water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

**WATER SERVICES**
**WATER SERVICES INFRASTRUCTURE GRANT**

**FEASIBILITY STUDY (REVISED)**

# CALVINIA BULK WATER SUPPLY
# HANTAM LOCAL MUNICIPALITY

**AUGUST 2021**

# CONTACT DETAILS OF APPLICANT:

LOCAL MUNICIPALITY:
Municipal Manager
Hantam Municipality
Municipal Offices
Hoof Street
CALVINIA
8190

| | |
|---|---|
| Tel: | 027 – 341 8500 |
| Fax: | 027 – 341 8501 |
| E-mail: | vanwykrj@hantam.gov.za |

Contact Person: Mr Riaan Van Wyk

ENGINEERING CONSULTANT:
BVi Consulting Engineers Northern Cape (Pty) Ltd
55 Bult Street
UPINGTON
8800

| | |
|---|---|
| Tel: | 054 – 337 6600 |
| Fax: | 054 – 337 6699 |
| E-mail: | gertm@bvinc.co.za |

Contact Person: Mr GH Meiring

## ISSUE & REVISION RECORD

### QUALITY APPROVAL

| | Capacity | Name | Signature | Date |
|---|---|---|---|---|
| Author | Engineer | G.H. Meiring | | 4 September 2019 |
| Client Approval | Senior Manager: Community and Technical Services | JR Van Wyk | | 4 September 2019 |

This report has been prepared in accordance with BVi Consulting Engineers Quality Management System. BVi Consulting Engineers is ISO 9001: 2008 registered and certified by NQA Africa.

### REVISION RECORD

| Revision Number | Description | Date Issued | Revision By |
|---|---|---|---|
| 00 | Study submitted to DWS for approval | 4 September 2019 | G.H. Meiring |
| 01 | Final Study submitted after comments received from DWS | 3 September 2021 | G.H. Meiring |
| | | | |

# *HANTAM MUNICIPALITY*
# *WATER SERVICES INFRASTRUCTURE GRANT*
# *FEASIBILITY STUDY*

## Contents

**1 PROJECT BACKGROUND ........ - 1 -**
1.1 HISTORY OF CALVINIA ........ - 1 -
1.2 SCOPE OF FEASIBILITY STUDY ........ - 3 -
1.3 EXISTING BULK WATER SUPPLY SYSTEM ........ - 3 -
1.3.1 Surface Water Source: ........ - 3 -
1.3.2 Groundwater Sources ........ - 4 -
1.3.3 Calvinia Water Treatment Plant ........ - 6 -
1.3.4 Calvinia Water Storage Capacity ........ - 9 -
1.4 Potential Water availability at Calvinia ........ - 10 -
1.4.1 Surface Water ........ - 10 -
1.4.2 Groundwater ........ - 12 -
1.5 Water quality analysis ........ - 14 -
1.6 Calvinia Water Demand ........ - 15 -
1.7 General Condition of Existing System ........ - 18 -
1.7.1 Condition of the Rising Main from Boreholes to Calvinia WTP ........ - 19 -
1.7.2 Design Capacity of Existing Borehole Water Supply Line ........ - 20 -
1.8 Storage Capacity of the Calvinia Bulk Water Supply System ........ - 20 -
**2 OPPORTUNITY STATEMENT ........ - 21 -**
2.1 Project Objectives ........ - 21 -
2.2 Current circumstances requiring the need for this study ........ - 22 -
**3 STRATEGIC FIT STATEMENT ........ - 24 -**
3.1 National Water Resource Management Strategy ........ - 24 -
3.2 Municipal Backlogs ........ - 24 -
3.3 Service Quality ........ - 25 -
3.4 Alignment with IDP and WSDP ........ - 25 -
**4 EXISTING DATA ........ - 26 -**
4.1 Population Data ........ - 26 -
4.2 Household and Per capita Income ........ - 27 -
4.3 Water Demand ........ - 29 -
4.4 Per Capita consumption ........ - 32 -
4.5 Demand Management ........ - 33 -
4.6 Current Water Pricing Structure ........ - 34 -
4.7 Water Quality Data ........ - 34 -

**5 ASSUMPTIONS ........ - 37 -**

5.1 Current and Future Demand ........ - 37 -
5.2 Current and Future Water Resources ........ - 37 -
5.3 Project Funding ........ - 38 -

**6 UNCERTAINTIES ........ - 39 -**

6.1 Possible Obstructions/Limitations ........ - 39 -
6.1.1 Cost Factor ........ - 39 -
6.1.2 Technical Capacity ........ - 39 -
6.1.3 Sustainability of the water resource ........ - 39 -
6.1.4 Sustainable management of the water resource by means of numeric modelling ........ - 40 -

**7 STRATEGIC RISKS ........ - 41 -**

7.1 Risks preventing the continuation of the project ........ - 41 -
7.2 Operational risks of the project ........ - 41 -

**8 OPTIONS CONSIDERED TO ADDRESS THE OBJECTIVES ........ - 42 -**

8.1 Philosophy and Criteria employed ........ - 42 -
8.2 The Doring River ........ - 42 -
8.3 Literature Survey ........ - 45 -
8.4 Availability of Water in the Doring River ........ - 47 -
8.5 Option 1: Abstraction of Water from the Doring River at Botterkloof Bridge ........ - 49 -
8.5.1 Concept for the solution ........ - 49 -
8.5.2 Physical Locations ........ - 52 -
8.5.3 Required Infrastructure for this option ........ - 53 -
8.5.4 Summary of Required Infrastructure for the Botterkloof Bridge option ........ - 54 -
8.5.5 Cost Estimate for Doring River Option 1: Botterkloof to Karee Dam ........ - 55 -
8.6 Option 2: Abstraction of surface water from the Doring/Tankwa Rivers confluence. ........ - 57 -
8.6.1 Concept for the solution ........ - 57 -
8.6.2 Physical Locations ........ - 59 -
8.6.3 Required Infrastructure for this option ........ - 60 -
8.6.4 Summary of Required Infrastructure for the Botterkloof Bridge option ........ - 62 -
8.6.5 Cost Estimate for Option 2: Doring/Tankwa Rivers Confluence to Karee Dam ........ - 63 -
8.7 Option 3: Groundwater exploration and augmentation of existing groundwater sources ........ - 66 -
8.7.1 Exploration: Hydrocensus, Identification of Drill Sites, Drilling, Yield Testing ........ - 67 -
8.7.2 Assessment of the Firm Yield potential of the new boreholes ........ - 73 -
8.7.3 Comparison of Sustainable Yield vs Aquifer Firm Yield Model ........ - 83 -
8.7.4 Fluoride removal from water ........ - 84 -
8.7.5 Activated Alumina process ........ - 86 -

8.7.6 Infrastructure required to utilize this option - 88 -
8.7.7 Cost Estimate for Option 3: Further exploitation of Groundwater sources - 91 -
8.8 Summary of Options investigated during the feasibility study. - 93 -
8.9 Life Cycle Cost Analysis - 94 -
**9 VALUE DRIVERS AND TRADE-OFFS - 96 -**
9.1 Capital Costs of the Project - 96 -
9.2 Production Cost of Water - 96 -
9.3 Product Quality - 97 -
9.4 Monetary Value of Health Benefits - 97 -
9.5 Socio-Economic Benefits - 98 -
9.6 Proposed Breakdown of Funding for the Project - 99 -
**10 STAKEHOLDERS INVOLVED IN THIS PROJECT - 102 -**
10.1 Calvinia Community - 102 -
10.2 Hantam Local Municipality - 102 -
10.3 Namakwa District Municipality - 102 -
10.4 Northern Cape Department of Environment and Nature Conservation - 102 -
10.5 Department of Water and Sanitation - 103 -
10.6 Northern Cape Department of Roads, Transport and Public Works - 103 -
10.7 Telkom - 103 -
10.8 Landowners affected by the project - 103 -
**11 DEVELOPMENT OF GROUNDWATER AT CALVINIA: OUTSTANDING ISSUES - 104 -**
11.1 Survey and Investigation - 104 -
11.2 Environmental Issues - 104 -
11.3 Water Use Licensing - 104 -
11.4 Way leaves and Consent Applications - 104 -
11.5 Risk Review - 105 -
**12 ASSESSMENT OF STUDY RESULTS - 106 -**

# ANNEXURES


| | | |
|---|---|---|
| ANNEXURE A | - | Karee Dam Catchment Area |
| ANNEXURE B | - | Karee Dam Catchment in relation to Drainage Area |
| ANNEXURE C | - | Calvinia Water Treatment Plant Layout |
| ANNEXURE D | - | Doring River Flow Data |
| ANNEXURE E | - | Option 1: Doring River: Botterkloof Layout Map |
| ANNEXURE F | - | Option 2: Doring / Tankwa River confluence Layout Map |
| ANNEXURE G | - | Option 3: Groundwater Exploitation Layout Map |
| ANNEXURE H | - | Details of Costing: All Options |
| ANNEXURE I | - | Calvinia Geohydrological Report: GEOSS |
| ANNEXURE J | - | Aquifer Firm Yield Model calculations |

## LIST OF FIGURES

**Figure 1: Locality Map of Calvinia** - 1 -
**Figure 2: Calvinia is home to the largest Post Box in South Africa** - 2 -
**Figure 3: Karee Dam viewed from the north** - 3 -
**Figure 4: Calvinia groundwater sources and connector pipelines** - 5 -
**Figure 5: Calvinia Water Treatment Plant** - 6 -
Figure 6: Manifold with common flowmeter for all wellfields - 7 -
**Figure 7: Dissolved Air Flotation plant** - 8 -
**Figure 8: Calvinia Old Reservoir - 1000m$^3$** - 9 -
**Figure 9: Calvinia New Reservoir – 1000m$^3$** - 9 -
Figure 10: Distribution of annual precipitation at Calvinia - 10 -
Figure 11: Calvinia Rainfall data - 11 -
Figure 12: Karee Dam level in August 2021 - 11 -
Figure 13: Calvinia North Wellfield boreholes - 13 -
**Figure 14: Water quality analysis of existing groundwater sources** - 15 -
Figure 15: Calvinia historic monthly demand - 17 -
**Figure 16:  Witwal Borehole near Calvinia** - 18 -
**Figure 17: Sandgat BH3 installation near Calvinia** - 19 -
**Figure 18: Typical 1.5 Megaliter Circular concrete reservoir** - 20 -
Figure 19: Long-term average rainfall and rain days for Calvinia - 23 -
Figure 20: Population Data for Calvinia - 26 -
Figure 21: Income distribution for Calvinia population - 27 -
Figure 22: Population profile for Brandvlei - 28 -
Figure 23: Water Demand compared with Yield - 30 -
Figure 24: Graphic presentation of historic and projected water demand - 31 -
Figure 25: Current Water Tariff structure for Brandvlei - 34 -
Figure 26: Water Quality analysis results for existing production boreholes at Calvinia - 35 -
Figure 27: Geographical location of the Doring River - 43 -
Figure 28: Bulshoek Dam and Clanwilliam Dam on the Olifants River - 44 -
Figure 29: Flow Data from the Doring River at Melkboom gauging station - 45 -
Figure 30: Olifants / Doring Rivers Mean annual Runoff (million m$^3$/annum) - 47 -
Figure 31: Water availability from the Olifants / Doorn River system - 48 -
Figure 32: Proposed Doring River Scheme layout from Botterkloof Bridge - 51 -
Figure 33: Botterkloof Bridge on the Doring River - 52 -
Figure 34: Hydraulic profile for the Botterkloof to Karee Dam Pipeline - 54 -
Figure 35: Summary of Capital Costs for Option 1 - 55 -
Figure 36: Proposed Layout of Option 2 from the Doring / Tankwa Confluence - 58 -
Figure 37: Doring River near to the Tankwa confluence - 59 -
Figure 38: Hydraulic profile of the Doring/Tankwa confluence option (Option2) - 61 -
Figure 39: Estimated Capital Cost required for Option 2 - 63 -
Figure 40: Study areas identified for groundwater exploration - 68 -
Figure 41: Sustainable Yield results for New Boreholes drilled at Calvinia - 70 -
Figure 42: Water quality analysis results for new boreholes at Calvinia - 70 -
Figure 43: Borehole CAL_NAT_6 equipped for use at Calvinia - 71 -
Figure 44: The "Box Model"aapproach - 75 -
Figure 45: Hydrogeological parameters for the relevant Quarternary catchments (WRC,2012) - 76 -

