



LANGEBERG MUNICIPALITY

SEWER MASTER PLAN

March 2012





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LIST OF ABBREVIATIONS & ACRONYMS

AADD	- Annual average daily demand
ADDWF	- Average daily dry weather flow
CEs	- Community Engineering Services consulting engineers
d	- Day
ECE	- Element consulting engineers
EGL	- Energy Grade Line (in m a.s.l.)
FDA	- Future Development Area
GIS	- Geographic Information System
GLS	- GLS consulting engineers
h	- Hour
ha	- Hectare
IMQS	- Infrastructure Management Query Station (software program)
IPDWF	- Instantaneous peak dry weather flow
IPWWF	- Instantaneous peak wet weather flow
kℓ	- Kilolitre
kℓ/d	- Kilolitre/day
km	- Kilometre
KV3	- Kwezi V3 consulting engineers
ℓ	- Litre
ℓ/day/UE	- Litre/day/unit erf
ℓ/min	- Litre/minute
ℓ/min/m pipe/m Ø	- Litre/minute/meter pipe length/meter pipe diameter
ℓ/min/UE	- Litre/minute/unit erf
ℓ/s	- Litre/second
m	- Metre
m a.s.l.	- Metres above mean sea level
m/s	- Metres per second
MIS	- Management Information System
Mℓ	- Megalitre
mm	- Millimetre
NRW	- Non-revenue water
P&G	- Preliminary and general
PDDWF	- Peak daily dry weather flow
PS	- Pumping Station

RES	- Residential
s	- Second
SEWSAN	- Sewer System Analysis program (software)
SG	- Surveyor General
SWIFT	- Sewer Water Interface For Treasury systems (software program)
TWD	- Total annual water demand
UE	- Unit erf
uPVC	- Unplasticised polyvinylchloride
UWD	- Unit Water Demand (e.g. $\ell/\text{stand}/\text{d}$, or $\text{k}\ell/\text{ha}/\text{d}$)
v	- Flow velocity (in m/s)
VAT	- Value Added Tax
WADISO	- Water Distribution System Optimization program (software program)
WWTP	- Wastewater Treatment Plant

1. INTRODUCTION

1.1 BRIEF

GLS consulting engineers (GLS) was appointed to update the master plan of the sewer distribution system for Langeberg Municipality. The project was funded by the Winelands District Municipality.

The project entails the establishment of computer models for the sewer systems in Langeberg Municipality, 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 an engineering graphical information system (GIS).

This master plan report lists the analyses and findings of the study on the sewer distribution systems of the towns within the Langeberg Municipality.

1.2 STUDY AREA

The location of Langeberg Municipality within the Western Cape is shown on Figure LBS1.1. The towns within the boundary of the Langeberg Municipality are:

- Ashton
- Bonnievale
- McGregor
- Montagu
- Robertson

Figures LBS1.2a - e show 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.

1.3 PREVIOUS MASTER PLANNING

Community Engineering Services (Pty) Ltd (CEs) conducted a sewer master plan for Langeberg Municipality for the town of Bonnievale in January 2006, Element Consulting Engineers (ECE) conducted a sewer master plan for Langeberg Municipality for the towns of Montagu and Ashton in November 2006 and Kwezi V3 Consulting Engineers (KV3) for the towns of McGregor and Robertson in August 2006. GLS conducted a sewer master plan for all the towns in the Langeberg Municipality in August 2009.

Various Engineering Consultants have been performing evaluation and planning of portions of the distribution systems in the area over the years. The most notable in this respect include studies and designs performed by KV3 and ECE.

This study entails the updating of the August 2009 master plan performed by GLS.

1.4 DEFINITIONS

1.4.1 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.

1.4.2 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 consumer's connection to the sewer distribution system. Some treasury records might not pertain to a sewer connection (or customer meter).

1.5 STRUCTURE AND SCOPE OF REPORT

This report addresses the disposal of sewage within the Langeberg Municipal area. This study is confined to the sewerage networks and therefore the process and sufficiency of the WWTP's are beyond the scope of this study.

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 Langeberg Municipality 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 Langeberg Municipality only.

