KNYSNA MUNICIPALITY

WATER MASTER PLAN

December 2018

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LIST OF ABBREVIATIONS & ACRONYMS

AADD	-	Annual average daily demand
AMP	-	Asset management plan
AR	-	Asset register
CAPEX	-	Capital expenditure
CRC	-	Current replacement cost
d	-	Day
DRC	-	Depreciated replacement cost
ECE	-	Element consulting engineers
EGL	-	Energy grade line (in m a.s.l.)
FCV	-	Flow control valve
GIS	-	Geographic information system
GLS	-	GLS consulting engineers
h	-	Hour
Ha	-	Hectare
HL	-	High level
IMQS	-	Infrastructure management query station (software package)
kℓ	-	Kilolitre
kℓ/d	-	Kilolitre/day
KM	-	Knysna Municipality
km	-	Kilometre
kW	-	Kilowatt
kWh	-	Kilowatt-hour
ℓ	-	Litre
ℓ/day/UE	-	Litre/day/unit erf
ℓ/h/connection	-	Litre/hour/connection
ℓ/min	-	Litre/minute
ℓ/s	-	Litre/second
LL	-	Low level
m	-	Metre
m a.s.l.	-	Metres above mean sea level
MISA	-	Municipal infrastructure support agent
m/s	-	Metres per second
Mℓ	-	Megalitre
Mℓ/a	-	Megalitre per annum
ML	-	Medium level
mm	-	Millimetre

NRW	-	Non-revenue water
OPEX	-	Operational expenditure
P&G	-	Preliminary and general
PDF	-	Peak day factor
PHD	-	Peak hour demand
PHF	-	Peak hour factor
PRV	-	Pressure reducing valve
PS	-	Pump/pumping station
PWF	-	Peak week factor
R	-	Rand
RO	-	Reverse osmoses
s	-	Second
SG	-	Surveyor general
SWIFT	-	Sewer water interface for treasury systems (software)
TWD	-	Total annual water demand
TWL	-	Top water level (in m a.s.l.)
UAW/UFW	-	Unaccounted-for-water
UE	-	Unit erf
uPVC	-	Unplasticised polyvinylchloride
UWD	-	Unit water demand (e.g. ℓ/stand/d, or kℓ/ha/d)
VAT	-	Value added tax
WADISO	-	Water distribution system optimization program (software)
WTP	-	Water treatment plant (potable water)

1. INTRODUCTION

1.1 BRIEF

GLS consulting engineers (GLS) were appointed as sub-consultants to Element Consulting Engineers to update the master plan of the water distribution system for Knysna Municipality (KM).

The project entails the updating of computer models for the water systems in Knysna, the linking of these models to the stand and water meter databases of the treasury's financial system, evaluation and master planning of the networks, and the posting of all information to the Infrastructure Management Query Station (IMQS).

This master plan report lists the analyses and findings of the study on the water distribution systems of the towns within KM.

1.2 STUDY AREA

The location of Knysna within the Western Cape is shown on Figure KMW1.1. The towns within the boundary of the KM are:

- Knysna town
- Sedgefield
- Belvidere
- Brenton on Lake
- Brenton on Sea
- Buffels Bay
- Karatara
- Rheenendal

Figure KMW1.2 shows the suburbs with suburb names entered during this investigation for all records in the geographic information system (GIS) database. The total area of these suburbs indicates the study area of this investigation.

1.3 PREVIOUS MASTER PLANNING

GLS conducted a water master plan study in December 2008 for KM for the towns of Knysna, Sedgefield, Belvidere, Brenton on Lake, Brenton on Sea, Buffels Bay, Karatara and Rheenendal. This previous master plan was updated by GLS in February 2016 and June 2017.

The previous water master plans where updated in this study.

1.4 DEFINITIONS

1.4.1 Water supply system

In this report the term *water supply system* is used to describe the reticulation system downstream of the clean water reservoir and upstream of individual consumer meters; it is also often termed the internal water reticulation system. Capital expenditure (CAPEX) relating to this system is the responsibility of the Municipality.

In order to further distinguish between CAPEX by the Municipality and by other role-players the following terms are defined:

- *Bulk water supply system* is used to describe the system upstream of the clean water reservoir, yet belonging to the Municipality, while the term.
- *External bulk water supply system*- is used to describe those parts of the water supply system that are owned by third parties.

1.4.2 Water management zones

Management zones are often termed bulk zones (as in SWIFT), distribution zones, or water pressure zones. Following the notation of the Water Demand Cookbook (McKenzie et al, Nov 2003) the following terms are used in this report. A *water management zone* can be either a district, a sub-district or a zone, where:

- a *district* is a unique area with individual bulk supply and boundaries usually fixed by topographical constraints. This would include various consumer categories (typically about 30 000 connections).
- a *sub-district* is a subdivision of a district and is identified by a reservoir, tower, pump, or pressure reducing valve (PRV) zone (typically 2000 to 10 000 connections). This would include various consumer categories.
- a *zone* is a subdivision of a district, identified by areas of similar characteristics (typically not larger than 2000 connections).

The set-up (identifying and installing, where necessary, zone valves) and maintenance of zones (training maintenance staff to understand why these zone valves should not be opened) is a particular challenge to many towns in South Africa.

1.4.3 Unaccounted-for-water (UAW)

The acronyms UAW and UFW are used in literature for the term *unaccounted-for-water*. In this report UAW is used. Generally speaking UAW is the difference between the volume of water purchased by a water service provider (or bulk supply to the town) and the volume of water sold to consumers (recorded by consumer meters and billed to consumers). However, the definition of UAW and the topic is much more involved - UAW is best described by a table and detailed report such as the one by McKenzie et al (2002), where a detailed table is provided to illustrate the different components of UAW.

In this report the term UAW is used to describe the non-revenue water, that is, all water use that is not recorded in the treasury system of the Municipality is considered to be "unaccounted-for", whether it is metered or not. Unless metered unbilled water use is specifically pointed out it is not included in the analysis in this investigation.

1.4.4 Stand

In this report *stand* is used to denote a piece of ground identified in the database of the Surveyor General (SG) as a unique property. A stand could have one or more (or no) metered connections to the water supply system. The words property, site, erf (or erven), and lot are also sometimes used elsewhere to describe a stand.

1.4.5 Treasury record

A *treasury record* is a consumer's account that is recorded in the treasury database of the Municipality. Each treasury record normally represents a water meter forming a consumer's connection to the water supply system. Some treasury records might not pertain to a water connection (or customer meter).

1.5 STRUCTURE AND SCOPE OF REPORT

This report addresses the distribution of potable water within the KM area. Water quality aspects and the analysis of the bulk water (raw water) pipelines upstream of the water treatment plants (WTP's) and reservoirs are beyond the scope of this report.

The contents of each chapter is arranged so that all of the text is grouped together, followed by the tables and then the figures if applicable to the chapter.

1.6 DISCLAIMER

The investigation has been performed and this report has been compiled based on the information made available to GLS. All efforts, within budget constraints, have been made during the gathering of information to ensure the highest degree of data integrity. The information supplied to GLS by the KM and other consultants at the outset of this master planning process is assumed to be the most accurate representation of the existing system up to date hereof.

Subsequent to the completion of the data capturing, the layout plans including the relevant attributes, were handed back to the Municipality so that the information could be verified by the Client. GLS can therefore under no circumstances be held accountable by any party for any direct, indirect, special or consequential damages as a result of inaccurate information received pertaining to the components of the existing system.

The information in this report is intended for use by the KM only.

Figure KMW1.1 **Locality plan - Knysna Municipality**

Figure KMW1.2a Towns and suburbs per treasury - Knysna, Belvidere & Brenton

Figure KMW1.2b Towns and suburbs per treasury - Sedgefield

Figure KMW1.2c Towns and suburbs per treasury - Buffels Bay

Figure KMW1.2d Towns and suburbs per treasury - Karatara

Figure KMW1.2e Towns and suburbs per treasury - Rheenendal

2. EXISTING SYSTEM

2.1 WATER SOURCES AND TREATMENT PLANTS

2.1.1 Knysna

Knysna is supplied with water mainly from the Knysna River (licensed capacity: 3077 Mℓ/a), Gouna River (licensed capacity: 840 Mℓ/a) and the Glebe Dam within the Grootkops River (licensed capacity: 511 Mℓ/a). Other sources includes the Bigai Springs (licensed capacity: 180 Mℓ/a) and abstraction from a few boreholes (150m^3/d or 55 Mℓ/a).

A 2 Mℓ/d Reverse Osmoses (RO) Plant also abstracts water from the lagoon downstream of the existing Knysna Wastewater Treatment Plant.

All surface water sources from the rivers are treated at the Knysna WTP from where it is supplied into the Knysna network. The capacity of the Knysna WTP is 21,25 Mℓ/d.

There are no external water suppliers within the jurisdiction of the Knysna Municipality.

2.1.2 Sedgefield

The Sedgefield area is supplied from the Karatara River supplemented by four boreholes (licensed capacity: 484m^3/d or 176 Mℓ/a) and a 1,5 Mℓ/d desalination plant at Myoli beach.

The surface water is purified at the Sedgefield WTP with a capacity of 4,0 Mℓ/d.

2.1.3 Belvidere

Belvidere is supplied with water from boreholes with a full capacity alternative supply directly from the Knysna network. Supplementation from the Knysna network occurs only in summer or holiday seasons.