Figure 46: Results of the Aquifer Firm Yield model ............................................................................- 76 -
Figure 47: Schematic of conceptual geological sections ......................................................................- 77 -
Figure 48: Position of Calvinia GRU's ...................................................................................................- 79 -
Figure 49: Typical illustration of severe dental fluorosis .....................................................................- 84 -
Figure 50: Process and instrumentation diagram for Activated Alumina Process ...............................- 86 -
Figure 51: Typical Activated Alumina fluoride removal plant ............................................................- 88 -
Figure 52: Proposed Layout for Calvinia Bulk Water Supply Option 3 - Groundwater exploitation..- 90 -
Figure 53: Capital requirement for the exploitation of Groundwater sources at Calvinia...................- 91 -
Figure 54: Life Cycle Cost analysis .......................................................................................................- 94 -

# LIST OF ABBREVIATIONS

| | |
|---|---|
| **BVi** | BVi Consulting Engineers (Northern Cape) Pty Ltd |
| **DEADP** | Department of Environmental Affairs and Development Planning |
| **DEAT** | Department of Environmental Affairs and Tourism |
| **DPW** | Department of Public Works |
| **DTEC** | Department of Tourism, Environment and Conservation (Northern Cape Province) |
| **DWA** | Department of Water Affairs (formerly the DWAF) |
| **DWAF** | Department of Water Affairs and Forestry |
| **EC** | Electrical Conductivity |
| **ECA** | Environment Conservation Act |
| **EIA** | Environmental Impact Assessment |
| **GA** | General Authorisation |
| **IWRM** | Integrated Water Resources Management |
| **ℓ/s** | Litres per second |
| **L/p/d** | Litres per person per day |
| **$m^2$ /d** | Square metres per day |
| **$m^3$ /a** | Cubic metres per annum |
| **$m^3$ /d** | Cubic metres per day |
| **$m^3$ /hr** | Cubic metres per hour |
| **$m^3$ /m** | Cubic metres per month |
| **mamsl** | Metres above mean sea level |
| **MAP** | Mean Annual Precipitation |
| **mbgl** | Metres below ground level |
| **mg/ℓ** | Milligrams per litre |
| **mS/m** | Milli-siemens per metre |
| **ML** | Mega Litre |
| **NBRI** | National Building Research Institute of the CSIR |
| **NEMA** | National Environment Management Act |
| **NGDB** | National Groundwater Database |
| **NWA** | National Water Act (Act No. 36 of 1998) |
| **NWRS** | National Water Resource Strategy |
| **O & M** | Operation and Maintenance |
| **OD** | Outer Diameter |
| **RBIG** | Regional Bulk Infrastructure Grant |
| **ROD** | Record of Decision |
| **R/kL** | Rand per kilo Litre |
| **SAFCMA** | South African Fibre-Cement Manufacturers Institute |
| **SRK** | SRK Consulting (SA) Pty Ltd |
| **TDS** | Total dissolved solids |
| **WSA** | Water Services Act |

# 1 PROJECT BACKGROUND

## 1.1 HISTORY OF CALVINIA

The town of Calvinia is 470 kilometers north of Cape Town on the R27 Regional Road between Vanrhynsdorp and Upington and lies at an altitude of approximately 1050 meters above mean sea level. The town is 60km northeast of Nieuwoudtville and 140km south-southwest of Brandvlei. Calvinia is located in the Great Karoo biome and located south of the Hantam Mountains on the banks of the Oorlogskloof River.


**Figure 1: Locality Map of Calvinia**

Calvinia was founded in 1845 on the farm Hoogekraal which was purchased by the Dutch Reformed Church in order to establish a parish for the community of the Hantam Karoo. The original name of the region and the village was Hantam. The name Hantam originates with the Khoi people and the name refers to "*the hill where the red nut sedge grows*".

Soon after the arrival of the first minister, Reverend N Hofmeyr in 1851, the village's name was changed to Calvinia in honour of the Protestant theologian, John Calvin.

Early in the 20th century a sizable Jewish Community made its home in Calvinia and contributed significantly to the commercial development of the town. A Jewish synagogue was built in the town in 1920. Over the years the Jewish Community dwindled and ultimately the synagogue closed and was converted into the Calvinia Museum.

Calvinia developed as a centre for a vast agricultural district and the arrival of the railway linking Calvinia with Hutchinson in 1917 aided the economic development of the town and the district.

**Figure 2: Calvinia is home to the largest Post Box in South Africa**

Calvinia is a pleasant town with a well-preserved architectural heritage that provides a window on its past. Calvinia's economy revolves primarily around the extensive sheep farming taking place in the area. It is also the administrative seat of the Hantam Local Municipality which administrates a vast area including the towns' of Brandvlei, Loeriesfontein, Nieuwoudtville and the hamlets of Middelpos and Swartkop. The Hantam Municipality falls within the Namakwa District of the Northern Cape Province.

The Hantam region contains very little vegetation, consisting primarily of very low shrubs and yellow grass among an arid rocky landscape. If you travel north towards Kenhardt, you will pass a landscape of nothingness for 200 km or more.

Temperatures vary from well below 0°C in winter months (-6.5°C), to well above 40 °C in summer. Calvinia also gets the odd bout of snow on the Hantam Mountains. Calvinia is located on the edge of the winter rainfall region. Rainfall ranges from 50 to 300 mm a year, with a mean of 228 mm, at Calvinia. Although the rain falls mainly in winter,  it does include sporadic summer thunderstorms.

## 1.2 SCOPE OF FEASIBILITY STUDY

This feasibility study aims to investigate and identify a project which will prove to be a sustainable technical and socio-economic solution for Calvinia's current water supply challenges. This study will focus on five core areas, i.e.:

1. Survey of the existing system, socio-economic data and current cost of water
2. The identification and preliminary investigation of possible solutions
3. Identification of suitable technical solution
4. Investigation into the sustainability and financial viability of the selected option
5. Recommendation to the client and funding institution

## 1.3 EXISTING BULK WATER SUPPLY SYSTEM

The existing bulk water supply system at Calvinia consists of the following components:

### 1.3.1 Surface Water Source:

The Karee Dam is 15m high earth fill embankment dam with an impoundment of 900 000 $m^3$. The dam is located in the Karee River and is fed by runoff from its own catchment area which is approximately 18 $km^2$. The Karee Dam was originally constructed in 1960 and the embankment was raised in 1968. The dam is owned by the Hantam Municipality and supplies water to Calvinia for domestic and industrial uses.

**Figure 3: Karee Dam viewed from the north**

The Karee Dam is classified and registered with the Department of Water & Sanitation as a Category II dam and has an embankment length of 925m with a concrete overflow weir of 100m in length and an open channel flood outlet designed to accommodate a flood of 334 $m^3/s$.

The outlet works comprises a circular reinforced concrete abstraction tower inside the impoundment. The tower is equipped with 4 number 300mm diameter inlet pipes equipped with gate valves at four different levels. Valves are controlled manually from a platform at the top of the abstraction tower. The abstraction tower can be reached by means of a pedestrian bridge between the embankment and the abstraction tower.

Abstracted water is passed beneath the dam embankment by means of a concrete- encased steel outlet pipe of 300mm diameter. The outlet pipe is also equipped with a control and scour valves directly downstream of the embankment.

The Karee Dam is the primary source of surface water for Calvinia.

### 1.3.2 Groundwater Sources

Calvinia can also be supplied with water from 7 existing boreholes which can deliver an estimated maximum of 1 440$m^3$/day or 60$m^3$/h when the water levels are within normal operating conditions.

The seven available boreholes are named and identified as follows:

| No | Identifier | Depth (m) | Static Water Level (mbgl) | Pump Depth (mbgl) | Sustainable Yield (l/s) |
|---|---|---|---|---|---|
| 1 | Golf Course BH | 225 | 36 | 100.0 | 2.5 |
| 2 | Witwal BH | 193 | 22.9 | 91.0 | 6.0 |
| 3 | Sandgat BH 3 | 15.12 | 8.41 | 13.20 | 1.5 |
| 4 | Sandgat BH 4 | 59 | 8.59 | 55.1 | 0.8 |
| 5 | Sandgat BH 5 | 197.8 | 20.91 | 189.2 | 3.0 |
| 6 | Deon Vlok BH | 250 | 22.6 | 150.0 | 16.0 |
| 7 | G39973 Kopasfontein BH (breccia pipe) | 360 | 19 | 180 | 24.0 |

The seventh borehole, **G39973**, was used in a pilot artificial recharge scheme, but the nature of the geology is such that the water is contaminated with high levels of arsenic. The municipality is able to remove this by oxidising the arsenic, but this water is only used in serious emergencies.

With the remaining 6 boreholes in production, the municipality is barely able to supply sufficient water to meet the Average Daily Demand, but totally unable to store any surplus, as the demand and supply basically just balance. This situation is a serious risk, as any breakdown in the system due to either pipe or pump failure inevitably leads to a water shortage being incurred.

In addition to the problem of available volume, the water quality on four of the boreholes is marginal and tastes very bad due to high salinity, sulphur and metals such as iron and manganese in solution.

The result of this situation is, that there is currently sufficient water for basic uses, but drinking water is a serious problem due to the poor quality from the existing groundwater sources. Residents of Calvinia, are therefore quite often dependant on bottled water, which is sold at a premium due to the high demand. Besides being a Basic Human Right entrenched in the Constitution of South Africa, the people in the Hantam area quite often need to buy bottled water, and a large portion of the community do not have the means to afford this.


**Figure 4: Calvinia groundwater sources and connector pipelines**

The water from the production boreholes is collected in a pipe network of approximately 25km in length. The furthest borehole being the Deon Vlok borehole located 19.9km from the Calvinia Water Treatment Plant.

Each of the boreholes is fitted with an electrically powered submersible pump which receives electrical power from a dedicated powerline. The borehole pump stations are currently also equipped with a telemetry system which allows remote operation.

The Golf Couse Borehole has a short pipeline and pumps directly into the supply network and does not pump to the Calvinia Water Treatment Plant.

### 1.3.3 Calvinia Water Treatment Plant

Calvinia Water Treatment Plant is located within the Akkerendam Nature Reserve approximately 5km north of the town. This plant treats the raw surface water from the Karee Dam as well as the groundwater from the borehole field.

**Figure 5: Calvinia Water Treatment Plant**

The plant is equipped with an electromagnetic flow meter followed by a flash mixing channel. The flocculant chemicals are dosed just before the flash mixer by means of a dosing pump. After flash mixing, the water flows through a flocculation channel where the floc is conditioned. The flow from the flocculation channel is then split into three equal streams by means of a division weir from where the water flows to three 8m diameter Dortmund type clarifiers. The clarified water is collected in annular concrete channels from wher it flows through a 300mm dia gravity pipe to the Filter Inlet channel. The water flows through 4 number rapid gravity filters to the Clear Water Sump below the filters. The water is chlorinated inside the Clear Water Sump, and is then pumped to the reservoirs. The old reservoir and new reservoir are connected with a 200mm dia uPVC pipe with the aim of balancing the levels of the two reservoirs.

The Treated Water is then withdrawn from the old Reservoir by means of 2 number 150mm dia. AC pipes, one feeding the Calvinia East network and the other feeding the Calvinia West network by means of gravity flow.

When water is supplied from the groundwater boreholes, the water from the various wellfields is collected in a manifold, and then passes through a common electromagnetic flowmeter and then into an aeration tank located just prior to the Inlet Works. The aerator serves to oxygenate the water in order to oxidize any metals such as iron, hydrogen sulphide, etc.

From the aerator, the water flows through the Inlet Works and flash mixer, where it can be dosed with a flocculant if required.

The groundwater then flows through the flocculation channels and can then be diverted to either the three Dortmund Clarifiers or the Dissolved Air Flotation unit, which is very effective in removing fine turbity below 20 NTU's.

From either the clarifiers or the DAF unit, the water is passed through the rapid gravity filters and then chlorinated before entering the Clear Water sump.