2. EXISTING SYSTEM

2.1 SYSTEM LAYOUT AND OPERATION

The layouts of the Langeberg sewer systems are shown on Figures LS2.1 with a separate figure for each area as follows:

- a - Ashton
- b - Bonnievale
- c - McGregor
- d - Montagu
- e - Robertson

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

Each system is operated in a main drainage area with a Wastewater Treatment Plant (WWTP), which in turn could be sub-divided into several sub-drainage areas each as shown on Figure LBS2.2.

There are 3 pumping stations in the Ashton system, 7 in the Bonnievale system, 4 in the Montagu system and 5 in the Robertson system as indicated on Figures LS2.1 and LS2.2.

Tables LS2.1a and LS2.1b provide a summary of all the system components.

Table LBS2.2 lists the actual and potential fully occupied present Peak Daily Dry Weather Flows (PDDWF's) of the drainage areas.

2.2 DATA INTEGRITY

The data captured for the sewer model consists of a blend of as-built plans, design drawings and GIS information. For some pipes only geographical information was available, and a default diameter of 150 mm Ø was assumed.

It is important that the integrity of the information be kept in mind when considering upgrades to the system. Figure LBS2.3 shows the integrity of the pipes in two categories:

- Pipes for which slopes (or invert levels of manholes) were available from the as-built drawings.
- Pipes for which invert levels were calculated based on minimum slopes.

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 in an attempt to continuously improve the data integrity.

2.3 DRAINAGE AREA, WATER DEMAND AND SEWER FLOWS

The total drainage area for each sewer system is shown on Figures LS2.2.

2.3.1 Ashton

The present fully occupied Annual Average Daily Demand (AADD), for the existing Ashton system that contributes to the domestic sewer flow is $\pm 6\,596$ kℓ/d, which includes non-revenue water (NRW).

The PDDWF for the Ashton system is estimated at $\pm 3\,026$ kℓ/d, or roughly 46% of the AADD. Approximately 88% of this is a direct contribution from connections to the sewerage system, and the other 12% is contributed by groundwater infiltration.

Note: Effluent from Langeberg & Ashton Foods is treated on their own site to the north of the town and only their domestic sewage is treated at the Ashton WWTP.

2.3.2 Bonnievale

The present fully occupied AADD, for the existing Bonnievale system that contributes to the domestic sewer flow is $\pm 4\,801$ kℓ/d, which includes non-revenue water (NRW).

The PDDWF for the Bonnievale system is estimated at $\pm 2\,807$ kℓ/d, or roughly 58% of the AADD. Approximately 95% of this is a direct contribution from connections to the sewerage system, and the other 5% is contributed by groundwater infiltration.

2.3.3 McGregor

The present fully occupied AADD, for the existing McGregor system that contributes to the domestic sewer flow is $\pm 1\,048$ kℓ/d, which includes non-revenue water (NRW).

The PDDWF for the McGregor system is estimated at ± 637 kℓ/d, or roughly 61% of the AADD. Approximately 86% of this is a direct contribution from connections to the sewerage system, and the other 14% is contributed by groundwater infiltration.

2.3.4 Montagu

The present fully occupied AADD, for the existing Montagu system that contributes to the domestic sewer flow is $\pm 5\,746$ kℓ/d, which includes non-revenue water (NRW).

The PDDWF for the Montagu system is estimated at $\pm 3\,976$ kℓ/d, or roughly 69% of the AADD. Approximately 85% of this is a direct contribution from connections to the sewerage system, and the other 15% is contributed by groundwater infiltration.

2.3.5 Robertson

The present fully occupied AADD, for the existing Robertson system that contributes to the domestic sewer flow is $\pm 8\,252$ kℓ/d, which includes non-revenue water (NRW).

The PDDWF for the Robertson system is estimated at $\pm 7\,080$ kℓ/d, or roughly 86% of the AADD. Approximately 88% of this is a direct contribution from connections to the sewerage system, and the other 12% is contributed by groundwater infiltration.

