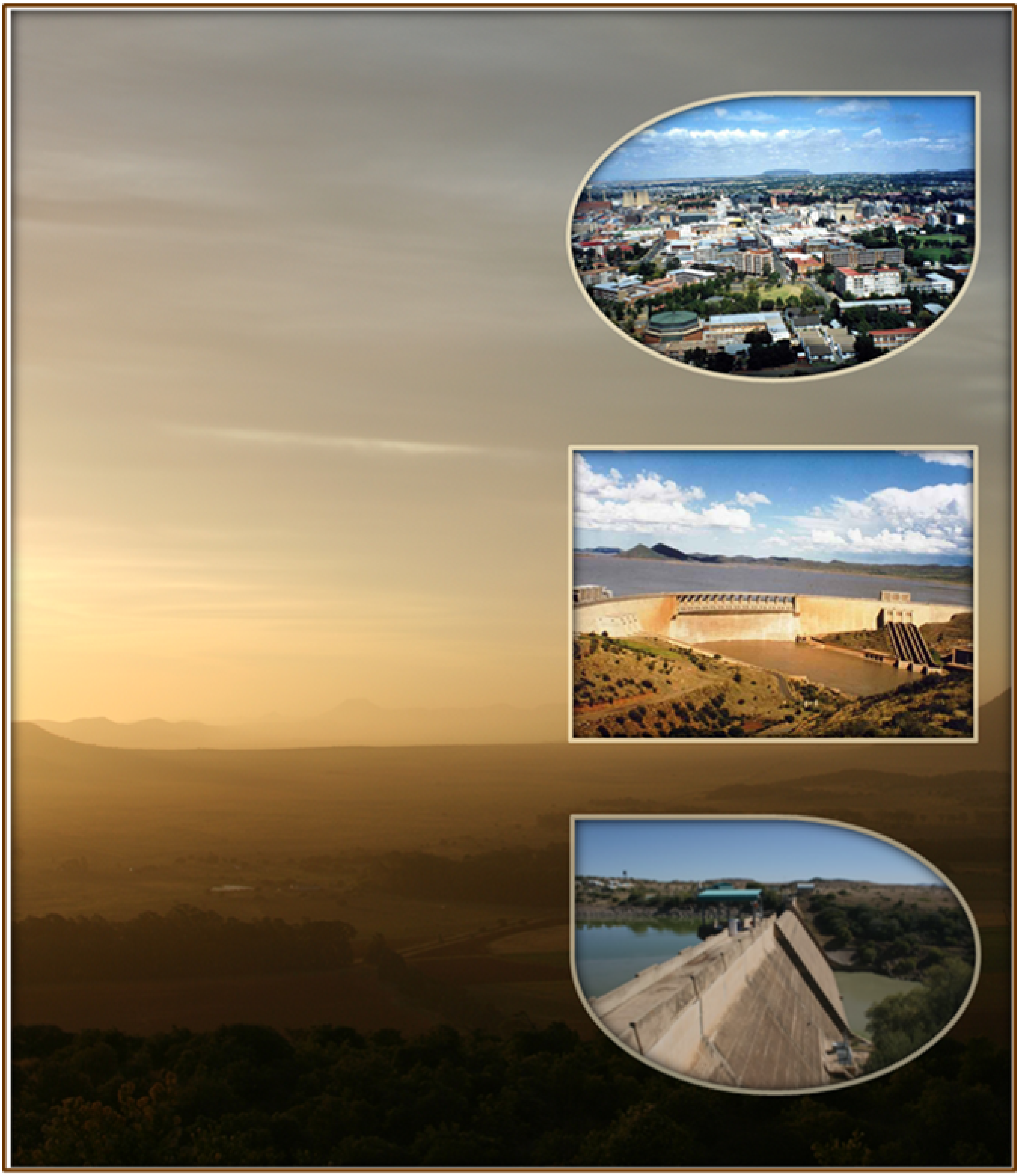

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REPUBLIC OF SOUTH AFRICA

Greater Bloemfontein Bulk Water Supply Augmentation Options

Greater Bloemfontein Reconciliation Strategy Support Study

Department of Water and Sanitation

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DEPARTMENT OF WATER AND SANITATION

Directorate: National Water Resource Planning

Reconciliation Strategy for the Greater Bloemfontein Water Supply System

GREATER BLOEMFONTEIN BULK WATER SUPPLY AUGMENTATION OPTIONS

September 2015

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Department of Water and Sanitation
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Reconciliation Strategy for the Greater Bloemfontein Water Supply System

APPROVAL

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Consultants	**:**	Aurecon South Africa (Pty) Ltd
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Acronyms

AADD	Average annual daily demands
ACIP	Accelerated Community Infrastructure Program
BW	Bloem Water
CME	Compliance monitoring enforcement
DWA	(Previous) Department of Water Affairs
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
ELU	Existing lawful use
EPC	Engineering-Procurement-Construction
EWR	Ecological water requirement
GBWSS	Greater Bloemfontein Water Supply System
I&APs	Interested and affected parties
LHWP	Lesotho Highlands Water Project
MCDA	Multi Criteria Decision Analysis
Ml/d	Megaliter per day
MMM	Mangaung Metropolitan Municipality
m^3/a	Cubic meter per year
m^3/s	Cubic meter per second
Mm^3/a	million cubic meters per year
NPV	Net present value
PSP	Professional service provider
PWD	Peak week demand
RL	Related level
URV	Unit reference value
V&V	Verification and validation
WC/WDM	Water conservation and water demand management
WRYM	Water Resources Yield Model
WSS	Water supply system
WTP	Water treatment plant
WWTP	Wastewater treatment plant

1. INTRODUCTION

1.1 Introduction

The water shortage which is being experienced in the Greater Bloemfontein area has prompted consideration of bringing forward the implementation of what had previously been considered to be medium to long term bulk water supply augmentation interventions. At a meeting held on the 10th of July 2014 between the Minister of Water and Sanitation and stakeholders in Bloemfontein, it was suggested that a pipeline from Gariep Dam should be seriously considered as a development option for augmenting Bloemfontein's water supply. During the time following this meeting the Department of Water and Sanitation (DWS) have co-ordinated various aspects of the investigation relating to the implementation of a pipeline scheme from Gariep Dam, and progress have been made on several fronts, albeit not adequately aligned and coordinated.

Both Bloem Water (BW) and Mangaung Metropolitan Municipality (MMM) have commenced planning initiatives investigating water supply from Gariep Dam. The DWS convened meetings on the 28th August 2014, 12th December 2014 and 19th February 2015 in order to coordinate planning activities and together with the BW and MMM to converge on a single solution which can be taken forward into a detailed feasibility study and ultimately engineering design phases. Neither BW nor MMM can plan independently of DWS as the custodian of all water resources within South Africa, as a water use licence would need to be applied for and granted by the DWS. Independent and uncoordinated planning by both BW and MMM could lead to wasteful capital expenditure by these organisations and should therefore be avoided, particularly taking account of South Africa's constrained economic climate as emphasised by the Minister of Economic Affairs in his 2015 Budget Speech.

At the meeting held on the 19th February 2015 (at the DWS Bloemfontein Head Office), presentations were made by MMM and BW on the progress and outcomes of their planning initiatives. As the Minister has mandated DWS to consolidate and lead the process going forward, it was decided that DWS would review the work done by BW and MMM and towards the end of March/early April 2015 report to all parties on the current status of these investigations. The findings of the review done by DWS are described in this document.

1.2 Proposed 2012 Reconciliation Strategy Actions

The Greater Bloemfontein Water Supply System (GBWSS) supplies water to the larger centres of Bloemfontein, Thaba Nchu and Botshabelo, as well as to the smaller towns of Wepener, Dewetsdorp, Reddersburg, Edenburg, and Excelsior.

A Water Reconciliation Strategy for the Greater Bloemfontein Area was developed in June 2012 by the then Department of Water Affairs (DWA), in cooperation with BW, MMM and other stakeholders. The strategy was developed to determine when the next interventions (e.g. schemes) that will make additional water available will be required to meet future water requirements for at least up to 2035. The strategy highlighted the water supply constraints and developed scenarios for future water augmentation schemes to ensure the ongoing reconciliation of water supplies and requirements.

The following specific recommendations were made in the Strategy:

a.	***Action***:	*Investigate the most appropriate means to scour Welbedacht Dam*
	Responsibility:	*DWS (in conjunction with BW)*
	Timing:	*2012*
b.	***Action:***	*Install two additional (1 m^3/s) pump sets at Tienfontein Pump Station. The first pumpset should be utilised to increase the design capacity of the pump station to 4 m^3/s and the second pumpset to provide additional standby capacity.*
	Responsibility:	*DWS and BW*
	Timing:	*2012*
c.	***Action***:	*Initiate a feasibility study to investigate the most appropriate means to augment Knellpoort Dam.*
	Responsibility:	*DWS*
	Timing:	*2012*
d.	***Action***:	*Investigate the treatment process to deal with high turbidity levels which currently limit the production capacity of the water treatment plant (WTP)*
	Responsibility:	*BW (in conjunction with DWS)*
	Timing:	*2012*
e.	***Action***:	*Increase the capacity of Novo Pump Station to 2.4 m^3/s*
	Responsibility:	*BW*
	Timing:	*2013 or dependent on operational requirements of BW*
f.	***Action:***	*Initiate a study to investigate the feasibility of obtaining additional water from the Orange River.*
	Responsibility:	*DWS*
	Timing:	*To be determined by the Strategy Steering Committee*

The recommendations a) to e) above form a basket of recommendations which are interdependent on each other to address the siltation problems of the Welbedacht water supply system in order to realise a greater yield from the Caledon system. Some work has been undertaken on these initiatives and these are discussed briefly in this document.

Recommendation f) indicated that **a study should commence to ascertain the most feasible way of abstracting and conveying additional water from the Orange River to the Greater Bloemfontein area**. It was further recommended that the study be the responsibility of the DWS. Part of the feasibility study would be to determine the optimal infrastructure solution (including the pipeline route) as well as the capacity and timing of the proposed infrastructure.

The Reconciliation Strategy further made the following recommendation with regards to water re-use.

g.	***Action:***	*Initiate a detailed feasibility study into water reuse as a potential supply intervention.*
	Responsibility:	*MMM*
	Timing:	*To be determined by the Strategy Steering Committee*

1.3 Purpose of this Report

The **main purpose of this report** is to describe the background to and progress made thus far with the evaluation of a pipeline scheme from Gariep Dam to augment the Greater Bloemfontein area in the long term. In addition the report provides an overview of the GBWSS, water supply challenges faced as well as a summary of potential supplementary augmentation measures.

1.4 Structure of this Report

This Report is presented in six chapters. The contents of these chapters are as follows:

Chapter 1: Introduction (this Chapter) explains the objective of this report and the report structure.

Chapter 2: Background introduces the reader to the GBWSS and the situation regarding the water supply situation in the Greater Bloemfontein area.

Chapter 3: Potential Short Term Interventions discusses possible measures that could be taken immediately to relieve the potential water shortage in water supply.

Chapter 4: Bulk Water Augmentation Options discusses the various bulk water augmentation options to augment the GBWSS.

Chapter 5: Water from Gariep Dam describes the options, findings to date and further recommendations for a pipeline scheme from the Gariep Dam, and is the key focus of this report.

Chapter 6: Other Potential Schemes describes potential options from the Caledon River and other augmentation schemes.

Chapter 7: The Way Forward recommends a way to proceed with the implementation of a scheme from the Gariep Dam.

2. BACKGROUND

2.1 The Greater Bloemfontein Water Supply System (GBWSS)

The GBWSS provides the majority of the potable water requirements of the larger centres of Bloemfontein, Thaba Nchu and Botshabelo, as well as the smaller towns of Wepener, Dewetsdorp, Reddersburg, Edenburg, and Excelsior, which are also dependent to varying degrees on local water sources. In recent years Bloemfontein has been the focus of development and growth resulting in a decline in demand in many of the small rural towns. Migration from farms to towns by farm workers in search of employment opportunities has further placed increased burden on the water supplies to the towns. Currently approximately 66% of the treated water is supplied by BW, primarily through the Welbedacht and Rustfontein Water Treatment Plants (WTPs) and the balance via MMM's Maselspoort WTP.

The strategy area comprising the catchment areas of the Caledon and Modder Rivers which currently supply the GBWSS is shown in **Figure 2-1** and the main components of the GBWSS are shown in **Figure 2-2**.

2.2 Bulk Water Supply Infrastructure

BW's Caledon-Bloemfontein transfer scheme (also referred to as the Welbedacht Scheme) supplies potable water from DWS' Welbedacht Dam to Bloemfontein, Botshabelo, Thaba Nchu, Dewetsdorp, Reddersburg, and Edenburg. Treated water is pumped via a 6.5 km pressure pipeline and a 106 km gravity pipeline to Bloemfontein. Siltation has significantly impacted on the yield of Welbedacht Dam requiring the construction of DWS' Knellpoort off-channel storage dam which is supplied with water transferred from the Caledon River via DWS' Tienfontein Pump station which is operated by BW.

BW's Novo Transfer Scheme is supplied with water abstracted from the Caledon River by the Tienfontein Pump Station, pipeline and canal which deliver the water to Knellpoort Dam. BW's Novo pump station transfers water from Knellpoort Dam via its 20 km pipeline and then via the upper reaches of the Modder River to DWS' Rustfontein Dam. Water is pumped from Rustfontein Dam to BW's Rustfontein WTP from which water is pumped to MMM's supply systems in Botshabelo/Thaba Nchu and Bloemfontein. Water is also released from Rustfontein Dam down the Modder River to Mockes Dam which supplies MMM's Maselspoort Scheme (weir and WTP) which supplies approximately 25% of Bloemfontein's water needs.

Groundwater is currently not utilised as a water resource for the supply of potable water to Bloemfontein but the small towns and communities in the vicinity of Bloemfontein are partially dependent on groundwater, and sustainable use of this resource has potential.

Treated waste water is released to the rivers and mostly utilised by farmers for irrigation except for that which flows into Mockes Dam and is re-used.

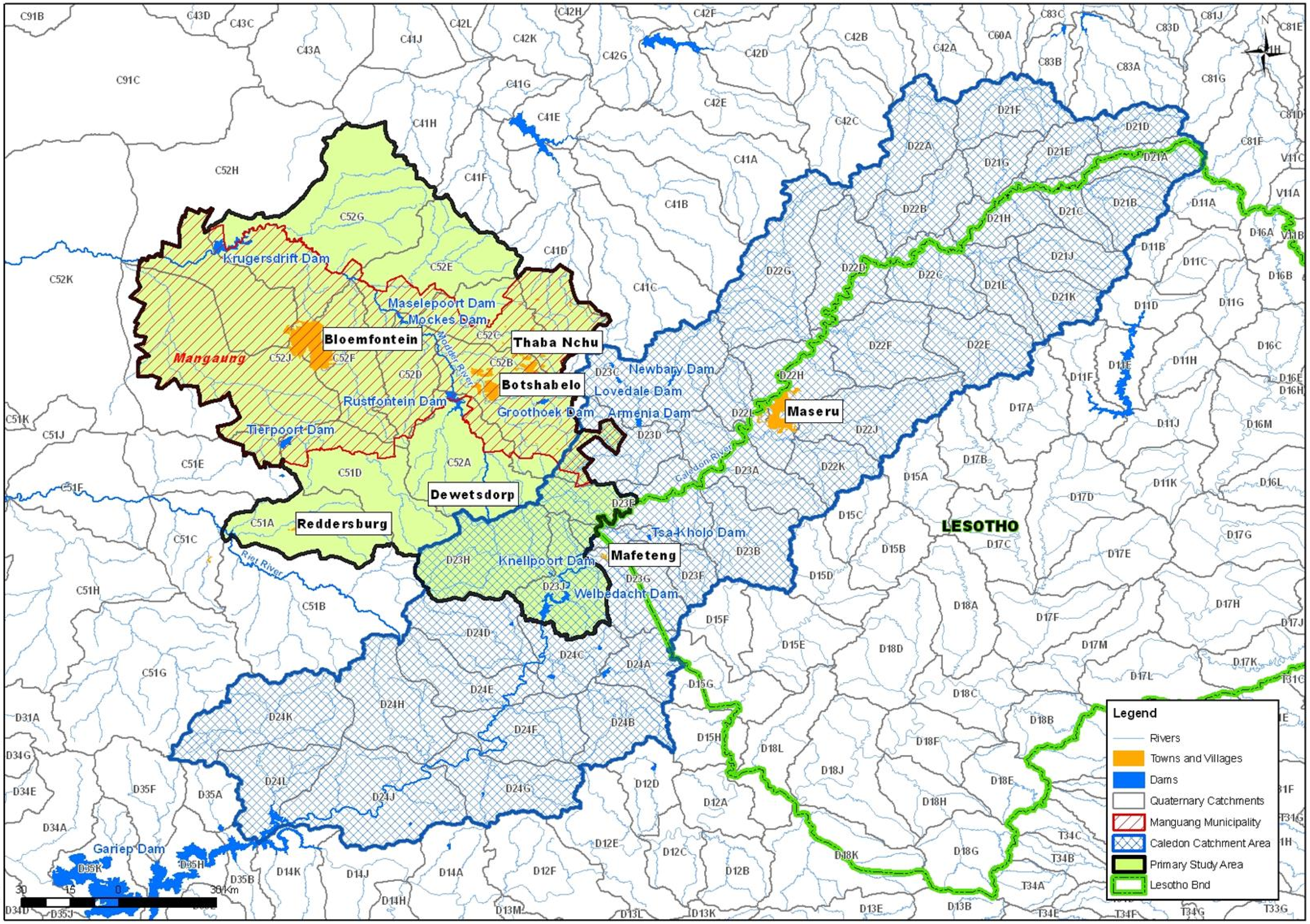

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Figure 2-1: **The Greater Bloemfontein Bulk Water Supply System and the Caledon Catchment**

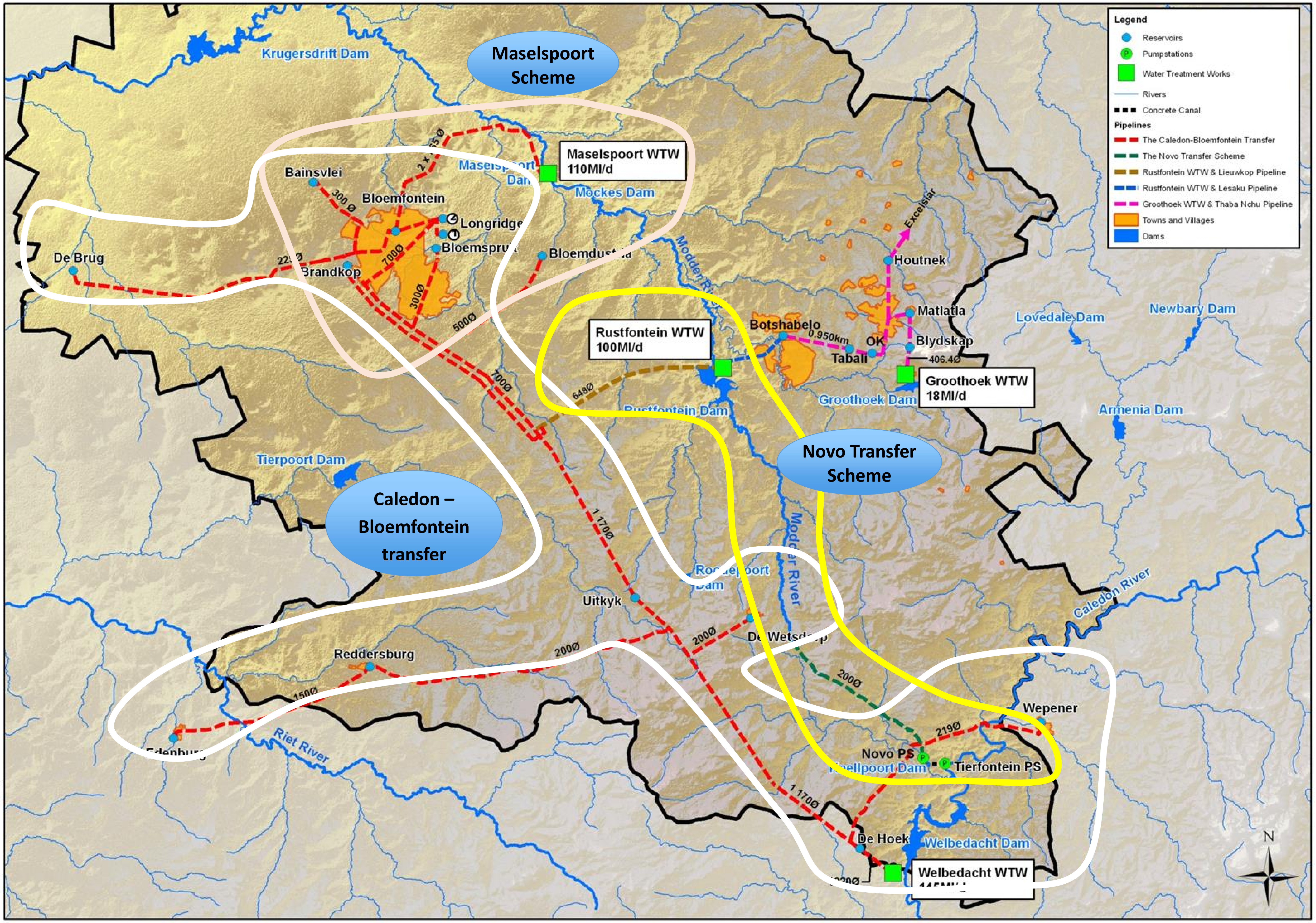


Figure 2-2: The Greater Bloemfontein Bulk Water Supply System

2.3 Validation and verification

In August 2011 the DWS appointed a professional service provider (PSP) to undertake validation and verification (V&V) of water use in the Upper Orange catchment, inclusive of the Modder and Caledon River upstream catchments, which are of significance for the Bloemfontein area. This work has been completed and the V&V outputs show that generally in the Upper Caledon and Modder catchments, the existing lawful use (ELU) does not differ significantly from volumes registered by water users. Further independent analysis undertaken for quaternary C52A does not align precisely with the V&V results. The further analysis does concur with the overall findings of the V&V. It further suggests that current water use may be significantly greater than ELU and that unauthorised water use needs to be addressed. This may potentially be as a result of unauthorised water use along the Modder River above Rustfontein Dam.

As a result, the following actions were initiated by DWS:

- In-field confirmation of potential unauthorised use.
- Handover to the Compliance Monitoring Enforcement team for identified cases.
- Issuing of Directives to identified users and further steps taken as required.

The Water Resources Yield Model (WRYM) was run for various scenarios of the existing lawful and current water use in the Upper Caledon and Modder River catchments based on results from the V&V study. Findings indicated that if water users utilised their full lawful allocation, i.e. the existing lawful use (ELU) this would have a minor impact on the yield. However if the current water demands are as estimated by the V&V study then the available system yield reduces significantly from 83 million m^3/a to 68 million m^3/a, i.e. a reduction of 18% in the yield of the GBWSS, potentially as a result of extensive unauthorised water use. The implication is therefore that the possible unauthorised water use could be impacting severely on the water balance of the GBWSS.

2.4 State of water resources in the GBWSS

The anticipated water requirement will exceed the historical firm yield of the GBWSS until 2016, assuming that water conservation and water demand management (WC/WDM) will be successful, that the Tienfontein pump station capacity will be increased and that sedimentation control interventions will be successfully implemented. This is the earliest date any bulk water supply interventions can be implemented. In the short term however, water shortages are being experienced because of drought and operational problems, and this would need to be addressed through short term measures.

Rainfall in Bloemfontein has been very low over recent years. This has increased the need for garden irrigation and has led to increased water demand. The current total accessible live storage in DWS' dams supplying the GBWSS is 170 million m^3, i.e. 63 million m^3 in Rustfontein Dam, 98 million m^3 in Knellpoort Dam and 9 million m^3 in Welbedacht Dam. On 15 September 2015 the remaining live storage was 72 million m^3. The total live storage in Mockes Dam is 5.5 million m^3; however the current storage is unknown.