**Figure 6: Manifold with common flowmeter for all wellfields**

**Figure 7: Dissolved Air Flotation plant**

The Treated Water is then withdrawn from the old Reservoir by means of 2 number 150mm dia. AC pipes, one feeding the Calvinia East network and the other feeding the Calvinia West network by means of gravity flow.

The Calvinia Water Treatment Plant is currently set up to treat either Surface Water from the Karee Dam, or Groundwater from the borehole field, or a combination of the two sources as a blended water.

The design capacity of the Calvinia Water Treatment Plant has recently been upgraded to 166$m^3$/h for the treatment of either Surface Water or Groundwater. The upgrade included the modification of the existing clarifiers, the construction of a new Chemical Dosing facility, construction of 4 number Rapid Gravity Filters and the construction of a Dissolved Air Flotation unit. The latter is especially usefull in mid-summer months when blue-green algae is prevalent in the surface water from Karee Dam.

### 1.3.4 Calvinia Water Storage Capacity

Calvinia is equipped with two number circular concrete storage reservoirs.
The old Calvinia Storage Reservoir has a domed concrete roof and a capacity of 1000m$^3$.
The New Calvinia Reservoir has a flat roof and also has a storage of 1000m$^3$.

The two reservoirs are interconnected and by adjusting valves, one, two or both reservoirs can be used in service to feed the towns' reticulation network.

**Figure 8: Calvinia Old Reservoir - 1000m$^3$**

**Figure 9: Calvinia New Reservoir – 1000m$^3$**

## 1.4 Potential Water availability at Calvinia

Hantam LM lies in an area that falls on the brink of summer and winter rainfall. Rainfall occurs throughout the year. The average rainfall of the area is less than 250 mm per year and the average annual evaporation is about 2200 mm.

### 1.4.1 Surface Water

The town of Calvinia relies largely on the Karee Dam for water supply. The Karee Dam can impound 944 000m$^3$, but the 1 in 50-year yield is calculated at only **370 000m$^3$/annum**. When rainfalls are good, and the dam is able to be filled in the winter months from May to September, the water supply from the dam is sustainable and easily supplies the Calvinia for 9 to 10 months of the year. The problem occurs when winter rainfalls are erratic and low, such as having occurred in 205/16 and 2016/17 seasons when only 30mm and 42mm were recorded in the catchment area.

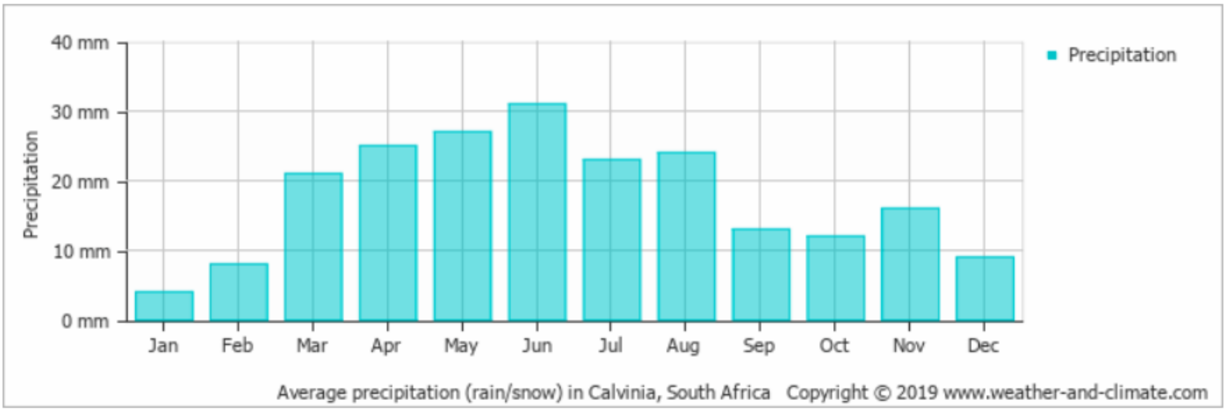



**Figure 10: Distribution of annual precipitation at Calvinia**

The distribution of rainfall in the Calvinia area is given as in Figure.10 and correlates with that experienced during 2019 and 2020, when 30mm and 42mm fell, but unfortunately this rain fell outside the limited catchment of the Karee Dam and subsequently did not contribute anything to runoff for the Karee Dam.

In 2020, rainfalls with a better distribution occurred and proceeded to increase the level of the Karee Dam to approximately 75% in July 2020. Good rains also fell during the summer months of 2021, with events in excess of 40mm being recorded. The latter events did however not contribute to the runoff for Karee Dam. Currently, the August 2021 waterlevel of the Karee Dam is at 21%, whereas it was 72% in August 2020. The rainfall in the Calvinia area remains sporadic and does not contribute to the Karee Dam impounding water as a rule.

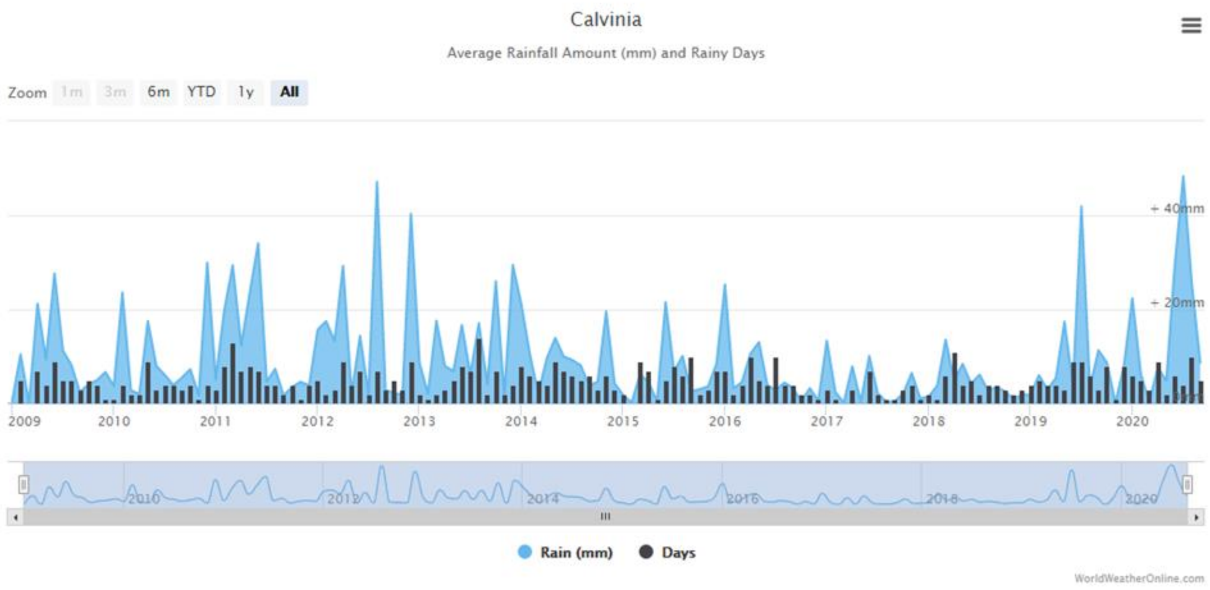



**Figure 11: Calvinia Rainfall data**

The current scenario will once again lead to a situation, where the dam is not full when summer starts and increases the town's reliance on groundwater sources. During times of drought, as what has occurred since 2015 in the Hantam region, the groundwater levels also drop significantly, making even the abstraction of groundwater a risky enterprise.

| Dam | River | Photo | Indicators | FSC | This Week | Last Week | Last Year |
|---|---|---|---|---|---|---|---|
| Boegoeberg Dam | Orange River | Photo | Indicators | 20.7 | #72.5 | #72.5 | 105.6 |
| Douglas Weir | Vaal River | Photo | Indicators | 16.3 | 109.8 | 109.3 | 107.8 |
| Karee Dam | Karee River | Photo | Indicators | 1.0 | 22.7 | 23.6 | 71.5 |
| Leeubos Dam | Swartbas River | Photo | Indicators | 1.0 | #0.0 | #0.0 | #0.0 |
| Spitskop Dam | Harts River | Photo | Indicators | 57.9 | 100.9 | 100.4 | 98.1 |
| Vaalharts Weir | Vaal River | Photo | Indicators | 50.7 | 93.0 | 91.5 | 77.4 |
| Total | | | | 147.3 | 94.0 | 93.3 | 92.3 |

**Figure 12: Karee Dam level in August 2021**

The only other sources of sustainable surface water in the Northern Cape, are the Orange River to the north, which is 284km away (Pelladrift), and the Doring River which is approximately a 100km southwest of Calvinia.

### 1.4.2 Groundwater

***Old Wellfield***

The existing groundwater sources at Calvinia currently comprise 7 boreholes, of which only six are used as production wells. These boreholes have a tested yield of 24 litres per second, or 86 $m^3/h$ in normal rainfall years where groundwater levels are stable. During periods of drought when there is no opportunity for recharge, the yield is in the order of 55 $m^3/h$ which only just meets the towns' peak demand. The probable annual yield from the existing groundwater sources is therefore calculated to be in the order of **400 000 $m^3$/annum**. Over the past two seasons, when drought conditions occurred, this yield declined to 38 $m^3/h$ or a annual yield of only **330 000 $m^3$**.

Investigations into the supply of groundwater are a part of Calvinia's history with the following studies having been done through the years:

1. Report GH283 – Schumann, 1947
2. Report GH460 – Schumann, 1947
3. Report C58 – Schumann, 1947
4. Report C537 – Schumann, 1966
5. Report GH3150 – Van Wyk, 1980
6.

The consulting engineering company, Ninham Shand, conducted a study in 1980 and they were convinced that the only solution to the town's water problems would be exploration for additional groundwater sources. The possibility of raising the dam wall of the Karee Dam was found to be not feasible due to the relatively small catchment area.

In 1983, Mr Paul Seward from the Department of Water Affairs conducted the Hantam Groundwater Study. (Report GH3190) He initiated a survey where 374 existing boreholes in the Calvinia area where surveyed and studied. This study showed conclusively that boreholes associated with alluvium, shale, or weathered shale are almost always low yielding and of poor quality. Mr Seward drilled 26 exploration boreholes in the Calvinia area of which two boreholes were selected as possible future production wells for Calvinia. On completion of this study, Mr Seward recommended that future exploration take place 20 – 30km from Calvinia as all current avenues with regards to groundwater in the immediate vicinity of the town had been exhausted.

He also noted that future exploration work should focus on groundwater occurrences associated with dolerite intrusions rather than the alluvium, shale and weathered shale occurrences. Mr Seward identified 5 possible areas for future exploration:

- Kreitzberg area
- Downes West
- Area East of Spitskop
- Oorlogskloof area
- Klein Doring River area

The groundwater work was continued in 1990, when Mr Alan Woodford conducted a study under Report GH3581. During this study, 107 exploration boreholes were drilled within a radius of 20km of Calvinia. He identified 3 boreholes with freshwater and a significant yield. These boreholes were equipped in 1996 and a pipeline was constructed between the boreholes and the Calvinia Water Treatment Plant and form part of the Old Wellfield. It was again made clear in 1990 by Mr Alan Woodford that the area around Calvinia had been depleted, and that the boundary for future groundwater development should be extended to a 40km radius from Calvinia. Mr Woodford also hinted at the use of reverse-osmosis treatment of saline groundwater sources in future. This is however an energy intensive exercise and would have an enormous impact on the affordability of the water for the community should this avenue be taken.

***Calvinia North Wellfield***

Hantam Municipality embarked on an extensive water exploration exercise in 2018, which was funded by Disaster Relief Funding after the Namakwa district was declared a Disaster Area. In excess of 40 boreholes were drilled from March 2018 to May 2018 in the Calvinia area.