2.4 WASTEWATER TREATMENT PLANTS

All the present sewer flows for each drainage area are treated at each town's WWTP. The status of each WWTP gathered from reports performed by Messrs Aurecon is briefly discussed as follows:

2.4.1 Ashton WWTP

The Ashton WWTP has a present hydraulic capacity of 2 500 kl/d. It is estimated that the capacity of this plant should be augmented to 3 500 kl/d in roughly the year 2020.

2.4.2 Bonnievale WWTP

The Bonnievale WWTP has a present hydraulic capacity of 1 800 kl/d. It is estimated that the capacity of this plant should be sufficient for the entire planning horizon of this study, i.e. the next 20 years.

2.4.3 McGregor WWTP

The McGregor WWTP has a present hydraulic capacity of 300 kl/d. It is estimated that the capacity of this plant should be augmented to 750 kl/d in roughly the year 2020.

2.4.4 Montagu WWTP

The Montagu WWTP has a present hydraulic capacity of 1 600 kl/d. This plant is presently operating over capacity and is therefore in urgent need of augmentation. It is estimated that the capacity of this plant should be augmented to 3 100 kl/d in the short term.

2.4.5 Robertson WWTP

The Robertson WWTP has a present hydraulic capacity of 5 200 kl/d. It is estimated that the capacity of this plant should be augmented to 6 500 kl/d in roughly the year 2023.

2.5 SEWER FLOW MEASUREMENTS AND CALIBRATION

No flow measurements were available to calibrate the Ashton, Bonnievale, McGregor and Montagu SEWSAN models.

In Robertson relatively good quality sewer flow measurements at Robertson WWTP were obtained which were used to calibrate the Robertson SEWSAN model.

A good comparison could be drawn between the PDDWF of the flow measurements at Robertson WWTP and the predicted flow volumes from the SEWSAN models.

The SEWSAN models in Ashton, Bonnievale, McGregor, Montagu and Robertson were populated with UH's as described in Figure LBS5.1, Chapter 5, which is based on the analysis of many flow recordings done for similar previous studies.

From this data the dry weather flow was predicted and the SEWSAN models adjusted to simulate the PDDWF.

2.6 EXISTING OPERATIONAL PROBLEMS

The following operational problems were indicated by the operational staff:

- None.

2.7 SPECIAL CONSIDERATIONS

2.7.1 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 layout.

2.7.2 Information to be clarified

It is recommended that field tests be carried out to verify pump duty points at all the pumping stations. The unknown pipe diameters and invert levels should also be determined in order to improve the confidence levels of the models.

3. PRESENT LAND USE, WATER DEMAND AND SEWAGE FLOW

3.1 METHODOLOGY

The SWIFT program is a link between treasury billing data, and water/sewer network models. (The name is derived from "*Sewer Water Interface For Treasury systems*"). The program was used to analyse the present land use and water demand situation in Langeberg, 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 Langeberg Municipality has an 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 February 2010 to January 2011 were used as the base information for the analysis.

3.3 LAND USE

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

- Residential stands
- Farms/Agricultural holdings
- Flats
- Business and commercial
- Educational
- Government/Institutional/Municipal
- Industrial
- Other/Unknown
- Parks

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 > 2 000 | - | larger than 2 000 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 UWD's that might not be applicable to them. The large water users are discussed later in this Chapter.

3.4 SWIFT RESULTS AND RESULTING WATER DEMANDS

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

All available treasury data in Langeberg Municipality 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 AADD and total 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 LBS3.1.

Figure LBS3.1 shows all the stands coloured in accordance with their land use according to the SWIFT analysis.

3.4.2 Non-revenue water

The total water inputs for each area were compared with the total water sales, which resulted in NRW figures of 29% in Ashton, 31% in Bonnievale, 21% in McGregor, 10% in Montagu and 24% in Robertson. The results are summarised in Table LW3.3.

The global NRW of 24% should be able to be reduced by implementing a Water Demand Management Programme.

3.4.3 Rationalized ("theoretical") unit water demands

The unit water demands (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 NRW) for each suburb with the actual water demand (excluding NRW) for the suburb. The results are summarised in Table LBS3.1.