2.1.4 Brenton

Brenton on Lake and Brenton on Sea are supplied with water from boreholes with full capacity alternative supply directly from the Knysna network. Supplementation from the Knysna network occurs only in summer or holiday seasons.

2.1.5 Buffels Bay

Buffels Bay is supplied with water extracted from the Goukamma River and pumped to the Buffels Bay WTP. The Buffels Bay WTP has a capacity of 0,95 Mℓ/d.

2.1.6 Karatara

Karatara abstracts raw water from the Karatara River. The raw water is purified at the Karatara WTP with a capacity of 0,79 Mℓ/d.

2.1.7 Rheenendal

Rheenendal is supplied with raw water from the Homtini River. The raw water is purified at the Keurhoek WTP with a capacity of 1,0 Mℓ/d.

2.2 BULK SUPPLY SYSTEM

The analysis of the bulk supply system, viz. the raw water system upstream of the storage reservoirs or WTP's is beyond the scope of this study.

2.3 RETICULATION SYSTEM LAYOUT AND OPERATION

2.3.1 General Description

The existing Knysna water supply system is discussed in this section.

The water distribution system layouts are shown on Figures KMW2.1, with a separate Figure for each area as follows:

- a - Knysna, Belvidere & Brenton
- b - Sedgefield
- c - Buffels Bay
- d - Karatara
- e - Rheenendal

This notation to distinguish between areas is used throughout this report for all Figures where appropriate.

The water distribution zones are shown in Figures KMW2.2

Table KMW2.1 provides a summary of the pipes, reservoirs, pumps and control valves in the existing system.

Table KMW2.2 provides a summary of the existing water demand of each zone in the system.

2.3.2 Knysna

The system is operated in 31 water distribution zones. There are 25 sets of reservoirs, one PRV zone, 5 tower zones and one booster pumping zone for Knysna. The two Belvidere-, 4 Brenton on Lake- and 3 Brenton on Sea zones are also linked to the Knysna system, bringing the total zones in the system to 40 zones.

2.3.3 Sedgefield

Sedgefield is operated in 2 zones supplied from 2 sets of reservoirs and 1 PRV zone. The main reservoir supplies to the set of two service reservoirs and the PRV is connected to the supply pipeline from the main reservoir to the service reservoirs.

2.3.4 Belvidere

The system is operated in 2 zones. There are 2 reservoirs, no PRV zones and no tower zones for Belvidere.

2.3.5 Brenton

The Brenton on Sea system is operated in 3 zones with 2 sets of reservoirs, one PRV zone and no tower zones. The Brenton on Lake system is operated in 4 zones with 1 set of reservoirs, 3 PRV zones and no tower zones.

2.3.6 Buffels Bay

Buffels Bay has one supply zone. The three reservoirs close to and above Buffels Bay are connected to the treatment process, but allow direct feed when necessary.

2.3.7 Karatara

Karatara has 2 supply zones from two reservoirs. The main reservoir feed both the Karatara town and the MTO reservoir, which supply to Bosdorp.

2.3.8 Rheenendal

The system is operated as 1 zone supplied from 1 reservoir assisted by a pressure tower.

2.4 EXISTING OPERATIONAL PROBLEMS

The operational staff indicated the following operational problems:

- In Knysna low residual pressures are experienced in the Knysna North-, Concordia-, Bongani-, Dam se Bos-, Sun Ridge-, Bigai- and Heuwelkruin zones under peak hour demand conditions
- In Sedgefield low residual pressures are experienced in the Smutsville area.

2.5 SPECIAL CONSIDERATIONS

2.5.1 General

Detailed drawings of the system are included in the plan book. The plan book should be used to indicate (by physical markings on the drawings) any additional information, or amendments, that would improve the quality of the final product.

2.5.2 Information to be clarified

Detail information regarding pump duty points, reservoir top water levels and volume, PRV settings and incomplete bulk water figures should be clarified as indicated in tables KMW2.1b - KMW2.1d & KMW3.3.

2.5.3 Data integrity

If this report is noted to have any discrepancies compared to alternative information, GLS should be contacted in this regard to ensure that the relevant sections of the system are verified as part of a future ongoing bureau service aimed at improving the data integrity in future.

Table KMW2.1a Existing water system summary - Pipes

Table KMW2.1b Existing water system summary - Reservoirs and water towers

Table KMW2.1c Existing water system summary - Pumps

Table KMW2.1d Existing water system summary - Pressure reducing valves

Table KMW2.2 Existing water system zone AADD's

Figure KMW2.1a **Existing water system layout - Knysna, Belvidere & Brenton**

Figure KMW2.1b **Existing water system layout - Sedgefield**

Figure KMW2.1c **Existing water system layout - Buffels Bay**

Figure KMW2.1d Existing water system layout - Karatara

Figure KMW2.1e Existing water system layout - Rheenendal

Figure KMW2.2a **Existing distribution zones - Knysna, Belvidere & Brenton**

FigureKMW2.2b Existing distribution zones - Sedgefield

Figure KMW2.2c **Existing distribution zones - Buffels Bay**

Figure KMW2.2d **Existing distribution zones - Karatara**

Figure KMW2.2e **Existing distribution zones - Rheenendal**

3. PRESENT LAND USE AND WATER DEMAND

3.1 METHODOLOGY

The Swift program is a link between treasury billing data, and water/sewer network models. (The name is derived from "***S****ewer* ***W****ater* ***I****nterface* ***F****or* ***T****reasury systems*"). The program was used to analyse the present land use and water demand situation in Knysna, as well as the projected potential water demand for a fully occupied existing system.

3.2 SWIFT ANALYSIS

A SWIFT analysis was conducted as part of this investigation. The KM has a R-Data treasury system, with a single treasury system for all the towns in the Municipal area. A data extraction routine for SWIFT was compiled as part of this investigation and will remain a standard part of the R-Data software suite in future.

The treasury records for the period September 2017 to August 2018 were used as the base information for the analysis.

3.3 LAND USE

With cognizance of the land use and zoning codes maintained in the treasury system being operated by the KM, the following land use categories were identified for this study:

- BUS_COMM - Business/Commercial
- CLUSTER - Town houses
- EDU - Educational
- FARM_AH - Farm/Agricultural holding
- FLATS - Flats
- GOVT_INST - Government/Institutional/Municipal
- IND - Industrial
- OTHER - All other categories
- PARKS - Parks and public open spaces
- INFORMAL - Informal
- RES - Residential stands

In order to account for the effect of stand size on residential water demand, the RES category is further subdivided into five sub-categories, based on stand size, as follows:

- RES 500 - smaller than 500 m^2
- RES 1 000 - 500 m^2 to 1 000 m^2
- RES 1 500 - 1 000 m^2 to 1 500 m^2
- RES 2 000 - 1 500 m^2 to 2 000 m^2
- RES 2 500 - 2 000 m^2 to 2 500 m^2
- RES >2 500 - larger than 2 500 m^2

The LARGE category is required to remove these special water consumers from their regular land use category, so as to prevent them from skewing the statistics for the specific category and to detach them from any theoretical unit water demand's (UWD's) that might not be applicable to them. The large water users are discussed later in this Chapter.

3.4 DISTRIBUTION ZONES AND ZONAL METER READINGS

3.4.1 General Description

Distribution zones are defined in Section 1.4 of this report.

No zonal meter readings are available for KM. Table KMW3.1 lists the total bulk water meter readings as obtained from the Municipality which represents the water supplied to each town.

3.5 INFORMAL SETTLEMENTS

The treasury data does not contain information on informal settlements in the study area.

The following informal settlements were however reported to be present in the Western Cape Completed Service Levels (data provided by WorleyParsons for DWA) dated January 2014:

Informal housing with no access to basic services:

- 900 households in Knysna
- 50 households in Rheenendal

Informal housing with access to shared services:

- 3287 households in Knysna
- 534 households in Sedgefield
- 50 households in Rheenendal

These settlements receive water from a number of yard taps/stand pipes in the adjacent areas. No meter readings are available for these taps, but estimates were however made in the water master plan for the consumption of these settlements.

3.6 SWIFT RESULTS AND RESULTING WATER DEMANDS

3.6.1 Suburb-by-suburb land use and water use statistics

All available treasury data in Knysna was analysed with the SWIFT program, in order to determine (for each stand/meter record) the suburb, the land use, whether it is occupied or vacant, its annual average daily demand (AADD) and total annual water demand (TWD) for the base year. This information was then totalised and summarised by SWIFT per suburb, and broken down into the various land use categories. Average unit water demands (ℓ/stand/d) were also determined for each land use category in each suburb. The results are summarised in Table KMW3.2.

Figure KMW3.1 shows all the stands coloured in accordance with their land use according to the Swift analysis.

3.6.2 Distribution zone land use and water use statistics

Each stand/record was linked or associated via GIS to its specific distribution zone(s) and the same totals and summaries as above were produced per distribution zone and were also broken down into the various land use categories. In this way the TWD per distribution zone was determined. The results are summarised in Table KMW2.2.

3.6.3 Unaccounted-for-water

The total water inputs for each area were compared with the total water sales, which resulted in UAW figures of 29% in Knysna, 23% in Belvidere, 31% in Brenton, unknown in Rheenendal, 34% in Sedgefield, 10% in Karatara and 12% in Buffels Bay. The results are summarised in Table KMW3.3.