In May 2018, the municipality commenced development of the Calinia North Wellfield, located within the Akkerendam Nature Reserve, just north of the town. A further 5 boreholes were equipped and connected to the Calvinia Water Treatment Plant using temporary above-ground pipelines in order to alleviate the situation. This wellfield theoretically had the following as result:

| No | Identifier | Depth (m) | Static Water Level (mbgl) | Pump Depth (mbgl) | Sustainable Yield (l/s) |
|---|---|---|---|---|---|
| 1 | Borehole CAL_DV1 | 150 | 49.5 | 124.0 | 5 |
| 2 | Borehole CAL_DV3 | 205 | 41.0 | 147.0 | 0.8 |
| 3 | Borehole CAL_DV4 | 205 | 12.1 | 100.0 | 1.5 |
| 4 | Borehole CAL_NAT 5 | 200 | 30.0 | 178.0 | 4.3 |
| 5 | Borehole CAL_NAT 6 | 200 | 11.8 | 100.0 | 1.5 |

**Figure 13: Calvinia North Wellfield boreholes**

These boreholes could, according to their sustainable yields, deliver an additional 13 liters per second, or 1 131m$^3$/day. Unfortunately, the reality proved otherwise. Borehole CAL_DV1 has a very slow recovery rate, and can only be pumped sustainably at a rate of about 3 l/s, similarly, Borehole CAL_NAT5 only delivers about 2 liters per second, bringing the available total flow from this wellfield down to about 8 l/s, or 690 m$^3$/day.

The total available groundwater at Calvinia is therefore currently as follows:

| | |
|---|---|
| **Old Wellfield:** | **1 320 m$^3$/day** |
| **Calvinia North Wellfield:** | **690 m$^3$/day** |
| **Total available Groundwater:** | **2 010 m$^3$/day** |

This daily volume calculated here is qualified, in as much that it is highly dependent on sufficient recharge of the aquifer on an annual basis. Recharge is again, fully dependent on rainfall within the catchment of the various boreholes. If the demand should exceed the groundwater recharge, this situation will change rapidly as the available water in the aquifirs are depleted.

## 1.5 Water quality analysis

During our investigation into the sustainable yields of the existing boreholes, water samples were taken from each borehole and analysed for quality. If the analysis results are compared with the SANS 241-1-2015 standard for Drinking Water, then it is clear that at least 4 of the 6 production boreholes have marginal quality with respect to salinity. Boreholes Sandgat 3, Sandgat 4 and Sandgat 5 all have elevated levels of Total Dissolved Solids exceeding 1200mg/l.

A human being only starts tasting salinity above 1000mg/l, and these boreholes' water exceed this considerably. From the analysis, it is clear, that the salinity is primarily caused by elevated levels of sodium and chloride in this water. There are also two boreholes with elevated levels of sulphur. In addition, the Golf Course borehole exuded high concentrations of hydrogen sulphide gas (rotten egg gas) which indicates that there is anaerobic biological activity in this borehole.

The results are as follows:

| Analyses | Ceres_RD | Sandgat_4 | Golf_course | Witwal_BH | Sandgat_3 | Deon_Vlok | Sandgat_5 | SANS 241-1:2015 |
|---|---|---|---|---|---|---|---|---|
| pH (at 25 °C) | 7.6 | 7.4 | 7.4 | 8.4 | 7.5 | 7.5 | 7.0 | ≥5 - ≤9.7 Operational |
| Conductivity (mS/m) (at 25 °C) | 59.2 | 598.6 | 214.0 | 93.0 | 605.0 | 150.0 | 279.0 | ≤170 Aesthetic |
| Total Dissolved Solids (mg/l) | 379.0 | 3831.0 | 1283.0 | 561.0 | 3600.0 | 901.0 | 1670.0 | ≤1200 Aesthetic |
| Turbidity (NTU) | 0.6 | 0.3 | 1.4 | 0.4 | 0.2 | 1.4 | 0.4 | ≤5 Aesthetic ≤1 Operational |
| Colour (mg/l as Pt) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤15 Aesthetic |
| Sodium (mg/l as Na) | 38.7 | 706.9 | 190.3 | 175.6 | 929.4 | 128.3 | 305.7 | ≤200 Aesthetic |
| Potassium (mg/l as K) | 1.4 | 1.0 | 5.1 | 7.4 | 1.8 | 3.1 | 4.6 | N/A |
| Magnesium (mg/l as Mg) | 12.5 | 118.8 | 60.4 | 0.4 | 139.1 | 55.3 | 70.8 | N/A |
| Calcium (mg/l as Ca) | 52.5 | 227.6 | 127.7 | 0.0 | 131.8 | 92.1 | 116.1 | N/A |
| Chloride (mg/l as Cl) | 51.0 | 1420.0 | 542.8 | 157.3 | 1564.2 | 225.3 | 761.9 | ≤300 Aesthetic |
| Sulphate (mg/l as SO4) | 26.0 | 664.0 | 112.0 | 94.0 | 769.0 | 177.0 | 194.0 | ≤250 Aesthetic ≤500 Acute Health |
| Nitrate Nitrogen (mg/l as N) | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | ≤11 Acute Health |
| Nitrite Nitrogen (mg/l as N) | 0.4 | 0.8 | 0.0 | 0.0 | 0.6 | 0.0 | 0.6 | ≤0.9 Acute Health |
| Ammonia Nitrogen (mg/l as N) | 0.3 | 0.4 | 0.3 | 0.6 | 0.3 | 0.0 | 0.3 | ≤1.5 Aesthetic |
| Total Alkalinity (mg/l as CaCO3) | 284.0 | 511.0 | 167.9 | 181.4 | 388.0 | 278.6 | 132.5 | N/A |
| Fluoride (mg/l as F) | 0.5 | 0.2 | 0.2 | 1.4 | 0.0 | 0.8 | 0.0 | ≤1.5 Chronic Health |
| Aluminium (mg/l as Al) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.3 Operational |
| Vanadium (mg/l as V) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | N/A |
| Total Chromium (mg/l as Cr) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.05 Chronic Health |
| Manganese (mg/l as Mn) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | ≤0.1 Aesthetic ≤0.4 Chronic Health |
| Iron (mg/l as Fe) | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | ≤0.3 Aesthetic ≤2 Chronic Health |
| Cobalt (mg/l as Co) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | N/A |
| Nickel (mg/l as Ni) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.07 Chronic Health |
| Copper (mg/l as Cu) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤2 Chronic Health |
| Zinc (mg/l as Zn) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | ≤5 Aesthetic |
| Arsenic (mg/l as As) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.01 Chronic Health |
| Selenium (mg/l as Se) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.04 Chronic Health |
| Cadmium (mg/l as Cd) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.003 Chronic Health |
| Antimony (mg/l as Sb) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.02 Chronic Health |
| Mercury (mg/l as Hg) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.006 Chronic Health |
| Lead (mg/l as Pb) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.01 Chronic Health |
| Uranium (mg/l as U) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.03 Chronic Health |
| Cyanide (mg/l as CN-) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.2 Acute Health |

**Figure 14: Water quality analysis of existing groundwater sources**

From this analysis, it was clear that, Calvinia is battling firstly with quantity, and secondly, that the quality of the existing available groundwater is marginal at best.

During dry years, the smells and tastes caused by these identified elements tend to be exaggerated as the water levels within the boreholes drops. The water exudes a horrendous odour, making any human being very wary of using the water, let alone drink it!

## 1.6 Calvinia Water Demand

Calvinia currently has 2 509 households consuming water at a rate of 125 litres per capita per day. This returns an annual average daily demand of 1568 m$^3$/day. Historical consumption figures are available for several years and indicated a growth of less than 1% per annum for the town.

If this data is used, a future demand of 1767m$^3$/day is projected for 2040. The per capita consumption of the past 3 years has been significantly lower at 87 litres per capita per day due to stringent water restrictions imposed by the municipality.

**BULK AND CONNECTOR SERVICES :** **CALVINIA** **DATE : 2019/08/24**

**DESIGN CRITERIA**

| Description | Unit | Criteria |
|---|---|---|
| Population | | 9680 |
| Houses | | 2509 |
| Persons per house | | 3.86 |
| Design Period | years | 20 |
| Max Persons per house | | 5 |
| Annual growth rate | | 0.6% |
| Water demand | l/person/day | 125 |

| | | |
|---|---|---|
| Design Loss Factor | Water treatment works (LFw) | 10.0% |
| Design Loss Factor | Total conveyance losses (LFr) | 10.0% |
| Summer peak factor (SPF) | | 1.50 |
| Peak factor reticulation (DPFR) | | 4 |

| | | |
|---|---|---|
| Water purification plant operational hours | hours/day | 20 |
| Design Pump period | hours/day | 20 |

| | | |
|---|---|---|
| Storage in elevated tanks | hours*AADD | 4 |
| Storage reservoirs | hours* AADD | 48 |

| | | | | |
|---|---|---|---|---|
| Annual Average Daily Demand (AADD) | AADD | 1568.1 $m^3$/day | 65.3 $m^3$/hour | 18.15 l/s |
| Gross Average Annual Daily demand (GAADD) | (1+Lfr)*AADD | 1724.9 $m^3$/day | 71.9 $m^3$/hour | 19.96 l/s |
| Summer Daily Demand Water Treatment Works and Raw water and Clean water pumps (SDDww) | SPF*GAADD*(1+LFw) | 2846.1 $m^3$/day | 142.3 $m^3$/hour | 39.53 l/s |
| Pipeline Flow between Main Storage and Elevated tank (20 Hours) | 2*GAADD | 3449.9 $m^3$/day | 172.5 $m^3$/hour | 47.91 l/s |
| Design Peak flow rate (DPFR) | DPF*GAAD | 6899.8 $m^3$/day | 287.5 $m^3$/hour | 79.9 l/s |
| Storage Capasity Elevated Storage | hours*AADD | 261.4 $m^3$ | | |
| Storage Capasity Main Storage | hours*AADD | 3136.3 $m^3$ | | |

| | | | | |
|---|---|---|---|---|
| Annual Average Daily Demand (AADD) | AADD | 1767.4 $m^3$/day | 73.6 $m^3$/hour | 20.46 l/s |
| Gross Average Annual Daily demand (GAADD) | (1+Lfr)*AADD | 1944.2 $m^3$/day | 81.0 $m^3$/hour | 22.50 l/s |
| Summer Daily Demand Water Treatment Works and Raw water and Clean water pumps (SDDww) | SPF*GAADD*(1+LFw) | 3207.9 $m^3$/day | 160.4 $m^3$/hour | 44.55 l/s |
| Pipeline Flow between Main Storage and Elevated tank (20 Hours) | 2*GAADD | 3888.3 $m^3$/day | 194.4 $m^3$/hour | 54.00 l/s |
| Design Peak flow rate (DPFR) | | 7776.7 $m^3$/day | 324.0 $m^3$/hour | 90.01 l/s |
| Storage Capasity Elevated Storage | hours*AADD | 294.6 $m^3$ | | |
| Storage Capasity Main Storage | hours*AADD | 3534.8 $m^3$ | | |

From the calculation above, it is clear that the town has a current Annual Average Daily Demand of 18 litre per second which peaks in summer at around 40 litres per second. This equates to an annual demand in the order of **629 625 kiloliters per annum**.

If a design horizon of 20 years and a population growth of 0.6% per annum are taken into account, the Annual Average Daily Demand required increases to 21 litres per second with a peak summer demand of 45 litres per second. The demand then increases to an annual figure of **709 560 kiloliters per annum**.

The Karee Dam is able to supply 370 000 kiloliters per annum if it is at Full Supply Level after the winter, which is approximately half of the annual demand.

The balance, or approximately 339 560 kilolters per annum shortfall, must be delivered from the groundwater sources. Theoretically, the current groundwater souces could deliver a volume of 419 428 kiloliters per annum, which should be sufficient. Unfortunately, due to the extensive drought experienced over the past 3 to 5 years, this is not being achieved. The current boreholes are only just able to supply this demand. If any breakdown or interruption in the supply of electricity occurs, the existing water supply system fails to meet the demand.