Table 2-1: Capacity and storage of the GBWSS dams

Dam name	Full supply capacity (FSC) (million m^3)	Live storage capacity (million m^3)	Current storage as % of FSC (million m^3)	% full as on 14/9/15
Rustfontein	71.3	63	17.7	24.8%
Knellpoort	130	98	49.4	38%
Welbedacht	9.6	9	4.7	48.5%
TOTALS	**216.4**	**170**	**71.8**	**33% of FSC** **42% of live storage**

2.5 Water restrictions

Following DWS' annual operational analysis of the GBWSS in October 2013, it became evident that water restrictions needed to be imposed, to avoid the risk of a shortfall in supply. DWS subsequently gazetted water restrictions for urban water consumers and farmers irrigating along the Modder River sub-catchment, as published in Government Gazette, 24 March 2014, No. 37421.

On 18 June 2014 the DWS Regional Chief Director requested MMM to impose Level 2 restrictions on its consumers. This requires the imposition of 20% restrictions on MMM's domestic and industrial consumers and 50% on irrigation by farmers in the Modder River sub-catchment upstream of Maselspoort Dam.

The MMM Council subsequently approved the following:

- Imposition of level 2 restrictions in terms of water restriction conditions, i.e. rules set by MMM Council in terms of water use by consumers as proposed by the Regional Office of DWS;
- Level 1 for water tariffs as approved by MMM Council.

Water Restrictions have since also been gazetted by MMM.

The reasons for restrictions to be imposed are the following (MMM):

- Very low rainfall in Bloemfontein during the (past) two years.
- Operational deficiencies arising from one of the two pumps at the Novo Pump Station being out of operation for seven months. As a result, sufficient water could not be pumped from Knellpoort Dam to the Modder River which supplies water to the Rustfontein and Mockes Dams.
- Operational deficiencies and the time taken to replace one of the four pumps at DWS' Tienfontein Pump Station also reduced the transfer of water from the Caledon River to Knellpoort Dam and therefore if BW's Novo pumps had been fully operational there would not have been sufficient water available in Knellpoort Dam to meet the full transfer requirements of the BW's Novo scheme.
- MMM is experiencing infrastructural challenges (old infrastructure which needs to be refurbished). This triggers water losses which further imposes severe strain on the availability of water resources.
- Consumers are not adequately utilising water in an effective and efficient manner.

MMM implemented water restrictions in late July 2015.

2.6 Operation and Maintenance

The yield of the GBWSS is currently being negatively impacted by the problems associated with the ongoing high siltation being experienced at Welbedacht Dam, Welbedacht WTP and Tienfontein Pump Station, as follows:

- Ongoing operation and maintenance problems are experienced at the Tienfontein pump station that is owned by DWS but is operated and maintained by BW.
- DWS' Welbedacht Dam: The capacity of the dam will continue to decrease, unless scouring of the sediment takes place, and this will have a knock-on effect on BW's Welbedacht WTP and the Tienfontein pump station.
- BW's Welbedacht WTP: The plant is unable to deal with the high turbidity levels during the summer months.

The system yield is also influenced by the integrity of BW's Welbedacht pipeline and the reduced treatment capacity of the Welbedacht Scheme in the summer months, role-players not adhering to operating rules and the lack of standby capacity to be utilised while maintenance is undertaken on existing infrastructure. There are clearly defined operating rules for the GBWSS. If these are not complied with this will lead to a reduction in the yield of the GBWSS.

2.7 The importance of water augmentation planning

The planning and implementation of interventions takes time, especially for a large scheme if conventional planning and construction approaches are followed. It is therefore imperative to clearly identify the steps to be taken in the process and to timeously plan for new longer term interventions.

2.8 Risks to Water Supply

It is critical that the recommendations associated with addressing the siltation problems around the Welbedacht and Knellpoort Dam are implemented, and a number of these recommendations have already been acted upon.

It must be noted that the risk of water shortages to which the greater Bloemfontein area is currently exposed is not directly as a result of the inadequate longer term planning. The timing of future water augmentations schemes to augment the Greater Bloemfontein Area is based on the historical firm yield of the system. The historical firm yield is the supply to consumers based on water availability during the worst drought in the history in the Orange and Caledon System. The last two year period did not fall into this category, although there was a year (4 summer months) of very low rainfall in this period. The current water shortages are as a result of operational problems that were experienced at the Tienfontein and Novo Pump Stations.

The key risks to water supply have been identified as:

- Dealing with sedimentation problems in the Caledon River which affect the operation of the Tienfontein Pump Station, reduce the storage in Welbedacht Dam and affect the operation of the Welbedacht WTP.
- Operation of the GBWSS, and particularly the Welbedacht scheme and the Tienfontein and Novo Pump Stations which need to be operated in accordance with defined operating rules, otherwise the planned yield will not be achieved.
- High current water use, inclusive of high potential unauthorised water use.
- Lack of integrity of the Welbedacht pipeline.
- Insufficient budget to effectively implement WC/WDM.

The risks of not meeting the water supply requirements of the BGWSS and the mitigation measures currently being implemented are shown in **Table 2-2**.

Table 2-2: Risks to Water Supply

Risks	Measures to be undertaken to mitigate risk
Tienfontein Pump Station: Capacity and Operation	DWS is replacing a damaged pump set and is considering installing 2 additional pump sets to provide 4 duty and 2 standby pumps.
Novo Pump Station: Capacity and Operation	BW has repaired the damaged pump and has installed additional capacity
Decreased production rate at Welbedacht WTP due to siltation. Ongoing Welbedacht siltation could put Tienfontein P/S at risk, as well as any further Caledon River Augmentation Schemes should this not be resolved.	BW is currently initiating a study to consider the design of desilting canals upstream of the Welbedacht WTP, potential redesign of the low lift pump station and increased diversion capacity. BW has also initiated a study of a bidirectional pipeline from the Welbedacht WTP to Knellpoort Dam to deliver additional water to Knellpoort Dam and to supply water to the WTP during periods of high silt load.
Integrity of Welbedacht Pipeline	BW undertook a leak investigation study and has budgeted to re-lay sections of the pipeline

Risks	Measures to be undertaken to mitigate risk
Insufficient Distribution Reservoir Storage Capacity	MMM is currently increasing storage capacity
Current agricultural water use (in excess of legal use) in areas upstream of Rustfontein Dam could decrease system yield	DWS has embarked on a programme of compliance monitoring and enforcement
WC/WDM programme not successfully implemented	MMM is proactively implementing WC/WDM. Budgetary constraints are a problem
Planning and Timing of new Augmentation Schemes	Studies need to be initiated

3. POTENTIAL SHORT TERM INTERVENTIONS

Potential short-term interventions were described in the Accelerated Action Plan to Augment Bloemfontein's Water Supply Report, DWS, August 2014.

3.1 Rapid Implementation of Maintenance and Repair

The current water supply crisis has arisen on account of the very low rainfall in Bloemfontein during the past years and the long time that was required to repair one of the two pumps at the Novo scheme which resulted in the excess draw down of Rustfontein Dam. Similarly the long time that was required to replace the damaged pump at the Tienfontein Pump Station contributed to the current relatively low water level in Knellpoort Dam.

Effective maintenance and operation of the water supply system is very important, especially during the current water crisis. It is therefore strongly recommended that accelerated procurement measures are put in place to minimise delays in repairing any infrastructure until such time as the storages in the Rustfontein and Knellpoort Dams improve.

It is also essential that DWS, BW and MMM cooperate closely with each other in effectively managing the infrastructure so as to minimise the risk during the current potential water supply crisis and in the future.

3.2 Intensification of WC/WDM and Water Restrictions

Due to the imbalance between supply and requirements, it will be important to immediately implement a strategy of heightened consumer water awareness. Further water restriction measures should also be considered.

3.3 Releases from the LHWP

The release of water from the Lesotho Highlands Water Project (LHWP) into the Little Caledon River in July 2014 rapidly filled Welbedacht Dam and this enabled the Tienfontein Pump Station to deliver water into the Knellpoort Dam. It is an option to make further releases from the LHWP for storage in Welbedacht Dam and interception by the Tienfontein Pump Station. As such transfers may influence the yield of the Vaal River System, the situation in the Vaal River System would need to be considered.

3.4 Management of Welbedacht, Knellpoort and Rustfontein Dams

A recently updated operating rule for this sub-system is described in the *July 2015 Monthly Monitoring Report of the Orange River System: Annual Operating Analysis 2015 - 2016*. Due to the increased Novo transfer capacity, it is no longer required to transfer large volumes in advance to Rustfontein Dam from Knellpoort Dam. The Novo transfer capacity is now sufficient to supply the entire demand imposed on the Modder River system. It is therefore suggested that Novo transfers should under most conditions only transfer enough water to keep Rustfontein between 23% to 25% of its gross storage. Thereby sufficient storage space is available in Rustfontein Dam to capture most of the local runoff and to reduce evaporation losses and spills. The improved Novo transfer capacity provides improved system flexibility.

3.5 Access to Low Level Storage in Rustfontein Dam

There is dead storage at Rustfontein Dam of about 6 million m^3 that cannot be accessed by the existing axial flow pumps which are located on the dam wall. Two options might be considered:

3.5.1 Extend Existing Axial Flow Pumps

It might be possible to access about 4 million m^3 of this dead storage by extending the existing pumps and their shafts shown in **Figure 3-1** by 3.5 m, if this would be feasible and provided that the configuration of the valley at the dam wall would permit this. It is unlikely that this option could be rapidly implemented as the following investigations would be necessary and the implementation of the changes would also take some time:

- A check of the original survey of the reservoir basin configuration at the dam wall or preferably a new under water survey of the area where the existing pumps would be extended.
- An investigation together with the supplier of the original pumps on the practicality of extending the pumps to access the additional dead storage and whether this could be accommodated by the existing motors.

Lowering of the existing pumps by 3.5 m would increase the active storage from Rustfontein Dam from 63.3 million m^3 to 67.3 million m^3. In view of this relatively small potential gain in storage of only about 4 million m^3 that this option would provide and the time and cost of implementing this option it is unlikely to be viable as a short term option, although it would have the advantage of being permanent.

3.5.2 Suspended Submersible Pumps

An alternative for accessing this dead storage that could be implemented more rapidly would be to suspend one or more smaller submersible pumps from the dam wall and to utilize flexible hoses to connect these to the existing delivery pipework. These submersible pumps would deliver significantly less water to the treatment works but could probably be implemented more rapidly. The suspended submersible pump option could probably access about 5 million m^3 of dead storage but because of their smaller pumping capacity this option should only be considered in the event of a potential long term failure of the pumps at the Novo Pump Station which might necessitate accessing this dead storage or if Knellpoort Dam drops below the minimum operating level. The storages in the Rustfontein and Knellpoort Dams need to be closely monitored and arrangements to rapidly acquire suitable submersible pumps should be put in place so that these could be timeously installed if required.

3.6 Access Low Level Storage in Knellpoort Dam

The lined intake tunnel to the Novo Pump Station at Knellpoort Dam was constructed by the DWA at the time that the dam was constructed as were the shafts for the axial flow pumps which were subsequently installed by BW. The critical levels and their storage implications are as follows as shown in **Figure 3-2**:

- Lowest pump operating level: RL1439 m.
- Lowest level of intake channel 1431.5 m.
- Water level in intake channel leading to intake through which water could flow by gravity is about RL1435 m, which would allow access to about 18 million m^3 of dead storage, and increase the available active storage from 98 million m^3 to 116 million m^3.

A possible option for accessing this additional 18 million m^3 of currently dead storage is described below:

- Install a steel or concrete shaft to extend the existing inverted intake from RL1434.8 m to lowest pump operating level of 1439 m.
- Install submersible pumps in the intake channel next to the inverted intake to deliver water into the raised intake. Excess water not abstracted by the Novo Pumps would overflow the raised intake at RL1439 m.
- Power cables and switch gear would have to be provided.

This option could be installed in a relatively short time provided that procurement could be expedited and that suitable large capacity submersible pumps are available. However all work would have to be undertaken from a barge and as most of this would be under water the costs would be high. The barge should also be utilized to recover the pumps for storage and possible future use.

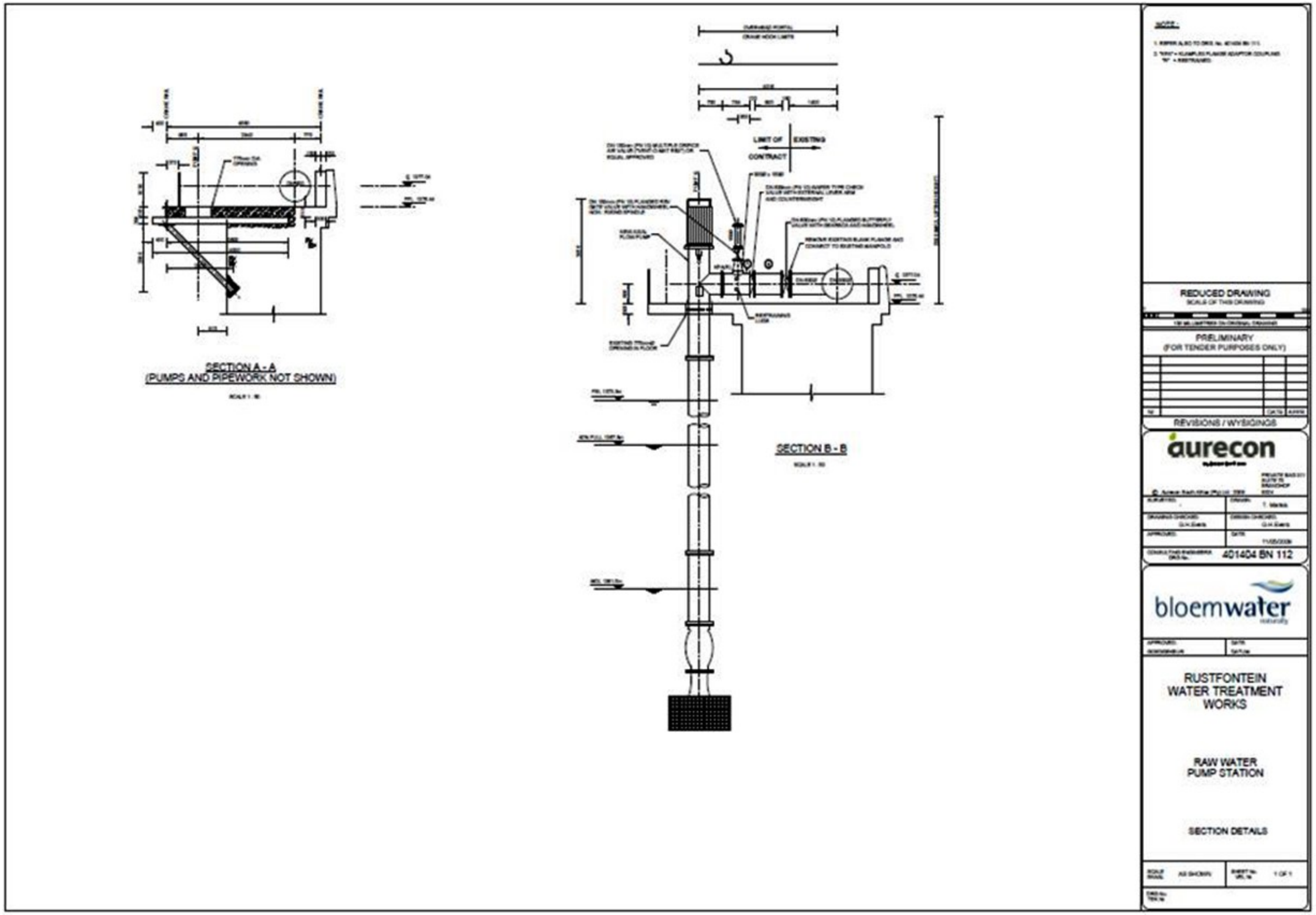


Figure 3-1: Rustfontein Pumps

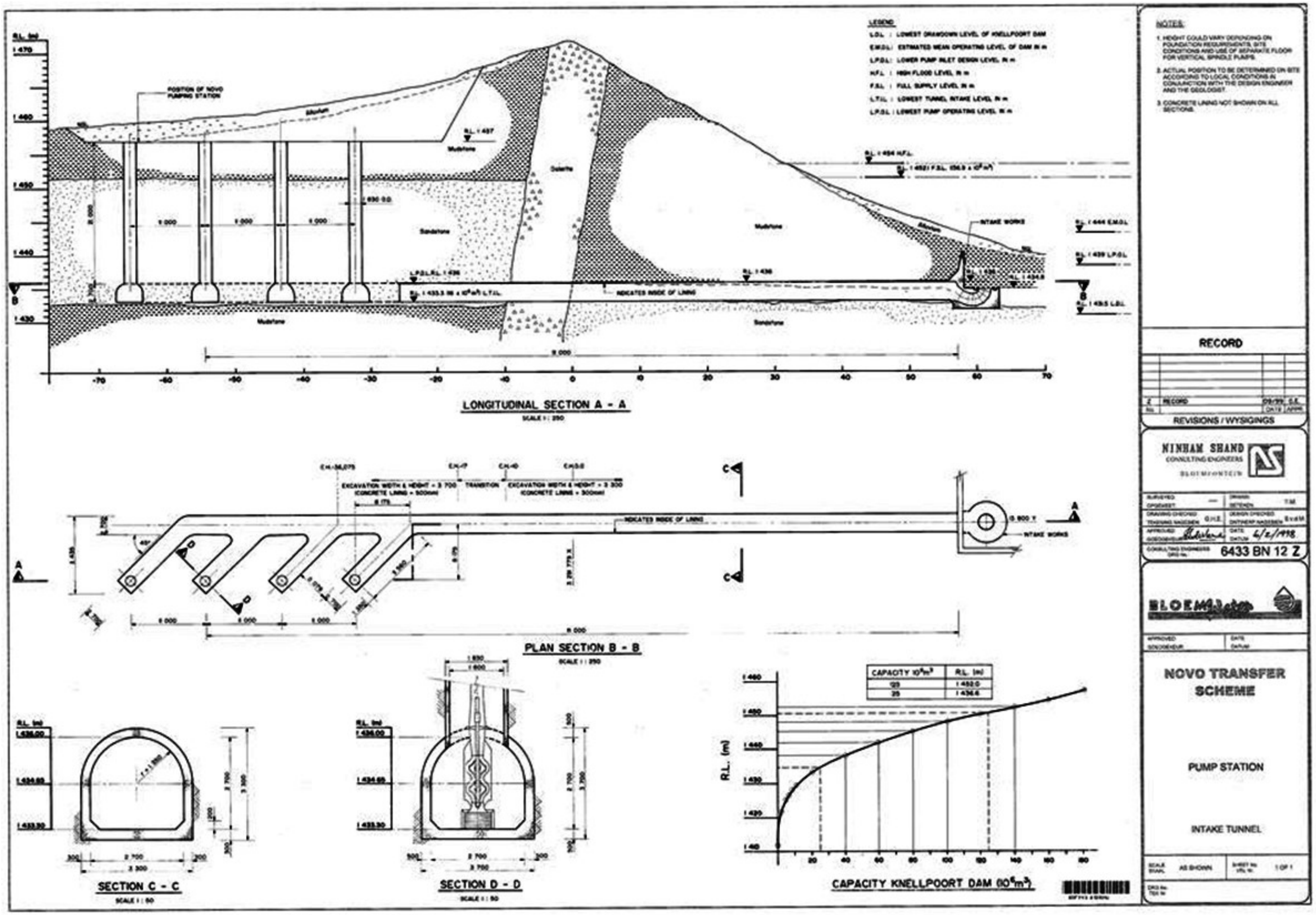


Figure 3-2: Novo Pump Station Intake at Knellpoort Dam

4. BULK WATER AUGMENTATION OPTIONS

The *Reconciliation Strategy Study for Large Bulk Water Supply Systems: Greater Bloemfontein Area* dated June 2012 and subsequent investigations by different role-players all identified the need to implement additional interventions from 2013 onwards in order meet the growing water demands on the GBWSS. The situation has been aggravated by breakdowns of equipment, the time taken to rectify these breakdowns, as well as the time taken to implement the recommended interventions for augmenting the supply from the Caledon River.

There are a number of potential options and sub-options to augment Bloemfontein's bulk water supply. The integration of proposed augmentation infrastructure with the existing GBWSS infrastructure is a key factor influencing the decision making process for the selection of one of these augmentation options irrespective if additional water is obtained from the Caledon or Orange Rivers.

The situation has now become critical necessitating the imposition of water restrictions and the identification of options that could be rapidly implemented to relieve the situation. Several options have been screened for early implementation from the following resources, these being:

- Water from the Gariep Dam,
- Water from the Upper Orange River,
- Water from the Caledon River, and
- Transferred water from the LHWP.

Both BW and MMM have independently undertaken investigative studies for obtaining water from Gariep Dam. It is imperative that such studies are undertaken in line with the Bloemfontein Reconciliation Strategy.

It is recommended that any new infrastructure should not be seen as infrastructure to replace existing infrastructure, but rather as augmentation infrastructure. From an operational perspective, a new pipeline from Gariep Dam would provide significant redundancy and flexibility in the early years and would allow other infrastructure to undergo rehabilitation (i.e. the Welbedacht pipeline). The new pipeline would also mitigate risk in the early years as BW and MMM would have multiple sources/infrastructure to rely upon. Ultimately both the new and existing infrastructure will be fully utilised. The main options for obtaining water from the Gariep Dam which were considered are indicated in **Table 4-1**.

Table 4-1: Main options for augmenting Bloemfontein's water supply from Gariep Dam

Option 1	A pipeline from Gariep Dam directly to Bloemfontein
Option 2	A pipeline from Gariep Dam to the upper reaches of the Modder River
Option 3	A pipeline from Gariep Dam to Knellpoort Dam

These options are shown in **Figure 4-1** on the following page.

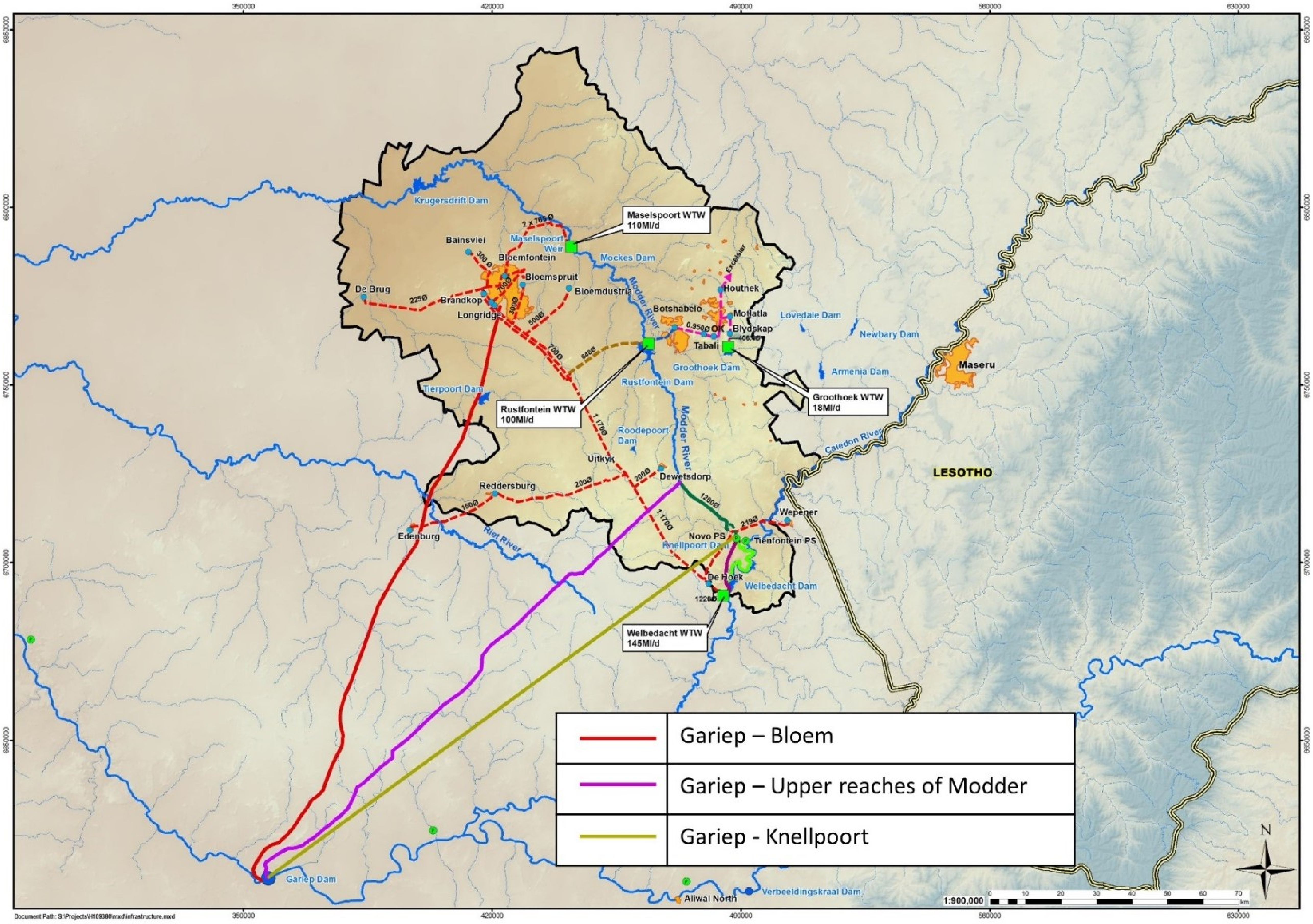


Figure 4-1: **Bulk augmentation options from Gariep Dam**

5. WATER FROM GARIEP DAM

5.1 Work done to date

The following reports have been prepared to date:

- Accelerated Action Plan to Augment Bloemfontein's Water Supply, DWS, August 2014,
- Assessment of Potential Bulk Water Supply Schemes, MMM, March 2015,
- New pipeline from Gariep Dam to Knellpoort Dam, BloemWater, February 2015, and
- Review of Options to Augment Bloemfontein's Water Supply, DWS, May 2015.