The large UAW figures of Brenton and Sedgefield should be reduced by implementing a suitable Water Demand Management plan.

No water meter reading were available for Rheenendal.

3.6.4 Rationalized (“theoretical”) unit water demands

The UWD’s per land use in each suburb were rationalised into rounded-up “theoretical” values. These values were calibrated by applying them to the total number of occupied stands in each land use category of each suburb, and comparing the resultant “theoretical” total water demand (excluding UAW) for each suburb with the actual water demand (excluding UAW) for the suburb. The results are summarised in Table KMW3.4.

3.6.5 Rationalized (“theoretical”) UAW

For planning and evaluation purposes, the UAW figures were also rationalised on a regional (wider-area) basis, as allowed by the sensibility of the results. After allowance was made for unmetered consumers and faulty bulk meters in the area, an UAW figure of 20% in Knysna, 15% in Belvidere, 43% in Brenton, 40% in Rheenendal, 28% in Sedgefield, 3% in Karatara and 15% in Buffels Bay were applied for modelling purposes of the existing system.

For modelling of the future system an UAW figure of 20% in Knysna, 20% in Belvidere, 25% in Brenton, 25% in Rheenendal, 20% in Sedgefield, 15% in Karatara and 15% in Buffels Bay were applied.

3.6.6 Theoretical present water demand

The rationalised UWD’s and UAW’s were applied to all the stands in each land use category of each suburb, as a “theoretical” model of the present water demand situation. For calibration, the resultant “theoretical” total water demand (inc. UAW) for each suburb was compared with the actual water demand (inc. UAW) for the suburb. The results for the formal areas are summarised in Table KMW3.4.

3.6.7 Potential land use and AADD of existing developments

The Swift program determines the total number of vacant stands in each land use category for each suburb and each distribution zone. These vacant stands do not contribute to the present water demand calculations (actual or theoretical) as described above. However, the Swift program also determines from treasury data what the land use or zoning rights of vacant stands might be. The rationalised theoretical UWD’s and UAW’s can therefore also be applied to these vacant stands in order to determine their potential water demand, should they become developed/occupied.

The theoretical present water demand model was therefore extended in Swift to include all vacant stands and a potential fully occupied present water demand (inc. UAW) for each suburb and distribution zone in Knysna was determined. The results are summarised per suburb in Table KMW4.2.

3.7 LARGE WATER USERS

Table KMW3.5 is a list of all the stands defined as large users in SWIFT for KM. The table shows the large users (AADD > 10 kℓ/d) sorted per demand. The tabulated information for each user (e.g. owner, consumer, address) is unchanged as recorded in the treasury system.

The water demand for each of the large users recorded in the treasury database is interrogated by SWIFT. The AADD calculated by SWIFT for each large user is used to calculate the peak flow for the relevant consumer. The location of each large user is identified uniquely in view of its demand in the water system model.

Table KMW3.1 Bulk water input

Table KMW3.2 Actual water use per suburb and land use (Swift result)

Table KMW3.3 UAW analysis summary

Table KMW3.4 Theoretical water use per suburb and land use (Swift result)

Table KMW3.5 Large water users (>10kℓ/d AADD)

Figure KMW3.1a **Land use per stand - Knysna, Belvidere & Brenton**

Figure KMW3.1b **Land use per stand - Sedgefield**

Figure KMW3.1c Land use per stand - Buffels Bay

FigureKMW3.1d **Land use per stand - Karatara**

Figure KMW3.1e **Land use per stand - Rheenendal**

FigureKMW3.2a Location of large water users - Knysna

Figure KMW3.2b Location of large water users - Sedgefield

FigureKMW3.2c **Location of large water users - Buffels Bay**

FigureKMW3.2d **Location of large water users - Karatara**

Figure KMW3.2e Location of large water users - Rheenendal

4. FUTURE LAND USE AND WATER DEMAND

4.1 FULL OCCUPATION OF EXISTING DEVELOPMENTS

For the future land use and water demand scenario the potential future developments for the area were taken into account. It was thus not only assumed that all existing but vacant stands in the treasury data would become "occupied", i.e. start using water (as for the existing system), but also that these potential future developments would materialise and start using water.

4.2 POTENTIAL FUTURE LAND DEVELOPMENTS AND WATER DEMAND

The potential areas for future developments were identified in consultation with the Municipality's town planning consultants. Each potential area was assigned an anticipated predominant land use, and a development phasing for the following years:

- Next 5 years
- 5 - 10 years
- 10 - 15 years
- After 15 years

The potential future land developments are shown on Figure KMW4.1, coloured according to the land use.

Typical UWD's (per ha or per stand/unit) were estimated for the potential future areas based on previous experience and statistics obtained from the SWIFT analysis of the present water demands.

4.3 FUTURE WATER DEMAND

The future AADD of the Knysna system is summarised in Table KMW4.2. The future AADD (modelled as the future system) represents an increase of ± 84% over the actual present AADD, and an increase of ± 57% over the potential fully occupied present AADD (after the municipal wide UAW is reduced through a Water Demand Management Programme).

Table KMW4.1 Potential future land developments

Table KMW4.2 Present and future water demand summary

Figure KMW4.1a Potential future developments - Knysna, Belvidere & Brenton

Figure KMW4.1b Potential future developments - Sedgefield

Figure KMW4.1c **Potential future developments - Buffels Bay**

Figure KMW4.1d Potential future developments - Karatara

Figure KMW4.1e **Potential future developments - Rheenendal**

5. EVALUATION AND PLANNING CRITERIA

5.1 WATER DEMANDS AND PEAK FACTORS

5.1.1 Planning

The major objectives pursued in the evaluation and planning of the water supply system as presented in this report can be summarised as follows:

- Establishing a model of the water network that accurately reflects the existing system.
- Detailed water demand analysis based on data in the treasury system.
- Conformity with operational requirements and criteria adopted for this study.
- Optimal use of existing facilities with excess capacity.
- Optimisation of the system with regards to capital -, maintenance - and operational cost.

The future system planning was done so as to satisfy the future water demands. The future AADD of the study area is anticipated to be 25 640 kℓ/d. This AADD will be realised in the year ± 2038 (20 year planning horizon) if the demand increases at a compound growth rate of ± 4,2 % per year.

At a more realistic growth rate of ± 2,0% (as agreed by KM in the Western Cape Completed Service Levels study performed by WorleyParsons for DWA) this AADD will be realised in the year ± 2057 (41 year planning horizon).

5.1.2 Present and future AADD's

Existing systems were evaluated on the basis of the existing AADD as documented, including UAW.

For planning of future systems it was accepted that all existing vacant stands are occupied and are using water in accordance with the assumed UWD's, and AADD's of all potential future developments were added.

5.1.3 Peak factors

The peak factors used for this study are dependent on type of land use in the area under consideration, and the magnitude of water demand in the area, and are summarised in Table HW5.1.

These peak factors are based on factors measured and used on previous studies in South Africa.

5.2 OPERATIONAL CRITERIA

5.2.1 Maximum and minimum pressures

The pressure criteria used for the evaluation and planning of the reticulation networks are listed in Table KMW5.2.

5.2.2 Fire fighting flows

Fire fighting flow and pressure criteria are listed in Table KMW5.2. The requirements are more or less in conformity with those prescribed by the so-called "Red Book" (Guidelines for Human Settlement Planning and Design - Dept. of Housing, August 2003).

5.2.3 Flow velocities

Flow velocities must be limited in order to protect pipeline coatings and reduce the effects of water hammer. The preferred maximum allowed is 1,8 m/s, but an absolute maximum of 2,2 m/s is acceptable where only intermittent peak flows occur.

5.2.4 Pump stations (PS)

PS should always have one standby pump available. An electrically driven standby pump should suffice except in the case of high-risk areas, where the standby pump should be diesel-driven.

5.2.5 Redundancy

Within distribution networks to end-users, branched systems should be avoided as far as possible, i.e. there must be at least two directions of flow to a consumer. For bulk supply systems branched portions may be acceptable, due to the role of reservoirs, and redundancy refers more to the level of integration in the system.

5.3 RESERVOIR SUPPLY RATES AND STORAGE CAPACITIES

Reservoirs in the system serve two main functions:

- Emergency storage, including that required for fire fighting, to provide sufficient water when a supply failure occurs.
- Balancing storage, required to balance out peaks in the demand.

For initial assessment of reservoir size these two functions are viewed integrally. The criteria for total reservoir volume used in this study for evaluation and planning is 48 hours of the AADD (of the reservoir supply zone) for gravity and pumped supply to the reservoir. It is noted that this could represent as little as 20 to 30 hours' storage of the peak day demand.

The volume required for the balancing function is dependent on the supply rate to the reservoir and is therefore closely related to the capacity of the feeder main to the reservoir.

In some cases where capacity appears to be a problem the relationship between balancing storage in a reservoir and the supply to the reservoir is dealt with as follows in order to optimise the system by means of time simulation:

- For new reservoirs, the optimum combination of supply rate and balancing volume was determined.
- For existing reservoirs, any excess capacity was utilised as balancing storage, in order to minimise the required supply rate and thus also the load on the system supplying the reservoir.
- For existing reservoirs with limited capacity for balancing, an economic analysis was done in order to determine whether to increase the supply rate to the reservoir so that the balancing load is minimised, or whether to increase the storage capacity.