The recorded annual consumption of Calvinia from 2013 to 2020 was provided to us by the Hantam Municipality as follows:

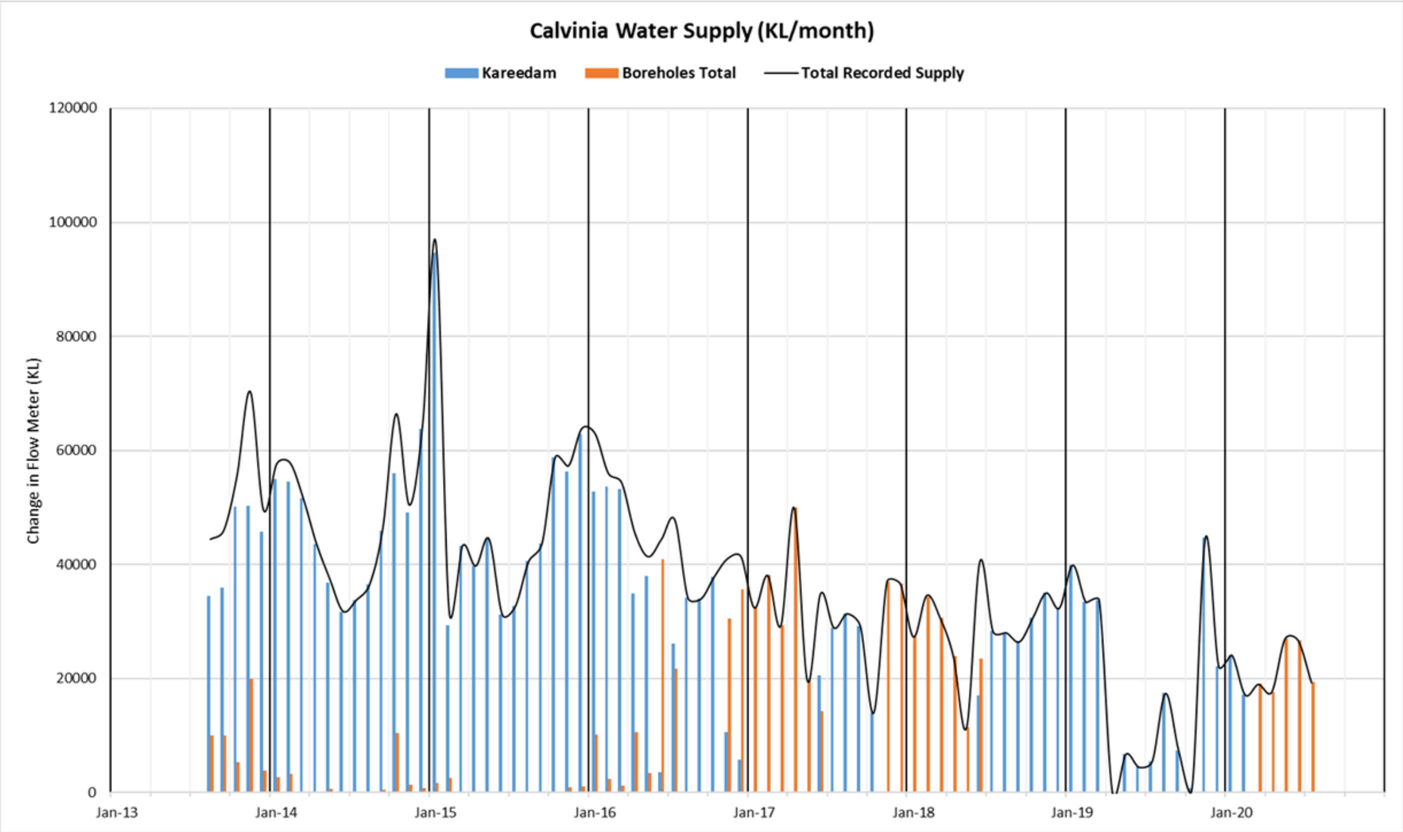



**Figure 15: Calvinia historic monthly demand**

From these figures, the effect of the drought is very clear, as demand declines significantly from January 2016, which had a demand of 63 587 kiloliter to January 2020, where the demand was only 27 725 kiloliters. This phenomenon occurred primarily due to very stringent water restrictions imposed by the Hantam Municipality, as they were simply not in a position to meet the normal demand.

Restrictions of 15 kiloliter per household per month were enforced, with any non-compliance being severely punished by charging a rate of R40-00 per kiloliter for any consumption above 15 kiloliter per month. Albeit extreme and severe, it has proved to be effective, as the demand per capita has reduced significantly. The downside of this situation, is that the municipality experience a massive loss of revenue, as it simply did not have sufficient water to sell.

## 1.7 General Condition of Existing System

The general condition of the existing borehole installations is fair. The majority of the installations are in working condition. Each borehole is adequately equipped with either a mechanical flow meter fitted with an optical pick-up, or an electromagnetic flowmeter for relaying abstraction volumes via a telemetry system to the municipal offices in Calvinia. The electricity supply to the existing boreholes is stable and reliable.

The boreholes are are all fenced off and security is mostly not an issue. The switchgear is fairly old, at especially the Old Wellfield boreholes and offers only very basic protection for the motors and will need replacement. At most of the borehole installations, the only protection available was a basic circuit breaker and nothing else. Almost none have low-level protection or no-flow protection installed.

**Figure 16: Witwal Borehole near Calvinia**

The Municipality were not able to say with any certainty as to what size of pumps in terms of flow and delivery head were installed in a any specific well.

All the pumps are currently controlled by means of a telemetry signal from either the municipal offices' SCADA system or from the Foreman's' cell phone.

**Figure 17: Sandgat BH3 installation near Calvinia**

Although all the installations are fitted with mechanical flow meters and the readings are recorded both manually as well as on the SCADA system, control of the system is generally acceptable. The Municipality also measures and records the static water levels of each of the boreholes with a manual dip meter on a weekly basis which is good information to have.

### 1.7.1 Condition of the Rising Main from Boreholes to Calvinia WTP

The water abstracted from the Old Wellfield at Calvinia is pumped through a Rising Main which starts out as a 110mm diameter pipe and then increases to 160mm diameter as the borehole flows are added. The existing rising main was refurbished and extended in 1996 and is still in a good condition.

The Rising Main is approximately 25km in length and is located largely on private property on which there is no servitude registered. Access to the pipe is often difficult as there are no public roads in close proximity to the pipeline. This means that every effort to repair the pipeline is preceded by the need to get permission from the landowner and then the battle over inaccessible terrain to reach the point of failure.

### 1.7.2 Design Capacity of Existing Borehole Water Supply Line

A design check was performed to determine whether the existing 160 mm diameter (COD) uPVC pipe line, was still adequate with regards to existing capacity. It was found that the pipeline could deal with a flow of 15 litres per second at a flow velocity of just above 1 m/s, which is adequate for the current boreholes.

## 1.8 Storage Capacity of the Calvinia Bulk Water Supply System

Currently, the only storage available are the two reservoirs located at the Calvinia Water Treatment Plant. They provide a total storage of 2 000m$^3$.

The guidelines in both the Red Book as well as the normative guidelines from the Department of Water & Sanitation require at least 48 hours of storage for ground level reservoirs in the case of a single source of supply and at least 4 hours storage in the case of elevated storage.

This means that the current storage should be a minimum of 3 132m$^3$ as main storage, as Calvinia is considered to have only a single source feeding the towns' reticulation network. This indicates that the existing reservoir is currently undersized by at least 56%. For future needs, the main storage should be increased by at least 1 500m$^3$ to provide a total storage of 3 500m$^3$ for future needs.

**These calculations indicate that additional ground level storage of at least 1 500m$^3$ is required to comply with the minimum current and future requirements at Calvinia.**

**Figure 18: Typical 1.5 Megaliter Circular concrete reservoir**

# 2 OPPORTUNITY STATEMENT

## 2.1 Project Objectives

This project aims to augment the current supply of water to the community of Calvinia by means of piped surface water from the Doring River, or groundwater, originating from two new well fields to be developed at the Kreitzberg Area along the Ceres-Karoo road and the Northwest Area along the gravel road from Calvinia to Loeriesfontein. The purpose of the project is to provide a system for supplying water suitable for human consumption by sustainable means for a period of at least 15 to 20 years.

This project comprises the development of either or both of the following:

1. ***A new abstraction structure on the Doring River, pumping water to Calvinia, or***

2. ***The development of two new well fields at Kreitzberg and along the Loeriesfontein road.***

The Doring River option aims to bring surface water to Calvinia by abstracting water from either at the Botterkloof Bridge area, or from a point approximately 4.5km downstream of the Doring / Tankwa River confluence.

From the Botterkloof site, the required infrastructure would consist out of a River Pump Station, a Rising Main pipeline and at least 2 Booster Pump Stations to enable delivery of water to Calvinia. For the Tankwa site, a River Pump Station would be required, a Rising Main pipeline delivering water to a Reservoir located at a high point approximately 30km from Middelpos, and a Gravity Main from the Tankwa Reservoir to Calvinia.

The development of the wellfields at Kreitzberg and the Northwest Area would entail the fitting and equipping of 12 newly drilled boreholes, the construction of a new collector network at Kreitzberg, the construction of an electrical power supply line from Calvinia to Kreitzberg wellfield as well as to the Northwest Wellfield, installation of a telemetry system for remote operation and control of the borehole fields, construction of a 2 new Collector Reservoirs, a Gravity Main pipeline from Kreitzberg to Calvinia, a Booster Pump Station from the Northwest Area to pump water to Calvinia and a Rising Main from the Northwest Area to the Calvinia Water Treatment Plant. The construction of a new 1,5 Megaliter Reservoir at Calvinia and a Treatment Facility for the removal of excess fluoride from the water.

This study aims to prove that one of the options proposed for this project is a feasible medium to long-term option, affordable for the community in terms of unit costs for water, and can be operated and maintained by the Hantam Municipality with their limited in-house resources.

## 2.2 Current circumstances requiring the need for this study

Since 2015, Calvinia has increasingly been experiencing water supply problems. These problems were primarily caused by the following:

**a. Extensions of the town due to the government drive to provide housing for indigent families.**

(Number of households have increased from 2 020 in 2001 to 2 560 in 2018)

**b. Lack of sufficient winter rainfalls to fill the Karee Dam.**

(Measured rainfall in the 2015/16 season amounted to only 30mm, and in 2016/17 only 42mm was measured in the Karee Dam catchment area. During the 2017/18 season, the Karee Dam filled up to only 65% of its total capacity. To date no winter rains of any significance has fallen since the winter commenced in May 2018. The dam is currently only 22% full.)

c. **Deterioration of the existing sources**

(Currently only 4 of the existing 7 production boreholes are able to deliver their tested sustainable yield. This is also due to the lack of rainfall, as there has been no significant groundwater recharge since 2015, subsequently, the groundwater levels have dropped dramatically.)

**d. Dry climate with little rainfall to recharge the aquifers currently utilized as water source.**

(Calvinia has an average rainfall of only **198mm per annum** and an average **evaporation rate of 1600mm per annum**. The town is located on the edge between the winter and summer rainfall regions. Winter rainfall normally occurs due to cold fronts which move inland from the southwest, summer rainfall is usually in the form of thunderstorms if they do occur. The past 10 years, the summer rainfall has not contributed to any meaningful run-off to recharge the existing aquifers. The Calvinia area is seriously prone to drought conditions, and have been throughout their history. The occurrence of 4 to 5 year droughts is a regular pattern in this area.)

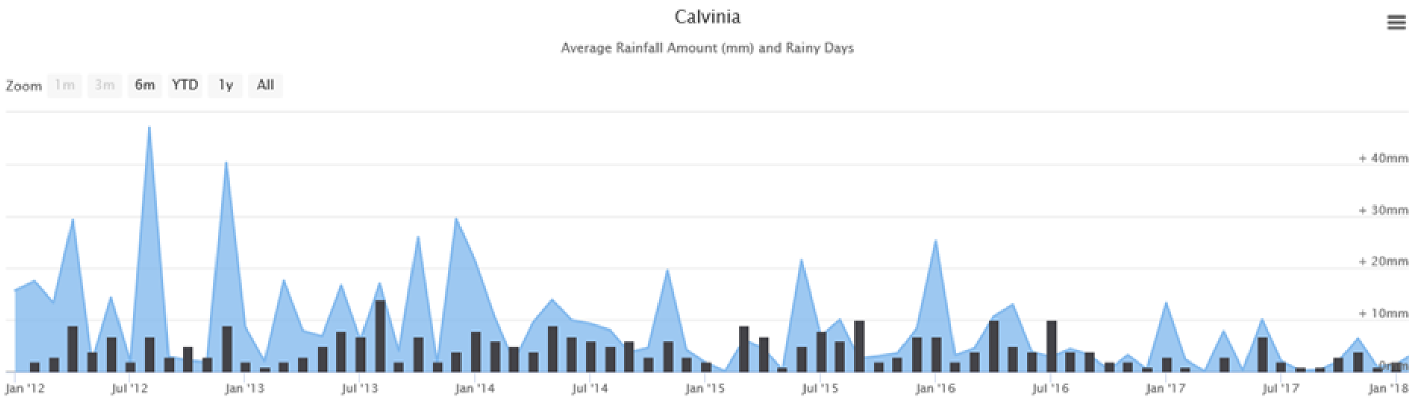



**Figure 19: Long-term average rainfall and rain days for Calvinia**

### e. Population growth

(Population has increased from 8 454 persons in 2001 to 9 680 persons in 2011(Census 2011))

### f. Supply of free basic water

(15.7% of the community, or 1 520 persons have a monthly income which is less than the value of two state pensions (R3 780-00) and rely on grants and state pensions for income; they are classified as indigent and therefore qualify for free basic services. This places enormous financial strain on the Municipality leading to shortage of funding for maintenance)

### g. Lack of potential resources to augment the current water supply

(Calvinia is located in close proximity to the Oorlogskloof River, this river is ephemeral and flows only occur after significant rainfall and then flow is fleeting. The closest other surface water source, is the Doring River. The only other source of water remaining for exploitation is further groundwater exploration in an area notorious for its lack of this resource.)