3.4.4 Rationalized ("theoretical") NRW

For planning and evaluation purposes, the NRW figures were also rationalised on a regional (wider-area) basis, as allowed by the sensibility of the results. A NRW figure of 17% for Ashton, 32% for Bonnievale, 20% for McGregor, 6% for Montagu and 18% for Robertson were applied for modelling purposes of the existing system.

A NRW figure of 15% for Ashton, 20% for Bonnievale, 15% for McGregor, 10% for Montagu and 15% for Robertson were applied for modelling of the future systems in the Langeberg Municipality

3.4.5 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 NRW'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. NRW) for each suburb and distribution zone in Langeberg was determined. The results are summarised per suburb in Table LBS3.1.

This potential future water demand so calculated is only for existing developments/stands that have been proclaimed and exist. Potential future land developments and upgrading/relocation of informal areas were dealt with as described in Chapter 4.

3.4.6 Large water users

Table LBS3.2 is a list of all the stands defined as large users in SWIFT for Langeberg Municipality. The table shows the large water users (> 20 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 sewer system model. The large users in the Langeberg Municipality have a total AADD of 3 944 kℓ/d (excluding NRW), representing ± 21,3% of all water sold in the Langeberg Municipality sewer system.

3.4.7 Informal settlements

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

The following information on informal settlements with basic services, as required by DWA, was gathered by WorleyParsons in May 2011:

- 279 households in Bonnievale.
- 115 households in McGregor.
- 40 households in Ashbury in Montagu.
- 512 households in Nkqubela in Robertson.

These readings are not included in the treasury data and therefore the settlements contribute to the NRW figure.

3.4.8 Present water demand summary

Table LBS3.4 is a summary of the present actual water demand in the various drainage areas.

3.5 WATER DEMAND USED FOR SYSTEM MODELLING

The SWIFT results presented in Section 3.4 were further analysed before populating the sewer models. The Swift results, however, provide valuable insight into the monthly water use patterns of each individual consumer – information that could be used to accurately estimate the unit water demand for the (fully occupied) existing system water model.

The reasons for further analysing the SWIFT results to obtain input parameters for the water models (instead of using SWIFT directly) include:

- All treasury records are not linked to the cadastral data (GIS) and neither have the existing links been verified, implying that a portion of the water demand calculated by Swift would be lost if populating the water models directly with the SWIFT result. These records, and especially the large users, were then linked by hand according to their addresses obtained from the treasury data.

3.6 PRESENT SEWER FLOW

3.6.1 Unit hydrograph types

After careful consideration of the various land uses and their unit water demands as established earlier in the chapter, it was decided to use 15 unit hydrographs (UH) for modelling the sewer flow contributions of typical erven. The 15 UHs are described in Figure LBS5.1, Chapter 5, and are based on the analysis of many flow recordings done for previous studies. Table LBS3.5 is a summary of how the various land uses were mapped to these UH's. Figure LBS3.1 shows the stands coloured in accordance with their land use allocation.

3.6.2 Sewer flow components

Each UH contribution by a typical stand consists of a leakage (base flow) component, and a domestic flow component. The UH can be used as is in the sewer system analysis, or a more accurate approach can be taken where only the shape of the UH is used, and all the ordinates are adjusted so that the volume of the hydrograph represents a certain percentage (typically 50% to 60%) of the AADD for water.

In addition to the domestic flow and leakage component, groundwater infiltration into pipes (typically $\pm 0,04$ l/min/m pipe/m Ø) is another base flow component that should be taken into account. This component typically increases the sewer flow to somewhere between 60% and 70% of the water AADD.

Stormwater ingress can also result in significant peaks in the sewer flow, even though the systems are ostensibly designed as "closed". For this study, the systems are analysed and designed with a 30% allowance for stormwater ingress. Previous studies proved that accommodation of stormwater ingress in sewer systems is very expensive, and that funds should be applied to solving the problem, rather than treating the symptom and shifting the problem downstream to the WWTP.

3.6.3 Present PDDWF

The present PDDWF of the drainage areas in Langeberg are summarised in Table LBS2.2. These PDDWF's are based on the UH's, by applying their shapes to represent certain percentages of the water AADD, with additional groundwater infiltration.