Balancing storage is an analytical exercise based on time simulation, but in contrast the emergency storage is a matter of perception and subjective assessment of the risk of non-supply of water. It is often not necessary to provide more than 30 h x AADD emergency storage in a reservoir (in addition to balancing storage), unless there are specific conditions or risks to justify a larger storage.

These criteria are summarized in Table KMW 5.3.

5.4 WATER TOWER SUPPLY RATES AND STORAGE CAPACITIES

Water towers serve merely to sustain pressure in a network, and should not be regarded as facilities for balancing peaks and for emergency supply. Because of their relatively small volumes, the supply rates to towers must be such that they can be kept full at all times. On the other hand, volumes must be large enough to allow room for operation of pumps filling the tower (where applicable) such that the number of pump cycles per day is limited. The following guidelines as summarised in Table KMW5.3 were used for evaluation and planning of water towers:

- Supply rate into tower - 1,0 to 1,1 x peak hour factors (PHF) x AADD
- Tower storage - 2h to 6h x AADD

5.5 OPTIMAL USE OF EXCESS CAPACITIES IN EXISTING FACILITIES

Many existing facilities may have excess capacity when measured in terms of the operational criteria described above. In whatever way it has come about, in the planning done for this study it was strived to utilise the excess capacities in existing facilities to its economically viable maximum.

5.6 ECONOMIC OPTIMISATION AND COST FUNCTIONS

All the strategic and technical alternatives studied were compared on mainly economic grounds, with a view to establishing a "master plan" which will result in the lowest present value of capital works, operations and maintenance.

The cost functions for cost estimates, cost comparisons and economic optimisation in general, are presented in Figure KMW5.4.

It should be noted that the proposed pipeline routes are indicated schematically on the master plan and that no detail topographical or geotechnical surveys have been conducted to verify these routes. The detail assessment of the routes are thus beyond the scope of this report and should be performed in the preliminary design stage during implementation. A variance of the cost estimates could therefore be experienced typically due to the presence of hard rock in the substrata along the pipeline route, existing services of which the crossings appear to be problematic or for which ever reason the pipeline route has to be lengthened.

Table KMW5.1 Design and evaluation criteria - Peak factors for water demand

Table KMW5.2 Design and evaluation criteria - Flow and pressure

Table KMW5.3 Design and evaluation criteria - Reservoirs and bulk supply

Table KMW5.4 Cost functions (Year 2018/19 Rand value, excluding P&G, contingencies, fees and VAT)

6. EVALUATION AND MASTER PLAN

6.1 EXISTING SYSTEM

6.1.1 Overview

The results of the existing system analysis are presented in the following Figures:

- Figure KMW6.1 shows the static pressures in each system, thus the maximum pressure that could be expected in the system at any time.
- Figure KMW6.2 shows the residual pressures in each system under peak hour demand conditions.
- Figure KMW6.3 shows the flow velocity in each system under peak hour demand conditions.

6.1.2 Discussion

Knysna

The static analysis indicates areas in the network where pressures are below 24m in the Knysna North-, Concordia-, Bongani-, Dam se Bos-, Sunridge-, Bigai- and Heuwelkruin zones. There are various areas where the static pressures exceed the normal 90m but mostly only marginally above 90m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for areas where static pressure was low in the first place. These areas are in the Knysna North-, Concordia-, Bongani-, Dam se Bos-, Sunridge-, Bigai- and Heuwelkruin zones.

There are a few pipes which have a velocity under peak hour demand conditions which exceeds 1,5 m/s. The most significant are the following:

- The bulk supply pipes from the Water Works reservoirs towards the western regions (supply towards Eastford Lower reservoir and towards Belvidere and Brenton when areas are supplied from the Knysna network).
- Supply pipes between White Location reservoir and the Heuwelkruin reservoir and tower (when Heuwelkruin reservoir is supplied with water from the White Location reservoir).
- Bigai rising main.
- Corlette Drive rising main.
- Rising main between Leisure Island reservoirs and Sparrebosch reservoirs.
- Supply pipeline towards The Heads.
- A few network pipes in Knysna North and Concordia areas.
- The supply pipe towards Thesen Hill reservoir.

The velocities in these pipes are all between 1,5 and 2,0 m/s except for the Thesen Hill supply pipe (2,5 m/s) and some of the network pipes in the Knysna North and Concordia areas (> 2,5 m/s).

Belvidere

The static analysis indicates no areas in the network where pressures are below 24m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.

The flow velocities in the system do not exceed 1,5 m/s.

Brenton

The static analysis indicates no areas in the network where pressures are below 24m. The lower lying areas close to sea level in Brenton on Lake and Brenton on Sea have static pressure above 90m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for the lower lying areas close to the sea where the pressure is above 90m.

The flow velocities in the system do not exceed 1,5 m/s.

Sedgefield

The static analysis indicates areas in the network where pressures are below 24m in the high lying areas, west of the town reservoirs and in the Smutsville area. Static pressure above 90m occurs along the high pressure zone supply pipe and in a few valleys of the high pressure zone.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for the areas where static pressure is below 24m. These areas increased in size in Smutsville and the higher areas to the west of the town reservoirs.

The main supply pipeline between the Sedgefield Main reservoir and the service reservoirs in Sedgefield experiences a flow velocity through the pipeline of above 1,5 m/s during peak demand conditions.

Buffels Bay

The static analysis indicates no areas in the network where pressures are below 24m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.

There are no pipes with a flow velocities exceeding 1,5 m/s in the system.

Karatara

The static analysis indicates no areas in the network where pressures are below 24m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range for the Karatara Rates area. In the Bosdorp zone, the residual pressure is mainly below 15m.

The flow velocities in the existing system do not exceed 1,5 m/s.

Rheenendal

The static analysis indicates no areas in the network where pressures are below 24m.

The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.

The flow velocities in the existing system do not exceed 1,5 m/s.

6.2 REPLACEMENT VALUE

Table KMW6.1 gives an estimate of the replacement value of the existing Knysna system, based on the cost functions shown on Table KMW5.4.

6.3 EXISTING BULK SUPPLY SYSTEM

Table KMW6.2 is a summary of the reservoir and feeder evaluation of the existing system. For each reservoir it shows:

- The potential present AADD of the zone(s) served by the reservoir, which might include a PRV or booster zone.
- The volume of the reservoir, in relation to the AADD served by the reservoir (expressed as h x AADD). The available balancing volume is the total volume minus the required 30 h x AADD emergency volume. If this is more than 18 h x AADD, the surplus is regarded as “spare” capacity.
- The feeder mains to the reservoir, and their capacities expressed as a ratio of the AADD served by the reservoir. Feeder main capacities have been estimated based on a maximum flow velocity of 1,8 m/s, and not on the actual hydraulic capacity. The required flow of feeder mains is also listed, based on the amount of balancing storage available, and the peak factors and pattern of demand in the reservoir zone. Where the feeder capacity exceeds the required flow, a “spare” capacity is indicated. Feeder mains with a negative “spare” capacity are deficient.

6.3.1 Reservoirs

Evaluated on a town-for-town basis, the overall reservoir storage volume available for each town is more than the required capacity of 48 h x AADD served, except for Rheenendal where the total reservoir storage is only 27 h x AADD served.

In Knysna the Heuwelkruin, Thesen Hill, Corletta Drive and The Heads Lower reservoirs have insufficient reservoir storage capacity available. The Heuwelkruin and Thesen Hill reservoirs are however supplied under gravity from the upstream Water Works reservoirs, which have sufficient spare capacity available.

The Coreletta Drive and The Heads Lower reservoirs are however only marginally below the required 48 h x AADD storage capacity criteria (47 h x AADD served vs the required 48 h).

6.3.2 Feeder mains

Most of the feeder mains in KM have sufficient capacity to supply the existing water demands, except for the following pipes that are currently at or near capacity:

- The 150 mm Ø supply pipe in Knysna from the WTP to Thesen Hill reservoir is near capacity.
- The 100 mm Ø supply pipe in Knysna from Bongani reservoir to Dam se Bos reservoir is near capacity and requires upgrading in the near future.
- The 75 mm Ø supply pipe in Knysna from the Concordia reservoir to Concordia tower is near capacity and requires upgrading in the near future.
- In Sedgefield the bulk supply towards the high pressure zone has insufficient capacity.

6.3.3 Pumping stations

The capacities of most of the existing pumping stations in KM are sufficient for the existing water demands, except for the Old Place to Bongani pumps (when Bongani reservoir is only supplied from Old Place), Ethembeni PS (this PS is possibly already upgraded, to be verified), Dam se Bos reservoir pumps, Dam se Bos tower pumps, Water Works PS to

North reservoir, Joodse Kamp to Concordia pumps and the Concordia PS. Upgrading of these pumping stations are proposed in order to augment bulk water supply in Knysna.

6.4 MASTER PLAN - KNYSNA

6.4.1 Proposed distribution zones

The proposed distribution zones are indicated on Figure KMW6.4a.