The sections below provide a brief overview of the content and findings of these reports.

5.1.1 Accelerated Action Plan to Augment Bloemfontein's Water Supply, DWS

The Accelerated Action Plan identified, evaluated and costed both short and long term options to augment Bloemfontein’s water supply. The long term options included those shown in Section 4 for obtaining water from Gariep Dam including a variety of options to obtain water from both the Orange and Caledon Rivers.

The following Orange River options were screened and costed:

- Water from Gariep Dam:
  - 90 million m^3/a scheme to supply Bloemfontein proposed by MMM,
  - 60 million m^3/a scheme to supply Bloemfontein,
  - 60 million m^3/a scheme to Rustfontein Dam.
- Water from the Upper Orange River:
  - 60 million m^3/a scheme from Oranjedraai,
  - 60 million m^3/a scheme from Aliwal North,
  - 60 million m^3/a scheme from Verbeeldingskraal.

The action plan also indicated estimated system yields and conventional and fast-tracked delivery timeframes for each of the potential options. The key action identified for the selection of long term options was to undertake pre-feasibility and feasibility studies (or one combined study) to determine the preferred option to implement. Some work has already been undertaken in this regard as part of the investigations that followed.

5.1.2 Assessment of Potential Bulk Water Supply Schemes, MMM

The assessment by MMM included an evaluation of all three bulk water supply scheme options referred to in Section 4 at a desktop level. The analysis suggests that, based on capital costs alone a pipeline from Gariep Dam directly to Bloemfontein will be the most cost effective. It also indicates that this will be the preferred option based on a very high level comparison of raw water quality, raw water losses, reliability of infrastructure and energy efficiency aspects.

5.1.3 New pipeline from Gariep Dam to Knellpoort Dam, BloemWater

The report provides comment on technical aspects of all three bulk water supply scheme options referred to in Section 4 at a desktop level, but these were not directly compared. The study focussed on assessing the option of supplying water from Gariep Dam to Knellpoort Dam in more detail than previous investigations. The key reason for focussing on supplying water from Gariep Dam to Knellpoort Dam is that it provides redundancy to existing and planned BloemWater infrastructure which reduces operational risk. The following sub-options associated with this main option were considered:

Table 5-1: Gariep Dam to Knellpoort Dam Pipeline Options evaluated by MMM

Option 3-1	Pump raw water from Gariep Dam to a high point relatively close to Gariep Dam and allow gravity flow to Knellpoort Dam
Option 3-2	Pump raw water from Gariep Dam to the Knellpoort watershed and allow gravity flow over the last few kilometres to Knellpoort Dam
Option 3-3	Pump raw water from Gariep Dam at a lower dynamic head and provide a second pump station approximately mid-way between Gariep Dam and the Knellpoort watershed
Option 3-A	Preferred option of the 3 above plus a gravity main from a point on the Gariep – Knellpoort pipeline to the existing Novo outfall near Dewetsdorp.

The financial analysis indicated that Option 3-3 was marginally cheaper than Option 3-2 and the report recommended that both options should undergo more detailed evaluation to determine a preferred option between them.

5.1.4 Review of Options to Augment Bloemfontein's Water Supply, DWS

The findings of the reports prepared by MMM and BW were presented to DWS at a meeting of key stakeholders on the 19th February 2015 (although the detailed reports were only made available a few weeks after the meeting). DWS reviewed these reports and investigated additional aspects not addressed in the MMM and BW investigations. Using the base information from these investigations, DWS developed additional scheme configurations and analysed these options.

General observations on aspects that need to be addressed are:

a) The size of a pipeline from the Gariep Dam should preferably be based on the transferring of the average annual daily demand (AADD) for the estimated additional water requirements of Bloemfontein within the evaluation period, with peaking provided from WTPs.
b) The additional yield added by the scheme should be based on the incremental yield of the GBWSS following system analysis.
c) The magnitudes of losses should be aligned with loss calculations of the WRYM for the GBWSS.
d) The geographic distribution of the future growth in water requirements should be considered as this will influence the siting of additional WTP capacity to serve the future growth requirements, inclusive of meeting peak water requirements. The phasing of the capacity of WTPs should be considered.
e) Net Present Value (NPV) and unit reference value (URV) calculations should be undertaken.
f) NPV calculations should be based on planning to meet growth in water requirements and not on the pumping of the full AADD, or peak week demand (PWD), from Year 1.
g) Redundancy in the WSS should be taken into consideration to allow for increased system resilience during component failure.

5.2 Technical factors considered in assessing augmentation options

5.2.1 Background

The work completed to date has focussed primarily on the technical requirements of the main options and associated costs. At the stakeholder meeting on the 19th February 2015, additional considerations that did not form part of the initial analyses were highlighted as items requiring further investigation. In particular, consideration of the spatial distribution of current and future water demands and the integration with existing and planned infrastructure are critical factors. The sections below provide a background perspective on these aspects.

5.2.2 Spatial Distribution of Water Requirements

In planning bulk water supply to a large area or one with spatially discrete subareas (zones), variation in the growth in water requirements must be considered (to 2035 and beyond). Infrastructure which is put in place now would need to be able to adequately serve the water users geographically in 2035. **Error! Reference source not found.** table below shows the estimated current and 2035 AADDs and PWDs for the Bloemfontein and Botshabelo/Thaba Nchu supply zones. An initial high level assessment indicates that the split in water requirements between Bloemfontein and Botshabelo/Thaba Nchu is approximately 75% and 25% respectively.

Table 5-2: Current and 2035 Average Annual Daily Demands and Peak Week Demands

Sub Areas	AADD Current Ml/d	Peak Current Ml/d	AADD 2035 Ml/d	Peak 2035 Ml/d
Bloemfontein	185	278	304	455
Botshabelo/Thaba Nchu	51	77	103	155
Total	**236**	**355**	**407**	**610**

5.2.3 Water Treatment Plant (WTP) capacity

The provision of sufficient water treatment capacity to meet the Peak Week demand must be available and should be part of any broader infrastructure planning study which is undertaken. The table below illustrates the current capacity of WTPs compared with the current peak week water requirements, and highlights where surpluses and deficits exist.

Table 5-3: Comparison of 2015 Peak Week WTP Capacity and Peak Week Demand

	Total Treatment Capacity (Ml/d)	Bloemfontein (Ml/d)	Botshabelo/Thaba Nchu (Ml/d)
Welbedacht WTP	145	145	
Rustfontein WTP	100	35 (potentially 50)	65 (Note2)
Maselspoort WTP	110	110	
Groothoek WTP (Note 1)	4.4 (18)		4.4 (design capacity = 18)
Total current WTP capacity	**359 (373)**	**290**	**69.4 (or 83 with Groothoek at 18 Ml/d)**
Current Peak Week Demand	**355**	**278**	**77**
Current Surplus	**4**	**12**	**-7.6 (Refer to Note 3) (or +6 with Groothoek at 18 Ml/d)**

Note 1: *Source is not sufficient to support capacity of WTP on a continuous basis. The availability of water source on a continuous basis is estimated to be 4.4 Ml/d.*

Note 2: *The current infrastructure capacity currently prevents more than 65 Ml/d from being utilised to supply Botshabelo/Thaba Nchu. BW is aware of this and is upgrading this infrastructure link.*

Note 3: *This could also be mitigated by transferring less water from Rustfontein through to Bloemfontein once the additional Lesaka pipeline has been constructed.*

This analysis assumes that a peak week factor of 1.5 applies to both Bloemfontein and to Botshabelo/Thaba Nchu. This would have to be confirmed by a more detailed analysis. The table below indicates the additional WTP capacity required by 2035.

Table 5-4: Comparison of 2015 Treatment Works Capacities and 2035 Peak Week Demands

	Total (Ml/d)	Bloemfontein (Ml/d)	Botshabelo/ Thaba Nchu (Ml/d)
Total current WTP capacity	359	290	69.4
Future Peak Week (2035)	610	455	155
Future WTP Capacity Required (2035)	**251**	**165**	**85.6**

The growth in water requirements and peak week water requirements in both the Bloemfontein and Botshabelo/Thaba Nchu areas will necessitate that additional WTP capacity is installed to serve the anticipated growth in both supply areas. It is important that this aspect be taken into account in the planning of any future pipeline and WTP infrastructure.

5.2.4 System Integration

It is clear that one should not consider the Gariep to Bloemfontein/Knellpoort Dam/Upper Reaches of Modder River scheme in isolation to the rest of the system both in terms of infrastructure and operations.

Future planning to meet the AADD and the PWD should also take account of the capacities of the existing and the planned future infrastructure as indicated below:

- It would be more cost effective to transfer water from Welbedacht Dam to the Longridge reservoirs than from Gariep Dam to the Longridge reservoirs. This is based on the assumption that the treatment facilities at Welbedacht will be upgraded by BW so that the full capacity of 145 Ml/day can be delivered in the summer months. Due to differences in elevation, the energy costs to transfer water from Welbedacht Dam to Bloemfontein will be less than the energy costs to transfer water from Gariep Dam to Bloemfontein.
- BW is currently planning to double a section of the Welbedacht pipeline between Leeukop and Brandkop reservoirs. This new infrastructure would provide additional redundancy and flexibility in the system. Should the Rustfontein WTP be upgraded this additional infrastructure could also be used to convey the additional flow to Bloemfontein. It is therefore important for BW to ensure that the design of the pipeline is adequate (in terms of pressure class) so that it can be used as a potential "multi-purpose pipeline" in the future (i.e. to convey water from either Welbedacht WTP or potentially from an upgraded Rustfontein WTP).
- MMM is currently planning to implement a water re-use scheme (at the new North Eastern WWTP). This scheme and the associated implications it may have in assisting to meet the AADD and PWD up to 2035 need to be integrated into the planning activities.
- The bi-directional pipeline currently being planned by BW should be designed to augment the supply to Knellpoort Dam (and thereby increase the yield of the system) and will also need to be designed to supply water from Knellpoort Dam to Welbedacht WTP to ensure that the Welbedacht WTP can operate at 145 Ml/d on a continuous basis all year round. The capacity and timing of this infrastructure is important and needs to be integrated into the longer term planning of all infrastructure.

5.3 Preliminary Assessment

5.3.1 Introduction

Based on the work done to date by MMM, BW and DWS and discussions held at the various technical meetings, a consolidated preliminary assessment of options was conducted as part of the report entitled "*Review of Options to Augment Bloemfontein's Water Supply, DWS, May 2015*". The findings are presented below.

5.3.2 Options considered

The three primary options which were considered are:

a) A pipeline from Gariep dam to Bloemfontein (Option 1),
b) A pipeline from Gariep Dam to the upper reaches of the Modder River (Option 2),
c) A pipeline from Gariep Dam to Knellpoort Dam (Option 3).

These three bulk water supply scheme options were refined further to create sub-options depending on where the peak week water requirements could be met from. Peak week water requirements from the following WTPs were considered:

i) From Gariep Dam WTP (only for Option 1)
ii) From Maselspoort WTP
iii) From Rustfontein WTP
iv) From Welbedacht WTP
v) From Groothoek WTP (Botshabelo & Thaba N'chu)

In order to facilitate a common understanding of the alternative augmentation alternatives being considered a conceptual diagram of each alternative has been prepared. Within each augmentation option various permutations and combinations for providing the AADDs and PWDs have also been portrayed. Please note that the AADD in this diagram does not necessarily represent the way that the infrastructure will be operated. The augmentation alternatives considered are listed in Table 5-5 below and are illustrated in detail in **Appendix A**. These options would still need to be refined to cater for any potential water losses. The full capital and operating costs (and NPV) of each alternative would also need to be determined taking the capital and operating costs and the growth in the water demands into account.

Table 5-5: Gariep Pipeline Scheme Augmentation Alternatives

OPTION 1: Gariep Dam to Bloemfontein	
Option 1a1:	210 Ml/d Gariep Dam to Bloemfontein Pipeline & new WTP + Upgrades: +86 Ml/d Rustfontein WTP & Rustfontein-Botshabelo/Thaba Nchu Pipeline
Option 1a2:	170 Ml/d Gariep Dam to Bloemfontein Pipeline & new WTP + Upgrades: + 86 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, + 40 Ml/d Maselspoort WTP, Maselspoort-Bloem Pipeline
Option 1a3:	170 Ml/d Gariep Dam to Bloemfontein Pipeline & new WTP + Upgrades: + 126 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, Rustfontein-Bloem Pipeline
Option 1a4:	170 Ml/d Gariep Dam to Bloemfontein Pipeline & new WTP + Upgrades: + 81 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, + 45 Ml/d Welbedacht WTP
OPTION 2: Gariep Dam to the upper reaches of the Modder River	
Option 2a1:	Gariep Dam to Upper Reaches of Modder River Pipeline 170 Ml/d + Upgrades: + 86 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, + 210 Ml/d Maselspoort WTP, Maselspoort-Bloem Pipeline
Option 2a2:	Gariep Dam to Upper Reaches of Modder River Pipeline 170 Ml/d + Upgrades: + 296 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, Rustfontein-Bloem Pipeline

Option 2a3:	Gariep Dam to Upper Reaches of Modder River Pipeline 170 Ml/d + Upgrades: + 251 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, Rustfontein-Bloem Pipeline, + 45 Ml/d Welbedacht WTP
OPTION 3: Gariep Dam to Knellpoort Dam	
Option 3a1:	170 Ml/d Gariep Dam to Knellpoort Dam Pipeline + Upgrades: Knellpoort-Modder River Pipeline + 86 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, + 210 Ml/d Maselspoort WTP, Maselspoort-Bloem Pipeline
Option 3a2:	170 Ml/d Gariep Dam to Knellpoort Dam Pipeline + Upgrades: Knellpoort-Modder River Pipeline + 296 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline
Option 3a3:	170 Ml/d Gariep Dam to Knellpoort Dam Pipeline + Upgrades: Knellpoort-Modder River Pipeline, + 251 Ml/d Rustfontein WTP, Rustfontein-Botshabelo/Thaba Nchu Pipeline, + 45 Ml/d Welbedacht WTP

The table below indicates the percentage split in terms of where water is treated to meet the PWD for the various options and sub-options considered.

Table 5-6: Relative contributions of WTP capacity to meet Peak Week demands

Main option	Sub-option	Gariep WTP	Rustfontein WTP	Maselspoort WTP	Welbedacht WTP	Groothoek WTP
Gariep - Bloem	Option 1a1	34%	30%	18%	16%	1%
	Option 1a2	28%	30%	25%	16%	1%
	Option 1a3	28%	37%	18%	16%	1%
	Option 1a4	28%	30%	18%	24%	1%
Gariep - upper Modder	Option 2a1		30%	52%	16%	1%
	Option 2a2		65%	18%	16%	1%
	Option 2a3		58%	18%	24%	1%
	Option 2a4		50%	33%	16%	1%
	Option 2a5		50%	25%	24%	1%
Gariep - Knellpoort Dam	Option 3a1		30%	52%	16%	1%
	Option 3a2		65%	18%	16%	1%
	Option 3a3		58%	18%	24%	1%
	Option 3a4		50%	33%	16%	1%
	Option 3a5		50%	25%	24%	1%

The detailed breakdown of pump station and pipeline and WTP capacities required for each option is indicated in the following two tables.

Table 5-7: Pump station and pipeline capacities to meet 2035 demand (in Ml/d)

Option Description	Sub-Option No	AADD / Peak	Gariep	Rustfontein		Maselspoort		Welbe-dacht	Bi-directional pipeline	Total delivered to Bloemfontein (sum of values in bold)	Rustfontein		Groothoek	Total delivered to Botshabelo & Thaba N'chu
			Add cap	Ex Cap	Add cap	Ex Cap	Add cap	Ex Cap	Add cap		Ex Cap	Add cap	Ex Cap	
Gariep - Bloemfontein	Option 1a1	AADD	170					134		304	65	34	4	103
		Peak	210	35		110		100		455	65	86	4	155
	Option 1a2	AADD	170					134		304	65	34	4	103
		Peak	170	35		110	40	100		455	65	86	4	155
	Option 1a3	AADD	170					134		304	65	34	4	103
		Peak	170	35	40	110		100		455	65	86	4	155
	Option 1a4	AADD	159					145	45	304	65	34	4	103
		Peak	170	30		110		145	45	455	65	86	4	155
Gariep - upper Modder	Option 2a1	AADD	170	35		110	25	134		304	65	34	4	103
		Peak	170	35		110	210	100		455	65	86	4	155
	Option 2a2	AADD	170	35	25	110		134		304	65	34	4	103
		Peak	170	35	210	110		100		455	65	86	4	155
	Option 2a3	AADD	170	35	14	110		145	45	304	65	34	4	103
		Peak	170	35	165	110		145	45	455	65	86	4	155
	Option 2a4	AADD	170	35	25	110		134		304	65	34	4	103
		Peak	170	35	120	110	90	100		455	65	86	4	155
	Option 2a5	AADD	170	35	14	110		145	45	304	65	34	4	103
		Peak	170	35	120	110	45	145	45	455	65	86	4	155
Gariep - Knellpoort Dam	Option 3a1	AADD	170	35		110	25	134		304	65	34	4	103
		Peak	170	35		110	210	100		455	65	86	4	155
	Option 3a2	AADD	170	35	25	110		134		304	65	34	4	103
		Peak	170	35	210	110		100		455	65	86	4	155
	Option 3a3	AADD	170	35	14	110		145	45	304	65	34	4	103
		Peak	170	35	165	110		145	45	455	65	86	4	155
	Option 3a4	AADD	170	35	25	110		134		304	65	34	4	103
		Peak	170	35	120	110	90	100		455	65	86	4	155
	Option 3a5	AADD	170	35	14	110		145	45	304	65	34	4	103
		Peak	170	35	120	110	45	145	45	455	65	86	4	155

Table 5-8: Water treatment plant capacities to meet 2035 demand (in Ml/d)

Main Option Description	Sub-Option No	AADD / Peak	Gariep	Rustfontein		Maselspoort		Welbe-dacht	Groothoek	Total treatment capacity Bloemfontein + Botshabelo & Thaba N'chu
			Add cap	Ex Cap	Add cap	Ex Cap	Add cap	Ex Cap	Ex Cap	
Gariep - Bloemfontein	Option 1a1	AADD	170	99				134	4	407
		Peak	210	100	86	110		100	4	610
	Option 1a2	AADD	170	99				134	4	407
		Peak	170	100	86	110	40	100	4	610
	Option 1a3	AADD	170	99				134	4	407
		Peak	170	100	126	110		100	4	610
	Option 1a4	AADD	159	99				145	4	407
		Peak	170	100	81	110		145	4	610
Gariep - upper Modder	Option 2a1	AADD		100	34	110	25	134	4	407
		Peak		100	86	110	210	100	4	610
	Option 2a2	AADD		100	59	110		134	4	407
		Peak		100	296	110		100	4	610
	Option 2a3	AADD		100	48	110		145	4	407
		Peak		100	251	110		145	4	610
	Option 2a4	AADD		100	59	110		134	4	407
		Peak		100	206	110	90	100	4	610
	Option 2a5	AADD		100	48	110		145	4	407
		Peak		100	206	110	45	145	4	610
Gariep - Knellpoort Dam	Option 3a1	AADD		100	34	110	25	134	4	407
		Peak		100	86	110	210	100	4	610
	Option 3a2	AADD		100	59	110		134	4	407
		Peak		100	296	110		100	4	610
	Option 3a3	AADD		100	48	110		145	4	407
		Peak		100	251	110		145	4	610
	Option 3a4	AADD		100	59	110		134	4	407
		Peak		100	206	110	90	100	4	610
	Option 3a5	AADD		100	48	110		145	4	407
		Peak		100	206	110	45	145	4	610

Most of the options shown above have been costed for comparative purposes. Option 3a4 and Option 3a5 were added at a late stage and have not been costed yet. It must be noted that the additional pipeline and pump station infrastructure costs required to feed Botshabelo and Thaba N'chu from Rustfontein WTP up to 2035 has not been costed as it is a common cost for all options. The required upgrades to Rustfontein WTP have however been included because this varies for the different options. The cost estimate was undertaken to determine estimated capital costs including determination of the net present value (NPV) costs.

Table 5-9: Estimated capital costs (R million)

Main Option Description	Sub-Option No	Pipelines and Pump stations	WTPs	Total
Gariep - Bloem	Option 1a1	3,385	2,299	**5,685**
	Option 1a2	2,969	2,267	**5,236**
	Option 1a3	3,254	2,267	**5,521**
	Option 1a4	2,965	1,943	**4,908**
Gariep - upper Modder	Option 2a1	3,079	2,131	**5,210**
	Option 2a2	3,683	2,131	**5,815**
	Option 2a3	3,569	1,807	**5,376**
Gariep - Knellpoort Dam	Option 3a1	3,541	2,131	**5,672**
	Option 3a2	4,145	2,131	**6,276**
	Option 3a3	4,031	1,807	**5,838**

Note: Costs exclude engineering design and land acquisition costs and includes P&Gs and contingencies

Table 5-10: Estimated Net Present Value costs (R million)

Main Option Description	Sub-Option No	Pipelines and Pump stations	WTPs	Total
Gariep - Bloem	Option 1a1	4,821	3,674	**8,495**
	Option 1a2	4,483	3,659	**8,142**
	Option 1a3	4,661	3,633	**8,295**
	Option 1a4	4,320	3,107	**7,427**
Gariep - upper Modder	Option 2a1	5,104	3,598	**8,702**
	Option 2a2	5,442	3,461	**8,904**
	Option 2a3	5,857	2,935	**8,793**
Gariep - Knellpoort Dam	Option 3a1	5,967	3,598	**9,565**
	Option 3a2	6,562	3,461	**10,024**
	Option 3a3	6,464	2,935	**9,399**

Note: Costs exclude engineering design and land acquisition costs and includes P&Gs and contingencies

Although the preliminary costing indicates that obtaining water from Gariep Dam directly to Bloemfontein is cheaper than delivering it to the Upper Modder River, the cost estimates are close enough to indicate that more detailed costing is required to confirm which the more cost effective option is. It also implies that factors other than capital cost may be impact on the final selection.

Figure 5-1 and **Figure 5-2** indicate a visual comparison of the current capital and NPV costs for the various options grouped by which WTP is mainly used to meet the PWD.