The "Actual" PDDWF scenario varies between 39% to 72% of the actual present AADD for the towns in the Municipal area.

3.6.4 Informal settlements

Most of the informal settlements are linked to the existing sewer system and do therefore contribute to sewer flows in the system.

4. FUTURE LAND USE, WATER DEMAND AND SEWER FLOW

4.1 FULL OCCUPATION OF EXISTING DEVELOPMENTS

For the future land use and sewer flow scenario, it was assumed that all existing but vacant stands in the area would become "occupied", i.e. start using water and discharging sewerage, as summarised in Table LBS2.2.

4.2 POTENTIAL FUTURE LAND DEVELOPMENTS

The potential areas for future developments were identified in consultation with the Municipality's town planning consultants. These areas are information gathered from the Spatial Development Framework for Langeberg Municipality supplied by the Planning Directorate of Langeberg Municipality

Each potential area was assigned an anticipated predominant land use, and will be phased in over a 20-year period.

The potential future land developments in Langeberg are shown on Figure LBS4.1, 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 WATER DEMANDS OF FUTURE LAND DEVELOPMENTS

Typical UWD's (per ha or per stand/unit) were assumed for the future development areas, based on the statistics obtained from the analysis of the present water demands of Langeberg, to determine their potential water demand. The results are listed in Table LBS4.1.

4.4 SEWER FLOWS OF FUTURE LAND DEVELOPMENTS

Tables LS4.1 and LS6.3 also shows the UH allocations to the future land developments, as well as estimates for their infiltration flows and PDDWF.

4.5 FUTURE WATER DEMAND

The future AADD of the Langeberg Municipality system studied for this report is $\pm 33\,374$ kℓ/d. The future AADD represents an increase of $\pm 25\%$ over the present fully occupied AADD that contributes to the sewer flow. The potential future developments account for $\pm 20\%$ of the future AADD.

4.6 FUTURE SEWER FLOW

The future PDDWF's of the drainage areas in Langeberg are summarised in Table LBS4.2. The future PDDWF of $\pm 21\,766$ kℓ/d is $\pm 65\%$ of the future AADD for the entire Langeberg Municipality.

5. EVALUATION AND PLANNING CRITERIA

5.1 SEWER FLOW AND PEAK FACTORS

5.1.1 Planning

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

- Establishing a model of the sewer 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 with regards to capital -, maintenance - and operational cost.

The study considered year 2031 (i.e. 20 years) as the horizon for planning purposes. The total PDDWF for the Langeberg system can then potentially be $\pm 21\,770$ kℓ/d.

5.1.2 Present and future PDDWF's

Existing systems were evaluated on the basis of their maximum potential present PDDWF, i.e. as though all presently developed stands are occupied based on their land use rights. For planning of future systems, PDDWF's of all potential future developments were added.

5.1.3 Unit sewer flows

The SEWSAN program uses a unit hydrograph for each erf linked to the model to simulate the leakage (base flow) and domestic contribution to sewer flow as a percentage of the AADD. The parameters of the unit hydrographs for the different types of erven are summarised in Figure LBS5.1. These are based on the analysis of many flow recordings, as performed for previous studies. In the analysis and planning of the system, the unit hydrograph ordinates are adjusted to reflect the actual percentages of the AADD.

5.1.4 Total base flow (Infiltration and Leakage)

As part of the unit hydrographs, each stand contributes a steady flow to the base sewage flow, in the form of leakage from cisterns and taps. The calibrated base flow rates for each UH type were calculated based on the assumption that domestic base flow accounts for $\pm 84\%$ of the total base flow in the system. The base flow rates for each UH type is listed in Figure LBS5.1. The other $\pm 16\%$ of the base flow is assumed to be groundwater infiltration through joints and cracks in the sewer pipe system. Based on flow measurements done for previous sewer system studies, a groundwater infiltration rate of $0,04$ ℓ/min/m pipe/m Ø was assumed for the sewer system (see Table LBS5.3).