The changes to the existing distribution zones are the following:

- The boundaries of the existing zones are increased to accommodate future development areas.
- Pressure management is proposed at the existing Eastford Lower reservoir zone in order to reduce static pressures at the lower lying developments within the supply area: Eastford Lower PRV 1, PRV 2 & PRV 3 zones should be implemented.
- Pressure management is proposed at the existing Eastford Upper reservoir zone in order to reduce static pressures at the lower lying developments within the supply area: Eastford Upper PRV 1, PRV 2, PRV 3, PRV 4, PRV 5 & PRV 6 zones should be implemented.
- A new Thesen Hill PRV zone is proposed in order to reduce static pressure at the lower lying erven within the existing Thesen Hill reservoir zone.
- A new Water Works Direct PRV zone is proposed in order to reduce high static pressures within the existing Water Works Direct zone.
- The zone boundaries of the Concordia reservoir zone are increased in order to improve water pressure in the Knysna North area.
- The zone boundaries of the Heuwelkruin tower zone are increased in order to accommodate the existing Heuwelkruin reservoir zone. The Heuwelkruin tower is supplied with water from the White Location reservoir zone.
- The zone boundaries of the Bigai booster zone are increased in order to improve water pressure in the area.
- The zone boundaries of the Noetzie reservoir zone are increased in order to improve water pressure in the area.
- A new Dam se Bos PRV zone is implemented for water demand management purposes.

The following new distribution zones are proposed:

- A new Corlette Drive booster zone is proposed for the higher lying erven of future area KN30 next to the Corlette Drive reservoir.
- New Kruisfontein reservoir and Kruisfontein booster zones are proposed to accommodate future development area KN40 (Kruisvallei). It is proposed that the existing Dam se Bos tower zone is decommissioned and accommodated within the proposed Kruisfontein reservoir zone.
- A new Heidevallei reservoir zone is proposed to accommodate the higher lying erven of future areas KN22, KN23 & KN28 in Heidevallei.
- A new River Reserve reservoir zone is proposed to accommodate future area KN5.
- A new Windheuwel reservoir zone is proposed to accommodate future areas KN12 & KN45.

6.4.2 Proposed future system and required works

The existing Knysna water distribution system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

The proposed master plan items are presented in Figure KMW6.5a.

A number of distribution pipelines are required to reinforce water supply within the Knysna water network, to implement the proposed changes to the existing distribution zones, to implement the proposed new reservoir zones and to supply future development areas with water when they develop.

6.4.3 Bulk System

The existing bulk water supply system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

The following new reservoirs will be required in future.

- A new 4,0 Mℓ reservoir is proposed at the existing Thesen Hill reservoir site to augment reservoir storage capacity for the Thesen Hill reservoir and PRV zones (item KKW.B2).
- A new 2,5 Mℓ clear well is proposed at the existing Knysna WTP in order to augment reservoir storage capacity (item KKW.B3).
- A new 1,5 Mℓ River Reserve reservoir is proposed to accommodate future area KN5 (item KKW.B11).
- A new 2,0 Mℓ Windheuwel reservoir is proposed to accommodate future areas KN12 & KN41 (item KKW.B18).
- A new 1,0 Mℓ Heidevallei reservoir is proposed to accommodate the higher lying erven of future areas KN22, KN23 & KN28 (item KKW.B22). It is proposed that bulk water supply to Concordia reservoir is augmented from the proposed Heidevallei reservoir. The reservoir should be supplied with water from the Old Place reservoir.
- A new 3,5 Mℓ Kruisfontein reservoir is proposed to accommodate future area KN40 (item KKW.B30).
- A new 0,5 Mℓ reservoir is proposed at the existing Corlette Drive reservoir site to accommodate future areas KN4 & KN30 (item KKW.B36).
- Additional 1,5 Mℓ reservoir storage capacity is proposed at the Old Place Upper reservoir site when the existing reservoir storage nears capacity (item KKW.B38).
- Additional 1,0 Mℓ reservoir storage capacity is proposed at the Bigai reservoir site when the existing reservoir storage nears capacity (item KKW.B41).
- A new 0,5 Mℓ reservoir is proposed at the existing Noetzie reservoir site when the existing reservoir storage nears capacity (item KKW.B42).

Feeder mains

The following new feeder mains will be required in future:

- New 250 mm Ø parallel reinforcement of the existing bulk supply pipeline between the Water Works reservoir and Thesen Hill reservoir (item KKW.B1).
- Connect the new Knysna North & White Location pump stations to the existing rising mains (after the existing pump stations are relocated to the Knysna WTP, items KKW.B5 & KWW.B7).
- New 315 mm Ø dedicated bulk pipeline to Eastford Lower reservoir (item KKW.B9).
- A new 160 mm Ø dedicated bulk pipeline is proposed between the Eastford Lower and Eastford Upper reservoirs (item KKW.B12). The existing network pipes should be isolated from the dedicated bulk pipeline (item KKW.B13).
- New 200 mm Ø parallel reinforcement of the existing 160 mm Ø feeder main between the Knysna North reservoir and the Joodse Kamp PS (item KKW.B15).
- Dedicated 160 mm Ø bulk pipeline between the Knysna North reservoir and the proposed Windheuwel reservoir (item KKW.B17).
- New 400 mm Ø parallel reinforcement of the existing 200 mm Ø bulk pipeline between the Water Works clear well and the Old Place Lower reservoir (item KKW.B19).
- Dedicated 400 mm Ø bulk pipeline between the Old Place Lower reservoir and the proposed Heidevallei reservoir (item KKW.B21).

- Dedicated 355 mm Ø bulk pipeline between the proposed Heidevallei reservoir and the existing Concordia reservoir (item KKW.B24).
- New 315 mm Ø bulk pipeline between the Concordia reservoir and the Bongani reservoir to augment bulk water supply to Bongani reservoir (item KKW.B25).
- New 250 mm Ø bulk pipeline between the Bongani reservoir and Dam se Bos reservoir to augment bulk water supply to Dam se Bos reservoir (item KKW.B27).
- Dedicated 250 mm Ø bulk pipeline between the Dam se Bos reservoir and the proposed Kruis fontein reservoir (item KKW.B29).
- New 200 mm Ø parallel reinforcement of the existing 150 mm Ø bulk pipeline towards the Vigilance Drive PS (item KKW.B33).
- Dedicated 250 mm Ø bulk pipeline between the Vigilance Drive PS and the Bigai reservoir (item KKW.B35).
- New 110 mm Ø parallel reinforcement of the existing 75 mm Ø bulk supply pipeline towards the Corlette Drive reservoir (item KKW.B40).

Pumping stations

The following items are proposed considering pumping stations:

- Relocate the Knysna North and White Location pumps to the Knysna WTP (items KKW.B4 & KKW.B6).
- New dedicated bulk PS to Eastford Lower reservoir (item KKW.B8).
- New bulk PS at the Knysna North reservoir to supply bulk water to the proposed Windheuwel reservoir (item KKW.B16).
- New dedicated bulk PS at the Old Place Lower reservoir to supply bulk water to the proposed Heidevallei reservoir (item KKW.B20).
- Dedicated bulk PS at the proposed Heidevallei reservoir to supply bulk water to the Concordia reservoir (item KKW.B23).
- New bulk PS at the Bongani reservoir to augment bulk water supply to Dam se Bos reservoir (item KKW.B26).
- New bulk PS at the Dam se Bos reservoir to supply bulk water to the proposed Kruisvallei reservoir (item KKW.B28).
- It is proposed that the Ethembeni PS is upgraded (item KKW.B31). This PS is however possibly already upgraded and this should be verified.
- Upgrade Xolweni pumps at the Joodse Kamp PS when existing supply reaches capacity (item KKW.B32).
- Upgrade bulk water supply to Bigai reservoir (item KKW.B34).
- Upgrade capacity of the Eastford PS (at the Eastford Lower reservoir) when existing supply reaches capacity (item KKW.B37).
- Upgrade capacity of the Old Place Upper PS (at the Old Place Lower reservoir) when existing supply reaches capacity (item KKW.B39).
- New booster PS when future area KN30 develops (item KKW20.1).
- New booster PS when higher lying areas of future area KN40 develops (item KKW15.1).

Pressure management

The following projects are proposed within the existing Knysna water system for pressure management purposes:

- Implement Thesen Hill PRV zone (project KKW-003)
- Implement Water Works Direct PRV zone (project KKW-007).
- Implement Dam se Bos PRV zone (project KKW-016).
- Implement Eastford Upper PRV zones (project KKW-017).

6.4.4 Cost estimates of future works

The cost estimates for the proposed future reinforcements to the Knysna system are summarised in Table KMW6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KWW6.4b.

The proposed projects with the highest priority in Knysna are included in Table KMW6.4c.

6.5 MASTER PLAN - BELVIDERE

6.5.1 Proposed distribution zones

The proposed distribution zone is indicated on Figure KMW6.4a.

No changes are proposed to the existing distribution zone boundary.

6.5.2 Proposed future system and required works

The Belvidere water distribution system is so small that it is almost insignificant when compared to the other towns in Knysna. The system has sufficient capacity to cater for the fully occupied existing load on the system.

6.5.3 Bulk System

The existing bulk water supply system has sufficient capacity to supply the future water demands for the fully occupied scenario.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

No future reservoirs are required.

Feeder mains

None.

Pumping stations

No future pumping stations are required.

6.5.4 Cost estimates of future works

None.

6.6 MASTER PLAN - BRENTON

6.6.1 Proposed distribution zones

The proposed distribution zone is indicated on Figure KMW6.4a.

There are no changes to the existing distribution zones besides the extension to accommodate future development area BRL1 in Brenton on Lake.

6.6.2 Proposed future system and required works

The existing Brenton water distribution system has sufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

6.6.3 Bulk System

The existing bulk water supply system has sufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

No future reservoirs are required.

Feeder mains

None.