# 3 STRATEGIC FIT STATEMENT

## 3.1 National Water Resource Management Strategy

The Second Edition of the National Water Resource Strategy (NWRS2) builds on the first National Water Resource Strategy (NWRS1) published in 2004. The purpose of the NWRS2 is to ensure that national water resources are protected, used, developed, conserved, managed and controlled in an efficient and sustainable manner towards achieving South Africa's development priorities in an equitable manner over the next five to 10 years. This Strategy responds to priorities set by Government within the National Development Plan (NDP) and National Water Act (NWA) imperatives that support sustainable development. The NWRS2 acknowledges that South Africa is a water-stressed country and is facing a number of water challenges and concerns, which include security of supply, environmental degradation and resource pollution, and the inefficient use of water.

As water is essential for human life, the first priority of the National Water Resource Strategy is to ensure that water resource management supports the provision of water services, i.e. suitably treated drinking water and safe sanitation to ALL people, but especially to the poor and previously disadvantaged.

One of the objectives of NWRS2 is the continuous development of groundwater as a resource. Groundwater is recognised as an important strategic water resource in South Africa, within a developmental water management approach.

Given the above, this project to augment the water supply to Calvinia, using either surface water or groundwater as source, meets the strategic objectives of the National Water Resource Strategy as well as the National Development Plan in that it will aim to augment the water supply of a town in which there are primarily, poor and previously disadvantaged persons residing. In addition, it will serve to prevent potential health problems which exist in Calvinia where the residents are consuming water of marginal quality, as that is what is available.

## 3.2 Municipal Backlogs

The Hantam Municipality, as many others in the Northern Cape, are continually trying to decrease their backlogs in terms of housing, water supply, sanitation and electricity.

Calvinia is well off in terms of backlogs in that the water reticulation system currently can provide 100% of households in the town with potable water to the RDP standard or better when sufficient bulk water is available.

The Municipal Annual Report July 2018 declares that all households in Brandvlei have yard taps or in-house water supply. These include the small number of informal houses (247 stands).

The sanitation in Calvinia is of similar situation with almost all households having flush toilets draining either to a conservancy tank (792 stands [31.5%]), or to a waterborne reticulation network (1 431 stands [57%]). There are only 39 stands (1,55%) with VIP toilets. A proposed RDP housing development comprising 247 stands has been on hold since 2011, and these stands are being temporarily served with Buckets (9.84%).

The complete infrastructure planning and design for these 247 stands was already completed in 2011, it is just a matter of funding that is preventing this infrastructure from being constructed.

## 3.3 Service Quality

Due to Hantam Municipality consisting of four towns, a political decision was taken by the municipal council that the standard of service in all three towns is to be similar for all residents. For this reason, Calvinia mostly has a better than RDP level of service.

This is problematic in terms of the fact that Calvinia's current water sources, the Karee Dam , and backup groundwater sources are being severely impacted by the continuing drought conditions. The current sources are just not able to supply the residents with sufficient water due to below normal winter rainfall, which have now for the 3rd year failed to fill the Karee Dam, and the lack of rainfall in general, which has led to below average recharge of the groundwater sources.

## 3.4 Alignment with IDP and WSDP

The Hantam Municipality have an active Integrated Development Planning process in place and their last valid IDP was recently completed. The Hantam Municipality Integrated Development Planning for 2015 to 2020 is available on their website.

The Water Services Development Plan for this Municipality is continuously updated and the last draft was submitted to DWA in 2017 for review. ***The provision of additional water to Calvinia is listed as a priority project in both the IDP and the WSDP.***

# 4 EXISTING DATA

## 4.1 Population Data

Population data for Calvinia from 1996 onwards is extremely difficult to obtain due to demarcation of municipalities having taken place. Since 1999, population data was collected by ward and not by town. Calvinia forms part of Hantam Ward 1 & 2 which includes tracts of farmland surrounding the town. The population of Calvinia is therefore as follows:

**POPULATION DATA: 2001** *(STATSSA CENSUS 2001)*

| POPULATION | HOUSEHOLDS | PERSONS / HH |
|---|---|---|
| 8 454 | 2 020 | 4.20 |

**POPULATION DATA: 2011** (STATSSA CENSUS 2011)

| POPULATION | HOUSEHOLDS | PERSONS / HH |
|---|---|---|
| 9 680 | 2 509 | 3.85 |

**Figure 20: Population Data for Calvinia**

This data reflects a population increase of some 14.5% over a period of 10 years which equates to an average of 1.4% per annum.

It is difficult to explain the reason for this, but it is assumed that because of the increase in the availability of subsidized housing, and improvement in the availability of basic services such as water and sanitation, more people and their extended families have started to live in Calvinia than before.

It must be noted that although the number of households have increased, as well as the population, the number of persons per household have decreased from an average of 4.2 in 2001 to an average of 3.85 in 2011. This is a clear indication that many backyard dwellers have now moved into their own homes.

The official growth rate for the Hantam Municipality area is indicated as **0.60% per annum** by Statistics SA. For the purposes of projecting future demand, the latter figure will be used in lieu of the growth rate of 1.9% as calculated.

### 4.2 Household and Per capita Income

The income distribution in Calvinia is given in the table below as supplied by Statistics SA for the 2011 Census.

| INCOME | No. OF PEOPLE | PERCENTAGE |
|---|---|---|
| No income | 581 | 6.00% |
| R1 - R4,800 | 252 | 2.60% |
| R4,801 - R9,600 | 426 | 4.40% |
| R9,601 - R19,600 | 1520 | 15.70% |
| R19,601 - R38,200 | 2255 | 23.30% |
| R38,201 - R76,400 | 1859 | 19.20% |
| R76,401 - R153,800 | 1278 | 13.20% |
| R153,801 - R307,600 | 1007 | 10.40% |
| R307,601 - R614,400 | 368 | 3.80% |
| R614,001 - R1,228,800 | 77 | 0.80% |
| R1,228,801 - R2,457,600 | 39 | 0.40% |
| R2,457,601+ | 19 | 0.20% |

**Figure 21: Income distribution for Calvinia population**

From this data it is quite clear that ***27.30% of the population in Calvinia have a disposable income below the generally accepted poverty threshold*** of R3 780-00 per month. During an on-site survey conducted in January 2017, people were often not willing to say what they were earning on a monthly basis. With the data that was collected, the following facts came to light:

- Of the 3 380 economically active (employed and unemployed but looking for work) people in the municipality, 3,88% are unemployed.
- The official unemployment level is however given as 29.4%.
- Some 6% of the population have no income whatsoever
- The balance of the population receives social grants from the government in the form of pensions, disability allowances, child welfare grants or guardianship grants. The income in these homes varies between R1 690-00 to R3 780-00 per household per month.
- The Hantam Municipality's Indigent policy states that any household with an income less than R3 780-00 per month is considered indigent. If this norm is

applied to the population of Calvinia, it means that 13% of the community, or some 1 259 persons lives in extreme poverty and qualify to register as indigents.

- Municipal records indicate that only 305 households of the 2 509 households are officially registered as indigents and these households are subsidized by an amount of R293-78 per month per household to cover the cost of basic services.

- The payment percentage for municipal accounts is reasonable at **68%.** Many of the municipal account holders have outstanding balances due to the Municipality. The implementation of pre-paid electricity metering has over the past few years given the Municipality a tool with which they could collect amounts from households in arrears. Subsequently, levels of debt are under relative control to a large degree, but the municipal council will need to improve the collection of bad debt.

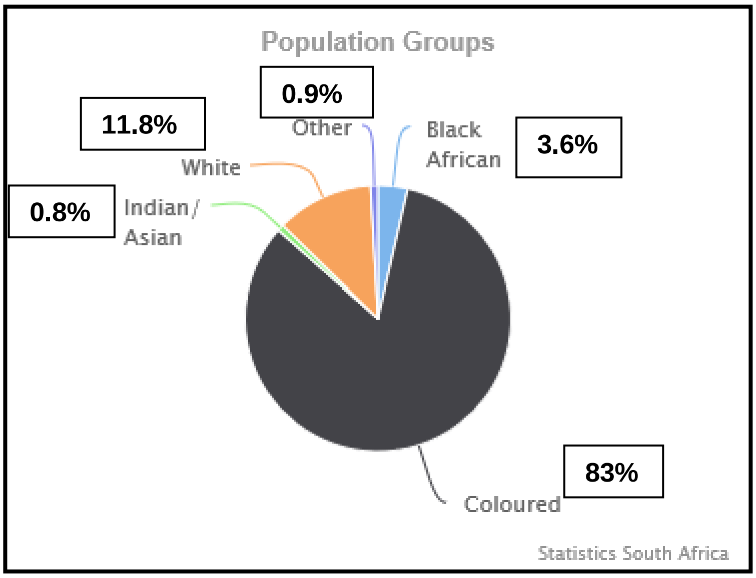



**Figure 22: Population profile for Brandvlei**

- The population is predominantly from the Coloured grouping

- Only 8.6% of the population are considered aged persons between 65 years and older, some 794 persons fall into this category.

## 4.3 Water Demand

The theoretical water demand for Calvinia is calculated in the table under Item 1.3.5 on page 17 as **1568m$^3$ per day**. This is the Average Annual Daily Demand based on a per capita consumption of 125 litres per day per person.

The water demand data for Calvinia based on historic records from 1975 to December 2018 indicate a Daily Demand between **968m$^3$/day in the winter months and 1 235m$^3$/day in the summer months** which correlates well with the theoretical calculation.

The annual safe 1: 50-year yield from the Karee Dam is calculated at **767m$^3$/day** or approximately 280 000m$^3$/annum. This why the town runs out of surface water towards the last months of the summer and then need to augment the supply from the groundwater sources.

The theoretical delivery capacity of the existing wellfield at Calvinia should be able to cope with this demand under normal circumstances. The capacity of the wellfield was determined by conducting sustainable yield tests on the boreholes in 2017 and determined to be in the order of **1 100 m$^3$/day.**

Unfortunately, it appears as if the installed pump capacity does not match the sustainable yield, as the measured delivery is only a maximum of 916 m$^3$/day under ideal conditions. The difference between the theoretical capacity and the current capacity is mostly due to the declining water table which increases the delivery head of the pumps, leading to lower flow rates.

During periods of below average rainfall as has been experienced at Calvinia since 2015, the lack of recharge has a significant effect on groundwater levels which then reduces the flow exponentially. During drought conditions, the available yield decreases from 1 100m$^3$/day to below 700m$^3$/day very rapidly. If the Karee Dam is unable to impound sufficient water in the winter months, it dries up by November as has occurred on three occasions since 2015. This occurrence places the sustainable supply of water to Calvinia under severe pressure and then stringent water restrictions need to be implemented to manage the situation.

