift Pump Station at Rustfontein and Potable Water Pipeline from Rustfontein to Bloemfontein

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
170	24	1 968
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
255	22	3 220

Raw Water Pump Station at Rustfontein Dam and Raw Water Pipeline from Rustfontein Dam to Water Treatment Plant (5% Water Treatment Plant Losses Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
179	24	2 066
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
268	22	3 381

Raw Water Pump Station at Knellpoort Dam and Raw Water Pipeline from Knellpoort Dam to Novo Outfall (5% Rustfontein Water Treatment Plant Losses and 17% Losses for Novo Pipeline to Rustfontein Dam Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
209	24	2 417
Peak Capacity		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
209	22	2 637

Raw Water Pump Station at Gariep Dam and Raw Water Pipeline from Gariep Dam to Knellpoort Dam (5% Rustfontein Water Treatment Plant Losses, 17% Losses for Novo Pipeline to Rustfontein Dam and 5% Losses in Knellpoort Dam Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
219	24	2 538
Peak Capacity		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
219	22	2 769

7.5 Adopted Pipeline Diameters and Flow Velocities

Diameters for the various pipelines were calculated based on the criteria provided in **Section 6**. Adopted pipeline diameters and flow velocities for the various pipelines are reflected in **Table 7.5** for average and peak flows. “Standard” pipe outside diameter dimensions and nominal wall thicknesses were adopted with the calculation of velocities.

Table 7.5: Adopted Pipeline Diameters and Flow Velocities

Pipeline Description	Adopted Pipeline Diameter (mm)	Average Flow		Peak Flow	
		Flow Rate (ℓ/s)	Flow Velocity (m/s)	Flow Rate (ℓ/s)	Flow Velocity (m/s)
Rustfontein to Bloemfontein	1500	1968	1,1	3220	1,8
Rustfontein Dam to Treatment Plant	1500	2066	1,1	3381	1,8
Knellpoort Dam to Novo Outlet	1700	2417	1,1	2637	1,2
Gariep Dam to Knellpoort Dam	1700	2538	1,1	2769	1,2

The optimum diameters will need to be confirmed during further assessments and optimization studies that may be required to confirm the feasibility of the scheme.

7.6 Hydraulic design

7.6.1 Static Heads

Static heads adopted for conceptual design calculations are summarized in **Table 7.6.1** below.

Table 7.6.1: Adopted Water Levels and Static Heads

Description of Structure, Feature or Dam	Adopted Water Level or Static Head
Longridge Reservoir	1 478 m a.s.l.
Rustfontein Potable Water Reservoir	1 367 m a.s.l.
Static Head (Potable Water Supply System to Bloemfontein)	111 m
Rustfontein WTP Inlet Chamber	1 378 m a.s.l.
Rustfontein Dam	1 368 m a.s.l.
Static Head (Rustfontein Raw Water Supply System)	10 m
Novo Break Pressure Tank (water shed at chainage 14 400 m)	1 583 m a.s.l.
Knellpoort Dam	1 445 m a.s.l.
Static Head (Knellpoort to Novo Outlet)	138 m
Break Pressure Tank (water shed at chainage 178 km)	1 580 m a.s.l.
Pump Station No 2 (at chainage 100 km)	1 460 m a.s.l.
Static Head (Gariep to Knellpoort, System No 2)	120 m
Pump Station No 2 (at chainage 100 km)	1 460 m a.s.l.
Gariep Dam (Pump Station No 1)	1 255 m a.s.l.
Static Head (Gariep to Knellpoort, System No 1)	205 m

7.6.2 Hydraulic Gradients

The hydraulic gradient for the supply system from Gariep Dam to Knellpoort Dam using a 1700 mm diameter rising main and two pump stations is shown in **Figure 7.6.2.1** below and are based on peak flow of 2 770 ℓ/s. The diameter of the gravity main is 1200 mm (chainage 178 km to Knellpoort Dam). Lower and varying flow rates will require further assessment during further studies that may follow in future.

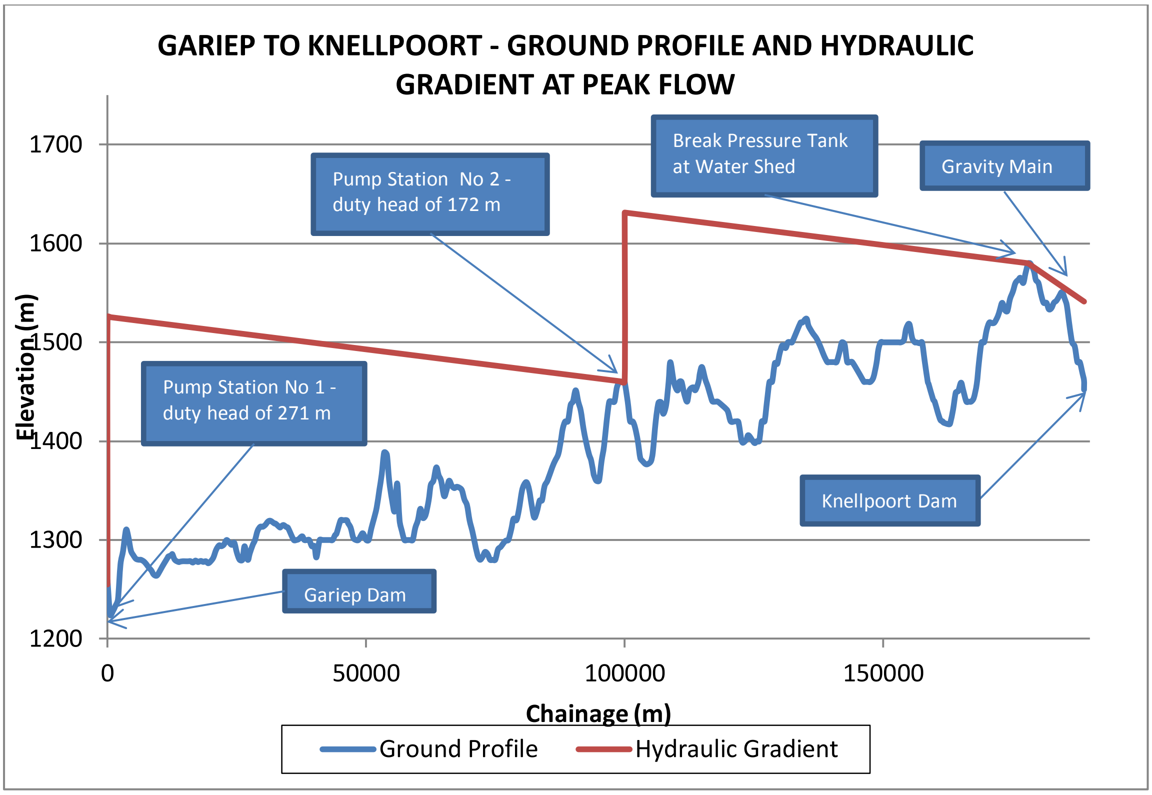

Figure 7.6.2.1: Gariep to Knellpoort - Ground Profile and Hydraulic Gradient based on 1700 mm Diameter Rising Main and two Pump Stations (Peak Flow)

The hydraulic gradient for the supply system from Knellpoort Dam to the Longridge Reservoirs in Bloemfontein using 1700 mm (Knellpoort Dam to Novo Break Pressure Tank) and 1500 mm (Rustfontein to Bloemfontein) diameter rising mains and three pump stations is shown in **Figure 7.6.2.2** below and are based on the peak flow applicable to each component. The diameter of the gravity main is 1200 mm (from Novo break pressure tank to Novo outfall). Lower and varying flow rates will require further assessment during further studies that may follow in future.