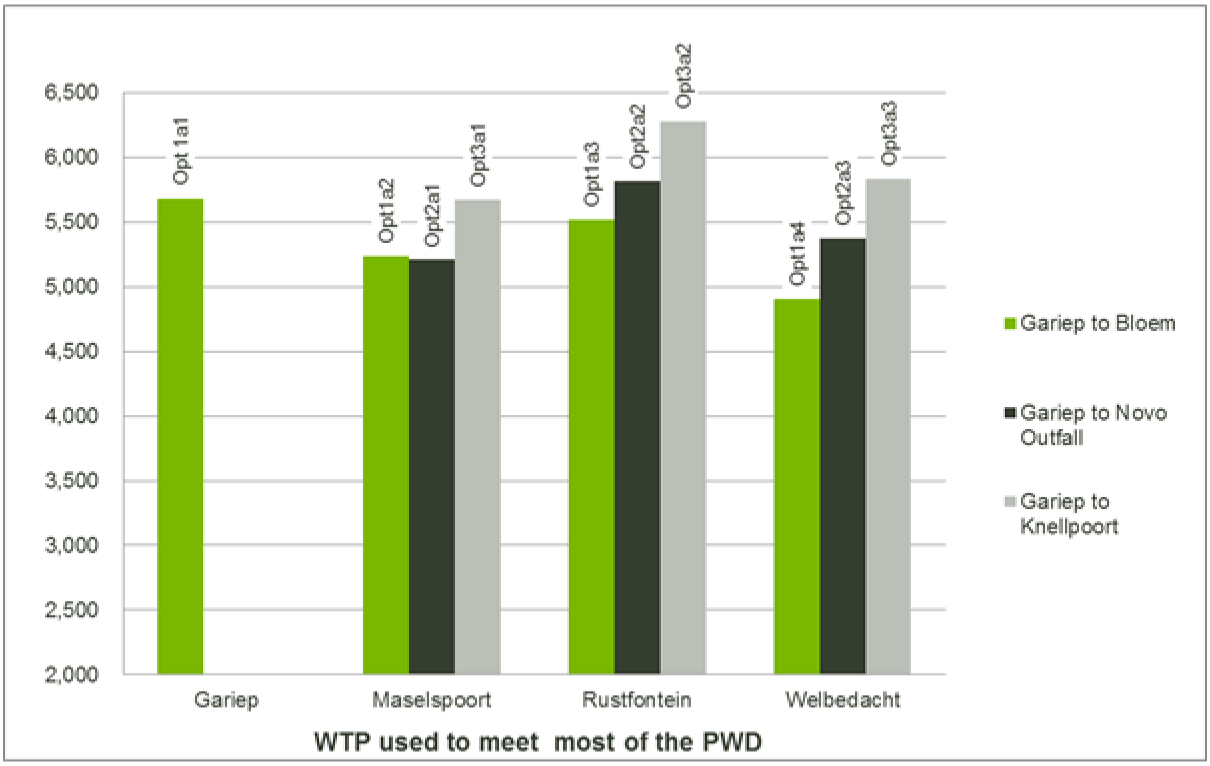


Figure 5-1: Comparative Capital Costs for various options

Note: Peak flows are meanly supplied from WTPs shown on the horizontal axis

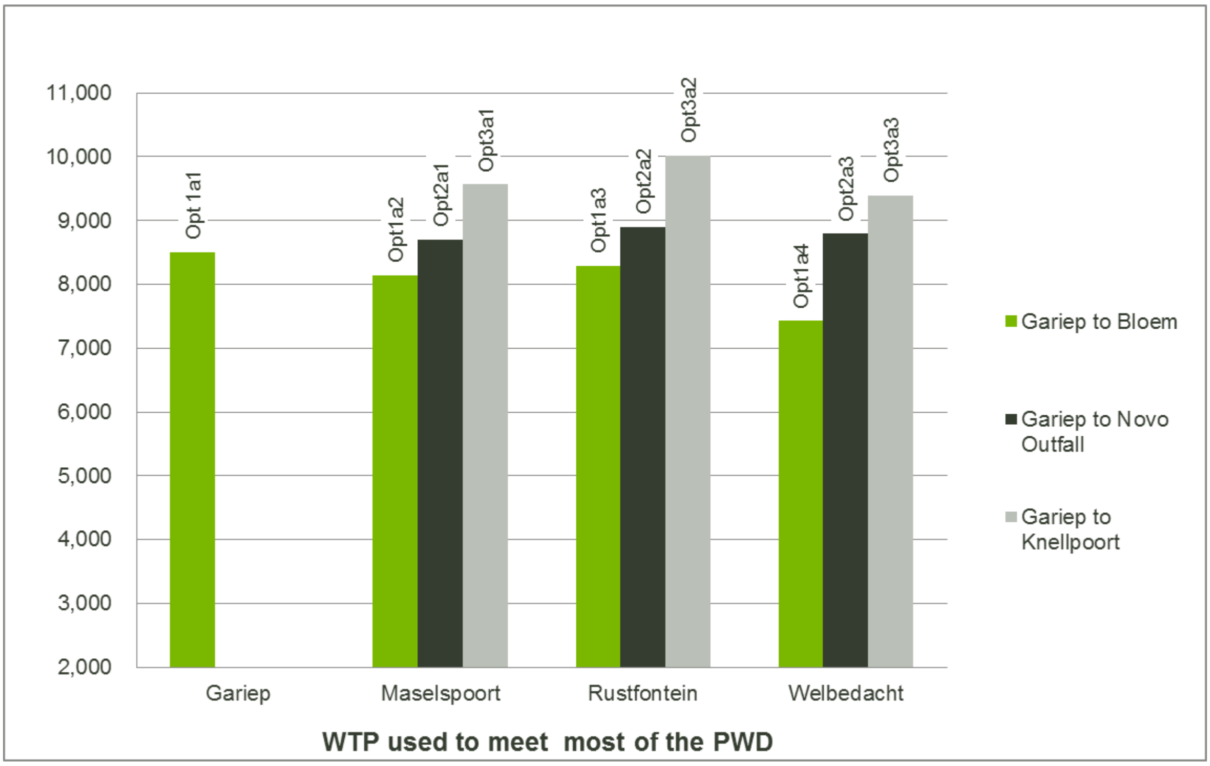


Figure 5-2: Comparative NPV Costs for various options

Note: Peak flows are meanly supplied from WTPs shown on the horizontal axis

5.4 Implementation Programme

The fast-tracked implementation programme for an augmentation scheme from the Gariep Dam approvals has the following characteristics:

- **Feasibility Study of 12 months**, with an additional contractual period of **implementation support of 3 months**,
- **Separate Environmental Impact Assessment (EIA) Study of 16 months**, overlapping with the Feasibility Study (and implementation support) and detailed design periods. Alternatively the EIA could be integrated with the Feasibility Study.

A breakdown of the preparation, procurement and undertaking of the Study is as follows:

Finalise TOR and bid specification and get approval:	1 month
Tender period:	1 month
Adjudication and award:	1 month
Inception Phase:	1 month
Pre-Feasibility Phase – Option Analysis:	2 months
Feasibility Phase:	9 months
Implementation Support (following Feasibility):	3 months

This implies an expected minimum contractual appointment of 15 months for the Study, ***even though the feasibility component could be completed within 12 months***.

This estimation of the programme is based on the following assumptions:

a) The programme constitutes an estimation of the absolute shortest timeframes that the evaluation of the project can practically be done at an acceptable standard, given the emergency situation,
b) High-priority expediting of procurement processes and the necessary approvals to be obtained within the Department,
c) Use of technology that render fast results and will prevent bottlenecks, such as LIDAR remote-sensing technology to produce the required survey information,
d) Larger PSP production teams to cut down on design time,
e) The inclusion of an extended contractual period for the PSP following completion of the Feasibility Study, to provide implementation support to the EIA Study and to facilitate the obtaining of the necessary licences and other approvals.
f) Fast-tracking of environmental approvals, requiring enhanced, high-level cooperative governance.

The attached priority, fast-tracked implementation programme for the Design and Construct contract to follow has the following characteristics:

- **Detail Design and Contractor Procurement of 14 months**, inclusive of additional investigations,
- **Construction period of 30 months**.

A breakdown of the preparation, procurement and undertaking of the Design & Construct period is as follows:

Finalise TOR and bid specification and get approval:	1 month
Tender period:	1 month
Adjudication and award:	1 month

Detail Design and Contractor Procurement:	14 months
Construction:	30 months

This estimation of the **Design & Construct** programme is based on the following assumptions:

a) The programme constitutes an estimation of short timeframes for the implementation of the project at acceptable standards, given the emergency situation,
b) It has been assumed that the Contractor will works on several fronts.
c) Limited delays on account of delays in the supply of materials such as large diameter steel pipes, pumps and equipment, and the impacts of higher summer flows in rivers or summer rainfalls.

An **alternative approach** to Design & Construct is to follow an **Engineering-Procurement-Construction**, or EPC approach, to shorten the implementation programme. This is a common form of contracting agreement in the construction industry. Under an EPC contract, the Contractor /Proposer designs the project, procures the necessary materials, equipment etc. and builds the project, either directly or by subcontracting the work.

The attached programme for the EPC contract to follow has the following characteristics:

- **EPC Detail Design of 5 months**,
- **EPC Construction period of 30 months**.

A breakdown of the preparation, procurement and undertaking of the EPC contract is as follows:

Finalise TOR and bid specification and get approval:	1 month
Tender period:	1 month
Adjudication and award:	1 month
EPC Detail Design:	5 months
EPC Construction:	30 months

By following an EPC procurement approach, the implementation programme could thus be shortened by an estimated 9 months.

The following estimated prioritised and fast-tracked implementation programmes have been included below:

- Feasibility Study,
- Detail design and construction for both traditional Design&Construct and EPC contracts, and
- Generic EIA.

FEASIBILITY STUDY AND IMPLEMENTATION SUPPORT

IMPLEMENTATION ACTIONS	Duration (mths)
1. PREPARATION AND PSP PROCUREMENT	**3**
1.1 DWS decision to proceed and budgeting	1
1.2 Prepare and approve TOR & procurement documentation	1
1.3 Expedited procurement of PSP: Tender period	1
1.4 Expedited procurement of PSP: Adjudicate and award	1
2. INCEPTION PHASE	**1**
2.1 Inception Report	1
3. PRE-FEASIBILITY PHASE: OPTION ANALYSIS	**2**
3.1 Water requirements analysis	1
3.2 Complete Option Analysis, building on work to date	1.5
3.3 Stakeholder interaction & Selection of Option	1
3.3 Pre-Feasibility Report	0.5
4. FEASIBILITY PHASE	**9**
4.1 Water requirement analysis for WSS and small towns	1.5
4.2 Evaluate best integration into Greater-Bloemfontein WSS	1
4.3 Site and route selection	1
4.4 Environmental & Social Assessment and Screening	2
4.5 Topographical/Lidar survey of pipe route and infrastructure sites	1
4.6 Geotechnical investigations	3.5
4.7 Feasibility and Preliminary Design and costing of selected option	5
4.8 Cathodic protection evaluation	5
4.9 Supporting evaluations: Power Supply, Construction & Access, O&M	4
4.10 Water use licences documentation	4
4.11 Regional Economic Impacts evaluation	4.5
4.12 Implementation Mechanism & Arrangements: Legal, Institutional & Financing	4
4.13 Detailed Implementation Programme with phasing & cash flow	1
4.14 Prepare EPC Documentation [OPTIONAL]	4
4.15 Land matters	4.5
4.16 Prepare Feasibility Report	1
4.17 Prepare Record of Implementation Decision (RID) Report	0.5
5. IMPLEMENTATION SUPPORT (FOLLOWING FEASIBILITY)	**3**
5.1 Technical Support to Separate EIA Process	3
5.2 Water use licence applications support	3
6. SEPARATE EIA STUDY (to be continued)	**16**
6.1 EIA Scoping and approval process	6
6.2 Specialist Studies and Environmental Impact Report	7
6.3 Environmental Approval support	-

Months: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

LEGEND:

- Critical path
- Key decision
- Deliverables

DESIGN AND CONSTRUCT [CONVENTIONAL]

IMPLEMENTATION ACTIONS	Duration (mths)	Months 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	…	46	47
1. PREPARATION AND PSP PROCUREMENT	3																												
1.1 DWS decision to proceed and budgeting	1																												
1.2 Prepare and approve TOR & procurement documentation	1																												
1.3 Expedited procurement of PSP: Tender period	1																												
1.4 Expedited procurement of PSP: Adjudicate and award	1																												
2. DETAIL DESIGN & CONTRACTOR PROCUREMENT [CONVENTIONAL]	14																												
2.1 Additional investigations	3																												
2.2 Detail Design and Bill of Quantities	7																												
2.3 Tender specifications, tender period, adjudication and award	4																												
2.4 Expropriation, Servitudes and other authorisations	14																												
3. IMPLEMENTATION SUPPORT	14																												
3.1 Technical Support to Separate EIA Process	3																												
3.2 Water use licensing and approvals support	14																												
4. SEPARATE EIA STUDY (continued)	16																												
4.1 EIA Scoping (complete)	-																												
4.2 Specialist Studies and Environmental Impact Report	7																												
4.3 Environmental Approval support	3																												
5. CONSTRUCTION	30																										…		
5.1 Construction	30																										…		

ALTERNATIVE: ENGINEER-PROCURE-CONSTRUCT [EPC]

IMPLEMENTATION ACTIONS	Duration (mths)	Months 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	…	37	38
1. PREPARATION AND PROCUREMENT OF EPC CONTRACTOR	3																												
1.1 Decision to proceed and budgeting	1																												
1.2 Prepare and approve TOR & procurement documentation	1																												
1.3 Expedited procurement of PSP: Tender period	1																												
1.4 Expedited procurement of PSP: Adjudicate and award	1																												
2. EPC DETAIL DESIGN	5																												
2.1 Detail EPC design	5																												
2.2 Expropriation, Servitudes and other authorisations	5																												
3. IMPLEMENTATION SUPPORT	5																												
3.1 Technical Support to Separate EIA Process	3																												
3.2 Water use licence applications support	5																												
4. SEPARATE EIA STUDY (continued)	16																												
4.1 EIA Scoping (complete)	-																												
4.2 Specialist Studies and Environmental Impact Report	7																												
4.3 Environmental Approval support	3																												
5. EPC CONSTRUCTION	30																										…		
5.1 EPC Construction	30																										…		

GENERIC EIA PROGRAMME

Tasks	Time period (statutory in blue)		Months 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Preliminary site visits, constraints reporting, and design freeze	Depending on the proponent and the process taken to finalise the design																
Compile Scoping Report	Max 60 days																
Submit Application form/s to DEA	One week	44 days															
Submit Scoping Report for a 30 day public comment	30 days																
Submit Scoping Report to DEA for decision-making	One week																
DEA decision-making period for accepting/rejecting Scoping Report	43 days	43 days															
DEA to accept Scoping Report OR Refuse Scoping Report	N/A																
Compile EIA & EMP Report	Max 60 days	106 days															
Submit EIA & EMP Report for 30 day public comment	30 days																
Submit EIA & EMP Report to DEA for decision-making (107 days)	Two weeks																
DEA decision-making period for making a decision on the EIA & EMP Report	107 days																
DEA Grant Environmental Authorisation OR Refuse Environmental Authorisation	N/A																
Notify I&APs of decision	12 days																
Appeal Period (20 days)	20 days																

Note: No allowance has been made for the December closure period of DEA and the impact of this on the schedule can only be established once the start date is known. Therefore 1 month can be added to this schedule for precautionary purposes.

5.5 The way forward

In addition to the evaluation of technical aspects and associated costs, there are several important criteria that need to be considered in order to differentiate between options and to select a preferred option. This is further supported by the preliminary costing indicating that pumping water from Gariep Dam directly to Bloemfontein is marginally cheaper than delivering it from Gariep Dam to the upper Modder River.

Although a significant amount of the base information is readily available from the investigations completed to date, it is still necessary to undertake a pre-feasibility / feasibility study to confirm the preferred option for obtaining water from Gariep Dam. Factors influencing the selection that are to be evaluated as part of these studies include the following:

- Cost
- Risk
- Operational flexibility/redundancy
- Regional economic impact
- Social and environmental Impact
- Institutional aspects / implementation approach
- Phasing and programme
- Availability of finance
- Ease of operation and maintenance

A description of additional investigations that would be required to finalise the pre-feasibility / feasibility study has been included under **Appendix B**, and the key items to consider in the investigation are as listed below:

- Identification and analysis of options,
- Selection of a preferred scheme to evaluate at feasibility level,
- Feasibility-level investigation of the selected scheme and preliminary design, taking into account technical, financial, environmental, socio-economic, legal and institutional aspects,
- Providing an estimate of cost with sufficient accuracy and reliability to ensure that management decisions can be made with confidence.
- Undertaking of geotechnical, soils and topographical surveys
- Planning of schemes in an integrated manner with existing bulk water infrastructure or new water supply infrastructure which is in the process of being implemented,
- Determining of the capacity and incremental yields of identified schemes and river losses associated with each identified scheme by water resource system analysis (using the WRYM),
- Current and future geographical water requirements distribution and the capacities of existing and planned future infrastructure should inform the location of future water augmentation infrastructure and future WTP capacity.
- Evaluation of WSS risks and planning for operational flexibility and redundancy,
- Taking into account the high priority attached to quick implementation,
- The importance of engaging with key stakeholders and I&APs,
- Evaluation of legal, institutional and financial aspects of implementing the scheme,
- Environmental impact assessment and authorisation support, potentially as a separate parallel study,
- Preparation of a Record of Implementation Decisions Report.

6. OTHER POTENTIAL SCHEMES

6.1 Introduction

The yield of the schemes on the Caledon River could be increased by one, many or a combination of interventions (**Figure 6-1**). The consideration of these interventions is important because:

- As previously mentioned, the integration between a proposed pipeline from Gariep Dam with existing and planned infrastructure is a key factor in determining its final route and technical characteristics.
- Almost all other options involve augmentation from the Caledon River, which have sedimentation-related issues to be resolved over time and could provide additional yield in the future.
- A few further alternative augmentation options may be considered.

Potential interventions to increase supply from the Caledon River include:

- Increasing summer supply from Welbedacht WTP,
- Addressing Siltation at Welbedacht Dam and WTP,
- Increasing the capacity of Tienfontein Pump Station,
- Duplication of the Novo Scheme,
- Bi-directional pipeline between Welbedacht and Knellpoort Dams,
- A combination of the abovementioned interventions, and
- Releases from the LHWP into the Little Caledon River.

6.2 Increasing summer supply from Welbedacht Water Treatment Plant

Due to the high turbidity of the raw water, especially during flood events, it is not possible to operate Welbedacht WTP at full capacity throughout the year. The WTP can be operated at its full capacity of 145 Ml/d in winter, but can only treat between 90 and 100 Ml/d in summer when the sediment load in the Caledon River is high. The operation of the Welbedacht WTP at full capacity throughout the year yield could potentially increase the yield of this scheme by about 7 million m^3/annum.

The storage capacity (and potential yield) of Welbedacht Dam could also potentially be improved through the scouring/flushing of Welbedacht Dam, however this would probably only be possible without reducing the flow to the WTP if the Bidirectional pipeline described below is implemented.

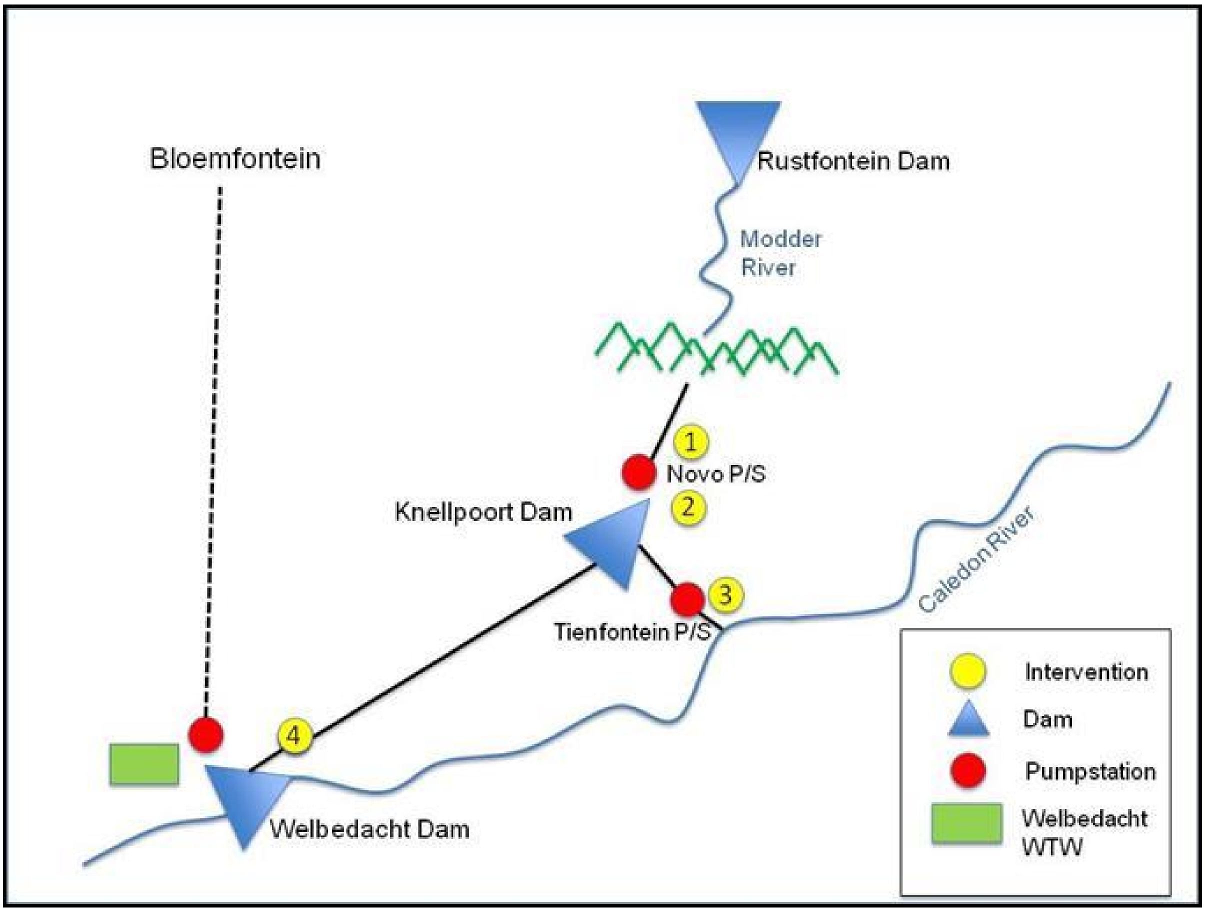


Figure 6-1: Caledon-Bloemfontein Transfer Scheme Interventions

6.3 Addressing Siltation at Welbedacht Dam and WTP

DWS are planning to issue a tender for a PSP to design desilting canals upstream of the Welbedacht WTP and for the potential redesign of the low lift pump station. This will address turbidity issues and allow the Welbedacht WTP to operate at full capacity throughout the year. The appointed PSP will also look at the need for the doubling up of existing pipelines and desilting canals between Tienfontein Pump Station and Knellpoort Dam. At this stage DWS is still in the process of appointing a PSP.

The following need to be investigated as part of feasibility study/design:

- Most suitable manner to augment Knellpoort Dam,
- Synergies with other supply schemes and infrastructure,
- Incremental yield generated and total yield available,
- Environmental implications,
- Water Quality,
- Cost Estimates, and
- Implementation programme.

6.4 Increasing capacity of Tienfontein Pump Station

The Tienfontein Pump Station is owned by DWS and operated by BW, however maintenance and the procurement thereof is undertaken by DWS. The pump station is situated on the Caledon River upstream of Welbedacht Dam and has been severely impacted by the sedimentation of the Caledon River upstream of the Dam. This and the ongoing maintenance problems limit the ability of the pump station to reliably deliver water to Knellpoort Dam.

The existing civil structure of the Tienfontein Pump Station consists of 7 pump bays, 4 of which normally have pump sets each with an installed capacity of 1 m^3/s, but one pump is currently being replaced. The Tienfontein Pump station has an operating capacity of 3 m^3/s (three duty pumps and one standby pump); however the capacity of the three remaining pumps is currently 2.8 m^3/s.

6.4.1 Upgrade to 4 m^3/s

The fourth pump at Tienfontein should be reinstalled by about December 2014. When this fourth pump is repaired or replaced the transfer capacity (excluding standby capacity) of the remaining three pumps will probably also be limited to about 2.8m^3/s.

DWS is proceeding with implementing the installation of two additional (1 m^3/s) pump sets at Tienfontein Pump Station. The first pump set would be utilised to increase the design capacity of the pump station to about 4 m^3/s and the second pump set to provide additional standby capacity. This would provide an additional yield of approximately 5 million m^3/a. The increase in the standby capacity (to 50% of design capacity) should facilitate maintenance of the pumps without impacting on the operating capacity of the pump station.

6.4.2 Upgrade from 4m^3/s to 7m^3/s

The replacement of the existing Tienfontein pump station with a new pump station designed for the high sediment load and with a pumping capacity of about 7 m^3/s has been proposed. This would provide an additional yield of 6 million m^3/annum compared with the 4 m^3/s capacity of the existing pump station after upgrading. It is intended that the proposed 7 m^3/s pump station and pumps would be designed for the local sedimentation circumstances and therefore should be more reliable than the existing pump station and pumps.