For purposes of comparison, the theoretical delivery capacity of the current well field is shown, as well as what is currently being delivered.

| Calender Year | Water Demand ($m^3$/day) | Karee Dam Yield ($m^3$/day) | Borehole Field Yield ($m^3$/day) | Combined Yield (Karee Dam + Groundwater) ($m^3$/day) |
|---|---|---|---|---|
| 1975 | 508 | 550 | 175 | 725 |
| 1979 | 595 | 575 | 175 | 750 |
| 1980 | 380 | 225 | 105 | 330 |
| 1982 | 875 | 325 | 175 | 500 |
| 1983 | 912 | 680 | 352 | 1032 |
| 1984 | 905 | 680 | 352 | 1032 |
| 1985 | 749 | 680 | 352 | 1032 |
| 1986 | 871 | 627 | 352 | 979 |
| 1987 | 985 | 727 | 352 | 1079 |
| 1988 | 1058 | 727 | 352 | 1079 |
| 1989 | 987 | 750 | 352 | 1102 |
| 1990 | 1150 | 750 | 450 | 1200 |
| 1991 | 1116 | 750 | 450 | 1200 |
| 1992 | 1173 | 765 | 450 | 1215 |
| 1993 | 1238 | 767 | 500 | 1267 |
| 1994 | 1275 | 775 | 525 | 1300 |
| 2008 | 1330 | 785 | 565 | 1350 |
| 2010 | 1358 | 845 | 575 | 1420 |
| 2012 | 1488 | 900 | 615 | 1515 |
| 2013 | 1618 | 965 | 680 | 1645 |
| 2014 | 1615 | 978 | 715 | 1693 |
| 2015 | 1656 | 1005 | 700 | 1705 |
| 2016 | 1457 | 850 | 685 | 1535 |
| 2017 | 1008 | 425 | 640 | 1065 |
| 2018 | 1296 | 625 | 680 | 1305 |
| **2019** | 1014 | **625** | **550** | **1175** |
| **2020** | **1435** | **780** | **705** | **1485** |
| **2021** | **1475** | **780** | **710** | **1490** |
| **2022** | **1479** | **780** | **715** | **1495** |
| **2023** | **1501** | **785** | **720** | **1505** |
| **2024** | **1524** | **785** | **725** | **1510** |
| **2025** | **1547** | **785** | **728** | **1513** |
| **2026** | **1570** | **785** | **730** | **1515** |
| **2027** | **1594** | **785** | **735** | **1520** |
| **2028** | **1618** | **785** | **741** | **1526** |
| **2029** | **1642** | **785** | **747** | **1532** |
| **2030** | **1667** | **785** | **753** | **1538** |

**Figure 23: Water Demand compared with Yield**

As shown above, since 2015, the towns’ water demand could not be met by even running the pumps for 24 hours due to the rapidly declining water table. The Karee Dam was empty during this period and water restrictions needed to be implemented to cope with the available water. This practice is not advisable as there is then no recovery period available for the respective boreholes. If there is a constant shortage of water, municipalities' dependent on groundwater often fall into this trap of over abstracting their boreholes in an effort to meet the demand. Since 2015, all boreholes remaining with water available had been pumped for 24 hours. Luckily, in 2018, Calvinia was blessed with winter rains on 3 occasions which lead to the Karee Dam impounding sufficient water to reach 65% of Full Supply Level. Subsequently, Calvinia never ran out of water, but did approach such a possibility on at least 3 occasions over the past 5 years.

Water restrictions were implemented by the Hantam Municipality from 1st February 2014 and the drop in water demand can be clearly seen, as the consumption declined significantly and is currently still below average due to the restrictions still being in place. Supply of water was restricted to 40 kilolitres per household per month. On exceeding 40 kilolitres, severe penalties were imposed on consumers. As can be seen from the sharp decline, the community responded positively to this arrangement and a disaster was subsequently averted.

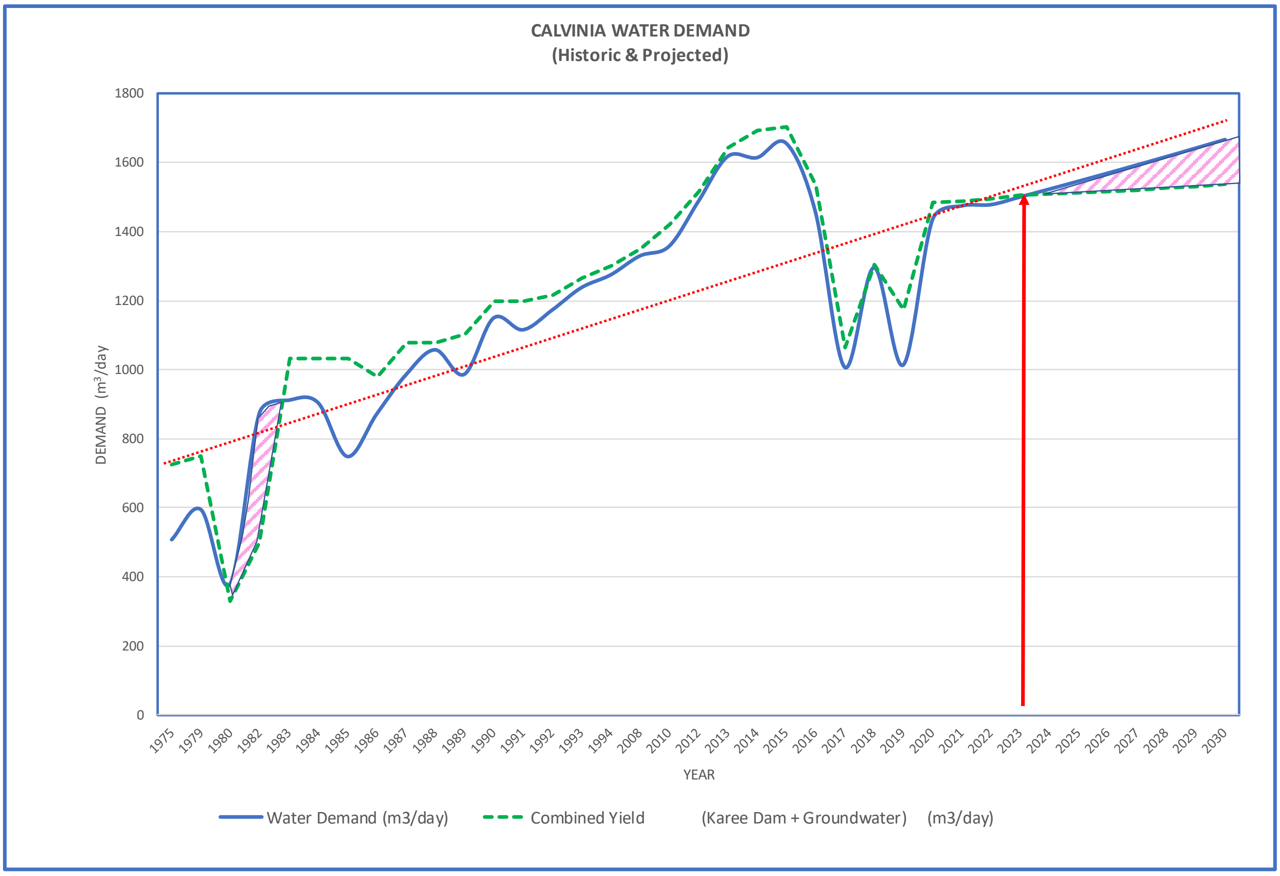



**Figure 24: Graphic presentation of historic and projected water demand**

The shaded areas in the graph indicate where the demand exceeds the yield from the water sources. *The calculation indicates that by 2023, the demand will exceed the current available yield from both the Karee Dam and the groundwater sources.*

If a linear growth curve is fitted to the available historic consumption data, excluding the data experienced during the drought conditions, a projected annual demand in the order of **560 000kl per annum (18 litres per second)** is expected by 2030. This figure corresponds well with that given in the May 2011 *"DEVELOPMENT OF RECONCILIATION STRATEGIES FOR ALL TOWNS IN THE CENTRAL REGION: - Reconciliation Strategy for Calvinia"* as commissioned by the Department of Water Affairs which returned a figure of 0.556 million $m^3$ per annum.

This projection assumes that the population will continue to grow at the current rate of 0.59% per annum which is often not the case in small Northern Cape towns. In fact, the Community Survey conducted in 2016, shows that the population in the Northern Cape has in fact decline by 0.2%.

If the bulk water requirement of Calvinia is calculated theoretically, using the existing population and growth rate and the parameters prescribed by the handbook for Human Settlement, Planning and Design Volume 1 (Red Book) and using a per capita consumption of *100 litres per person per day*, the expected current and future flows are slightly lower at 14.52 **litres per second** for the current situation and **16.37 litres per second** for the future scenario.

## 4.4 Per Capita consumption

During the development of the Department of Water Affairs' All Towns' Study in 2011, the per capita consumption of Calvinia was determined to be **125 litres per capita per day**. It was, at the time, deemed acceptable given that the study worked on a norm of 150 litre/capita /day for the underdeveloped Rural Areas and Low income group.

Since 2014, the per capita consumption for Calvinia has decreased to around **98 litres per capita per day** primarily due to the water restrictions imposed. This is still well below the national average of 150 litres / capita / day for lower income population.

For calculation purposes of this study, BVi have, in agreement with the Hantam Municipality, decided to use a per capita consumption of 100 litres per person per day.

## 4.5 Demand Management

The Municipality has on several occasions endeavoured to manage this situation by implementing water conservation programs. Examples of this are:

- implementation of a stepped tariff structure,
- repairs to leaking toilet cisterns,
- promotion of water wise gardening
- Eradication of alien plants in the aquifer catchment area
- Rainwater harvesting project
- Re-use of treated effluent for irrigation of sports fields in lieu of potable water
- Restrictions on the use of private and public swimming pools

A study was also conducted by BVi Consulting Engineers in 2012 to calculate the unaccounted-for water as well as the physical losses in the water supply system. The losses for Calvinia were quantified as follows:

**Unaccounted for water:** **22%**

(Difference between water supplied and water billed)

**Physical Losses:** **13%**

(Difference between water produced and water supplied)

The large percentage of unaccounted for water my be due to the Free Basic Water Policy where everybody does not necessarily receive a monthly account, and given that some 305 households in Calvinia receive this benefit, this apparent loss could be reduced significantly if the recordkeeping is conducted more effectively. Our study showed that there was a deficit for 8 months of the year, while for 4 months there was a surplus.

The physical losses, although still within the acceptable range of 15%, are mostly attributed to the waste incurred at the Calvinia Water Treatment Plant due to desludging of clarifiers and backwashing of filters. Calvinia does suffer the occasional pipe failure, but the reticulation network losses are minimal. There is currently a MIG project underway to irrigate the town and school sport fields with Treated Effluent. Once this project is completed, a saving in excess of 300m3/day on drinking water can be generated.

The Municipality does have a Free Basic Water Policy in place for registered indigents only and all households have metered connections. These connections are however not limited in terms of volume which means there is no control over consumption. Users simply get their free allocation and are billed for the balance.

## 4.6 Current Water Pricing Structure

| CALVINIA BULK WATER SUPPLY<br>WATER TARIFFS FOR 2018 / 19 | |
|---|---|
| **0kl – 6kl – Indigents** | **FREE** |
| **0kl – 6kl** | **R5.39** |
| **7kl – 30kl** | **R6.96** |
| **31kl – 40kl** | **R7.15** |
| **41kl – 60kl** | **R7.63** |
| **60kl and higher** | **R7.74** |
| **> 40kl per household during restrictions** | **R45.00** |
| **> 60kl per household during restrictions** | **R65.00** |

**Figure 25: Current Water Tariff structure for Brandvlei**

When compared with other towns in the Northern Cape, the tariffs are in fact quite low and could be increased substantially. Again, the setting of tariffs is heavily influenced by political decision makers as they always have the interests of their communities, who are generally poor, in mind. Again, one set of tariffs is applied for all the towns within the Hantam Municipality and this is not necessarily a true reflection of the operational cost of each towns' system.