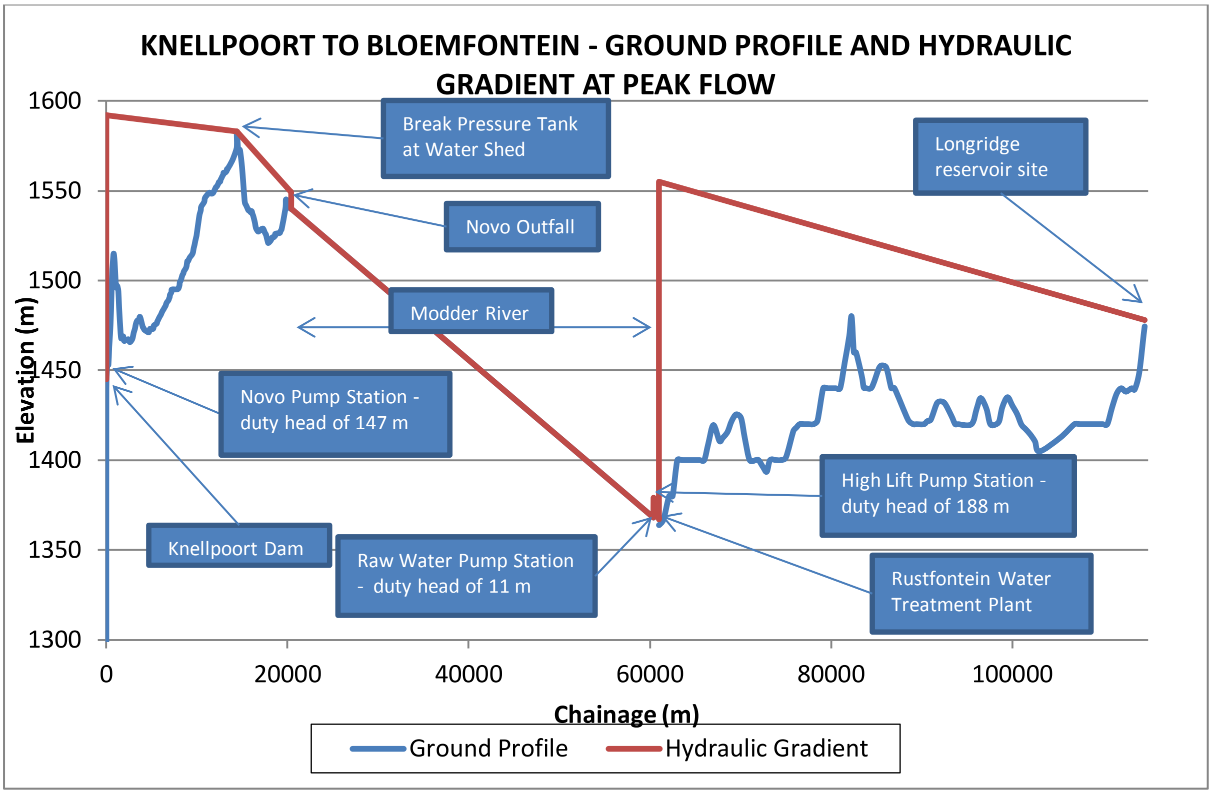

Figure 7.6.2.2: Knellpoort to Bloemfontein - Ground Profile and Hydraulic Gradient at Peak Flow

Pumping heads for the various pump stations, at average and peak flows, are summarized in **Table 7.6.2** below.

Table 7.6.2: Pumping Heads at Average and Peak Flows

Pump Station Description	Pumping Head	
	Average Flow	Peak Flow
Gariep to Knellpoort – Pump Station No 1	260 m	271 m
Gariep to Knellpoort – Pump Station No 2	163 m	171 m
Knellpoort To Novo Outlet	145 m	147 m
Rustfontein Raw Water	10 m	11 m
Rustfontein High Lift	140 m	188 m
TOTAL	**718 m**	**788 m**

7.6.3 Required Pipeline Wall Thicknesses and Grade of Steel

Maximum working pressures and required pipe wall thicknesses for the various pipelines are provided in **Table 7.6.3** below.

Table 7.6.3: Maximum Working Pressures, Required Wall Thicknesses and Steel Grade

Pipe Section (chainage)	Pipe Diameter (mm)	Maximum Working Pressure (m)	Required Wall Thickness (mm) and Steel Grade
Gariep to Knellpoort			
CH 0 km to CH 3 km	1 700 mm	301 m	15 mm, Grade X52
CH 3 km to CH 20 km	1 700 mm	256 m	12 mm, Grade X52
CH 20 km to CH 100 km	1 700 mm	230 m	11.5 mm, both Grades X42 and X52
CH 100 km to CH 105 km	1 700 mm	252 m	12 mm Grade X52
CH 105 km to CH 178 km	1 700 mm	240 m	11.5 mm, both Grades X42 and X52
CH 178 km to CH 189 km	1 200 mm	90 m	8 mm Grade X42
Knellpoort to Novo Outfall			
CH 0 km to CH 14,4 km	1 700 mm	152 m	11.5 mm Grade X42
CH 14,4 km to CH 20,4 km	1 100 mm	43 m	7,5 mm Grade X42
Rustfontein Dam to Water Treatment Plant			
CH 0 km to CH 0,3 km	1 500 mm	11 m	10 mm Grade X42
Water Treatment Plant to Bloemfontein			
CH 0 km to CH 53,6 km	1 500 mm	191 m	10 mm Grades X42 and X52

As reflected in **Table 7.6.3** above, the majority of the pipeline will require minimum wall thicknesses i.e. maximum D/t ratio of approximately 150. Thicker walls will only be required between chainage 0 km to chainage 20 km and between chainage 100 km and chainage 105 km along the Gariep – Knellpoort pipeline. Steel grades higher than grade X52 could be considered for these high pressure sections of the pipeline during further studies that may be required.

7.6.4 Additional Pipeline Related Infrastructure

The following additional pipeline related infrastructure has been included for in the cost estimates:

- 2 Mℓ break pressure tank at chainage 178 km along the Gariep – Knellpoort pipeline
- 2 Mℓ break pressure tank at chainage 14,4 km along the Knellpoort – Novo Outlet pipeline
- Outlet structures at the Knellpoort Dam and Novo Outlet discharge points
- 5 Mℓ surge tank at chainage 21,5 km along the Rustfontein – Bloemfontein pipeline

7.7 Pump Stations

The characteristics adopted for the various pump stations are summarized in **Table 7.7** below for peak (duty) flow. Pumping power at average flows are also provided in **Table 7.7**.