Pumping stations

No future pumping stations are required

6.6.4 Cost estimates of future works

None

6.7 MASTER PLAN - SEDGEFIELD

6.7.1 Proposed distribution zones

The proposed distribution zones are indicated on Figure KMW6.4b.

The changes to the existing distribution zones are the following:

- The boundaries of the existing zones are increased to accommodate future development areas.
- The zone boundaries between the Sedgefield reservoir and Sedgefield high pressure zones are adjusted in order to improve water pressure in the higher lying erven of Smutsville.

The following new distribution zones is proposed:

- A new Sedgefield main reservoir booster zone is proposed when future area S15 develops.

6.7.2 Proposed future system and required works

The existing Sedgefield water distribution system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

The proposed master plan items are presented in Figure KMW6.5b.

A number of distribution pipelines are required to reinforce water supply within the Sedgefield water network, to alter the existing zone boundaries and to supply future development areas with water when they develop.

6.7.3 Bulk System

The existing bulk water supply system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

The following new reservoir will be required in future.

- A new 2,5 Mℓ reservoir is proposed at the existing Sedgefield duty reservoirs site to augment reservoir storage capacity for Sedgefield (item KSW.B2).

Feeder mains

The following new feeder main will be required in future:

- New 315 mm Ø parallel reinforcement of the existing 200 mm Ø bulk pipeline between the Sedgefield main reservoir and the duty reservoirs (item KSW.B1).

Pumping stations

The following item is proposed considering pumping stations:

- New booster PS when future area S15 develops (item KSW3.1).

6.7.4 Cost estimates of future works

The cost estimates for the proposed future reinforcements to the Sedgefield system are summarised in Table KMW6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KWW6.4b.

The proposed projects with the highest priority in Sedgefield are included in Table KMW6.4c.

6.8 MASTER PLAN – BUFFELS BAY

6.8.1 Proposed distribution zones

The proposed distribution zone is indicated on Figure KMW6.4c.

No changes are proposed to the existing distribution zone boundary.

6.8.2 Proposed future system and required works

The Buffels Bay water distribution system is so small that it is almost insignificant when compared to the other towns in Knysna. The system has sufficient capacity to cater for the fully occupied existing load on the system.

6.8.3 Bulk System

The existing bulk water supply system has sufficient capacity to supply the future water demands for the fully occupied scenario.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

No future reservoirs are required.

Feeder mains

None.

Pumping stations

No future pumping stations are required.

6.8.4 Cost estimates of future works

None

6.9 MASTER PLAN - KARATARA

6.9.1 Proposed distribution zones

The proposed distribution zones are indicated on Figure KMW6.4d.

The only changes to the existing distribution zones are that the boundaries of the existing zones are increased to accommodate future development areas.

6.9.2 Proposed future system and required works

The existing Karatara water distribution system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

The proposed master plan items are presented in Figure KMW6.5d.

A number of distribution pipelines are required to reinforce water supply within the Karatara water network and to supply future development areas with water when they develop.

6.9.3 Bulk System

The existing bulk water supply system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

The following new reservoir will be required in future.

- A new 1,0 Mℓ reservoir is proposed at the existing Karatara WTP site to augment reservoir storage capacity for Karatara (item KKAW.B1).

Feeder mains

None.

Pumping stations

No future pumping stations are required

6.9.4 Cost estimates of future works

The cost estimates for the proposed future reinforcements to the Karatara system are summarised in Table KMW6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KWW6.4b.

6.10 MASTER PLAN - RHEENENDAL

6.10.1 Proposed distribution zones

The only change to the existing distribution zone is that the boundary of the existing zone is increased to accommodate future development areas.

6.10.2 Proposed future system and required works

The existing Rheenendal water distribution system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

The proposed master plan items are presented in Figure KMW6.5e.

New distribution pipelines are required to reinforce water supply within the Rheenendal water network and to supply future development areas with water when they develop.

6.10.3 Bulk System

The existing bulk water supply system has insufficient capacity to supply the future water demands for the fully occupied scenario and the additional future development areas.

Table KMW6.5 is a summary of the reservoir and feeder evaluation of the future system for the future water demand.

Reservoirs

The following new reservoir will be required in future.

- A new 2,5 Mℓ reservoir is proposed at the existing Rheenendal WTP site to augment reservoir storage capacity for Rheenendal (item KRHW.B1).

Feeder mains

None.

Pumping stations

The following item is proposed considering pumping stations:

- Upgrade existing Rheendal booster PS when future areas RH1 & RH2 develop (item KRHW.B2).

6.10.4 Cost estimates of future works

The cost estimates for the proposed future reinforcements to the Rheenendal system are summarised in Table KMW6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KWW6.4b.

6.11 OPERATION AND MAINTENANCE COSTS

This capital expenditure plan allows only for capital expenditure required to upgrade the system to meet future growth. No provision is made in this master plan for the following:

- Increased operation and maintenance costs that go hand in hand with the infrastructure upgrades
- Replacement of old infrastructure that reaches the end of reliable operation.

6.12 UPDATING AND MAINTENANCE OF THE COMPUTER MODEL AND MASTER PLAN

The calibrated computer model of the distribution system is a handy tool for the day to day management of the system and can also be used as a basis for the calculation of services contributions by developers. The utility value of the model will however be lost if it is not properly maintained. The model should therefore be kept up to date with new developments and extensions to the system, and a link to the treasury water sales data.

6.13 MONITORING OF THE SYSTEM

An extensive monitoring programme is suggested which will gather information to assist with the updating of the master plan and the day to day management of the system. This programme has even more significance in the context of the Water Services Act 2007, which basically enforces proper system- and water demand management.

Monitoring of the system could be through a live link like telemetry and through a system which is updated only periodically such as SWIFT. Telemetry monitoring can be used for a number of reasons, some of which are:

- To monitor reservoir levels for operational reasons.
- To monitor pumps on or off for operational reasons.
- To continuously log flow meters to determine flow/demand patterns, also giving an indication of when the maximum flow velocities or pipeline capacities are reached.
- To monitor network residual/static pressures where problems are expected/ experienced.

Monitoring of the system through SWIFT is a more long-term process and typical objectives are:

- To determine the total system non-revenue water (NRW) as obtained from the meter database.
- To determine the NRW per subsystem, again as per meter database.
- To pick up meter irregularities such as broken meters, meters slowing down, meters which were replaced, meters which clocked over, etc.

6.14 WATER DEMAND MANAGEMENT

Continuous attention and support to water demand management with the aim of permanent reduction in demand should be considered as it could substantially impact the capital expenditure required to meet the future demand. A long-term water conservation and water demand management strategy study was conducted for the KM in April 2014, defining priorities for water loss reduction and demand management measures for each town. The KM should ensure that these strategies are pursued actively.

6.15 ASSET MANAGEMENT

It is recommended that the current databases as well as hydraulic analyses and master planning results be extended and applied to support the asset register (AR) and asset management plan (AMP). The following aspects are of importance in this respect:

- The data bases must be revisited to ensure compliance with the AR with respect to componentization and hierarchy. Due to the process followed in compiling the databases it is not expected that this will be a major task, but the specific rules for componentization, hierarchy and continuous update of the AR within e.g. a unique numbering system was not available at the time.

- Similarly the master plan projects should be aligned with the format stipulated in the AMP.
- The data integrity allocation during the establishment of the data base should be applied to inform the data improvement plan which is a subset of the AMP.
- The results of the hydraulic analyses should be applied to assist in determining important component attributes in the AR, such as criticality, utilization, performance and remaining useful lifetime.
- Attributes that will assist in performing AMP related actions, such as risk based pipe replacement prioritization, should be captured. These would e.g. include geological environment, location with respect to areas or consumers sensitive to spillages or flooding etc.
- The units and unit rates used should be checked and adjusted to be consistent for the determination of asset valuations in line with current replacement cost (CRC), fair values according to depreciated replacement cost (DRC) and budgets which include both operational expenditure (OPEX) and capital expenditure (CAPEX).

6.16 CONCLUSION

It is recommended that the water master plan as described in this report be implemented in order to allow the water distribution system of the KM to keep in step with the anticipated growth and expansion of water demand.