5.1.5 Stormwater Ingress

Based on simultaneous sewer flow and rainfall measurements undertaken for previous sewer system studies, it is estimated that $\pm 1,0\%$ of all rainfall during heavy storms, which falls within 25 m of either side of a sewer pipe, typically ingresses into the sewer system. Storm and ingress criteria used for wet weather system analysis and planning (where applied) are shown in Table LBS5.3.

5.2 OPERATIONAL CRITERIA

5.2.1 Minimum gradients

The minimum gradient of gravity mains should be such that a minimum flow velocity of $> 0,6$ m/s at full flow capacity, can be maintained. Table LBS5.1 shows such minimum gradients for different diameter pipes.

5.2.2 Flow velocities – Gravity mains

A minimum of $0,6$ m/s should be maintained in all gravity mains to ensure that sufficient scouring of the mains takes place. The maximum flow velocity under full flow conditions should be not more than $2,5$ m/s to prevent damage to the pipelines, although a higher flow velocity of up to $4,0$ m/s may be acceptable over short pipe lengths and for short periods. Flow velocity criteria are summarised in Table LBS5.2.

5.2.3 Flow velocities – Rising mains

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 Pipe roughness coefficient

The Manning flow formula is used by the SEWSAN program and a Manning-n roughness coefficient of $0,012$ was assumed for all the pipes in the model.

5.2.5 Hydraulic capacity of sewerage network

There are basically two design philosophies, which could be used for this planning study. These are the Instantaneous Peak Dry Weather Flow (IPDWF) philosophy, with spare capacity allowed for stormwater ingress, and the Instantaneous Peak Wet Weather Flow (IPWWF) philosophy, where the system is designed to accommodate stormwater ingress, but with pipes allowed to flow 100% full (see Table LBS5.2). It was found however that the effect of 1% stormwater ingress (see par. 5.1.5) is dramatic, resulting in very high IPWWF, and consequently very large and uneconomical pipes sizes. The IPDWF philosophy, as described below, was therefore used.

Pipe sizes in gravity mains should be such that the peak dry weather flow can be accommodated in the pipeline whilst flowing 70% or less full. The remaining 30% of the flow area is for the accommodation of stormwater ingress. Should stormwater ingress cause this "spare capacity" to be exceeded, resulting in pipeline overflow, certain measures should be taken by the system manager to prevent ingress of stormwater into the sewer system.

The "spare capacity" for a regular gravity pipe which is unaffected by upstream pumps is defined as follows:

$$\text{Spare capacity (\%)} = \frac{\text{Full flow capacity} - \text{IPDWF}}{\text{Full flow capacity}} \times 100 \%$$

If however there are upstream pump stations affecting the flow in a gravity pipe the "spare capacity" for of the pipe has to be redefined with cognisance of the pump flows, as follows:

$$\text{Spare capacity (\%)} = \frac{\text{Full flow capacity} - \text{Upstream pump flow} - \text{IPDWF}}{\text{Full flow capacity} - \text{Upstream pump flow}} \times 100 \%$$

5.2.6 Pump stations

The following criteria apply to the design and evaluation of pumping stations:

- Pump configurations should be such that there is always at least one standby pump available for emergency purposes.
- Pumping station capacity should be such that it equals or exceeds the peak wet weather flow which arrives at the pumping station, or the peak dry weather flow plus an allowance for stormwater ingress. In the case of a 30% allowance, the pump therefore must have a capacity equal to:

$$\frac{\text{IPDWF}}{(1 - 0,3)} = \frac{\text{IPDWF}}{0,7} = 1,43 \times \text{IPDWF}$$

- The sump at the pumping station should be sized to ensure that the pump does not switch on and off more than six times per hour.

5.2.7 Hydraulic influence of pump stations

Although sewer pump stations operate intermittently, their flows can influence the hydraulics of the downstream pipes at any time during the day. Pumps are therefore modelled as "continuous" pumps, which pump at specified capacity for 24 h per day.

5.3 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.

5.4 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 LBS5.2.

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.

6. EVALUATION AND MASTER PLAN

6.1 EXISTING SYSTEM

6.1.1 Replacement value

Table LBS6.1 provides an estimate of the replacement value of the existing Langeberg Municipality system, based on the cost functions shown on Figure LBS5.2. It amounts to a total value of R 237,8 m and a PDDWF unit value of $\pm 22\,298\text{ R/k}\ell/\text{d}$.