Table 7.7: Pump Station Details

Description	Gariep - Knellpoort		Novo	Rustfontein	
	Number 1	Number 2		Raw Water	High Lift
Duty Flow (ℓ/s)	2 769	2 769	2 637	3 381	3 220
Duty Head (m)	271	172	147	11	188
Pump Efficiency (%)	85	85	85	85	85
Motor and Drive Efficiency (%)	94,5	94,5	94,5	94,5	94,5
Pumping Power at Duty (kW)	9 165	5 817	4 735	455	7 394
Spare Motor Capacity at Duty (%)[1]	20	20	20	20	20
Pumping Power including Margin (kW)	10 998	6 980	5 682	545	8 872
Number Off Duty Pumps in Parallel	3	3	3	3	3
Input Power of Individual Motors (kW)	3 700	2 400	1 900	200	3 000
Total Power of Installed Units (kW)	14 800	9 600	7 600	800	12 000
Variable Speed Drives Included	Yes	Yes	Yes	Yes	Yes
Pumping Power at Average Flow (kW)	8 075	5 062	4 290	263	3 375

[1] 10% required at run out, preliminary allowance of 20% at duty

Total pumping power required to transfer average flow amounts to 21 065 kW.

7.8 Water Treatment Plant

A conventional water treatment process with two stage settling has been allowed for in the cost estimates.

7.9 Reservoir at Longridge

A 30 Mℓ reservoir at Longridge has been allowed for in the cost estimates.

7.10 Capital Cost Estimate

The estimated construction costs for the various infrastructure components are summarized in **Table 7.10** below.

Table 7.10: Summary of Estimated Construction Costs

Component	Estimated Cost
Refurbishment of Gariep Dam Outlet and Suction Main	R 75 000 000
Gariep to Knellpoort – Pump Station No 1	R 235 000 000
Gariep to Knellpoort – Pump Station No 2	R 163 000 000
Gariep – Knellpoort 1 700 mm pipeline (CH 0km to CH 178 km)	R 3 946 000 000
Gariep – Knellpoort 1 200 mm pipeline (CH 178km to CH 189 km)	R 145 000 000
Pump Station at Knellpoort	R 139 000 000
Knellpoort to Novo Outfall – 1 700 mm pipeline (CH 0km to CH 14,4 km)	R 318 000 000
Knellpoort to Novo Outfall – 1 100 mm pipeline (CH 14,4km to CH 20,4km)	R 72 000 000
2 No 2 Mℓ break pressure tanks	R 12 000 000
2 No Outlet structures at the Knellpoort Dam and Novo Outlet	R 6 000 000

Rustfontein Raw Water Pump Station	R 26 000 000
Rustfontein Raw Water Pipeline	R 54 000 000
Rustfontein Water Treatment Plant	R1 122 000 000
Rustfontein High Lift Pump Station	202 000 000
Rustfontein to Bloemfontein Potable Water Pipeline (1 500 mm X 53,6 km)	R 965 000 000
5 Mℓ surge tank along the Rustfontein – Bloemfontein pipeline	R 10 000 000
30 Mℓ Reservoir at Longridge	R 40 000 000
TOTAL (VAT excluded)	**R 7 530 000 000**

8. CONCEPTUAL DESIGN AND COST ESTIMATES FOR GARIEP – NOVO OUTFALL – MASELSPOORT - BLOEMFONTEIN SCHEME

8.1 Description of Main Project Components

A bulk water supply system to augment water supply from the Gariep Dam to Bloemfontein, via the Novo Outfall and the Maselspoort Dam, will require the following main project components:

- Raw water transfer system from Gariep Dam to Novo Outfall
  - Raw water pump station downstream from the Gariep Dam
  - Raw water pipeline and associated infrastructure to transfer raw water from the Gariep Dam to the Novo Outfall
  - One or more high lift pump stations located along the raw water pipeline route
- Extensions to the water transfer and treatment systems at Maselspoort Dam to supply potable water to Bloemfontein
  - Raw water pump station at the Maselspoort Dam
  - Raw water pipeline to transfer raw water from Maselspoort Dam to the water treatment plant
  - Water treatment plant at Maselspoort located next to the existing water treatment plant
  - High lift pump station downstream from the water treatment plant
  - Potable water pipeline and associated infrastructure to transfer potable water from Maselspoort to Bloemfontein
  - A reservoir to receive potable water at Bloemfontein

A desk top study of the above project components has been undertaken and more detail of the various components is provided in **Section 8.1** to **Section 8.10**. A preliminary scheme layout is reflected in **Figure 5**.

8.2 Raw Water Abstraction from Various Dams

8.2.1 Gariep Dam

Raw water will be abstracted through the existing multi-level outlet through the Gariep Dam wall. The existing 84 inch (approximately 2 100 mm) diameter outlet pipeline for water supply to Bloemfontein will have more than sufficient capacity to cater for the proposed design capacity.

The outlet infrastructure in the dam wall has not been in operation since 1971 and the condition of the infrastructure should be assessed during a future feasibility study to establish the extent of refurbishment work that may be required to the infrastructure. The capital cost estimates include an estimated amount of R 75 million for potential refurbishment work to the dam outlet infrastructure.

8.2.2 Maselspoort Dam

The existing raw water pump station at Maselspoort is located on the eastern bank of the dam upstream from the dam wall. The site of the Maselspoort Water Treatment Plant will be congested, after the process upgrades that are currently underway, have been completed. For the purposes of this report it is assumed that a suitable area for an additional water treatment plant will be available at Maselspoort.

The exiting raw water pump station cannot accommodate additional pump sets to transfer an additional 3 400 ℓ/s (at peak) to a new water treatment plant for water from Gariep Dam. A new pump station structure and pumping equipment will thus be required to accommodate the flow from the Gariep Dam.

Various alternatives could be considered for the abstraction of additional raw water from the Maselspoort Dam. A conservative approach was adopted and allowance was made for an abstraction tower to be constructed on the eastern bank of the Maselspoort Dam. Alternative options could be considered during further studies that may follow in future.

8.3 Pipeline Routes, Vertical Alignments and Lengths

8.3.1 Gariep Dam to Novo Outlet

A preliminary scheme layout is reflected in **Figure 5**.

An assessment to identify existing infrastructure along a straight line between the Gariep Dam wall and the Novo Outlet yielded limited clearly defined existing infrastructure. A pipeline route was therefore selected along various short sections of road and power lines and the remainder of the route is through farm land. A route that would be favourable from accessibility and mitigation of environmental and social impacts could not be identified in the available time. The selected pipeline route will cross a water shed at an elevations higher than the Novo Outfall between approximate chainages 139 km and 152,5 km.

An alternative pipeline route that would avoid crossing the water shed at an altitude higher than the Novo Outlet could not be identified in the available time. Such potential route would have to deviate substantially from the route that have been adopted and would therefore be substantially longer and more expensive.

Figure 5 reflects the pipeline route that was adopted for conceptual design purposes.

The length of the selected pipeline route is approximately 179,5 km.

8.3.2 Maselspoort Dam to Bloemfontein

The routes of the existing raw and potable water pipelines were adopted for the transfer of water from Maselspoort to Bloemfontein. It was assumed that the water treatment plant will be located to the east of the Maselspoort Dam (next to the existing) and the raw water pipeline route will therefore follow a route towards the east of the dam. The potable water pipeline from Maselspoort to Bloemfontein (Naval Hill reservoir site) is reflected on **Figure 5**.