Table KMW6.1 Existing water system replacement value - Summary

Table KMW6.2 Bulk supply capacities - Existing Knysna system

Table KMW6.3 Present and future zone AADD's

Table KMW6.4a Proposed works, cost estimates and phasing - Future system

Table KMW6.4b Proposed projects, cost estimates and phasing - Future system

Table KMW6.4c Priority water projects - Knysna Municipality

Table KMW6.5 Bulk supply capacities - Future Knysna system

Figure KMW6.1a Existing system static pressure - Knysna, Belvidere & Brenton

Figure KMW6.1b **Existing system static pressure - Sedgefield**

Figure KMW6.1c **Existing system static pressure - Buffels Bay**

Figure KMW6.1d Existing system static pressure - Karatara

Figure KMW6.1e **Existing system static pressure - Rheenendal**

Figure KMW6.2a Existing system residual pressure - Knysna, Belvidere & Brenton

Figure KMW6.2b **Existing system residual pressure - Sedgefield**

FigureKMW6.2c **Existing system residual pressure - Buffels Bay**

FigureKMW6.2d **Existing system residual pressure - Karatara**

Figure KMW6.2e **Existing system residual pressure - Rheenendal**

Figure KMW6.3a Existing system peak flow velocity - Knysna, Belvidere & Brenton

FigureKMW6.3b **Existing system peak flow velocity - Sedgefield**

FigureKMW6.3c **Existing system peak flow velocity - Buffels Bay**

FigureKMW6.3d **Existing system peak flow velocity - Karatara**

Figure KMW6.3e **Existing system peak flow velocity - Rheenendal**

FigureKMW6.4a **Future distribution zones - Knysna, Belvidere & Brenton**

FigureKMW6.4b Future distribution zones - Sedgefield

FigureKMW6.4c **Future distribution zones - Buffels Bay**

FigureKMW6.4d Future distribution zones - Karatara

Figure KMW6.4e **Future distribution zones - Rheenendal**

Figure KMW6.5a Future required works - Knysna, Belvidere & Brenton

FigureKMW6.5b **Future required works - Sedgefield**

FigureKMW6.5c **Future required works - Buffels Bay**

Figure KMW6.5d Future required works - Karatara

Figure KMW6.5e **Future required works - Rheenendal**

7. MASTER PLAN COST SUMMARY

This report describes the study undertaken with respect to the updating of the master plan for the water distribution system of the Knysna Municipality (KM). The initial water master plan was compiled by GLS consulting engineers (GLS) and documented in a report, dated December 2008. This master plan was subsequently updated by GLS in February 2016 and June 2017. The latest version of the water master plan is documented in this report, dated December 2018.

7.1 SCOPE OF WATER MASTER PLAN STUDY

The scope of this update study was briefly defined as the following:

- Updating of existing computer models for the KM water distribution systems.
- The linking of these models to the latest water meter data and analysis of water demand based on the treasury's financial system.
- Evaluation and master planning of the water distribution systems.
- Present all information electronically in geographic information system (GIS) format as well as a master plan document including tables and plans.

7.2 STUDY AREA

The location of Knysna within the Western Cape is shown on Figure KMW1.1. The towns within the boundary of the KM are:

- Knysna town
- Sedgefield
- Belvidere
- Brenton on Sea
- Brenton on Lake
- Buffels Bay
- Rheenendal
- Karatara

Figure KMW1.2 shows the suburbs with suburb names entered during this investigation for all records in the GIS database. The total area of these suburbs indicates the study area of this investigation.

7.3 WATER SOURCES

Knysna

Knysna is supplied with water mainly from the Knysna River (licensed capacity: 3077 Mℓ/a), Gouna River (licensed capacity: 840 Mℓ/a) and the Glebe Dam within the Grootkops River (licensed capacity: 511 Mℓ/a). Other sources includes the Bigai Springs (licensed capacity: 180 Mℓ/a) and abstraction from a few boreholes (150m^3/d or 55 Mℓ/a).

A 2 Mℓ/d Reverse Osmoses (RO) Plant also abstracts water from the lagoon downstream of the existing Knysna Wastewater Treatment Plant.

All surface water sources from the rivers are treated at the Knysna Water Treatment Plant (WTP) from where it is supplied into the Knysna network. The capacity of the Knysna WTP is 21,25 Mℓ/d.

There are no external water suppliers within the jurisdiction of the Knysna Municipality.

Sedgefield

The Sedgefield area is supplied from the Karatara River supplemented by four boreholes (licensed capacity: 484m^3/d or 176 Mℓ/a) and a 1,5 Mℓ/d desalination plant at Myoli beach.

The surface water is purified at the Sedgefield WTP with a capacity of 4,0 Mℓ/d.

Belvidere

Belvidere is supplied with water from boreholes with a full capacity alternative supply directly from the Knysna network. Supplementation from the Knysna network occurs only in summer or holiday seasons.

Brenton

Brenton on Lake and Brenton on Sea are supplied with water from boreholes with full capacity alternative supply directly from the Knysna network. Supplementation from the Knysna network occurs only in summer or holiday seasons.

Buffels Bay

Buffels Bay is supplied with water extracted from the Goukamma River and pumped to the Buffels Bay WTP. The Buffels Bay WTP has a capacity of 0,95 Mℓ/d.

Karatara

Karatara abstracts raw water from the Karatara River. The raw water is purified at the Karatara WTP with a capacity of 0,79 Mℓ/d.

Rheenendal

Rheenendal is supplied with raw water from the Homtini River. The raw water is purified at the Keurhoek WTP with a capacity of 1,0 Mℓ/d.

7.4 GENERAL DESCRIPTION OF THE WATER SUPPLY SYSTEM

The water distribution system layouts are shown on Figures KMW2.1, with a separate Figure for each area Knysna, Rheenendal, Sedgefield, Karatara, and Buffels Bay as operated by the KM.

7.4.1 Bulk supply system

The analysis of the raw water system upstream of the WTP's is beyond the scope of this study.

7.4.2 Water treatment plants

Raw water from the various sources in KM is supplied to the following WTP's where it is treated:

• Knysna	- Capacity	21,25 Mℓ/d
• Sedgefield	- Capacity	4,0 Mℓ/d
• Buffels bay	- Capacity	0,95 Mℓ/d
• Karatara	- Capacity	0,79 Mℓ/d
• Rheenendal	- Capacity	1,00Mℓ/d
Total Capacity		**27,99 Mℓ/d**

The total WTP capacity of the systems in KM treating their own raw water is roughly equal to 2,02 x the present annual average daily demand (AADD) of 13,89Mℓ/d for those systems.

The analysis of the capacities of the existing KM WTP's is however beyond the scope of this study.

7.4.3 Reticulation systems

With reference to Figures KMW2.1 & KMW2.2, the following water systems are operated by the KM:

Knysna

The system is operated in 31 water distribution zones. There are 25 sets of reservoirs, one pressure reducing valve (PRV) zone, 5 tower zones and one booster pumping zone for Knysna. The two Belvidere-, 4 Brenton on Lake- and 3 Brenton on Sea zones are also linked to the Knysna system, bringing the total zones in the system to 40 zones.

Sedgefield

Sedgefield is operated in 2 zones supplied from 2 sets of reservoirs and 1 PRV zone. The main reservoir supplies to the set of two service reservoirs and the PRV is connected to the supply pipeline from the main reservoir to the service reservoirs.

Belvidere

The system is operated in 2 zones. There are 2 reservoirs, no PRV zones and no tower zones for Belvidere.

Brenton

The Brenton on Sea system is operated in 3 zones with 2 sets of reservoirs, one PRV zone and no tower zones. The Brenton on Lake system is operated in 4 zones with 1 set of reservoirs, 3 PRV zones and no tower zones.

Buffels Bay

Buffels Bay has one supply zone. The three reservoirs close to and above Buffels Bay are connected to the treatment process, but allow direct feed when necessary.

Karatara

Karatara has 2 supply zones from two reservoirs. The main reservoir feed both the Karatara town and the MTO reservoir, which supply to Bosdorp.

Rheenendal

The system is operated as 1 zone supplied from 1 reservoir assisted by a pressure tower.

7.4.4 Reservoirs

The reservoir storage volumes for the systems in KM are:

•	Knysna	- Capacity	40,33 Mℓ
•	Sedgefield	- Capacity	8,00 Mℓ
•	Buffels Bay	- Capacity	1,24 Mℓ
•	Karatara	- Capacity	0,94 Mℓ
•	Rheenendal	- Capacity	0,34 Mℓ
	Total Capacity		**50,85 Mℓ**

The total storage capacity of 50,85 Mℓ represents ± 88 hours x the present AADD of 13,89 Mℓ/d for the KM.

7.4.5 Pumping stations (PS)

The following PS are in the respective systems:

- Knysna, Belvidere & Brenton: 27 PS
- Sedgefield: 1 PS
- Buffels Bay: 1 PS
- Karatara: 1 PS
- Rheenendal: 2 PS

7.4.6 Pipelines

The total length of pipelines in the KM supply system amounts to 468,045 km.

7.4.7 Replacement value

The year 2018/19 replacement value of the system (excluding raw water storage dams, water treatment plants, control valves and other small components) is estimated as follows:

Knysna, Belvidere& Brenton	R	716,01 million
Sedgefield	R	135,98 million
Buffels Bay	R	15,27 million
Karatara	R	23,36 million
Rheenendal	R	12,01 million
Total	**R**	**902,52 million**

7.5 WATER DEMAND

A summary of all the present and future water demands on the water supply system is shown on Table KMW4.2.

7.5.1 Present water demand

The analysis of the meter reading data from the municipal treasury data as well as bulk water meter reading data indicated that:

- The present annual total water demand (TWD) supplied from July 2017 to June 2018 is 5 072 716 kℓ (bulk water input from the WTP's) which equates to an AADD of 13,9 Mℓ/d.
- The present water sold to consumers during the same period is 3 609 329kℓ.
- The unaccounted for water (UAW) is therefore 1 463 387 kℓ, or 29% of total bulk water input. These Values include metered non-revenue water (NRW) to Knysna northern areas.
- For planning and evaluation purposes, the UAW figures were rationalised on a regional (wider-area) basis, as allowed by the sensibility of the results. After allowance was made for unmetered consumers and faulty bulk meters in the area, an UAW figure of 29% in Knysna, 23% in Belvidere, 31% in Brenton, 30% in Rheenendal, 34% in Sedgefield, 10% in Karatara and 12% in Buffels Bay were applied for modelling purposes of the existing system.
- The present water demand used for modelling of the existing KM water systems equates to an AADD of 13,9 Mℓ/d.