6.1.2 External contributions to sewer flow

None.

6.1.3 Existing drainage areas and sewer flows

Table LBS6.2 provides a breakdown of the existing land use in each sub-drainage area, as well as the estimated contribution of each land use type to the total PDDWF for that area.

6.1.4 Spare capacities

Figure LBS6.1 shows the relative spare capacities in the existing Langeberg Municipality system under IPDWF. The red and light blue lines indicate pipes where capacity problems ($< 30\%$ spare) may be experienced.

6.1.5 Flow velocities under peak demand

Figure LBS6.2 shows the flow velocities in the existing Langeberg Municipality system under full flow conditions. A small number of pipes have velocities less than $0,6\text{ m/s}$. It can be noted however, that a minimum slope resulting in $v = 0,6\text{ m/s}$ was assumed for a number of pipes in the system, where insufficient information was available. See par. 2.2 and Figure LBS2.3.

6.1.6 Flow hydrographs

The present PDDWF Hydrographs at each WWTP are shown on Figure LBS6.6.

6.2 FUTURE DRAINAGE AREAS AND SEWER FLOWS

6.2.1 Extended drainage areas

The proposed extended and new drainage areas for the future systems are shown on Figure LBS6.3.

6.2.2 Accommodation of future land developments

The future land developments are accommodated in the extended drainage areas. Table LBS6.3 is a summary of the future land development areas linking to the Langeberg system, their PDDWF and IPDWF, UH's, areas, land use and estimated additional pipe lengths. The connections of these future areas and sub-areas to the existing sewer system are indicated on Figure LBS6.4.

6.2.3 External contributors to sewer flow

None

6.2.4 Future sewer flow

Table LBS6.4 provides a breakdown of the future land use in each sub-drainage area, as well as the estimated contribution of each land use type to the total PDDWF for that area.

6.3 MASTER PLAN

The master planning for each of the towns in Langeberg Municipality is discussed separately below. Items are identified to accommodate anticipated full development of each town, as provided by the Municipality's Town planners.

The required works for the entire study area are shown on Figure LBS6.4. Details of the required items, cost estimates and phasing are also indicated in Table LBS6.5. Note that the internal network pipes in future developments were treated as schematic and are not included as Master Plan Items. Certain pump stations were also not included as Master Plan Items because relevant information regarding capacities and head were not obtained from the Municipality. Table LBS6.6 shows the required pumping capacities for the existing and future scenarios.

6.3.1 Ashton

The existing drainage areas are increased to accommodate proposed future development areas.

New gravity outfall sewers are required to collect the sewage from future development areas A01 - A09.

A new pumping station and rising main that discharged into the existing Ashton Gravity drainage area is proposed for the lower lying areas of future development area A07.

A number of existing outfall sewers require upgrading by replacement with larger sewers. The slopes of these outfall sewers were unknown and modelled on minimum slope and if the gradient turns out to be steeper, upgrades of these items might not be required.

When the Ashton pumping station reaches capacity, it should be upgraded to a capacity of 80 ℓ/s and the existing rising main should be upgraded to a diameter of 315 mm.

6.3.2 Bonnievale

The existing drainage areas are increased to accommodate proposed future development areas.

New gravity outfall sewers are required to collect the sewage from future development areas B03 & B06 – B09.

When overflow problems occur in the 160 mm diameter outfall sewer in Milners Road in the Happy Valley drainage area and the 160 mm diameter outfall sewer to pumping station 4, these outfall sewers should be replaced with a larger diameter. The slopes of these outfall sewers were unknown and modelled on minimum slope and if the gradient turns out to be steeper, upgrades of these items might not be required.

It must however be noted that no pumping station information was available for this study. The pump capacities were therefore assumed according to the minimum required scouring velocities in each rising main. (This is normally the minimum standard for any sewer pumping station and rising main design).

When pumping station 3 reaches capacity, it should be upgraded to a capacity of 105 ℓ/s and the existing rising main should be upgraded to a diameter of 355 mm.