DWS is appointing a PSP to undertake the following:

- Double the pipeline at Tienfontein to the canal,
- Add another de-silting canal at Tienfontein,
- Add de-silting canals at the Welbedacht abstraction in order that water can be abstracted even when the Caledon River is in flood,
- Replace the low level pump station,
- Other Dam Safety related rehabilitation work.

6.5 Duplication of Novo Scheme

BW's Novo Transfer Scheme pumps water from Knellpoort Dam via a 20 km long 1 200 mm steel pipeline into the upper reaches of the Modder River, to augment the flows into Rustfontein Dam.

The Novo Pump Station currently houses 2 pump sets with a capacity of 1.7 m^3/s (without standby capacity) when the water level in Knellpoort Dam is at full supply level. One of these pump sets was out of commission for 7 months and was recommissioned in June 2014. BW has let a contract for the installation of a third pump set to increase the capacity of the pump station to 2.4 m^3/s (without standby capacity).

It has been assumed that the Novo scheme would have to be duplicated (pipeline and pump station) to serve the proposed Knellpoort Dam augmentation by the proposed bidirectional pipeline between the Knellpoort and Welbedacht Dams/Knellpoort Dam raising described below. The total pumping head for the Novo scheme of 160 m has been included in the pumping head of all these schemes which would utilise Knellpoort Dam.

It is recommended that the raising of Knellpoort Dam should form part of any further investigations of the bi-directional pipeline and schemes from the Orange River. The scheme would require the duplication of the pump station and the 1 200 mm pipeline, but it has been assumed that it would be possible to utilise the existing intake works, however this would have to be confirmed.

6.6 Bi-directional pipeline between Welbedacht and Knellpoort Dams

The Final report J 33162-C-01 dated December 2014 and entitled “Preliminary Hydropower Potential Assessment” which was prepared by BW investigated the feasibility of generating hydroelectric power within the Welbedacht and Knellpoort Dams system, with the aim of augmenting the electric power supply to the system. As indicated by the title this report mainly considers possibilities for hydropower generation and not the augmentation of the yield of the system.

BW’s assessment of the hydropower potential of various schemes was based on available flow records and no system yield analyses were undertaken. BW assumed that each year the proposed bi-directional pipeline would deliver 0.88 m^3/s from Welbedacht Dam to Knellpoort Dam during the high flow months of January, February and March and that 0.88 m^3/s would be transferred from Knellpoort Dam to Welbedacht Dam during the low flow months of June, July and August. The report mentions that during the winter months when there is insufficient inflow from the Caledon River into Welbedacht Dam to supply the Welbedacht WTP, water is released from Knellpoort Dam to supplement the supply to Welbedacht Dam, and that about 50% of these releases are lost. The report indicates that about 6 million m^3 is released annually and therefore it can be inferred that about 7 million m^3/annum of the available yield of the system is lost. However if the losses are only 10%, as assumed for the System Modelling, then the yield of the proposed scheme would only amount to 0.8 million m^3/annum.

The DWS’ *Reconciliation Strategy Study* and the later “*Accelerated Action Plan to Augment Bloemfontein’s Water Supply*” dated August 2014 investigated options for utilising a bi-directional pipeline to supply the Welbedacht WTP during periods of low flow in the Caledon River and to augment the supply of BW’s system from Knellpoort Dam via the Novo Scheme. It was determined that this scheme could augment the supply from the Caledon River (from Welbedacht Dam to Knellpoort Dam) by 46 million m^3/a. This would however be dependent on the capacity of the infrastructure constructed.

It is important for BW to investigate the bi-directional pipeline between Welbedacht and Knellpoort Dams for the purpose of augmenting water supply as well as for providing Welbedacht WTP with good quality water. The correct pipeline capacity needs to be installed to be able to obtain the requisite yield and upgrading or duplication of the Novo pumping scheme may also be required.

6.7 Addressing Siltation at Welbedacht Dam and WTP

On account of the high turbidity of the river water in Welbedacht Dam, especially during flood events it is not possible to operate Welbedacht WTP at full capacity throughout the year. The WTP can operate at its full capacity of 145 Ml/d in winter, but can only treat between 90 and 100 Ml/d in summer when the silt load in the Caledon River is high. It is estimated that the yield of the system could potentially be increased by about 7 million m^3/annum if the WTP would be operated at full capacity all year round.

The storage capacity (and potential yield) of Welbedacht Dam could also potentially be improved through the scouring/flushing of Welbedacht Dam, however if it is not feasible to interrupt the flow to the WTP then one option would be to supply the works via the bidirectional pipeline.

The 2012 Reconciliation Strategy recommended that the best approach to these sediment control interventions should be investigated.

DWS are planning to issue a tender for a PSP to design desilting canals upstream of the Welbedacht WTP and for the potential redesign of the low lift pump station. This will address turbidity issues and allow the Welbedacht WTP to operate at full capacity throughout the year. The appointed PSP will also look at the need for the doubling up of existing pipelines and desilting canals between Tienfontein Pump Station and Knellpoort Dam. At this stage DWS are still in the process of appointing a PSP.

The following need to be investigated as part of feasibility study/design:

- Most suitable manner to augment Knellpoort Dam.
- Synergies with other supply schemes and infrastructure.
- Incremental yield generated and total yield available.
- Environmental implications.
- Water Quality.
- Cost Estimates.
- Implementation programme.

6.8 Alternative infrastructure option

To facilitate the maximum use of future infrastructure currently being planned by both BW and MMM, an alternative infrastructure solution (Option 4) to the three Gariep pipeline options, termed "*Integration with planned future infrastructure*" has been developed. This solution focusses on water re-use and the proposed bi-directional pipeline between Welbedacht Dam and Knellpoort Dam. This alternative infrastructure solution provides the same AADD and PWD capacity as a pipeline from Gariep Dam (options 1 to 3). It is proposed that this infrastructure solution be costed to have a comparative reference for the Gariep pipeline options.

The detailed breakdown of pump station and pipeline and WTP capacities required for this option is indicated in the following two tables.

Table 6-1: Pump station and pipeline capacities to meet 2035 demand (in Ml/d)

Sub-Option No	AADD / Peak	Rustfontein		Maselspoort		Welbe-dacht	Bi-directional pipeline	Total delivered to Bloemfontein	Rustfontein		Groothoek	Total delivered to Botshabelo & Thaba N'chu
		Ex Cap	Add cap	Ex Cap	Add cap	Ex Cap	Add cap		Ex Cap	Add cap	Ex Cap	
Option 4a	AADD	35		110	25	134	125	304	65	34	4	103
	Peak	35		110	210	100	125	455	65	86	4	155
Option 4b	AADD	35	25	110		134	125	304	65	34	4	103
	Peak	35	210	110		100	125	455	65	86	4	155
Option 4c	AADD			110	60	134	125	304	65	34	4	103
	Peak	35	120	110	90	100	125	455	65	86	4	155

Table 6-2: Water treatment plant capacities to meet 2035 demand (in Ml/d)

Main Option Description	Sub-Option No	AADD / Peak	Rustfontein		Maselspoort		Welbe-dacht	Groothoek	Total treatment capacity Bloemfontein + Botshabelo & Thaba N'chu
			Ex Cap	Add cap	Ex Cap	Add cap	Ex Cap	Ex Cap	
Integration with planned future infrastructure	Option 4a	AADD	100	34	110	25	134	4	407
		Peak	100	86	110	210	100	4	610
	Option 4b	AADD	100	59	110		134	4	407
		Peak	100	296	110		100	4	610
	Option 4c	AADD	99		110	60	134	4	407
		Peak	100	206	110	90	100	4	610

Most of the options shown above have been costed for comparative purposes. Option 4c were added at a late stage and have not been costed yet. It must be noted that the additional pipeline and pump station infrastructure costs required to feed Botshabelo and Thaba N'chu from Rustfontein WTP up to 2035 has not been costed as it is a common cost for all options. The required upgrades to Rustfontein WTP have however been included because this varies for the different options. The cost estimate was undertaken to determine estimated capital costs including determination of the NPV costs.

Table 6-3: Estimated capital costs (R million)

Main Option Description	Sub-Option No	Pipelines and Pump stations	WTPs	Total
Integration with planned future infrastructure	Option 4a	907	2,131	**3,038**
	Option 4b	1,512	2,131	**3,643**

Note: Costs exclude engineering design and land acquisition costs and includes P&Gs and contingencies

Table 6-4: Estimated Net Present Value costs (R million)

Main Option Description	Sub-Option No	Pipelines and Pump stations	WTPs	Total
Integration with planned future infrastructure	Option 4a	1,769	3,598	**5,368**
	Option 4b	2,364	3,461	**5,826**

Note: Costs exclude engineering design and land acquisition costs and includes P&Gs and contingencies

6.9 Releases from LHWP into the Little Caledon River

The LHWP Delivery Tunnel North can discharge water into the Little Caledon River, which flows into the Caledon River and past the Tienfontein Pump Station (which can pump water into the Knellpoort Dam) and from there into Welbedacht Dam. Along its course to Welbedacht Dam these rivers pass irrigated areas and various towns in South Africa and Lesotho which abstract water from the rivers and riparian vegetation and evaporation results in other losses. Therefore it is very important to assess the losses that occurred during the recent release of water authorised by the Minister of DWS in order to gain a better understanding of these losses and the management of such releases so as to be able maximise their utilisation, should it be necessary to make additional releases to augment the bulk supply to Bloemfontein.

The abstraction of water at the Tienfontein Pump Station is limited by the ability to divert water into the Tienfontein pump station and by the capacity of the pumps. It is understood that sand bags were placed in the Caledon River to divert the recent LHWP releases into the pump station. The utilization of this water also depends on the pumping capacity available at the Tienfontein pump station.

The main advantage of such a release is that it can be implemented at very short notice whereas there are also the following disadvantages:

- River losses and losses in diverting the water from the Caledon River into the Tienfontein Pump Station.
- The limited available storage in Welbedacht Dam (the dam will fill very quickly and will then spill)
- The potential loss of yield of the Vaal Water Supply System. The economic value of water would need to be considered when deciding where best to utilise the water.

If further releases are made it is recommended that these are optimised based on the experience of the previous release and that monitoring be undertaken to further optimise the beneficial utilisation of such releases.

6.10 Other implementation options

Other options to supplement available water for the Greater Bloemfontein area includes:

- Water conservation and water demand management (WC/WDM)
- Potential unauthorised use compliance monitoring enforcement
- Water re-use
- Groundwater

These initiatives have been described and are being led by various representatives within DWS, MMM and BW.

6.10.1 Water Conservation and Water Demand Management

MMM is in the process of implementing various WC/WDM initiatives. The objective of these initiatives is to reduce non-revenue water (NRW), reduce water demand and improve efficiency of the water supply system. The work completed to date is covered by the following programs:

- Thaba Nchu rural villages leak repairs and pipe replacement.
- Accelerated Community Infrastructure Program (ACIP 1 and 2).
- Mangaung Real Water Loss Reduction Program.
- Replacement and Installation of water meters and associated works.

MMM is currently preparing a 10-year WC/WDM strategy. The content of this strategy will be presented to the next Strategy Steering Committee meeting scheduled to be held in November 2014.

Funding is currently a limiting factor in achieving the required targets.

6.10.2 Potential Unauthorised Use Compliance Monitoring Enforcement

DWS is currently also investigating unauthorised water use. The process entails in-field confirmation of potential unauthorised use followed by handover to the Compliance Monitoring Enforcement (CME) office. The CME office will issue directive to users to stop unlawful water use and is able to take further steps where necessary.

6.10.3 Water Re-use

Water reuse includes the direct or indirect re-use of treated effluent. Public resistance to this intervention may be encountered, possibly stemming from concerns of poor design or control of processes which may allow sub-standard water to be introduced into the potable water supply system, or for religious reasons.

Waste water treatment plant (WWTP) return flows from upstream of Mockes Dam flow into the dam where it is mixed with runoff and releases from Rustfontein Dam. Water is abstracted from Mockes Dam for irrigation and for treatment at Maselspoort to supply Bloemfontein.

Other water available for re-use would only be that arising from the growth in return flows from other WWTPs in the catchment area after 2009. It was assumed in the Reconciliation Strategy that the then return flows from the WWTPs were being used by the agricultural sector and that the system was in balance at the time (2012). It was further assumed that the wastewater return flows generated by the anticipated future growth in water requirements could be used to supply a water re-use scheme. The yield of this option, for the purposes of the scenario planning, was assumed to be 10.8 million m^3/a in the Reconciliation Strategy, but may ultimately be significantly more, depending on the growth in water use and return flows.

It was for this reason that re-use as a future water augmentation measure was not regarded as an immediate priority and was shown to come on line in approximately 2028. **Table 6-5** shows a comparison between the water requirements and waste water return flows when the Reconciliation Strategy was developed (between 2009 and 2012) and the recent water requirements and increases in waste water flows (2013 and 2014). From the table is it clear that the increase in water requirement from 2009 to 2015 is 6.51 million m^3/a. If one assumes that approximately 50% of this water requirement is returned back to the river, the current (2015) return flows available for a water re-use scheme would be in the order of 3.3 million m^3/a (or 9.9 Ml/d).

Table 6-5: Water Requirements and Waste Water Return Flows

	Water Requirements		Waste Water Return Flow Increases	
Year	Total Water Requirements in million m^3/a	Growth from the 2009 base in million m^3/a	Available for Re-use (in terms of Reconciliation Strategy) in million m^3/a	Available for Re-use (in terms of Reconciliation Strategy) in Ml/d
2009	79.8			
2010	78.7	(1.08)		
2011	77.0	(2.82)		
2012	80.8	0.96	0.48	1.3
2013	85.5	5.68	2.84	7.8
2014	86.3	6.51	3.25	8.9

While is it commendable that MMM is investigating and planning for water re-use the MMM needs to be aware that the actual usage may be limited in the early years. This is because the water requirement differential needs to increase to make this augmentation scheme a significant source, otherwise the usage may be at the expense of water being available to the agricultural sector. The available water for re-use will increase as the water requirement for the Greater Bloemfontein area increases. The potential for re-use up to 2035 also needs to be integrated into the overall infrastructure planning for meeting the future AADD and PWDs. **Re-use of wastewater will have to be implemented in conjunction with another augmentation scheme which will provide the additional input source volume to make the scheme viable.**

6.10.4 Groundwater

Should groundwater be developed to supply the full current and projected water requirements of Wepener, Dewetsdorp, Reddersburg, Edenburg and Excelsior, then the water demand on the Greater Bloemfontein system would be reduced by approximately 4%. This would reduce the risk of non-supply and also keep the system in balance until 2016 where after a new augmentation scheme would be required.

Groundwater to augment the greater Bloemfontein area itself was ruled out as a feasible large scale augmentation options due to current abstraction levels, high costs and low borehole yields.

7. THE WAY FORWARD

The following way forward is proposed:

1) Reach agreement on the responsible authority to undertake a comprehensive feasibility study of a pipeline scheme from Gariep Dam, to augment the GBWSS.

2) Preparation of a draft terms of reference, arrangement of finance and procurement of a PSP to undertake a feasibility study, inclusive of a pre-feasibility phase.

3) Select a preferred augmentation option following pre-feasibility evaluation.

4) Proceed with a detailed feasibility study, detailed design and construction.

8. REFERENCES

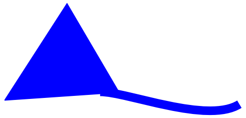
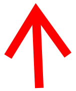
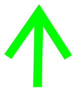
1. Bloem Water, 2011. Extension of the Capacity of the Novo Transfer Scheme Study (EB/2009/5). Prepared by V&V Consulting Engineers Pty (Ltd) *et al* for Bloem Water.
2. Bloem Water, 27 February 2015. New Pipeline from Gariep Dam to Knellpoort Dam Feasibility Study Report, Final Report. Prepared by Babereki Consulting Engineers.
3. Department of Water and Sanitation, August 2014. Accelerated Action Plan to Augment Bloemfontein's Water Supply, Prepared by Aurecon South Africa.
4. Department of Water Affairs, South Africa. 2012. Reconciliation Strategy Report for the Large Bulk Water Supply Systems of the Greater Bloemfontein Area. Prepared by Aurecon in association with GHT Consulting Scientists and ILISO Consulting as part of the Water Reconciliation Strategy Study for the Large Bulk Water Supply Systems: Greater Bloemfontein Area. DWA Report No. P WMA 14/C520/00/0910/05.
5. Department of Water Affairs, South Africa. May 2015. Review of Options to Augment Bloemfontein's Water Supply Report. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area.
6. Department of Water Affairs, South Africa, 2014. Final Reconciliation Strategy (July 2014) – internal draft. Prepared by WRP Consulting Engineers *et al* as part of the Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River.
7. Department of Water Affairs, South Africa. June 2014. Progress Report of the Strategy Steering Committee meeting 5 held on the 19th June 2014. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area.
8. Department of Water Affairs, South Africa. May 2014. Minutes of the Technical Support Committee Meeting held on the 8th May 2014. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area.
9. Department of Water Affairs, South Africa. July 2015. Monthly Monitoring Report of the Orange River System: Annual Operating Analysis 2015 - 2016. Prepared by WRP Consulting Engineers.
10. Department of Water Affairs, South Africa. November 2013. Progress Report of the Strategy Steering Committee Meeting. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area.
11. Mangaung Metro Municipality, March 2015. Water Supply Augmentation to the Greater Bloemfontein Area from the Orange River, Assessment of Bulk Supply Options, Draft report. Prepared by Bigen Africa Services (Pty) Ltd for Mangaung Metro Municipality.
12. Mangaung Metro Municipality, 23 June 2014. Caledon Modder Sub System: Limiting of Water Use in terms of Item 6 of Schedule 3 of the National Water Act of 1998 (Act 36 of 1998): Implementation of Water Restriction. Internal Letter to the City Manager from Directorate Engineering Services.

Appendix A

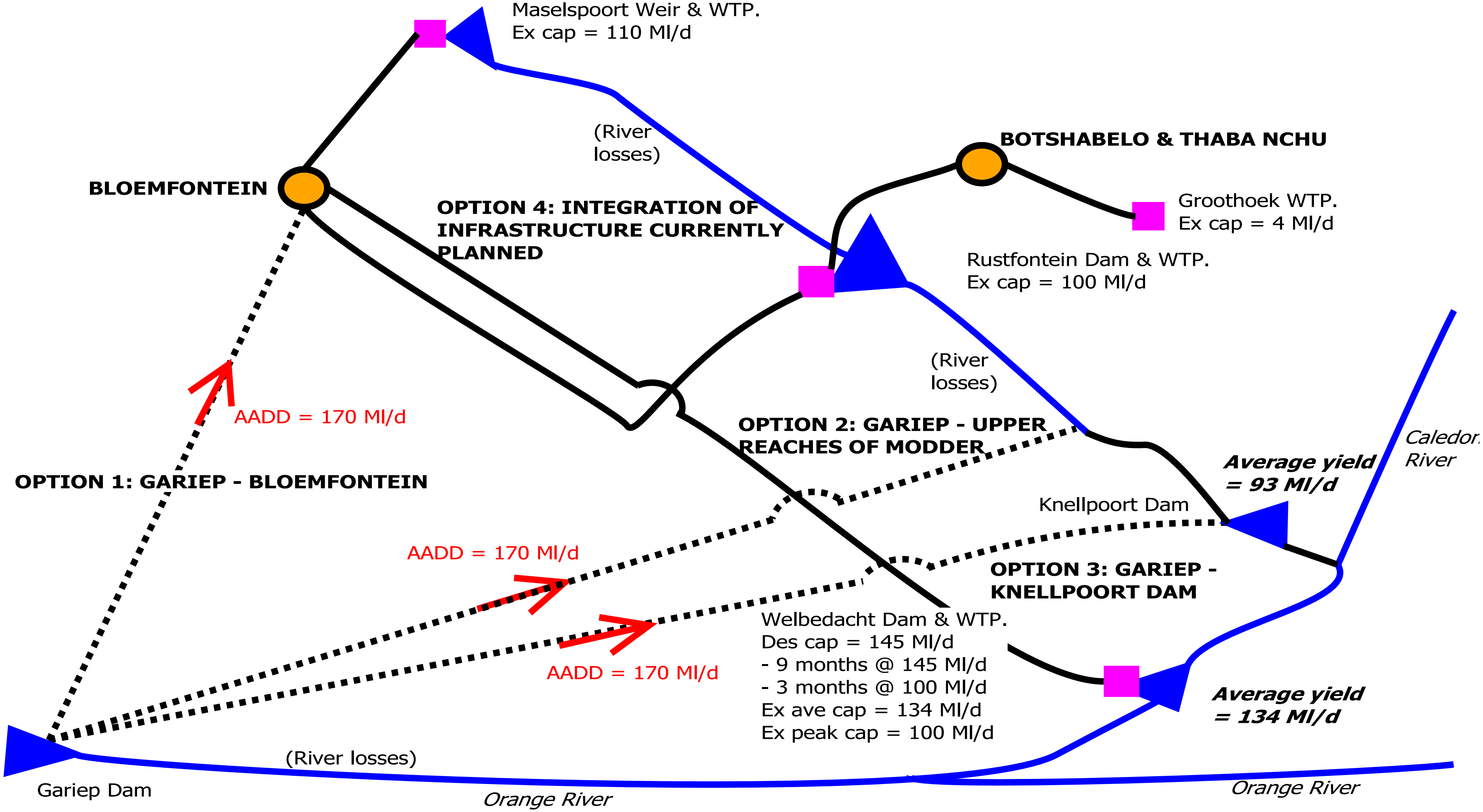
Conceptual layouts for augmenting water supply from Gariep Dam

APPENDIX A: Conceptual layouts for augmenting water supply from Gariep Dam

KEY

	Denotes storage dam
 Rustfontein Dam & WTP. Ex cap = 100 Ml/d Add cap = 34 Ml/d (Tot cap = 134 Ml/d) Add cap = 86 Ml/d (Tot = 186 Ml/d)	Ex cap = Existing treatment capacity Add cap = Additional treatment capacity required to satisfy 2035 AADD Add cap = Additional treatment capacity required to satisfy 2035 Peak Demand
(solid line)	Denotes existing pipeline
(dotted line)	Denotes potential future pipeline
 AADD = 134 Ml/d	Denotes flow in pipeline to meet AADD requirements
 Peak = 100 Ml/d	Denotes flow in pipeline to meet Peak Week Daily Demand requirements