The existing raw and potable water pipelines are respectively approximately 600 m and 20 km long and these lengths were adopted for conceptual design purposes.

8.4 Design Flows

As indicated in **Section 3**, the augmentation project from the Gariep Dam is based on a capacity of 255 Mℓ per day to cater for the 7-day sustained peak demand projected for 2035. A peak factor of 1,5 was adopted with demand projections in this report and the average annual daily demand will therefore be 170 Mℓ per day for 2035. The average and peak flows applicable to each of the various scheme components were calculated based on the criteria provided in **Section 6** and are summarized in **Table 8.4** below.

Table 8.4: Design Capacities

Water Treatment Plant and High Lift Pump Station at Maselspoort and Potable Water Pipeline from Maselspoort to Bloemfontein

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
170	24	1 968
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
255	22	3 220

Raw Water Pump Station at Maselspoort Dam and Raw Water Pipeline from Maselspoort Dam to Water Treatment Plant (5% Water Treatment Plant Losses Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
179	24	2 066
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
268	22	3 381

Raw Water Pipeline from Gariep Dam to Novo Outlet and Raw Water Pump Stations along this Pipeline Route (5% Maselspoort Water Treatment Plant Losses, 5% Conveyance Losses from Rustfontein Dam to Maselspoort Dam and 17% Conveyance Losses from Novo Outlet to Rustfontein Dam Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
219	24	2 538
Peak Capacity		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
219	22	2 769

8.5 Adopted Pipeline Diameters and Flow Velocities

Diameters for the various pipelines were calculated based on the criteria provided in **Section 6**. Adopted pipeline diameters and flow velocities for the various pipelines are reflected in **Table 8.5** for average and peak flows. "Standard" pipe outside diameter dimensions and nominal wall thicknesses were adopted with the calculation of velocities.

Table 8.5: Adopted Pipeline Diameters and Flow Velocities

Pipeline Description	Adopted Pipeline Diameter (mm)	Average Flow		Peak Flow	
		Flow Rate (ℓ/s)	Flow Velocity (m/s)	Flow Rate (ℓ/s)	Flow Velocity (m/s)
Maselspoort to Bloemfontein	1500	1968	1,1	3220	1,8
Maselspoort Dam to Treatment Plant	1500	2066	1,1	3381	1,8
Gariep Dam to Novo Outfall	1700	2538	1,1	2769	1,2

The optimum diameters will need to be confirmed during further assessments and optimization studies that may follow in future.

8.6 Hydraulic design

8.6.1 Static Heads

Static heads adopted for conceptual design calculations are summarized in **Table 8.6.1** below.

Table 8.6.1: Adopted Water Levels and Static Heads

Description of Structure, Feature or Dam	Adopted Water Level or Static Head
Naval Hill Reservoir	1 484 m a.s.l.
Maselspoort Potable Water Reservoir	1 301 m a.s.l.
Static Head (Potable Water Supply System to Bloemfontein)	183 m
Maselspoort WTP Inlet Chamber	1 309 m a.s.l.
Maselspoort Dam	1 296 m a.s.l.
Static Head (Rustfontein Raw Water Supply System)	13 m
Break Pressure Tank (water shed at chainage 178 km)	1 642 m a.s.l.
Pump Station No 2 (at chainage 100 km)	1 540 m a.s.l.
Static Head (Gariep to Knellpoort, System No 2)	102 m
Pump Station No 2 (at chainage 60 km)	1 540 m a.s.l.
Gariep Dam (Pump Station No 1)	1 255 m a.s.l.
Static Head (Gariep to Knellpoort, System No 1)	285 m

8.6.2 Hydraulic Gradients

The hydraulic gradient for the supply system from Gariep Dam to the Novo Outfall using a 1700 mm diameter rising main and two pump stations is shown in **Figure 8.6.2.1** below and are based on peak flow of 2 770 ℓ/s. The diameter of the gravity main is 1400 mm (chainage 152,5 km to chainage 172,5 km) and 1 100 mm (chainage 172,5 km to Novo Outfall). Lower and varying flow rates will require further assessment during further studies that may follow in future.

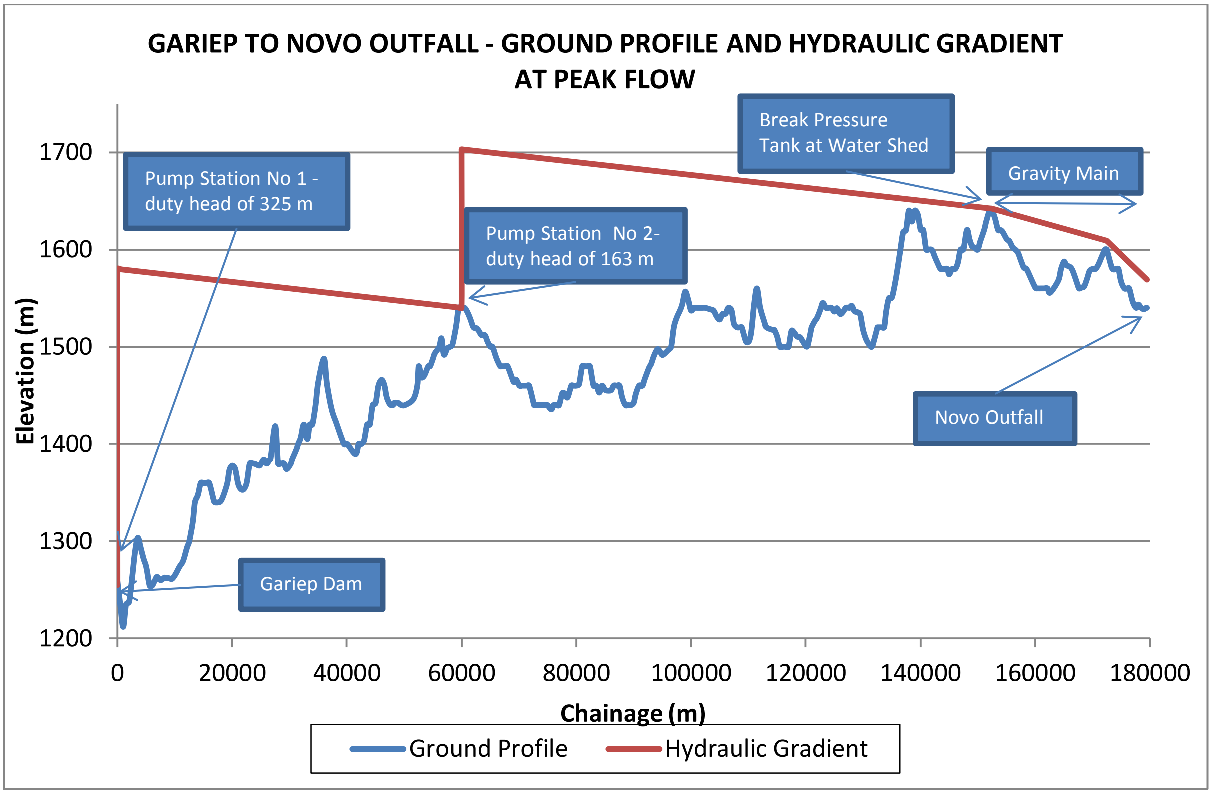

Figure 8.6.2.1: Gariep to Novo Outfall - Ground Profile and Hydraulic Gradient based on 1700 mm Diameter Rising Main and two Pump Stations (Peak Flow)

The hydraulic gradient for the supply system from the Novo Outfall to the Naval Hill Reservoirs in Bloemfontein using 1500 mm diameter rising mains and two pump stations is shown in **Figure 9.6.2.2** below and are based on the peak flow applicable to each component. Lower and varying flow rates will require further assessment during further studies that may follow in future.