6.3.3 McGregor

The existing drainage area is increased to accommodate proposed future development areas Mc01 – Mc05.

When overflow problems occur in the 100 mm – 200 mm diameter section of outfall sewer near the McGregor WWTP due to the servicing of all stands and development of the future areas, these outfall sewers should be replaced with a larger diameter.

A new pumping station and rising main is proposed for future development area Mc01.

All erven not serviced with waterborne sewers should be linked to the proposed sewer layout in order to extend the network to the entire McGregor town.

6.3.4 Montagu

The existing drainage areas are increased to accommodate proposed future development areas.

It is proposed that when development of future development area M11 commences, the existing Ashbury pumping station is decommissioned and the flow from the Ashbury drainage area is diverted with new gravity outfall sewers (items LMS1.08 – LMS1.14 & LMS1.20) to the existing Montagu PS1 drainage area.

Upgrading of a few existing outfall sewers by replacement with larger sized sewers is proposed.

New gravity outfall sewers are required to collect the sewage from future development area M07.

When the Montagu pumping station 2 reaches capacity, it should be upgraded to a capacity of 41 ℓ/s and the existing rising main should be upgraded to a diameter of 250 mm.

When the Montagu pumping station 1 reaches capacity, it should be upgraded to a capacity of 120 ℓ/s and the existing rising main should be upgraded to a diameter of 355 mm.

6.3.5 Robertson

The existing drainage area is increased to accommodate proposed future development areas.

Upgrading of a few existing outfall sewers by replacement with larger sized sewers is proposed.

New gravity outfall sewers are required to collect the sewage from future development areas R06 - R08, R16 & R24.

When the Robertson pumping station reaches capacity, it should be upgraded to a capacity of 27 ℓ/s and the existing rising main should be upgraded to a diameter of 200 mm if high pump velocities are not desired.

6.4 FUTURE SYSTEM

6.4.1 Spare capacities

Figure LBS6.5 shows the relative spare capacities in the future Langeberg Municipality system under IPDWF. All pipes were planned in accordance with the IPDWF philosophy for spare capacity > 30%.

6.4.2 Flow velocities under peak flow conditions

All future pipes were planned for $v > 0,6$ m/s under full flow conditions. A few existing pipes with sufficient capacity but low velocities are however still present as indicated on Figure LBS6.2.

6.4.3 Flow hydrographs

The future PDDWF hydrographs are shown on Figure LBS6.6, for each WWTP.

6.4.4 Pumping stations and rising mains

In the town of Ashton the Ashton pumping station and rising main should be upgraded in the future when capacity problems occur. A new pumping station and rising main is proposed for a future development area.

In Bonnievale the Bonnievale 3 & 6 pumping stations and rising mains should be upgraded in the future when capacity problems occur.

A new pumping station and rising main is proposed for a future development area in McGregor.

In the town of Montagu the Montagu 1 & 2 pumping stations and rising mains should be upgraded in the future when capacity problems occur. It is proposed that the Ashbury pumping station is decommissioned and the flow from the Ashbury drainage area is diverted to the Montagu 1 drainage.

In Robertson the Robertson pumping station should be upgraded in the future when capacity problems occur.

The rest of the pumping stations in Langeberg were modelled with assumed scouring velocities in the accompanying rising mains. It is recommended that the duty points of these pumping stations (and diameters of the rising mains) be verified by field pumping tests.

The telemetry system whereby the pumping stations are closely monitored should also be upgraded and utilized to its full potential in order to assist with the operation and management of the systems.

7. MASTER PLAN COST SUMMARY

7.1 PROJECTED CAPITAL EXPENDITURE

Table LBS7.1 is a summary of the costs associated with the proposed master plan for the sewer system.

7.2 MASTER PLAN UNIT COST

The master plan implementation at cost of R 54,1 million, will increase the total sewer system capacity of the towns within Langeberg Municipality from its present PDDWF of $\pm 10\,664$ kℓ/d to the future PDDWF of $\pm 21\,766$ kℓ/d. This amounts to an implementation unit cost of R 4 606 R/kℓ/d.