7.5.2 Future water demand

With all vacant erven within the municipality occupied and the municipal wide unaccounted for water figure for KM reduced, the AADD of the existing KM could increase from 13 898 kℓ/d to 16 350 kℓ/d. In addition to this it is estimated that the future developments (as shown on Figure KMW4.1) can contribute a further 9 291 kℓ/d, bringing to 25 640 kℓ/d the total future AADD for the KM reticulation system for which this planning study was performed.

7.6 COMPUTER MODEL ANALYSIS AND EVALUATION OF EXISTING SYSTEM

The existing computer model of the existing water supply system was updated with the latest as-built information, using the water distribution system optimization program (WADISO) SA software. The model is complete, detailed, and geographically accurate, and can therefore also serve as the GIS “as-built” record of the system.

The model was subjected to a typical present peak hour demand (PHD), and evaluated with respect to:

- Supply rates to reservoirs in relation to demand served
- Reservoir capacities in relation to demand served by reservoir
- Flow velocities
- Minimum pressures
- Static pressures

7.6.1 Reticulation system

Presently the water supply systems operates and functions without major problems, and this was reflected in the computer model analysis. A few localised problems were however identified. The analysis of the water systems for each area can be summarised as follows:

<u>Knysna</u>

- The static analysis indicates areas in the network where pressures are below 24 m in the Knysna North-, Concordia-, Bongani-, Dam se Bos-, Sunridge-, Bigai- and Heuwelkruin zones. There are various areas where the static pressures exceed the normal 90m but mostly only marginally above 90 m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for areas where static pressure was low in the first place. These areas are in the Knysna North-, Concordia-, Bongani-, Dam se Bos-, Sunridge-, Bigai- and Heuwelkruin zones.
- There are a few pipes which have a velocity under peak hour demand conditions which exceeds 1,5 m/s.

<u>Sedgefield</u>

- The static analysis indicates areas in the network where pressures are below 24 m in the high areas to west of the town reservoirs and in the Smutsville area. Static pressure above 90m occurs along the high pressure zone supply pipe and in a few valleys of the high pressure zone.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for the areas where static pressure is below 24m. These areas increased in size in Smutsville, the higher areas close and to the west of the town reservoirs.
- The main supply pipeline between the Sedgefield Main reservoir and the service reservoirs in Sedgefield experiences a flow velocity through the pipeline of above 1,5 m/s during peak demand conditions.

<u>Belvidere</u>

- The static analysis indicates no areas in the network where pressures are below 24 m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.
- The flow velocities in the existing system do not exceed 1,5 m/s.

Brenton

- The static analysis indicates no areas in the network where pressures are below 24 m. The lower lying areas close to sea level in Brenton on Lake and Brenton on Sea have static pressure above 90m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range, except for the lower lying areas close to sea where the pressure is above 90m.
- The flow velocities in the existing system do not exceed 1,5 m/s.

Buffels Bay

- The static analysis indicates no areas in the network where pressures are below 24 m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.
- The flow velocities in the existing system do not exceed 1,5 m/s.

Karatara

- The static analysis indicates no areas in the network where pressures are below 24 m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range for the Karatara Rates area. In the Bosdorp zone, the residual pressure is mainly below 15m.
- The flow velocities in the existing system do not exceed 1,5 m/s.

Rheenendal

- The static analysis indicates no areas in the network where pressures are below 24 m.
- The residual pressures in the existing system under peak hour demand conditions are mainly in the 24m to 90m range.
- The flow velocities in the existing system do not exceed 1,5 m/s.

7.6.2 Bulk supply system

The analysis of the existing pump stations and supply rates to reservoirs and reservoir capacities in relation to demand served by the reservoir (as shown in Table KMW6.2) showed that:

- Evaluated on a town-for-town basis, the overall reservoir storage volume available for each town is more than the required capacity of 48 h x AADD served.
- In Knysna the Heuwelkroon, Thesen Hill and Dam se Bos reservoirs have insufficient reservoir storage capacity available. The Heuwelkroon and Thesen Hill reservoirs are however supplied under gravity from the upstream Water Works reservoirs, which have sufficient spare capacity available.
- In Sedgefield the duty reservoirs have insufficient reservoir storage capacity available. This is however only marginally (47 h x AADD served vs the required 48 h).
- In Knysna the bulk supply pipes towards the Thesen Hill reservoir, the Dam se Bos reservoir and the Concordia tower have insufficient capacity.
- In Sedgefield the bulk supply towards the high pressure zone has insufficient capacity.
- The capacity and duty points of all pump station in Knysna should be verified.

7.7 MASTER PLAN FOR SYSTEM EXTENSIONS/AUGMENTATION

7.7.1 Planning horizon

The extensions to the existing system were planned to keep in step with a growth in demand from the present (2018) AADD of ± 13,9 Mℓ/d, to a planning horizon AADD of 25,6 Mℓ/d. At a growth rate of ± 2,0% (as agreed by KM in the Western Cape Completed Service Levels study performed by WorleyParsons for DWA) this AADD will be realised in the year ± 2055 (40 year planning horizon).

7.7.2 Raw water source

The analysis of the raw water sources is beyond the scope of this study.

7.7.3 Water treatment plants

The analysis of the capacities of the existing KM WTP's is beyond the scope of this study.

7.7.4 Required works

An extended computer model representing the future scenario was set up to plan and size the components of the future water supply system. The motivation for the works and a detailed description for each component, are provided in the main body of the report.

The required works to reinforce the system for existing and potential future deficiencies, are shown on Figure KMW6.5 and listed with short descriptions in Table KMW6.4a. These proposed master plan items are grouped together in proposed projects which are summarised in Table KMW6.4b.

The major new components of the future system with the highest priorities are summarized below:

- New clear well & bulk PS at Knysna WTP
- Concordia reservoir network augmentation
- Concordia tower network augmentation
- Implement Thesen Hill PRV zone
- Sedgefield network upgrades - Phase 1
- Implement Water Works direct PRV zone
- Heuwelkroon network upgrades
- Thesen Hill reservoir storage & bulk supply augmentation
- Sedgefield bulk supply augmentation - Phase 1
- Bigai booster zone extension & augmentation
- Noetzie reservoir zone extension & augmentation
- Dam se Bos pressure management
- Eastford Upper pressure management
- Eastford Lower reservoir bulk supply augmentation
- Bigai reservoir bulk supply augmentation
- Heidevallei reservoir zone implementation
- Rheenendal bulk supply upgrade
- Sedgefield bulk supply augmentation - Phase 2
- Eastford Upper reservoir bulk supply augmentation
- Concordia reservoir bulk supply augmentation
- Old Place Lower reservoir bulk supply augmentation

7.7.5 Cost estimates and phasing in of works

The total cost (year 2018/19 value) for the required works is estimated at R220,44 million (including P&G's, contingencies and fees, excluding VAT). This total can be broken down as follows:

Water reticulation network	:	R	48,12 million
Bulk supply pipelines	:	R	51,63 million
Additional pump capacity	:	R	31,49 million
Additional storage capacity	:	R	85,94 million
Water demand management	:	R	3,26 million
Total		**R**	**220,44 million**

The capital investment of R 220,44 million is required over time to increase the system capacity from the present AADD of roughly 13,9 Mℓ/d, to the future horizon of 25,6 Mℓ/d AADD.

Tables KMW6.4a & KMW6.4b also gives an indication of when the works are required. The required expenditure should be phased to remain in line with the increase in AADD.

The proposed projects with the highest priority in the KM system are included in Table KMW6.4c. The estimated cost of items required over the next 3 to 5 years is ± R115,8 million.

7.8 MASTER PLAN UNIT COST

The required capital expenditure for these priority water infrastructure projects is as follows:

- R 34,2 million for the 2018/19 financial year
- R 21,8 million for the 2019/20 financial year
- R 59,8 million for the 2020/21 financial year

Table KMW7.1 is a summary of the total costs associated with the proposed master plan for the water system for the next 20 to 25 years, which amounts to R 220,44 million.

The master plan implementation at cost of R 220,44 million will increase the KM system capacity from its present AADD of 13,9 Mℓ/d to the future AADD of 25,6 Mℓ/d. This amounts to an implementation unit cost of R 18 841 R/kℓ/d.

7.9 UPDATING AND MAINTENANCE OF THE COMPUTER MODEL AND MASTER PLAN

The calibrated computer model of the distribution system is a handy tool for the day to day management of the system and can also be used as a basis for the calculation of services contributions by developers. The utility value of the model will however be lost if it is not properly maintained. The model should therefore be kept up to date with new developments and extensions to the system, and a link to the treasury water sales data.

7.10 MONITORING OF THE SYSTEM

An extensive monitoring programme, mainly through an extension of the already established telemetry system, is suggested which will gather information to assist with the updating of the master plan and the day to day management of the system.

7.11 WATER DEMAND MANAGEMENT

Continuous attention and support to water demand management with the aim of permanent reduction in demand should be given as it could substantially impact the capital expenditure required to meet the future demand.

7.12 ASSET MANAGEMENT

It is recommended that the current databases as well as hydraulic analyses and master planning results be extended and applied to support the asset register (AR) and asset management plan (AMP).

7.13 CONCLUSION

It is recommended that the water master plan as described in this report be implemented in order to allow the KM water distribution system to keep in step with the anticipated growth and expansion of water demand.

Table KMW7.1 Master plan cost summary