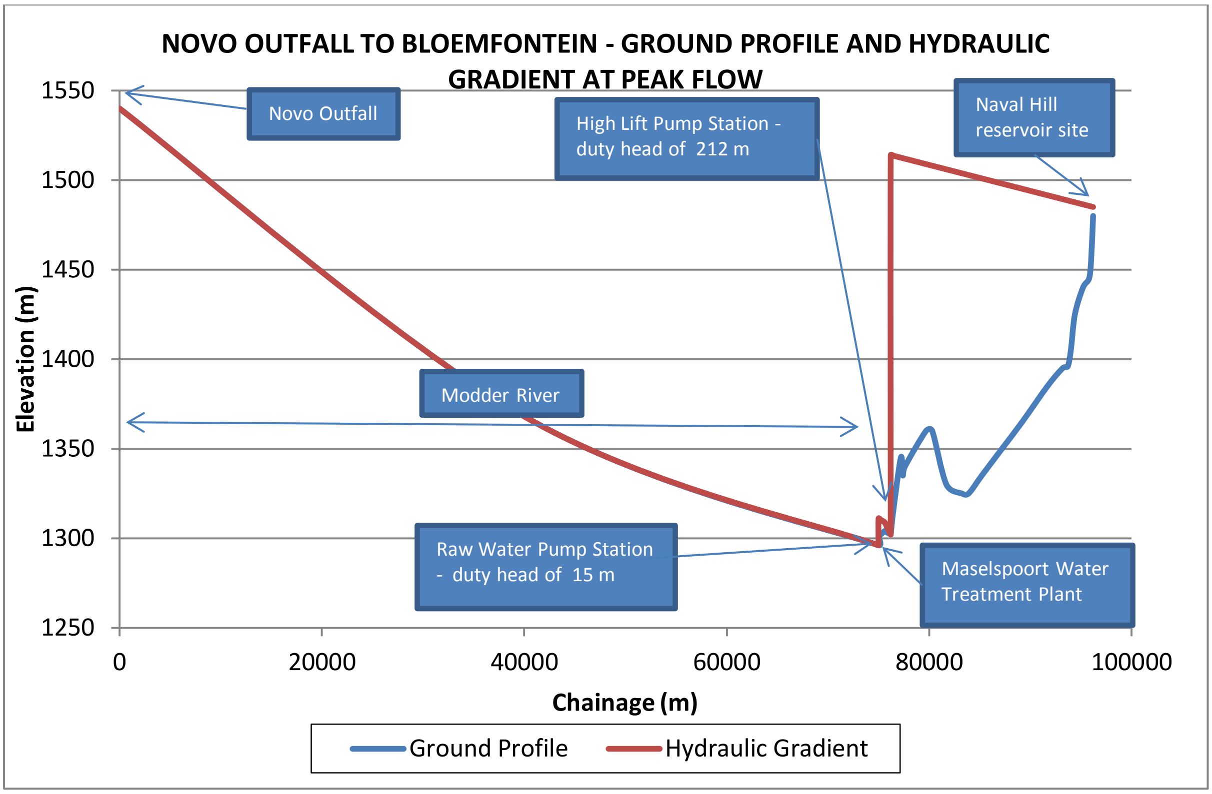

Figure 9.6.2.2: Novo Outlet to Bloemfontein - Ground Profile and Hydraulic Gradient at Peak Flow

Pumping heads for the various pump stations, at average and peak flows, are summarized in **Table 8.6.2** below.

Table 8.6.2: Pumping Heads at Average and Peak Flows

Pump Station Description	Pumping Head	
	Average Flow	Peak Flow
Gariep to Novo Outfall – Pump Station No 1	319 m	325 m
Gariep to Novo Outfall – Pump Station No 2	154 m	163 m
Maselspoort Raw Water	14 m	15 m
Maselspoort High Lift	194 m	212 m
TOTAL	**681 m**	**715 m**

8.6.3 Required Pipeline Wall Thicknesses and Grade of Steel

Maximum working pressures and required pipe wall thicknesses for the various pipelines are provided in **Table 8.6.3** below.

Table 8.6.3: Maximum Working Pressures, Required Wall Thicknesses and Steel Grade

Pipe Section (chainage)	Pipe Diameter	Maximum Working Pressure	Required Wall Thickness and Steel Grade
Gariep to Novo Outfall			
CH 0 km to CH 2,5 km	1 700 mm	368 m	17,5 mm, Grade X52
CH 2,5 km to CH 13 km	1 700 mm	322 m	15 mm, Grade X52
CH 13 km to CH 60 km	1 700 mm	231 m	11.5 mm, Grades X42 and X52
CH 60 km to CH 78 km	1 700 mm	255 m	12 mm Grades X52
CH 78 km to CH 152,5 km	1 700 mm	235 m	11.5 mm, Grades X42 and X52
CH 152,5 km to CH 172,5 km	1 400 mm	70 m	9,5 mm Grade X42
CH 172,5 km to CH 179,5 km	1 100 mm	40 m	7,5 mm Grade X42
Maselspoort Dam to Water Treatment Plant			
CH 0 km to CH 0,6 km	1 500 mm	15 m	10 mm Grade X42
Water Treatment Plant to Bloemfontein			
CH 0 km to CH 20 km	1 500 mm	212 m	10 mm, Grades X42 and X52

As reflected in **Table 8.6.3** above, the majority of the pipeline will require minimum wall thicknesses i.e. maximum D/t ratio of approximately 150. Thicker walls will only be required between chainage 0 km to chainage 13 km and between chainage 60 km and chainage 78 km along the Gariep – Novo Outlet pipeline. Steel grades higher than grade X52 could be considered for these high pressure sections of the pipeline during further studies that may be required.

8.6.4 Additional Pipeline Related Infrastructure

The following additional pipeline related infrastructure has been included for in the cost estimates:

- 2 Mℓ break pressure tank at chainage 152,5 km along the Gariep – Novo Outfall pipeline
- 5 Mℓ surge tank at chainage 138 km along the Gariep – Novo Outfall pipeline
- Outlet structure at the Novo Outlet discharge point

8.7 Pump Stations

The characteristics adopted for the various pump stations are summarized in **Table 8.7** below for peak (duty) flow. Pumping power at average flows are also provided in **Table 8.7**.