MAIN OPTIONS CONSIDERED



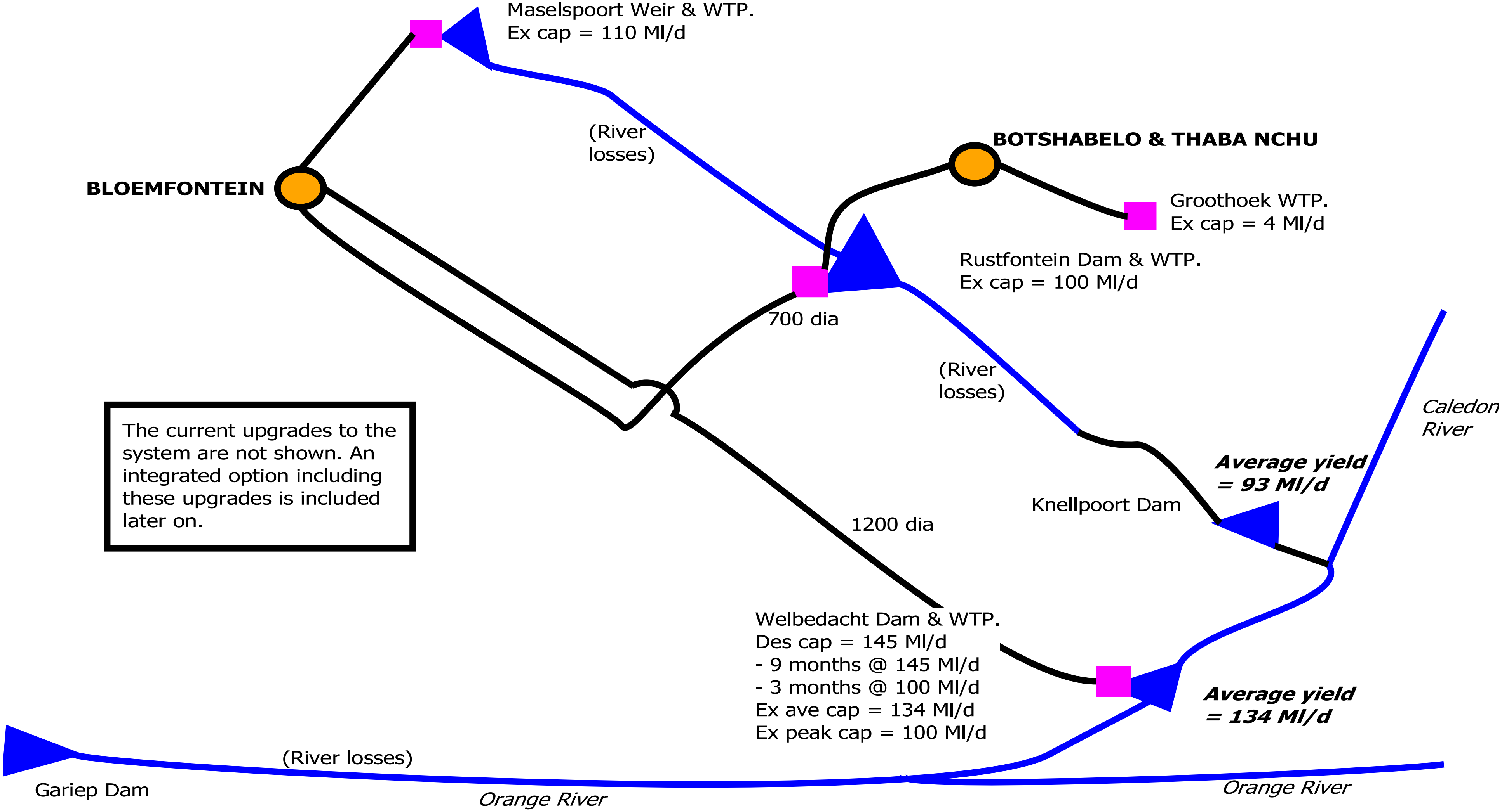
DETAILED OPTIONS CONSIDERED

OPTION 1: GARIEP- BLOEMFONTEIN	
OPTION 1a1:	GARIEP-BLOEM PIPELINE & WTP 210 Ml/d + UPGRADES: +86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, TIENFONTEIN
OPTION 1a2:	GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 40 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, TIENFONTEIN
OPTION 1a3:	GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 126 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN
OPTION 1a4:	GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 81 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 45 Ml/d WELBEDACHT WTP, KNELLPOORT-WELBEDACHT PIPELINE, , TIENFONTEIN
OPTION 2: GARIEP-UPPER REACHES OF THE MODDER RIVER	
OPTION 2a1:	GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 210 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, , TIENFONTEIN
OPTION 2a2:	GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 296 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN
OPTION 2a3:	GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 251 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, + 45 Ml/d WELBEDACHT WTP, KNELLPOORT-WELBEDACHT PIPELINE, TIENFONTEIN

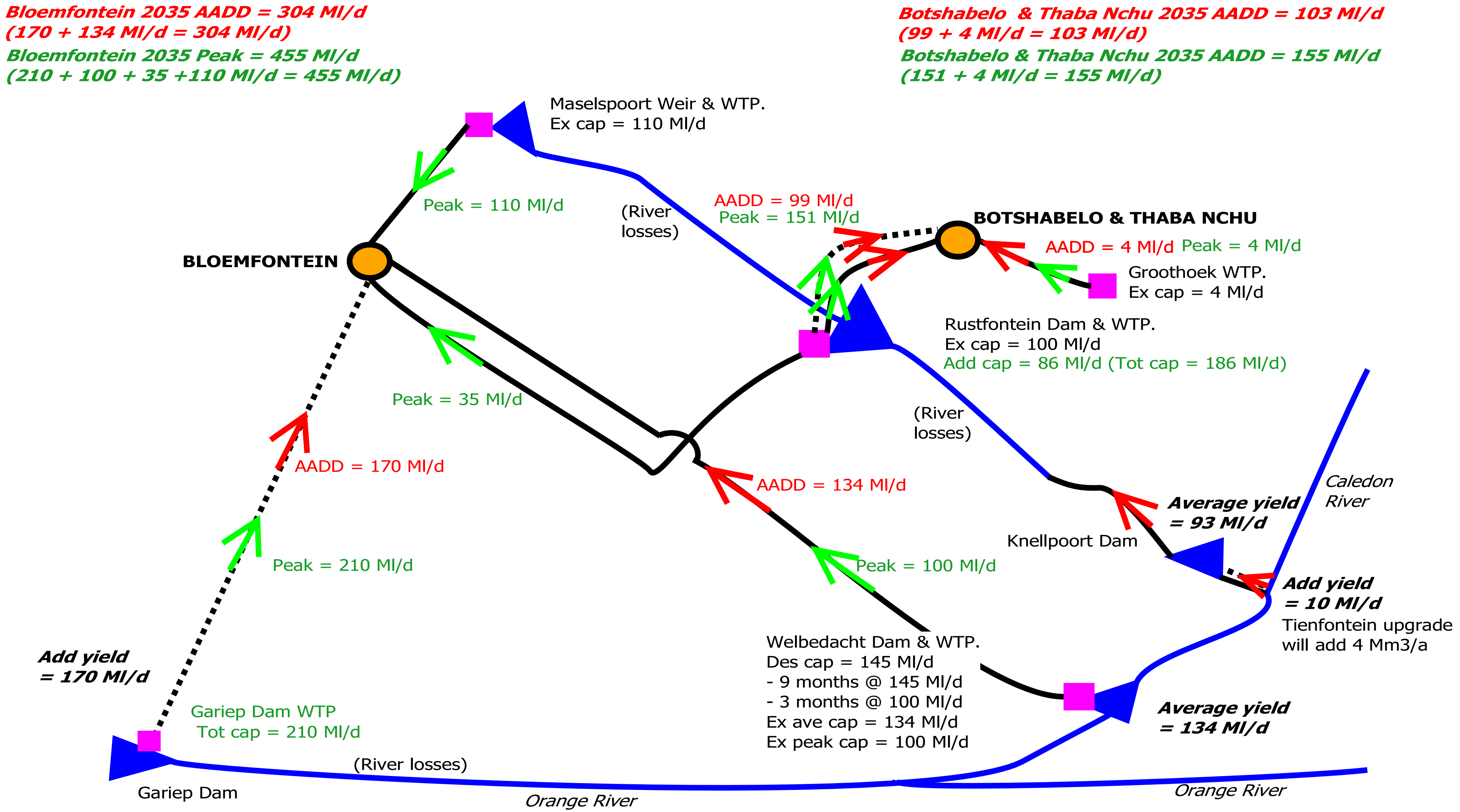
DETAILED OPTIONS CONSIDERED

OPTION 3: GARIEP – KNELLPOORT DAM	
OPTION 3a1:	GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-MODDER RIVER PIPELINE + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 210 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, TIENFONTEIN
OPTION 3a2:	GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-MODDER RIVER PIPELINE + 296 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN
OPTION 3a3:	GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-WELBEDACHT PIPELINE, + 251 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, + 45 Ml/d WELBEDACHT WTP, TIENFONTEIN
OPTION 4: INTEGRATION OF PLANNED INFRASTRUCTURE INTO 2035 SOLUTION	
OPTION 4a:	BI-DIRECTIONAL PIPELINE, + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE + 103 Ml/d MASELSPOORT WTP, KNELLPOORT-WELBEDACHT PIPELINE,+ 45 Ml/d WELBEDACHT WTP, TIENFONTEIN
OPTION 4b:	BI-DIRECTIONAL PIPELINE, + 189 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN –BLOEM PIPELINE, + 62 Ml/d MASELSPOORT WTP, KNELLPOORT-WELBEDACHT PIPELINE,+ 45 Ml/d WELBEDACHT WTP

EXISTING INFRASTRUCTURE



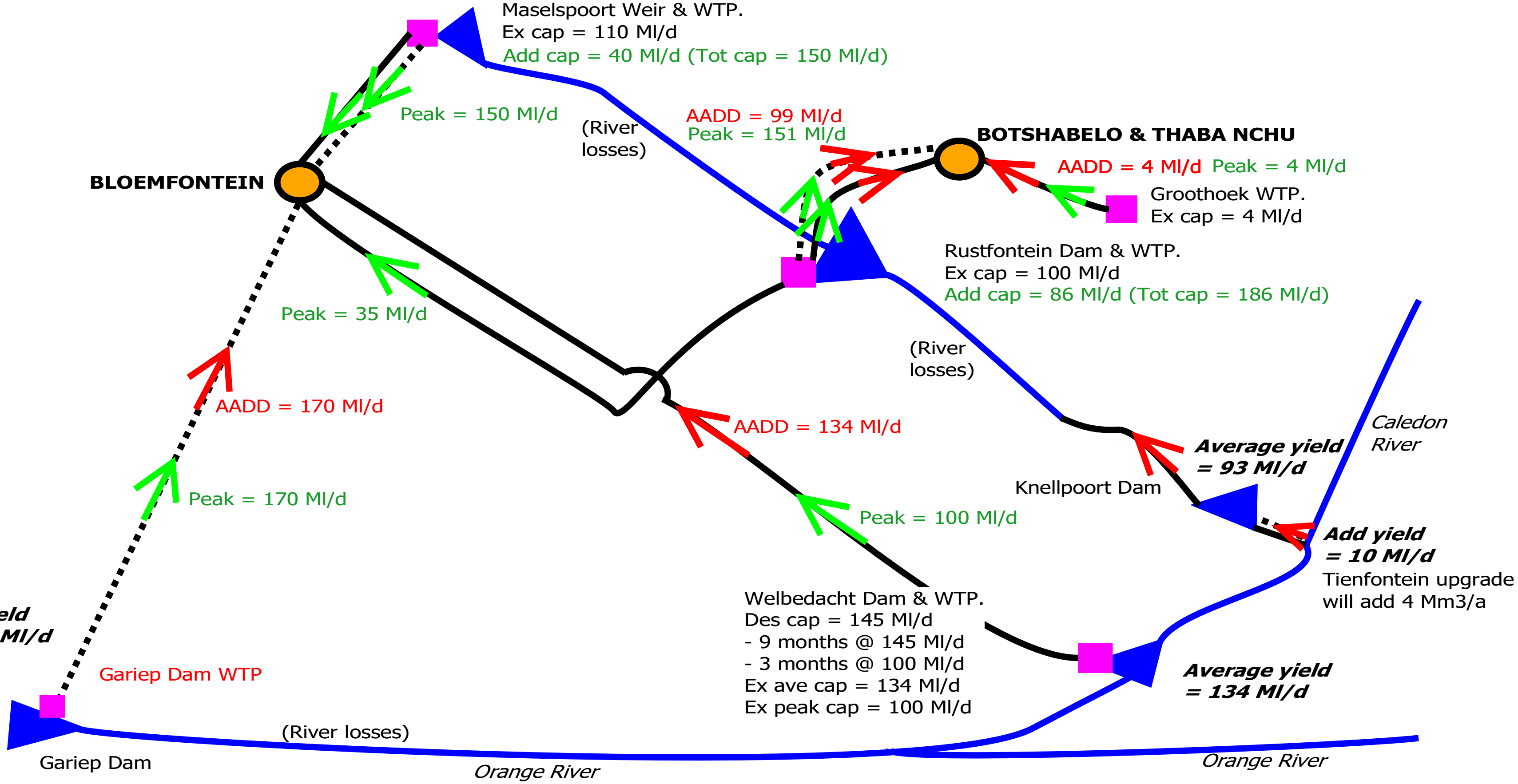
OPTION 1a1: GARIEP-BLOEM PIPELINE & WTP 210 Ml/d + UPGRADES: +86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, TIENFONTEIN



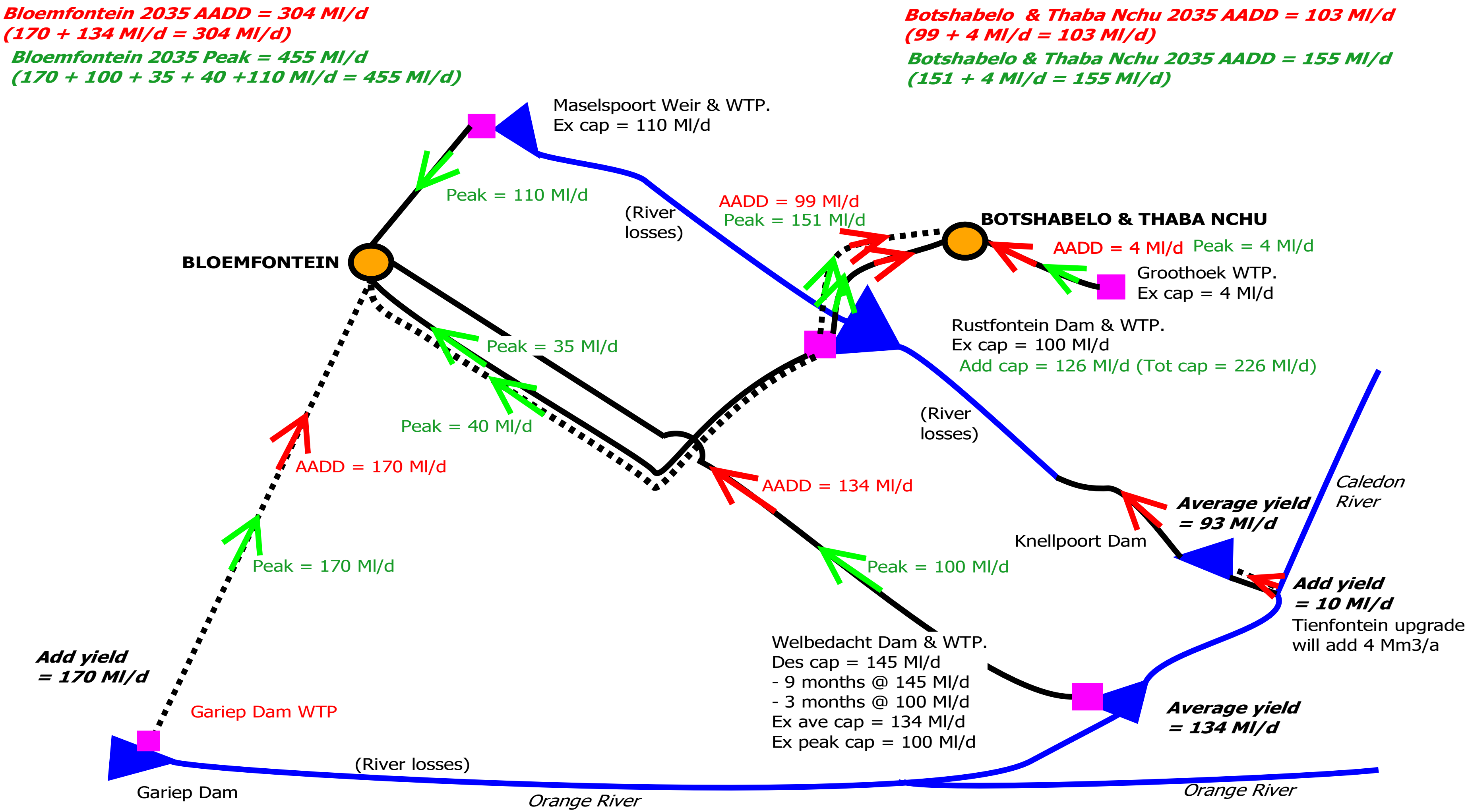
OPTION 1a2: GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 40 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, TIENFONTEIN

Bloemfontein 2035 AADD = 304 Ml/d
(170 + 134 Ml/d = 304 Ml/d)
Bloemfontein 2035 Peak = 455 Ml/d
(170 + 100 + 35 +150 Ml/d = 455 Ml/d)

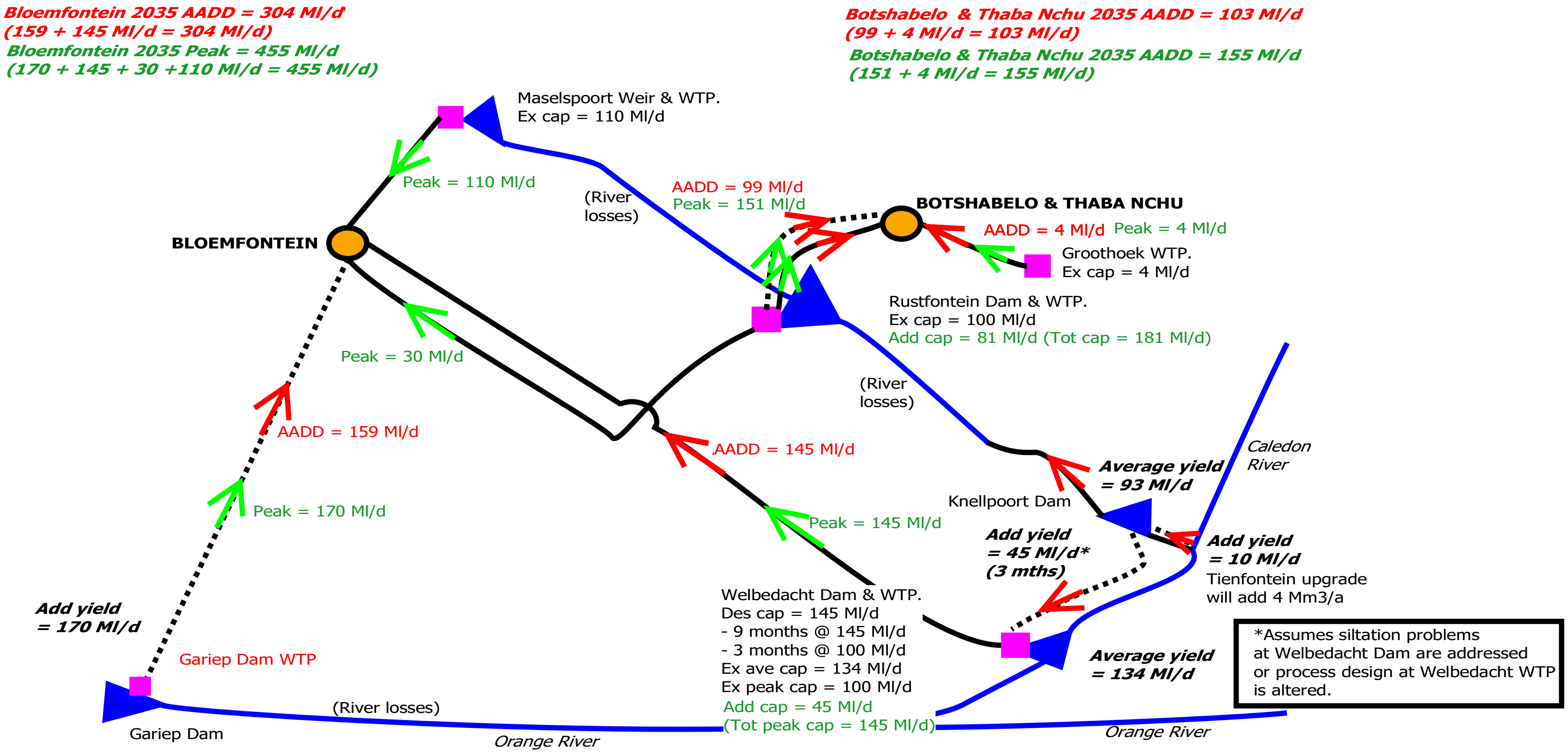
Botshabelo & Thaba Nchu 2035 AADD = 103 Ml/d
(99 + 4 Ml/d = 103 Ml/d)
Botshabelo & Thaba Nchu 2035 Peak = 155 Ml/d
(151 + 4 Ml/d = 155 Ml/d)



OPTION 1a3: GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 126 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN



OPTION 1a4: GARIEP-BLOEM PIPELINE & WTP 170 Ml/d + UPGRADES: + 81 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 45 Ml/d WELBEDACHT WTP, KNELLPOORT-WELBEDACHT PIPELINE, TIENFONTEIN



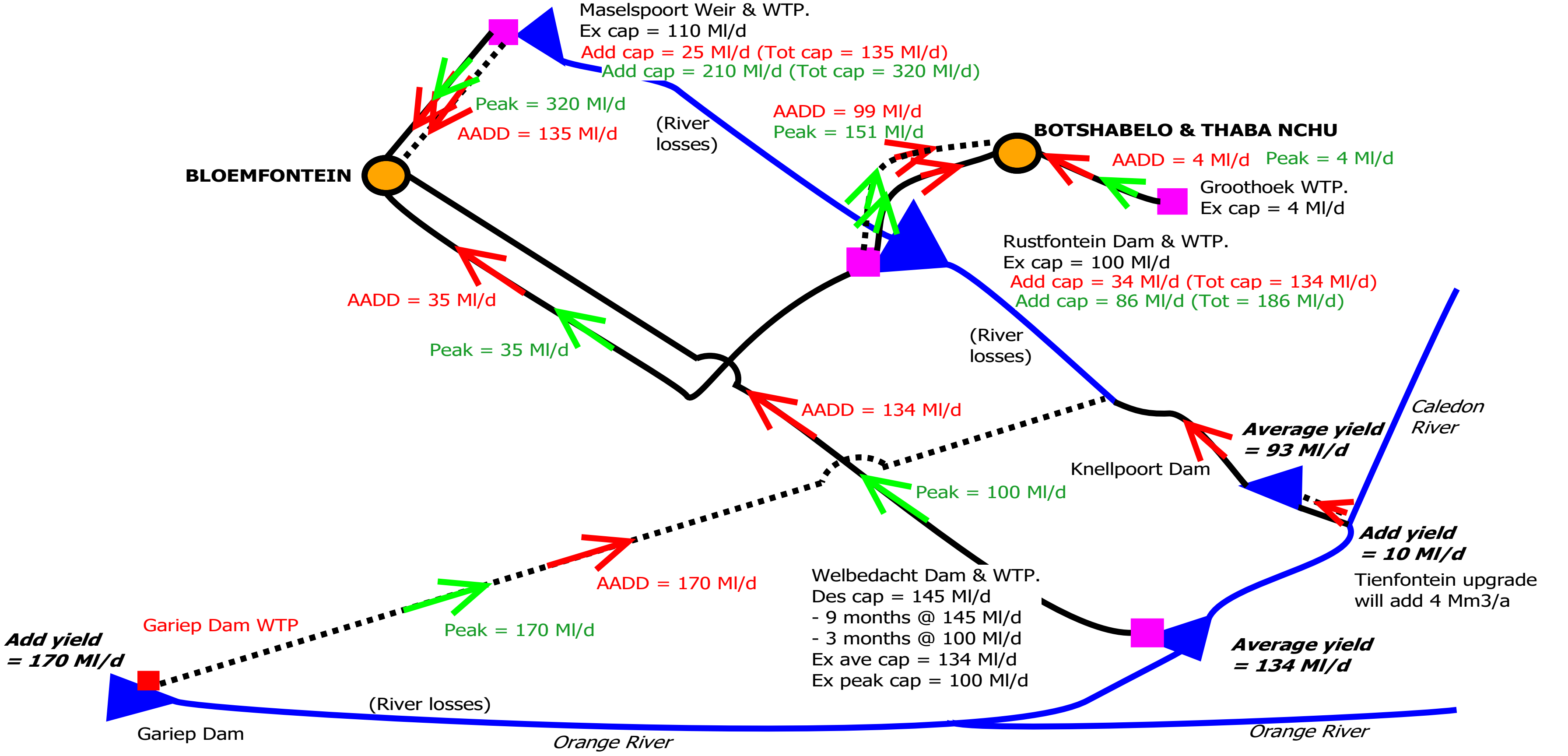
OPTION 2a1: GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 210 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, TIENFONTEIN

Bloemfontein 2035 AADD = 304 Ml/d
(134 + 35 + 135 Ml/d = 304 Ml/d)