Table 8.7: Pump Station Details

Description	Gariep – Novo Outlet		Rustfontein	
	Number 1	Number 2	Raw Water	High Lift
Duty Flow (ℓ/s)	2 769	2 769	3 381	3 220
Duty Head (m)	325	163	15	212
Pump Efficiency (%)	85	85	85	85
Motor and Drive Efficiency (%)	94,5	94,5	94,5	94,5
Pumping Power at Duty (kW)	10 991	5 513	620	8 337
Spare Motor Capacity at Duty (%)[1]	20	20	20	20

Pumping Power including Margin (kW)	13 189	6 615	744	10 005
Number Off Duty Pumps in Parallel	3	3	3	3
Input Power of Individual Motors (kW)	4 400	2 200	250	3 400
Total Power of Installed Units (kW)	17 600	8 800	1 000	13 600
Variable Speed Drives Included	Yes	Yes	Yes	Yes
Pumping Power at Average Flow (kW)	9 888	4 775	354	4 663

[1]10% required at run out, preliminary allowance of 20% at duty

Total pumping power required to transfer average flow amounts to 19 680 kW.

8.8 Water Treatment Plant

A conventional water treatment process with two stage settling has been allowed for in the cost estimates.

8.9 Reservoir at Naval Hill

A 30 Mℓ reservoir at Naval Hill has been allowed for in the cost estimates.

8.10 Capital Cost Estimate

The estimated construction costs for the various infrastructure components are summarized in **Table 8.10** below.

Table 8.10: Summary of Estimated Construction Costs

Component	Estimated Cost
Refurbishment of Gariep Dam Outlet and Suction Main	R 75 000 000
Gariep to Novo Outlet – Pump Station No 1	R 269 000 000
Gariep to Novo Outlet – Pump Station No 2	R 154 000 000
Gariep – Novo Outlet 1 700 mm pipeline (CH 0km to CH 152,5 km)	R 3 401 000 000
Gariep – Novo Outlet 1 400 mm pipeline (CH 152,5km to CH 172,5 km)	R 336 000 000
Gariep – Novo Outlet 1 100 mm pipeline (CH 172,5km to CH 179,5 km)	R 85 000 000
2 Mℓ break pressure tank	R 6 000 000
5 Mℓ surge tank along the Gariep – Novo Outlet pipeline	R 10 000 000
Outlet structure at Novo Outlet	R 3 000 000
Maselspoort Raw Water Pump Station	R 28 000 000
Maselspoort Raw Water Pipeline	R 11 000 000
Maselspoort Water Treatment Plant	R 1 122 000 000
Maselspoort High Lift Pump Station	R 221 000 000
Maselspoort to Bloemfontein Potable Water Pipeline (1 500 mm X 20 km)	R 360 000 000
30 Mℓ Reservoir at Naval Hill	R 40 000 000
TOTAL (VAT excluded)	**R 6 120 000 000**

9. CONCEPTUAL DESIGN AND COST ESTIMATES FOR GARIEP - BLOEMFONTEIN SCHEME

9.1 Description of Main Project Components

A bulk water supply system to augment water supply from the Gariep Dam directly to Bloemfontein will require the following main project components:

- Raw water pump station downstream from the Gariep Dam
- Transfer pipelines and associated infrastructure to transfer water from the Gariep Dam to Bloemfontein
- One or more high lift pump stations located along the transfer pipeline route
- Water treatment plant located at a hydraulic break in the supply system, i.e. upstream from a pump station
- A reservoir to receive potable water at Bloemfontein

A desk top study of the above project components has been undertaken and more detail of the various components is provided in **Section 9.1** to **Section 9.10**. A preliminary project layout is reflected in **Figure 5**.

9.2 Raw Water Abstraction from Gariep Dam

Raw water will be abstracted through the existing multi-level outlet through the Gariep Dam wall. The existing 84 inch (approximately 2 100 mm) diameter outlet pipeline for water supply to Bloemfontein will have more than sufficient capacity to cater for the required supply of 255 Mℓ per day (at peak).

The outlet infrastructure in the dam wall has not been in operation since 1971 and the condition of the infrastructure should be assessed during a future feasibility study to establish the extent of refurbishment work that may be required to the infrastructure. The capital cost estimates include an estimated amount of R 75 million for potential refurbishment work to the dam outlet infrastructure.

9.3 Pipeline Route, Vertical Alignment and Length

A straight line between the Gariep Dam wall and the Longridge reservoir site in Bloemfontein would approximately follow the N1 National Road. A pipeline route along the N1 National Road, referred to as the "N1 pipeline route", was evident to be favourable from a pipeline length, mitigation of environmental and social impacts and accessibility perspectives. This pipeline route will however cross a water shed at an elevation higher than the Longridge reservoirs and will introduce some technical challenges to be addressed during the design and operation of the supply system.

An alternative pipeline route, referred to as the "western pipeline route", to avoid crossing the water shed at an altitude higher than the Longridge reservoir site, was investigated. The "western pipeline route" is approximately 32 km longer than the "N1 pipeline route" and crossing the water shed at an altitude of less than 1470 m, i.e. the Longridge reservoir site level, will not be possible. Other than being approximately 18% longer than the "N1 pipeline route", the "western pipeline route" is not considered to be favourable from accessibility and mitigation of environmental and social impact perspectives.

The "N1 pipeline route" was adopted for conceptual design purposes. The route starts at the termination point of the existing outlet pipe from the Gariep Dam and follows Road R701 for approximately 8 km, the N1 National Road for approximately 169 km with the last 1 km of the route deviating from the N1 National Road towards the Longridge reservoir site.

The length of the "N1 pipeline route" is approximately 178 km.

9.4 Design Flows

As indicated in **Section 3**, the augmentation project from the Gariep Dam is based on a capacity of 255 Mℓ per day to cater for the 7-day sustained peak demand projected for 2035. A peak factor of 1,5 was adopted with demand projections in this report and the average annual daily demand will therefore be 170 Mℓ per day for 2035. The average and peak flows applicable to each of the various project components were calculated based on the criteria provided in **Section 6** and are summarized in **Table 9.4** below.

Table 9.4: Design Capacities

Water Treatment Plant and High Lift Pump Station for Potable Water Pipeline along route from Gariep to Bloemfontein

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
170	24	1 968
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
255	22	3 220

Raw Water Pump Station at Gariep Dam and Raw Water Pipeline from Gariep Dam to Water Treatment Plant (5% Water Treatment Plant Losses Included)

Average Annual Daily Demand		
Average Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Average Flow (ℓ/s)**
179	24	2 066
7- day Sustained Peak Demand		
Peak Capacity (Mℓ per day)	**Supply Period (hours per day)**	**Peak Flow (ℓ/s)**
268	22	3 381

9.5 Adopted Pipeline Diameters and Flow Velocities

Diameters for the pipelines were calculated based on the criteria provided in **Section 6**. Adopted pipeline diameters and flow velocities for the various pipelines are reflected in **Table 9.5** for average and peak flows. "Standard" pipe outside diameter dimensions and nominal wall thicknesses were adopted with the calculation of velocities.

Table 9.5: Adopted Pipeline Diameters and Flow Velocities

Pipeline Description	Adopted Pipeline Diameter (mm)	Average Flow		Peak Flow	
		Flow Rate (ℓ/s)	Flow Velocity (m/s)	Flow Rate (ℓ/s)	Flow Velocity (m/s)
Treatment Plant to Bloemfontein	1 500	1 968	1,1	3 220	1,8
Gariep Dam to Treatment Plant	1 500	2 066	1,1	3 381	1,8

The optimum diameters will need to be confirmed during further assessments and optimization studies that may follow in future.