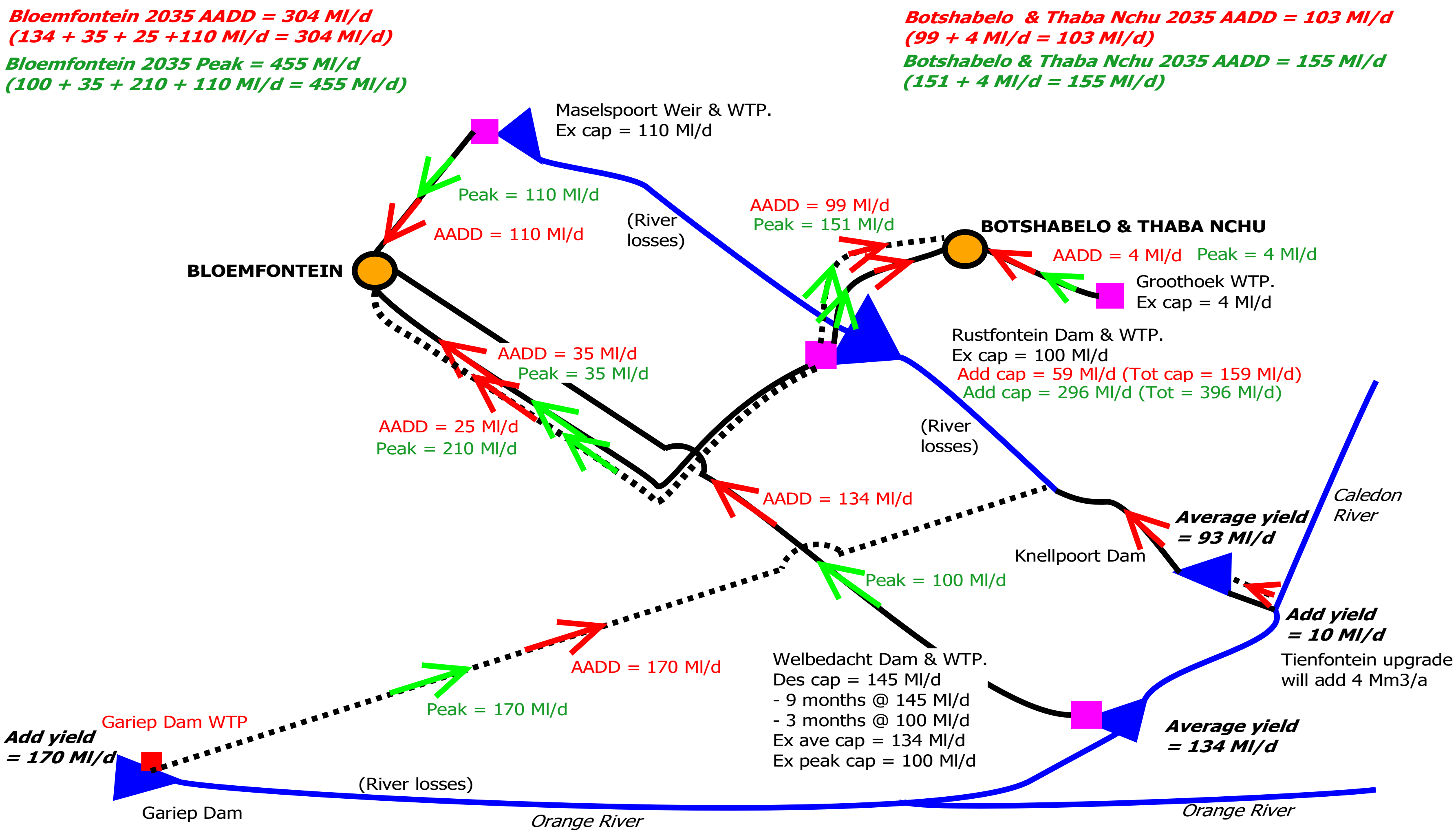
Bloemfontein 2035 Peak = 455 Ml/d
(100 + 35 + 320 Ml/d = 455 Ml/d)

Botshabelo & Thaba Nchu 2035 AADD = 103 Ml/d
(99 + 4 Ml/d = 103 Ml/d)

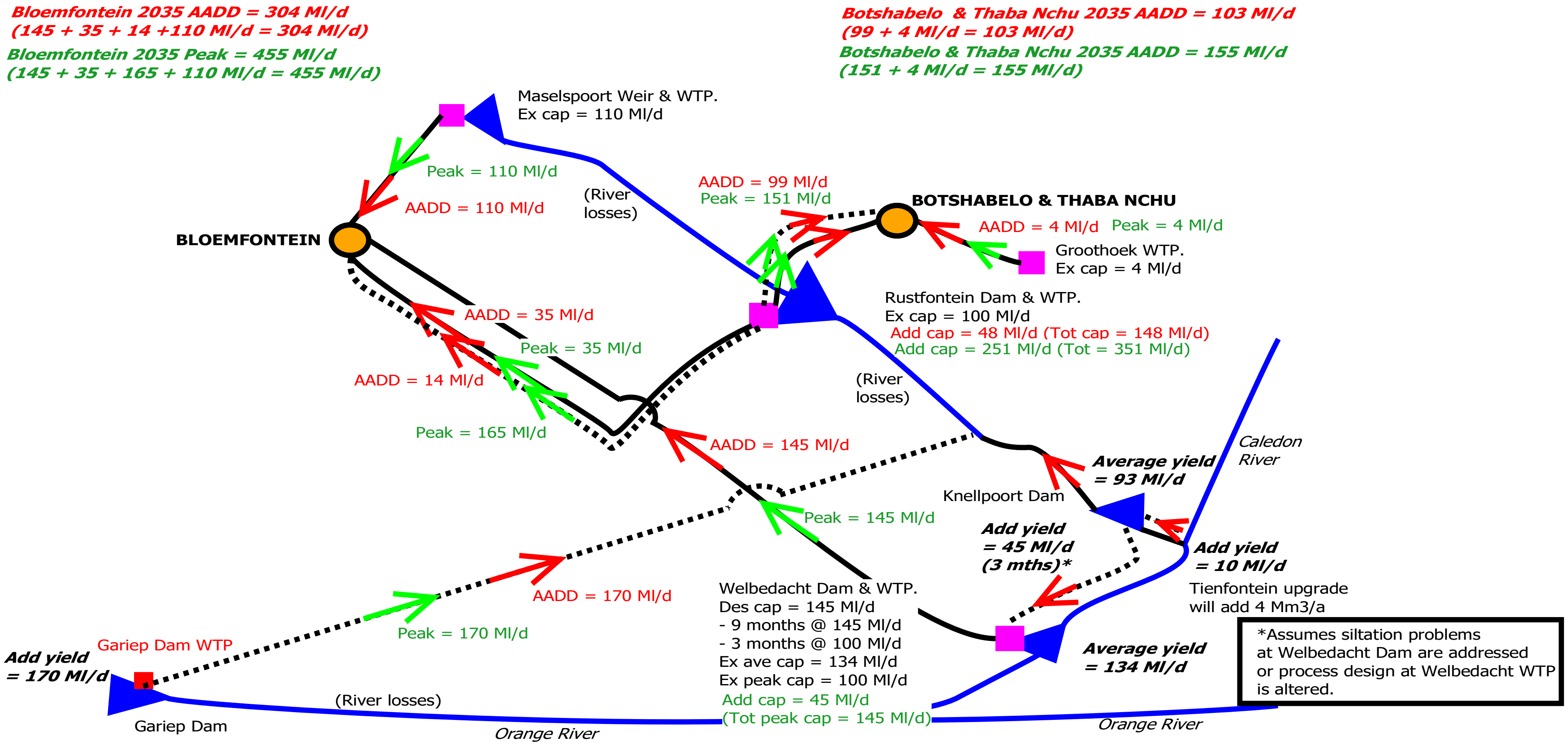
Botshabelo & Thaba Nchu 2035 AADD = 155 Ml/d
(151 + 4 Ml/d = 155 Ml/d)



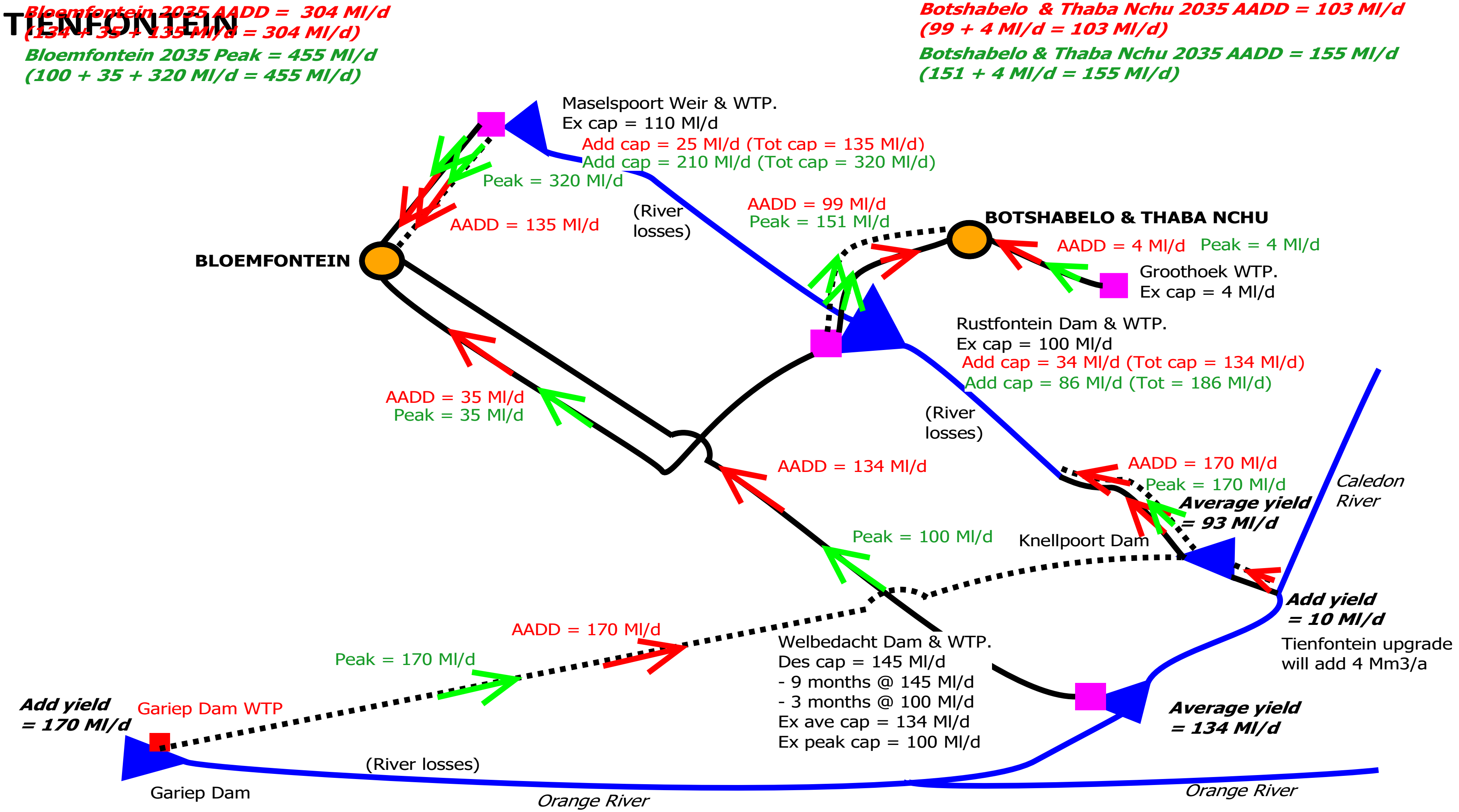
OPTION 2a2: GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 296 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN



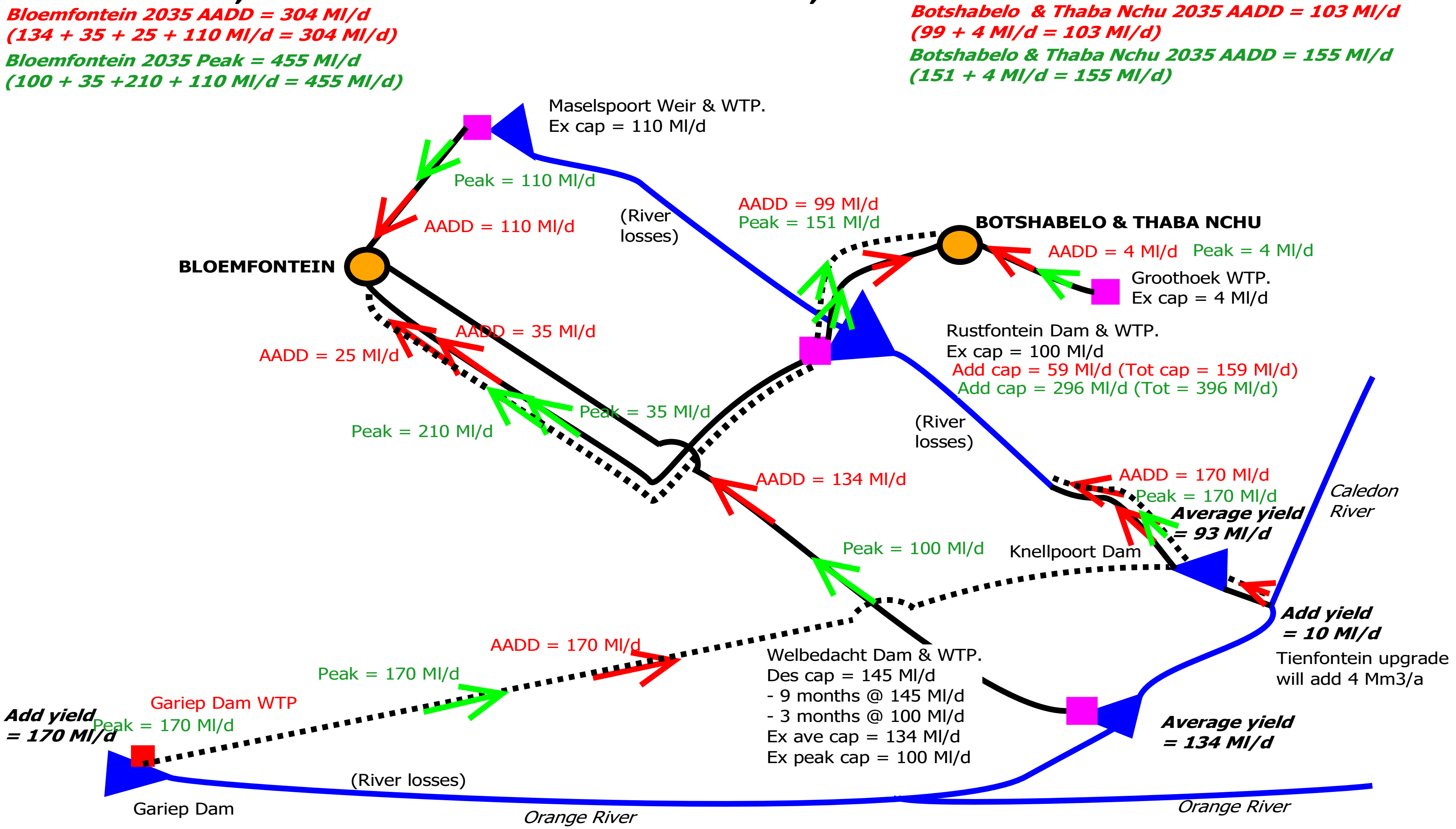
OPTION 2a3: GARIEP-UPPER REACHES OF MODDER RIVER 170 Ml/d + UPGRADES: + 251 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, + 45 Ml/d WELBEDACHT WTP, KNELLPOORT-WELBEDACHT PIPELINE, TIENFONTEIN



OPTION 3a1: GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-MODDER RIVER PIPELINE + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, + 210 Ml/d MASELSPOORT WTP, MASELSPOORT-BLOEM PIPELINE, TIENFONTEIN



OPTION 3a2: GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-MODDER RIVER PIPELINE + 296 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, TIENFONTEIN



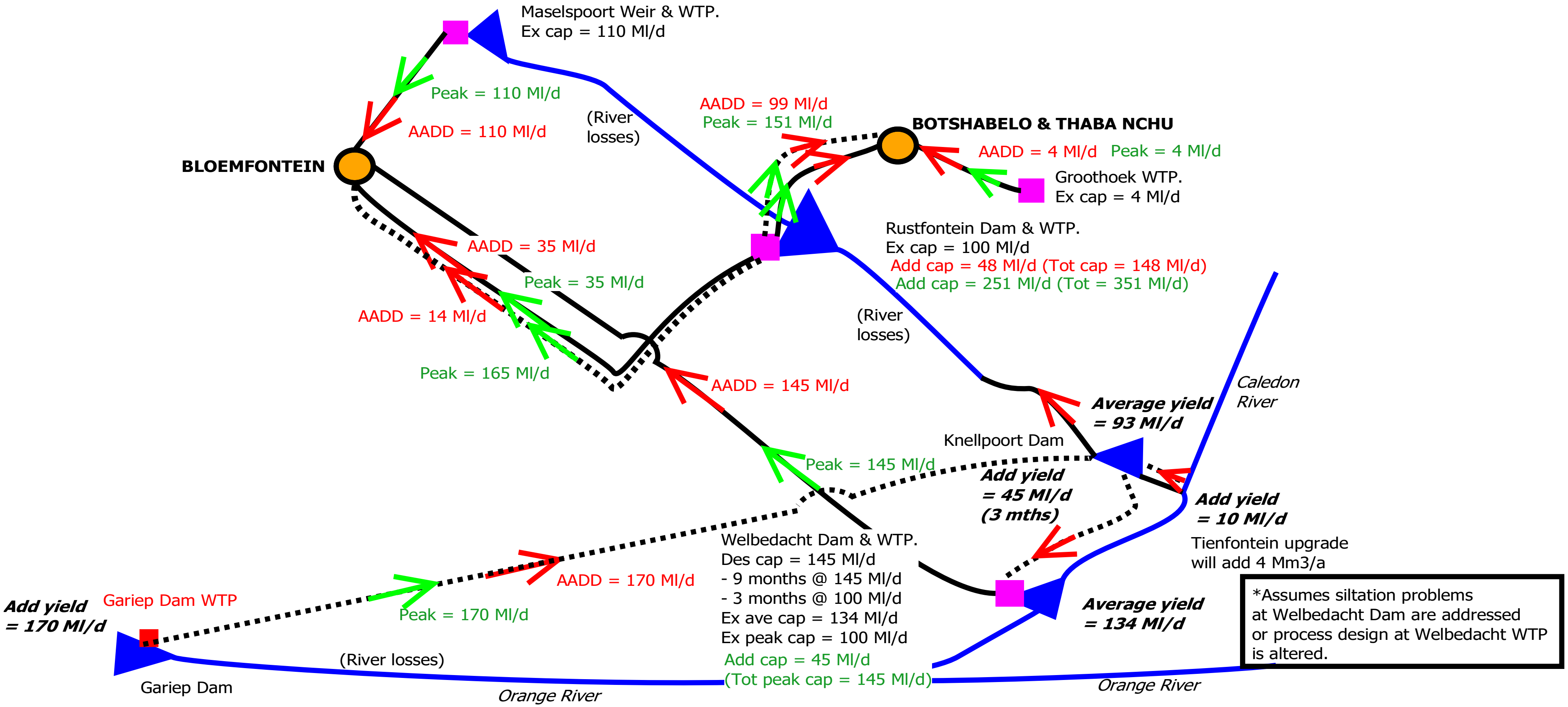
OPTION 3a3: GARIEP-KNELLPOORT 170 Ml/d + UPGRADES: KNELLPOORT-WELBEDACHT PIPELINE, + 251 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN-BLOEM PIPELINE, + 45 Ml/d WELBEDACHT WTP, TIENFONTEIN

Bloemfontein 2035 AADD = 304 Ml/d
(145 + 35 + 14 +110 Ml/d = 304 Ml/d)

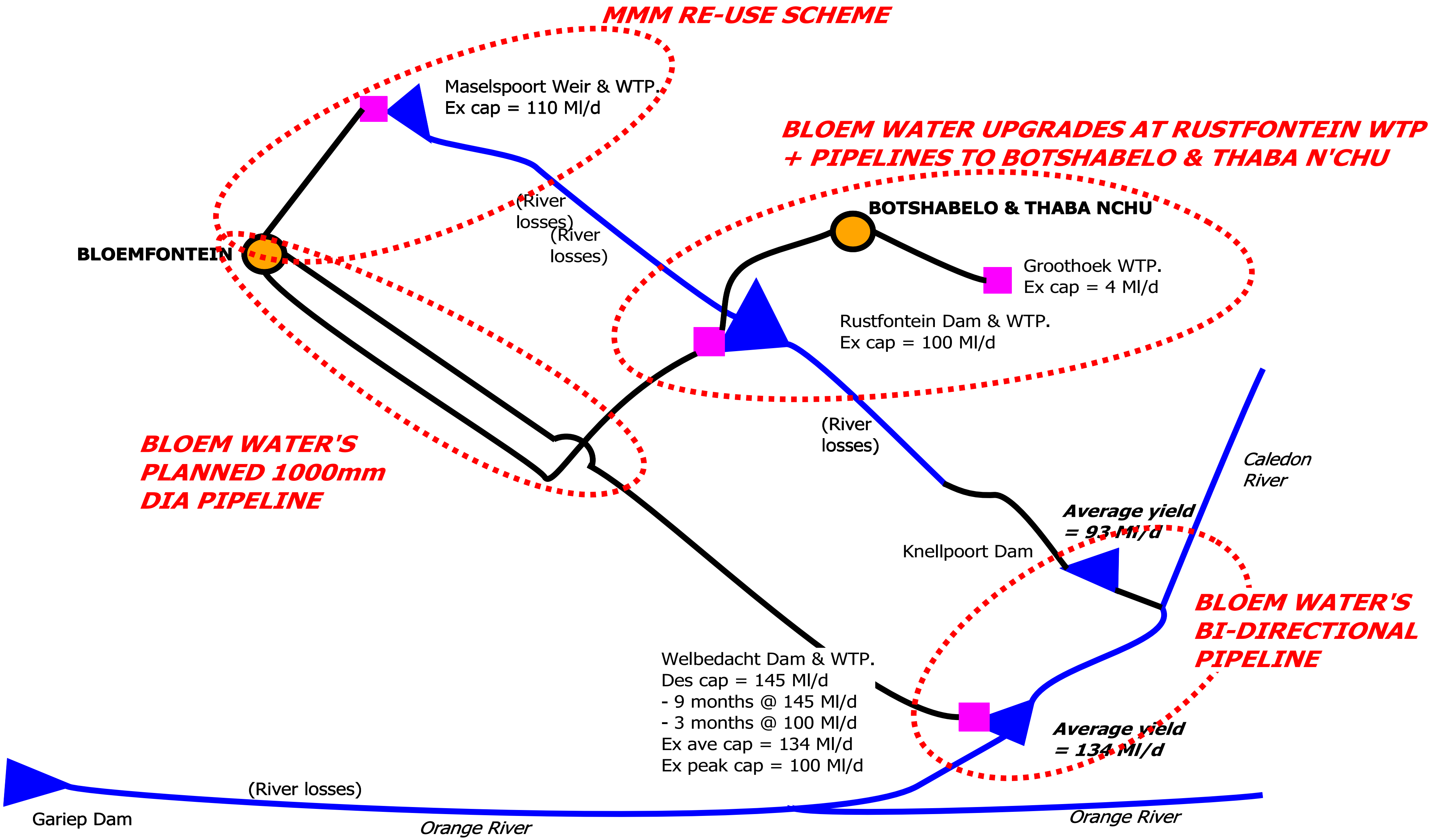
Bloemfontein 2035 Peak = 455 Ml/d
(145 + 35 + 165 + 110 Ml/d = 455 Ml/d)

Botshabelo & Thaba Nchu 2035 AADD = 103 Ml/d
(99 + 4 Ml/d = 103 Ml/d)