9.6 Hydraulic Design

9.6.1 Static Heads

Static heads adopted for conceptual design calculations are summarized in **Table 9.6.1** below.

Table 9.6.1: Adopted Water Levels and Static Heads

Description of Structure, Feature or Dam	Adopted Water Level or Static Head
Longridge Reservoir	1 478 m a.s.l.
Potable Water Pump Station (at chainage 22 km)	1 370 m a.s.l.
Static Head (Potable Water Supply System to Bloemfontein)	108 m
Water Treatment Plant (at chainage 22 km)	1 380 m a.s.l.
Gariep Dam (Pump Station No 1)	1 255 m a.s.l.
Static Head (Gariep to Water Treatment Plant)	125 m

9.6.2 Hydraulic Gradients

The hydraulic gradient for the supply system from Gariep Dam to Bloemfontein using 1500 mm diameter pipelines and two pump stations is shown in **Figure 9.6.2** below and are based on peak flow of 3 220 ℓ/s. Lower and varying flow rates will require further assessment during further studies that may follow in future.

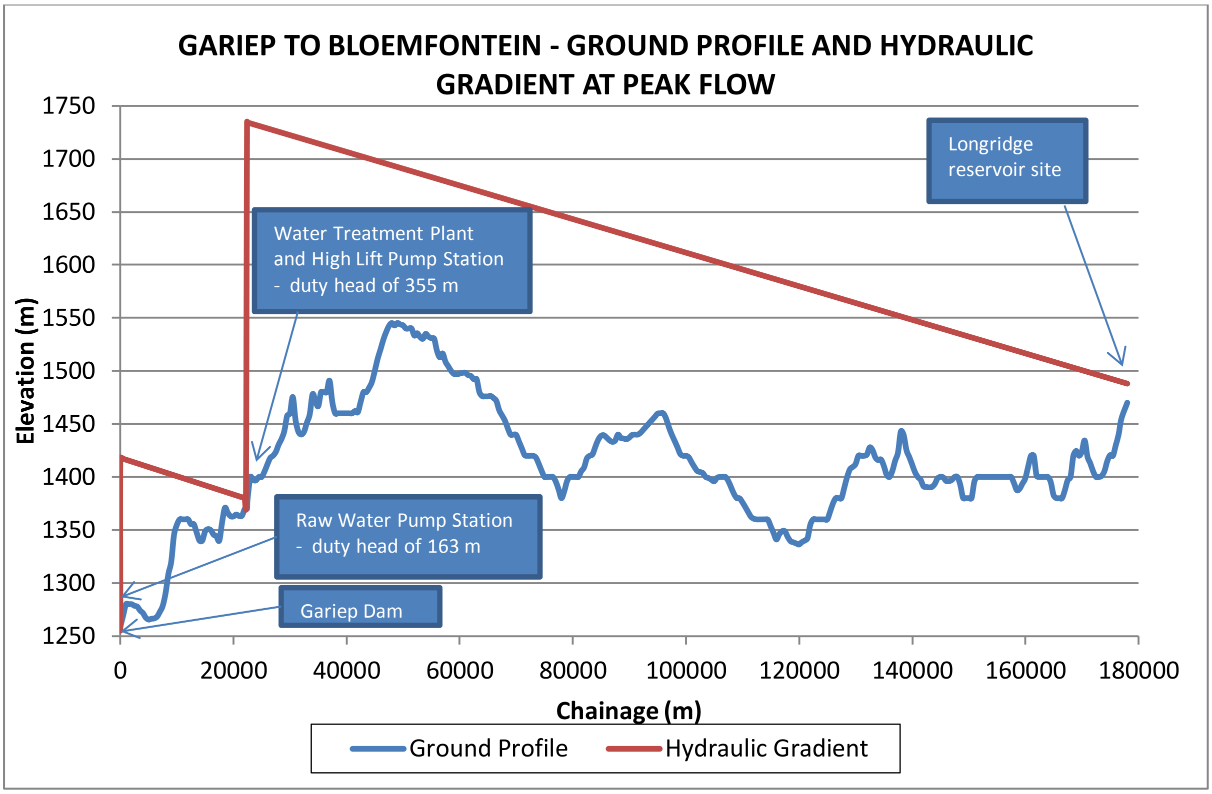

Figure 9.6.2: Gariep to Bloemfontein - Ground Profile and Hydraulic Gradient based on 1500 mm Diameter Pipelines and two Pump Stations (Peak Flow)

Pumping heads for the various pump stations, at average and peak flows, are summarized in **Table 9.6.2** below.

Table 9.6.2: Pumping Heads at Average Flow

Pump Station Description	Pumping Head	
	Average Flow	Peak Flow
Raw Water Pump Station	140 m	163 m
High Lift Pump Station	203 m	355 m
TOTAL	**343 m**	**518 m**

9.6.3 Required Pipeline Wall Thicknesses and Grade of Steel

Maximum working pressures and required pipe wall thicknesses for the pipelines are provided in **Table 9.6.3** below.

Table 9.6.3: Maximum Working Pressures, Required Wall Thicknesses and Steel Grade

Pipe Section (chainage)	Pipe Diameter	Maximum Working Pressure	Required Wall Thickness and Steel Grade
Gariep to Bloemfontein			
CH 0 km to CH 22 km	1 500 mm	150 m	10 mm, Grade X42
CH 22 km to CH 26 km	1 500 mm	355 m	15 mm, Grade X52
CH 26 km to CH 34 km	1 500 mm	300 m	12.5 mm, Grades X52
CH 34 km to CH 178 km	1 500 mm	240 m	10 mm, Grades X42 and X52

As reflected in **Table 9.6.3** above, the majority of the pipeline will require minimum wall thicknesses i.e. maximum D/t ratio of approximately 150. Thicker walls will only be required for 12 km of the pipeline length (chainage 22 km to chainage 34 km). Steel grades higher than grade X52 could be considered for these high pressure sections of the pipeline during further studies that may be required.

9.6.4 Additional Pipeline Related Infrastructure

Allowance has been made in the cost estimates for a 5 Mℓ surge tank at chainage 48 km along the Gariep – Bloemfontein pipeline

9.7 Pump Stations

The characteristics adopted for the two pump stations are summarized in **Table 9.7** below for peak (duty) flow. Pumping power at average flows are also provided station in **Table 9.7**.

Table 9.7: Pump Station Details

Description	Raw Water	High Lift
Duty Flow (ℓ/s)	3 381	3 220
Duty Head (m)	163	355
Pump Efficiency (%)	85	85
Motor and Drive Efficiency (%)	94,5	94,5
Pumping Power at Duty (kW)	6 731	13 961
Spare Motor Capacity at Duty (%)[1]	20	20
Pumping Power including Margin (kW)	8 077	16 753
Number Off Duty Pumps in Parallel	3	3
Input Power of Individual Motors (kW)	2 700	5 400
Total Power of Installed Units (kW)	10 800	21 600
Variable Speed Drives Included	Yes	Yes
Pumping Power at Average Flow (kW)	3535	4 880

[1] 10% required at run out, preliminary allowance of 20% at duty

Total pumping power required to transfer average flow amounts to 8 415 kW.

9.8 Water Treatment Plant

A conventional water treatment process has been allowed for in the cost estimates.

9.9 Reservoir at Longridge

A 30 Mℓ reservoir at Longridge has been allowed for in the cost estimates.

9.10 Capital Cost Estimate

The estimated construction costs for the various infrastructure components are summarized in **Table 9.12** below.

Table 9.10: Summary of Estimated Construction Costs

Component	Estimated Cost
Refurbishment of Gariep Dam Outlet and Suction Main	R 75 000 000
Raw Water Pump Station	R 178 000 000
Raw Water and High Lift Pipelines (1 500 mm X 178 km)	R 3 222 000 000
5 Mℓ surge tank along the Gariep – Bloemfontein pipeline	R 10 000 000
High Lift Pump Station	R 317 000 000
Water Treatment Plant	R 918 000 000
30 Mℓ Reservoir at Longridge	R 40 000 000
TOTAL (VAT excluded)	**R 4 760 000 000**

10. RELATIVE COMPARISON OF POTENTIAL BULK WATER AUGMENTATION SCHEMES

A relative comparison of the capital cost, raw water quality, raw water losses, reliability of infrastructure and energy efficiency associated with each of the three schemes assessed in this report, are provided in **Section 10**.

10.1 Capital Costs

The estimated capital costs for the three schemes are summarized in **Table 10.1** below.

Table 10.1: Summary of Capital Costs

Scheme Description	Capital Cost	% Higher
Gariep - Bloemfontein	R 4 760 million	n.a.
Gariep – Novo Outfall – Maselspoort - Bloemfontein	R 6 120 million	29%
Gariep – Knellpoort – Rustfontein - Bloemfontein	R 7 530 million	58%

10.2 Raw Water Quality

A detail assessment of Orange River raw water quality was not undertaken. High peaks in turbidity values can be expected in the Orange River upstream of the Gariep Dam during periods of high rainfall or flood conditions. The retention period of water contained in the Gariep Dam is expected to be relatively long especially at higher dam water levels. High raw water turbidity values and silt entering the dam are therefore expected to settle naturally within the dam upstream from the raw water abstraction point at the dam wall. Good quality raw water is expected from the Gariep Dam.

The Modder River catchment is known for exceptionally high turbidities during periods of high rainfall or flood conditions. Turbidities during such periods could easily exceed 1000 N.T.U's and existing treatment processes in the catchment include for dual stage sedimentation. Raw water from Gariep Dam will be discharged into the Modder River for the two schemes that require water treatment at Rustfontein and Maselspoort and will thus be "contaminated" with high turbidities during periods of high rainfall or flood conditions. Dual stage sedimentation will therefore be required for these two water treatment plants to cater for periods of high turbidities resulting in additional capital costs. Treatment costs and treatment plant losses will also be higher for such high turbidity raw water.

Treated sewage effluent from Botshabelo and Thaba Nchu is being discharged into the Modder River upstream from Mockes Dam. Upgrading of the Maselspoort water treatment plant is currently underway to, in future, treat raw water containing treated sewage effluent. Raw water from Gariep Dam released to the Maselspoort Dam will be "contaminated" with treated sewage effluent that will required advanced treatment processes. The cost of such treatment processes are substantially higher than conventional treatment and will be required for water from Gariep Dam that will be discharged in the Modder River for extraction at Maselspoort Dam.. **Such higher capital and treatment costs have not been included in the cost estimates**.

Based on the above paragraphs it can be concluded that, from a raw water quality perspective, the Gariep directly to Bloemfontein is the most attractive scheme and Gariep to Bloemfontein via Maselspoort is the least attractive scheme.

10.3 Raw Water Losses

Based on the criteria provided in **Section 6**, raw water losses for each of the schemes are as follows:

Gariep – Bloemfontein

- 5% treatment plant losses

Gariep – Knellpoort – Rustfontein – Bloemfontein

- 5% losses in Knellpoort Dam
- 17% conveyance losses from Novo Outfall to Rustfontein Dam
- 5% treatment plant losses

Gariep – Novo Outfall – Maselspoort – Bloemfontein

- 17% conveyance losses from Novo Outfall to Rustfontein Dam

- 17% conveyance losses from Rustfontein Dam to Maselspoort Dam
- 5% treatment plant losses

10.4 Reliability of System Infrastructure and Maintenance Requirements

The number of pump stations, pipelines and dams associated with each scheme is summarized in **Table 10.4** below.

Table 10.4: Infrastructure Components Associated with Each Scheme

Infrastructure Components[1]	Scheme		
	Gariep - Rustfontein	Gariep - Maselspoort	Gariep - Bloemfontein
Rivers or Dams (number off)	3	4	1
Pump Stations (number off)	5	4	2
Pipelines (number off)	5	4	2
Treatment Plants (number off)	1	1	1
Total Main Components	**14**	**13**	**6**

[1]Reservoirs not taken into consideration

Based on the number of nodes or links the Gariep – Bloemfontein scheme would be the most reliable.

10.5 Energy Efficiency

Energy requirements for the various schemes, at average flow, are provided in **Table 11.5** below.

Table 11.5: Average Flows, Total Pumping Heads, Total Pumping Power and Energy Requirements (Average Flows)

Parameter	Scheme		
	Gariep - Rustfontein	Gariep - Maselspoort	Gariep - Bloemfontein
Potable Water Supplied (average) (ℓ/s)	1 968	1 968	1 968
Total Pumping Head (m)	718	681	343
Total Pumping Power (kW)	21 065	19 680	8 415
Energy per kℓ/s supplied (kW)	10 704	10 000	4 276
Unit Energy Cost (R/kl)	2.23	2.08	0.89

Energy requirements for the Gariep – Bloemfontein scheme are substantially lower than for the other two schemes.

10.6 Relative Comparison of Augmentation Schemes

The results of assessments included in **Sections 10.1 to 10.5** above are summarized in **Table 10.6** below. Each supply system is rated as being most attractive (1 or green rating), neutral (2 or yellow rating) or least attractive (3 or red rating) for each of the assessed parameters. Equal weightings were allocated for each of the parameters to calculate a weighted average rating.

Table 11.6: Rating of Supply Systems for Assessed Parameters

Parameter	Scheme		
	Gariep - Rustfontein	Gariep - Maselspoort	Gariep - Bloemfontein
Capital Cost	3	2	1
Raw Water Quality	2	3	1
Raw Water Losses	3	3	1
Reliability of Infrastructure	3	3	1
Energy Efficiency	3	3	1
Weighted Average Rating	2.8	2.8	1

As reflected in **Table 11.6** above, the Gariep – Bloemfontein scheme is the most favourable for all assessed parameters.

11. CONCLUSIONS

11.1 It is evident that the Gariep – Bloemfontein scheme presents the lowest capital and operating cost compared to the other two schemes.

11.2 Further optimisation of the Gariep – Bloemfontein scheme is possible.

12. RECOMMENDATIONS

12.1 It is recommended that the scheme optimisation and feasibility study for the Gariep – Bloemfontein scheme should continue as per current arrangements.