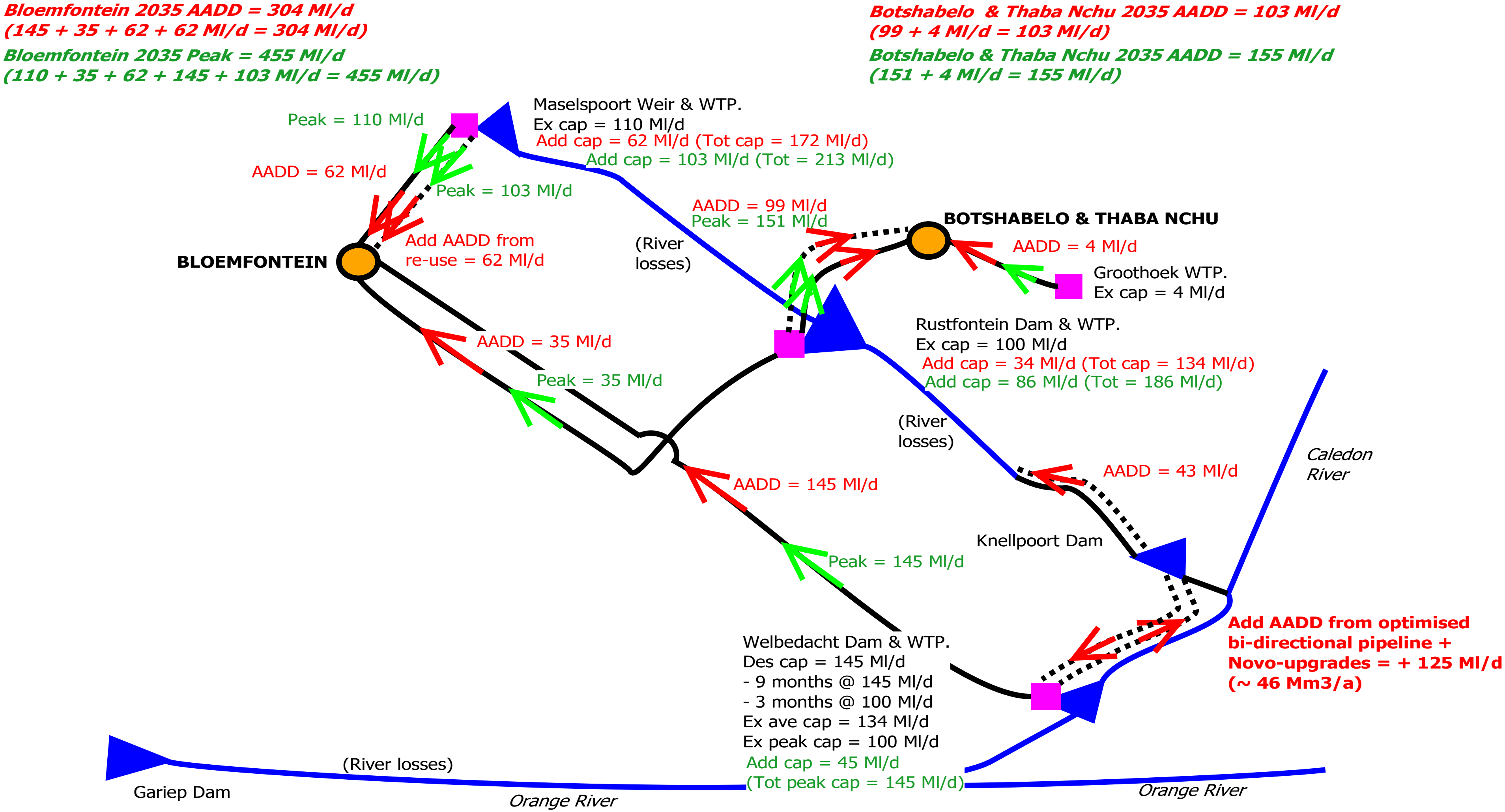
Botshabelo & Thaba Nchu 2035 AADD = 155 Ml/d
(151 + 4 Ml/d = 155 Ml/d)



INTEGRATION OF PROPOSED INFRASTRUCTURE INTO 2035 SOLUTION



OPTION 4a: BI-DIRECTIONAL PIPELINE, + 86 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE + 103 Ml/d MASELSPOORT WTP, KNELLPOORT-WELBEDACHT PIPELINE,+ 45 Ml/d WELBEDACHT WTP, TIENFONTEIN



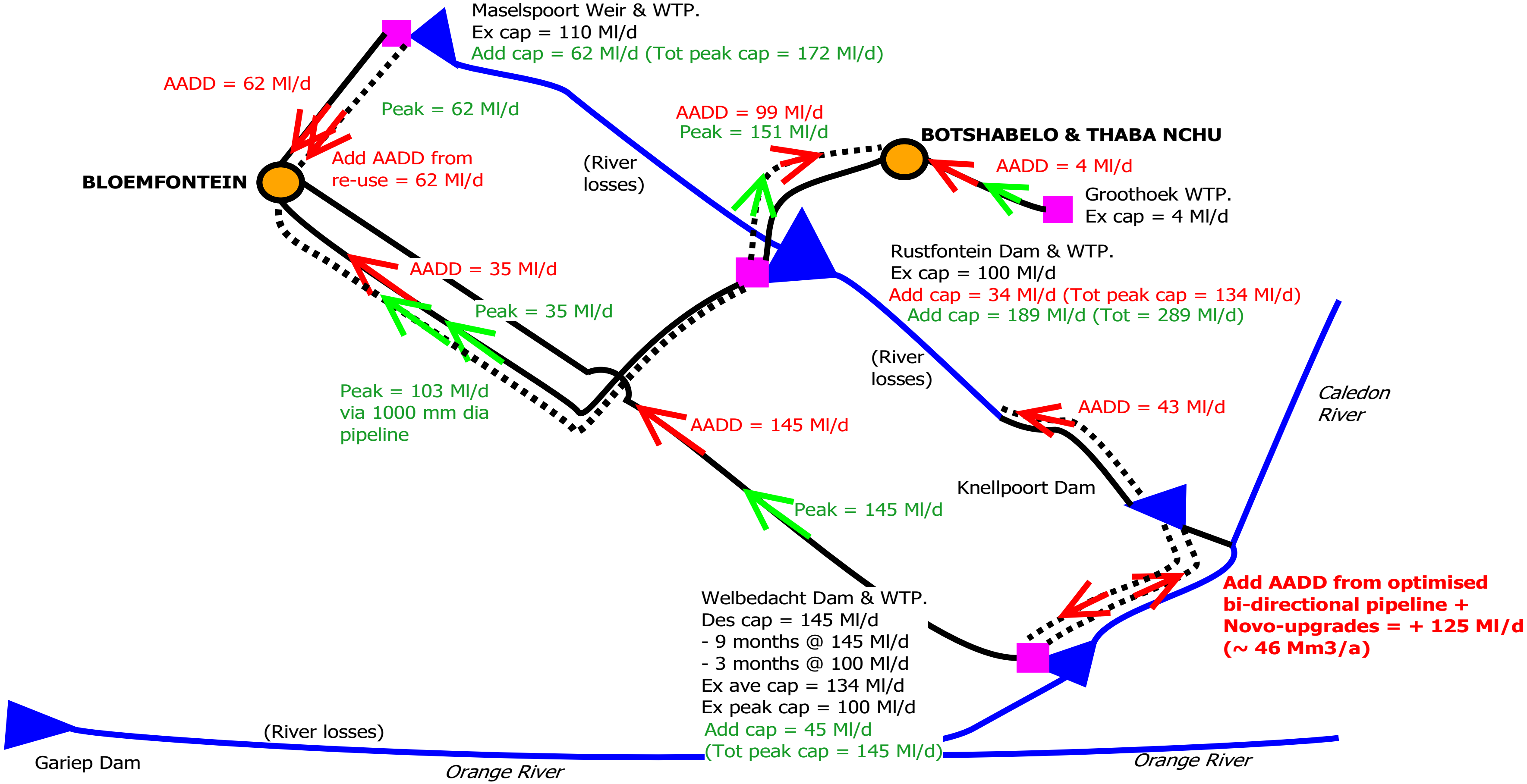
OPTION 4b: BI-DIRECTIONAL PIPELINE, + 189 Ml/d RUSTFONTEIN WTP, RUSTFONTEIN-BOTSHABELO/THABA NCHU PIPELINE, RUSTFONTEIN –BLOEM PIPELINE, + 62 Ml/d MASELSPOORT WTP, KNELLPOORT-WELBEDACHT PIPELINE,+ 45 Ml/d WELBEDACHT WTP

Bloemfontein 2035 AADD = 304 Ml/d
(145 + 35 + 62 + 62 Ml/d = 304 Ml/d)

Bloemfontein 2035 Peak = 455 Ml/d
(110 + 35 + 62 + 103 + 145 Ml/d = 455 Ml/d)

Botshabelo & Thaba Nchu 2035 AADD = 103 Ml/d
(99 + 4 Ml/d = 103 Ml/d)

Botshabelo & Thaba Nchu 2035 AADD = 155 Ml/d
(151 + 4 Ml/d = 155 Ml/d)



Appendix B

Additional recommended investigations to finalise the pre-feasibility and feasibility studies for augmenting water supply from Gariep Dam

APPENDIX B: Additional recommended investigations to finalise the pre-feasibility and feasibility studies for augmenting water supply from Gariep Dam

1. Phase 1: Pre-feasibility Phase

The broad aim of the pre-feasibility investigation is to identify and conceptualise all possible schemes options which could augment the water supply to the Greater Bloemfontein Area, compare the conceptualised schemes and select the most appropriate scheme to investigate at a more detailed feasibility investigation level.

1.1 Water requirements

Water requirements are dependent on population growth and economic growth (incl. service delivery) Undertake an analysis of the current and future water requirements and growth in water requirements for the Greater Bloemfontein System up to 2050. The analysis must include a determination of the potential growth in annual average daily demand (AADD) and peak week demand (PWD). The spatial distribution of the water requirements is of particular importance and the PSP is to determine the water requirements for the Bloemfontein supply zone as well as the Botshabelo and Thaba Nchu supply zones. Updated information also needs to be obtained on the water requirements on the smaller towns between the Gariep Dam and the Greater Bloemfontein Area

The estimated water requirements must take into account the likely effectivity of water conservation and water demand management initiatives of the MMM as well as the potential influence of MMM's water re-use scheme.

1.2 Preliminary identification and analysis of options

A number of schemes have been identified to augment the water supply to the Greater Bloemfontein Area. A number of these schemes were identified in the Reconciliation Strategy for the Greater Bloemfontein Supply Area. Further schemes were also identified as part of the DWS report entitled: "*Accelerated Action Plan to Augment Bloemfontein's Water Supply*". Both Bloem Water and Mangaung Metropolitan Municipality have undertaken studies to consider alternative ways of augmenting the Greater Bloemfontein Area from Gariep Dam. The following schemes should inter alia be considered:

1) Augmenting Knellpoort Dam from the Caledon System (bi-directional pipeline from Welbedacht Dam to Knellpoort Dam).
2) Further increasing the capacity of Tienfontein Pump Station.
3) Optimising the yield of the Caledon River (addressing the siltation problems which will ensure that Welbedacht WTP can operate at its design capacity of 145 Ml/d).
4) Augmenting the supply to the Greater Bloemfontein Area from Gariep Dam (various options were identified in the DWS report entitled "Accelerated Action Plan to Augment Bloemfontein's Water Supply") as well as subsequent to the report.
5) Augmenting Knellpoort Dam from the Orange River upstream of Gariep Dam

This list is not necessary exclusive and the PSP if to identify if any other water supply options exist which could augment the supply to the Greater Bloemfontein Area. The PSP should become familiarised with the above-mentioned schemes and the required infrastructure components for each of the identified schemes. Consolidate information of all available options identified to date**. Large scale augmentation from a groundwater source was not deemed feasible in the Reconciliation Strategy Study. It is also not a requirement that the PSP consider water re-use as the feasibility of this scheme is being considered separately by MMM.**

The following shall be considered and investigated as part of the pre-feasibility study:

- Determine conceptual layouts for each of the identified schemes. This would include any abstraction works (including weir if required), pumps stations, pipelines, reservoirs and electrical infrastructure requirements. The identified schemes should be conceptualised on a comparable basis in terms of downstream infrastructure requirements.
- The infrastructure must be conceptualised to meet the AADD and PWD up to 2050
- Determine the capacity and yield of each of the identified schemes. The scheme needs to be analysed within the water resources yield model (WRYM) to be able to identify the incremental increase in overall system yield. It is important to take into consideration and analyse (in the WRYM) the river losses associated with each identified scheme. This may impact on the available yield of certain schemes.
- Desktop study of available geotechnical information.
- Determine comparative capital and operational costs of the various options. Determine the net present value (NPV) and unit reference value (URV) for each of the identified schemes.
- System risks. This includes potential Eskom outages, bursts on the Welbedacht pipeline, and droughts.
- Operational flexibility/redundancy: the scheme will fit into an existing system and some schemes may lend themselves more to creating operational flexibility and redundancy in the existing system.
- Social and environmental impact: Each scheme should undergo a high level environmental screening to identify any fatal flaws or significant environmental impacts/constraints which could impact on the costing.
- Programme: a preliminary programme needs to be complied for each option.
- Ease of operation and maintenance.
- Regional socio-economic benefits: A high level socio-economic assessment should be undertaken for each schemes in order to determine which scheme has the greatest socio economic benefit to the area.

NB: It is important when conceptualising options that the existing and planned infrastructure of both BW and MMM (e.g. the water re-use plant currently being planned by MMM) needs to be taken into account. The schemes should therefore be conceptualised in an integrated manner optimally making use of planned and future infrastructure. The conceptualised schemes must augment the supply to the greater Bloemfontein region and it is not the intention that the scheme replace an existing scheme (e.g. the Welbedacht WTP and Welbedacht pipeline.

It is further important to note that each of the identified options (schemes) should be conceptualised and costed in such a manner that schemes are comparable. The DWS report entitled "*Review of Options to Augment Bloemfontein's Water Supply*" illustrates this concept.

1.3 Meetings with key stakeholders and interested and affected parties

The service provider will identify interested and affected parties and stakeholders that will either be affected by the implementation and operation of the possible schemes, or where an early involvement will benefit the planning and implementation process. The PSP shall and arrange and facilitate meetings or discussion with key interested and affected parties where these will assist in the planning process.

1.4 Multi Criteria Decision Analysis (MCDA) workshop to select preferred option for detailed feasibility study

Prepare a background information document on all schemes conceptualised with sufficient information to inform the decision makers at the MCDA workshop. Identify the factors which need to be taken into consideration in the MCDA process and which factors will be used for comparing and evaluating the schemes. Host a MCDA workshop with decision makers, engineers, environmental practitioners and stakeholders including but not necessarily limited to DWS, MMM and BW. It is important that representatives have sufficient knowledge of the GBWSS and factors affecting bulk water supply. Apply

MCDA in an interactive workshop environment and ensure appropriate participation of participants to ensure that project outcomes are widely acceptable and supported.

NOTE: For a significantly fast-tracked programme it may be difficult to accommodate a full MCDA process and a simpler, yet effective key stakeholder meeting should be arranged to select the preferred option to evaluate further.

1.5 Preparation of Pre-feasibility Study Report

Compile a pre-feasibility study report which describes the various options, MCDA process results and preferred option(s) selected for detailed feasibility study. The outcomes of the pre-feasibility study should be approved by DWS prior to beginning with the detailed feasibility study.

2. Phase 2: Detailed Feasibility Study

The aim of the feasibility investigation component of this study is to produce a preliminary design for the selected scheme to a level necessary to immediately after this study, if necessary, to be able to commence with the detailed design and construction of the scheme.

2.1 Feasibility and preliminary design of selected option

Undertake a full feasibility study and technical evaluation on the preferred alternative(s). Alternative pipeline routes and configurations need to be identified and costed. The scheme needs to be optimised in order to determine the most optimal solution and lowest NPV.

The following will be required to fulfil this task:

- Confirm all infrastructure requirements and components for the preferred scheme.
- Determine the optimum supply pipeline routes and tie-in points to existing, or proposed supply networks;
- Make a recommendation on the size and material of the supply pipeline. The pipeline material cost is a significant portion of the total pipeline cost (approximately 50-60%). It is therefore imperative to optimize the pipeline material cost for the schemes accurately in terms of the pipe wall thickness. The PSP shall not only consider internal pressures but also take external loads into consideration in the design as the wall thickness for large pipelines are most likely determined by the external loads. A representative E-modulus for the soil interaction shall be applied. The PSP shall also analyse alternative booster pump station locations along the pipeline route in order to minimise the scheme's total NPV cost.
- Undertake all necessary hydraulic and transient analyses on the supply reservoir, pump station and pipeline. If necessary the effect of this pumping main on existing potable water infrastructure, must be established.
- Consider operational and maintenance requirements, flexibility or risks related to replacement, upgrade or refurbishment needs / potential, ability to implement, and operational practicality.
- All civil, electrical and mechanical infrastructure components must be considered.
- Detail how the preferred scheme is going to be integrated into, and operated within the existing bulk water supply system serving the Greater Bloemfontein Area.
- Assess if there are opportunities to phase the implementation of the infrastructure.
- Determine the impacts of all proposed infrastructure on existing and proposed infrastructure and services in the area, e.g. roads, telecommunication, electricity. Show how these services will be avoided, e.g. pipe jacking, tunnelling;
- Evaluate water quality and type of treatment required to meet potable water treatment standards at the various treatment plant locations. Also consider integration with existing WTPs where applicable. Undertake a feasibility design of the new WTP(s). A process flow diagram of the WTP(s) will be required.
- Prepare preliminary design drawings for all infrastructure components. This should include: basic layout drawings, cross sections and pipeline long section drawings.

2.2 Geotechnical Investigations

A geotechnical investigation must be undertaken for the proposed infrastructure required. This geotechnical study should include:

- Excavation and profiling of trial pits along the centrelines at recommended intervals. For the purposes of adjudication of proposals it is recommended that a fixed allowance for the number of trial pits are made.
- Undertaking DCP tests at 100mm intervals. It is recommended that a fixed allowance for the number of DCP tests are made.
- Determination of Atterberg limits and particle size distribution by sieve analyses of in situ material.
- Determining the potential activity of clayey soils utilising foundation indicator laboratory tests, i.e. hydrometer analysis;
- Record rock levels;
- Determination of the availability of bedding material;
- Provide GPS co-ordinates of all trial pits; and
- Carry out an investigation into the requirements for cathodic protection and make recommendations and estimate costs for any such requirements.
- Test pitting of potential borrow pits to determine suitability of materials for pipe bedding and backfill.
- Identification of commercial sources of fine and coarse concrete aggregate in the area
- Laboratory testing and reporting
- Identification of areas affected by potential subsoil seepage.
- Preliminary assessment of road and rail crossings and the feasibility of pipe jacking where required.

A provisional sum should be allowed for geological investigations.

2.3 Topographical Survey

Undertake detailed topographic surveys of the supply pipeline routes and areas where the associated infrastructure is to be located. The survey should allow for a 50m buffer on either side of the pipeline route. The survey must be undertaken in sufficient detail for detailed design. The topographical survey shall capture specific site features and existing infrastructure within the proposed project area at a suitable scale. This task will include:

- Preparation of aerial photography and detailed topographical mapping (possibly 0,5m contours) from airborne LiDAR surveys for the entire pipeline route and infrastructure locations.
- Undertake topographical surveys of the existing infrastructure that intersects new infrastructure including existing roads, overhead power lines, underground pipelines, power lines, telecommunication cables, etc.
- Undertake bathymetric surveys where new infrastructure is underwater (e.g. major river crossings, intake structure at Gariep Dam, etc.).
- Capture pertinent topographical survey information where new infrastructure connects to existing infrastructure.
- Include cadastral boundaries on layout plans.

2.4 Power Supply

Identify options for sustainable electrical supply (including bulk supply lines, routes and sub stations). These options should be based on a total electrical requirement including the abstraction, treatment and supply systems. As part of this analysis the PSP must, amongst others:

- Investigate supply from existing electrical providers;
- Investigate the possibility of supply from alternative energy sources ;
- Determine the acceptability and sufficiency of the electrical resource;
- Determine capital cost of reticulation to the site and the expected schedule of supply; and
- Establish the requirement for electrical servitudes and undertake a full economic analysis of all viable options such that a recommendation can be made to the client.

2.5 Construction and Access

Assess site establishment and site access requirements. This must include the:

- Requirement for the construction of temporary and permanent access roads;
- The preferred access for light and heavy duty construction traffic and equipment; and
- Location of potential construction site camps, workshops and materials holding yards.

The recommended footprint for construction and the access roads must be taken into account in the EIA.

2.6 Operations and Maintenance

Recommend operations and maintenance requirements for the plant and associated infrastructure. This should include:

- Details of the operational staff requirement;
- Determine the optimal operating philosophy of the water supply systems to ensure complete integration of the desalinated water with the existing supply systems;
- Electrical quantities and costs for abstraction, treatment and supply;
- Chemical costs;
- Operational requirements for the inlet and outlet works to prevent biofouling under various flow scenarios; and
- Requirement for maintenance on civil, mechanical and electrical components of the abstraction, plant and supply infrastructure

2.7 Environmental Impact Assessment, Water Use License and other approvals

In terms of Section 24 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) as amended, the proposed infrastructure will require environmental authorisation. Therefore the environmental process must fulfil the requirements of all relevant legislation, including but not limited to:

a) National Environmental Management Act, 1998 (Act No. 107 of 1998)
b) National Water Act, 1998 (Act No. 36 of 1998)
c) National Heritage Resources Act, 1999 (Act No. 25 of 1999)
d) Minerals and Petroleum Resources Development Act (No 28 of 2002)

The Professional Service Provider (PSP) shall be required to undertake all tasks required for the completion of the Scoping and EIA Phases. Previous studies that have been undertaken as part of the feasibility study will be made available to the PSP. The required tasks shall include the following main activities:

a) Site visits during Scoping and EIA;
b) Scoping Report and Plan of Study for EIA;
c) EIA Report and Environmental Management Programme;
d) The following additional specialist studies that may be required as part of this EIA process would include, but is not be limited to:
    i) Agriculture;
    ii) Aquatic;
    iii) Botanical;
    iv) Heritage; and

v) Social.

The need to ensure continuity for Interested and Affected Parties (I&APs) between the Pre-feasibility Phase, Feasibility Phase and EIA process is recognised. Therefore, the I&AP database developed in the initial phase of the project will be extended to ensure that all registered parties are informed about the EIA process. Appropriate comprehensive public participation must be undertaken in accordance with the legislative requirements and should be outlined in the technical proposals to be submitted. The public participation process should include notification of the environmental authorisation.

Suitable quarries and borrow areas that will be utilised for construction must also be identified during the feasibility phase. As per the requirements of the Minerals and Petroleum Resources Development Act, No 28 of 2002 (M&PRDA), all mining activities, including the extraction of material from borrow pits and quarries that are greater than 5 ha in size, require authorisation from the Department of Mineral Resources. This permit process would require the following:

- An application form and fee for the permit application.
- An EMPR that must describe the surrounding environment, assess the potential impacts of the proposed prospecting or mining operation on the environment, socio-economic conditions and cultural heritage, as well as propose suitable mitigation measures for closure and rehabilitation.
- A survey and site mine plan of suitable quarries and borrow areas.

Depending on the size and location of the quarries and borrow areas, approval may also be required in terms of NEMA and the NHRA.

A proposed programme for the required processes and time allowed for decision making by authorities must be provided in the Proposal, including key milestones and deliverables.

2.8 Regional Economic Impacts

The impacts of the project development on the regional economics should be evaluated in this study. From an economic perspective, the following should be undertaken:

- Assess the current economic base and activities
- Describe the current infrastructure and services
- Identify and describe the socio-economic impacts associated with the preferred scheme
- Develop quantifiable measures and qualitative indicators to be used to objectively evaluate the impact
- Assess the economic impact of the scheme on the Greater Bloemfontein Area and also where applicable on some of the smaller towns affected by the preferred scheme
- Assess the contributions to GDP and GGP
- Assess the employment opportunities and contribution to the primary and secondary economics

2.9 Legal, Institutional and financing arrangements

The appointed PSP should provide suggestions or a framework for necessary legal, institutional and financing arrangements for the project. The main tasks are listed as follows:

- Describe the legal provisions which must be adhered to during the planning process and how these were addressed during the planning study
- Describe the legal steps which will have to be followed subsequent to project approval to achieve implementation.
- Determine the total capital funding requirements of the scheme.
- Describe the relevant financing/funding strategies and make a recommendation.
- Determine the cash flow for implementation and operation and maintenance and make recommendations on how these costs are to be redeemed.
- Determine the most suited organisation to own and operate the infrastructure
- Determine the additional human resources needed for operation and maintenance of the project.

2.10 Phasing and programme

Prepare a detailed implementation programme of all infrastructure components from the detailed design phase through to commissioning with associated cash flows and milestones dates.

2.11 Record of implementation decisions (RID)

On completion of the study, the appointed PSP should prepare the Record of Implementation Decisions (RID). In the RID, implementation decisions, requirement and specifications for design and construction of the project, including the financing and institutional arrangement etc. should be detailed.

2.12 Land Matters

The PSP will investigate and report on the following aspects pertaining to land matters:

- In terms of all infrastructure components recommend whether areas should be bought out by DWS or whether servitudes should be arranged.
- Determine cost estimates for the servitudes and land to be acquired for the proposed project
- Determine compensation values to be paid

2.13 Stakeholder participation

Many stakeholders at local, provincial and national level have a direct interest in the planning, implementation and operation of new infrastructure feeding the greater Bloemfontein area. The project team should cooperate closely with key stakeholders throughout and allow opportunities for a broader group of stakeholders to be engaged with respect to the progress and findings of the feasibility study. The PSP is to illustrate how stakeholders will be incorporated into the feasibility study.