## 4.7 Water Quality Data

The quality of the water from the existing individual boreholes is of marginal quality with salinity levels exceeding the SANS 241 requirement. Two boreholes have elevated levels of sulphur occurring and the Golf Course Borehole has high levels of hydrogen sulphide gas in solution. The water from the Kopasfontein boreholes (Breccia Pipe) has very high levels of arsenic and should only be used in emergency situations and with the required treatment taking place.

| Analyses | Ceres_RD | Sandgat_4 | Golf_course | Witwal_BH | Sandgat_3 | Deon_Vlok | Sandgat_5 | SANS 241-1:2015 |
|---|---|---|---|---|---|---|---|---|
| pH (at 25 °C) | 7.6 | 7.4 | 7.4 | 8.4 | 7.5 | 7.5 | 7.0 | ≥5 - ≤9.7 Operational |
| Conductivity (mS/m) (at 25 °C) | 59.2 | 598.6 | 214.0 | 93.0 | 605.0 | 150.0 | 279.0 | ≤170 Aesthetic |
| Total Dissolved Solids (mg/l) | 379.0 | 3831.0 | 1283.0 | 561.0 | 3600.0 | 901.0 | 1670.0 | ≤1200 Aesthetic |
| Turbidity (NTU) | 0.6 | 0.3 | 1.4 | 0.4 | 0.2 | 1.4 | 0.4 | ≤5 Aesthetic ≤1 Operational |
| Colour (mg/l as Pt) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤15 Aesthetic |
| Sodium (mg/l as Na) | 38.7 | 706.9 | 190.3 | 175.6 | 929.4 | 128.3 | 305.7 | ≤200 Aesthetic |
| Potassium (mg/l as K) | 1.4 | 1.0 | 5.1 | 7.4 | 1.8 | 3.1 | 4.6 | N/A |
| Magnesium (mg/l as Mg) | 12.5 | 118.8 | 60.4 | 0.4 | 139.1 | 55.3 | 70.8 | N/A |
| Calcium (mg/l as Ca) | 52.5 | 227.6 | 127.7 | 0.0 | 131.8 | 92.1 | 116.1 | N/A |
| Chloride (mg/l as Cl) | 51.0 | 1420.0 | 542.8 | 157.3 | 1564.2 | 225.3 | 761.9 | ≤300 Aesthetic |
| Sulphate (mg/l as SO4) | 26.0 | 664.0 | 112.0 | 94.0 | 769.0 | 177.0 | 194.0 | ≤250 Aesthetic ≤500 Acute Health |
| Nitrate Nitrogen (mg/l as N) | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | ≤11 Acute Health |
| Nitrite Nitrogen (mg/l as N) | 0.4 | 0.8 | 0.0 | 0.0 | 0.6 | 0.0 | 0.6 | ≤0.9 Acute Health |
| Ammonia Nitrogen (mg/l as N) | 0.3 | 0.4 | 0.3 | 0.6 | 0.3 | 0.0 | 0.3 | ≤1.5 Aesthetic |
| Total Alkalinity (mg/l as CaCO3) | 284.0 | 511.0 | 167.9 | 181.4 | 388.0 | 278.6 | 132.5 | N/A |
| Fluoride (mg/l as F) | 0.5 | 0.2 | 0.2 | 1.4 | 0.0 | 0.8 | 0.0 | ≤1.5 Chronic Health |
| Aluminium (mg/l as Al) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.3 Operational |
| Vanadium (mg/l as V) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | N/A |
| Total Chromium (mg/l as Cr) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.05 Chronic Health |
| Manganese (mg/l as Mn) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | ≤0.1 Aesthetic ≤0.4 Chronic Health |
| Iron (mg/l as Fe) | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | ≤0.3 Aesthetic ≤2 Chronic Health |
| Cobalt (mg/l as Co) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | N/A |
| Nickel (mg/l as Ni) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.07 Chronic Health |
| Copper (mg/l as Cu) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤2 Chronic Health |
| Zinc (mg/l as Zn) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | ≤5 Aesthetic |
| Arsenic (mg/l as As) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.01 Chronic Health |
| Selenium (mg/l as Se) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.04 Chronic Health |
| Cadmium (mg/l as Cd) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.003 Chronic Health |
| Antimony (mg/l as Sb) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.02 Chronic Health |
| Mercury (mg/l as Hg) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.006 Chronic Health |
| Lead (mg/l as Pb) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.01 Chronic Health |
| Uranium (mg/l as U) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.03 Chronic Health |
| Cyanide (mg/l as CN-) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ≤0.2 Acute Health |

**Figure 26: Water Quality analysis results for existing production boreholes at Calvinia**

The water from all the boreholes is pumped into a common reservoir and a blend of the above water is supplied to the residents. As can be seen from the above table, all parameters with a yellow background have aesthetic issues in terms of taste, while the parameters highlighted in red have potential health effects. In this case, the primary problems are high levels of sodium, chloride, Total Dissolved Solids and Sulphate.

Salinity or the presence of high concentrations of sodium, chloride and other soluble salts is a common occurrence in groundwater. Typically, humans require minimum quantities of these salts to maintain the body's electrolyte equilibrium, but excessive salinity can lead to issues with hypertension, cardiovascular disease and renal disease.

### *Sodium*

The taste threshold for sodium is between 135 and 200mg/l, where after a faint salty taste is detected by most people. Above 400mg/l, the taste is distinctly salty, but with no adverse health effects for healthy persons. Above 600mg/l, it becomes undesirable for persons on a sodium restricted diet. Several of the existing boreholes at Loeriesfontein exceed the taste thresholds for sodium.

### *Chloride*

Chloride is only detectable by taste above concentrations of 200mg/l. Similar to sodium, chlorides become definitely salty to taste above 400mg/l and objectionable above 600mg/l. Again, several boreholes at Loeriesfontein exceed the latter concentration.

### *Total Dissolved Solids*

This indicates the concentration of various inorganic salts dissolved in water. TDS is also proportional to Electrical Conductivity of the water. Virtually all natural waters contain varying concentrations of TDS, with surface waters generally having a significantly lower concentration than groundwater sources. Again, TDS is an indication of salinity in water. Typically, salty taste is only detected above 1000mg/l with no health effects. Between 1000 and 2000mg/l, the salty taste is definite and may become objectionable.

### *Sulphate*

Consumption of excessive amounts of sulphate in drinking water typically results in diarrhoea. Sulphate imparts a bitter or salty taste to water, and is associated with varying degrees of unpalatability.

High concentrations of sulphate exert predominantly acute health effects (diarrhoea). These are temporary and reversible since sulphate is rapidly excreted in the urine. Individuals exposed to elevated sulphate concentrations in their drinking water for long periods, usually become adapted and cease to experience these effects. Sulphate concentrations of 600 mg/litre and more cause diarrhoea in most individuals. Sulphate imparts a salty or bitter taste to water. The taste threshold for sulphate falls in the range of 200 - 400 mg/litre and depends on whether the sulphate is predominantly associated with either sodium, potassium, calcium or magnesium, or mixtures thereof.

Complaints about bad tasting water are common in Calvinia and people, as a rule, try to avoid drinking the municipal water when supplied from the boreholes due to this taste problem. The matter can be alleviated by means of an ion exchange process which targets the removal of the sulphates.

# 5 ASSUMPTIONS

## 5.1 Current and Future Demand

From the historical data collected and analysed, the current demand equates to a figure of **473 000 $m^3$ per annum**.

Projected future demand at a growth rate of 0.60% is calculated at **575 000$m^3$ per annum by 2030** which is a mere 11 years away.

Calvinia’s water supply is highly dependent on sufficient winter rains to fill the Karee Dam. If the Karee Dam does not impound sufficient water, the existing wellfield struggles to meet the demand. Our calculations indicate that by 2022, the towns’ demand and what the existing sources can supply will balance. From 2023 onwards, a deficit will be experienced. The fact that Calvinia is dependent on a single wellfield is problematic. Subsequently, it will be strategically important to find additional sources for Calvinia other than the existing wellfield. If Calvinia were to run out of water, the towns’ location and distance from other known sources of water, makes carting of water, even in an emergency, almost impossible due to the volumes required and vast distances for carting.

## 5.2 Current and Future Water Resources

There are no further opportunities to exploit more water from the Karee Dam. Subsequently, Calvinia is fully dependent on groundwater resources to meet the demand for at least 4 to 6 months of every year.

There are possibilities of additional groundwater resources that need to be explored within a radius of 40km around Calvinia as per reports done previously by both private consultants as well as the Department of Water Affairs. This area is however notorious for its scarcity of water as well as the poor chemical quality generally encountered.

In terms of surface water possibilities, Calvinia is located very far from any potentially viable surface water resources. The Orange River is located approximately 284km northwest. There is a possibility of bringing Orange River from Kenhardt, where a transfer scheme was constructed in 2010. Kenhardt is 278km from Calvinia. The

Doring River, 100km to the southwest, is the other option, unfortunately, this river is not perennial, and only flows from May to October every year after precipitation has occurred in the Koue Bokkkeveld.

The only other source of water remaining for relatively affordable exploitation, is further **groundwater exploration** in an area notorious for its lack of this resource.

## 5.3 Project Funding

As the current Municipal Infrastructure Grant for the Hantam Municipality only runs to some R9 000 000 – 00 per annum for the whole municipal area, it is simply not feasible to fund projects such as proposed in this document with this source.

Having a tax base consisting of more than 85% indigent households, it is basically impossible for this Municipality to increase their revenues from this source. In addition, this situation makes it increasingly difficult for them to qualify for commercial loans from banks, etc. to fund a project of this nature.

It is therefore assumed that the primary funding for this project will need to be in the form of a grant from a government department or an external benefactor.

The Regional Bulk Infrastructure Grant only funds the social component of these type of projects. Subsequently, the Hantam Municipality will need to fund the economic component by means of counter funding. In the case of Calvinia, this will difficult for them, as the proportion of the economic component to the social component is fairly high. It may be pertinent for the Hantam Municipality to apply for exemption with regards to the counter funding requirement.

# 6 UNCERTAINTIES

## 6.1 Possible Obstructions/Limitations

### 6.1.1 Cost Factor

The primary obstructions and limitations of a proposed project to augment the Calvinia water supply from any possible resource, be it ground or surface water, is the cost factor.

The financial position of the Hantam Municipality is similar to many others in the Northern Cape Province. This situation means that this Municipality is not able to embark on critical projects of this nature without financial assistance in the form of a grant.

Should the Municipality take up a loan to fund such a project, they would not be able to service the loan repayments from sales of water due to the socio-economic status of the majority of their inhabitants.

### 6.1.2 Technical Capacity

The Hantam Municipality does have sufficient, although basic, technical capacity to operate and maintain relatively simple installations such as borehole pump stations and pipelines. This is probably not the case when higher technologies such as reverse osmosis are to be employed. Therefore, the level of technology being used to address this problem should be appropriate for the skills and capacity of the municipal operational staff.

### 6.1.3 Sustainability of the water resource

The third serious obstruction is the availability and medium to long term sustainability of possible water sources. Groundwater sources are largely dependent on recharge from seasonal rainfall. Typically, groundwater sources are no more than an underground reservoir of which the water level must be very carefully managed.

The ideal would be to have several such resources which can be utilized on an alternating basis. This scenario must however be managed by means of ***constant data collection***, **modelling, interpretation of the results and decision making** in terms of utilization.

It is seriously doubted whether the existing municipal resources, in terms of required expertise, are able to manage groundwater resources, to the required degree necessary, to make this water source sustainable over the long-term.

### 6.1.4 Sustainable management of the water resource by means of numeric modelling

A solution for the latter lack of capacity does however exist in that the required expertise can be contracted in on a six-monthly basis as a minimum. Such expertise, in the form of an experienced engineer or experienced geohydrologist, should develop a numerical model for the various aquifers, and continuously feed data into the model, in order to refine and calibrate it.

As more data is collected, the model becomes a predictive model, which can be an extremely useful tool for the management of groundwater resources. It is the opinion of BVi Consulting Engineers, that the development and implementation of such a numerical ground water model is not negotiable, given that Calvinia is largely dependent on groundwater resources for the foreseeable future.

# 7 STRATEGIC RISKS

## 7.1 Risks preventing the continuation of the project

The primary risks preventing the continuation of the proposed water project are:

- **Lack of sufficient funding**
- Sustainability of proposed new water resources due to erratic climate factors
- Objections by private landowners with regards to land access or servitudes
- Possibility of environmental constraints on the proposed routes

## 7.2 Operational risks of the project

The operational risks of the project are fairly limited. The following have been identified as possible operational risks:

- Continued availability of electrical power supply from ESKOM
- Possibility of vandalism and sabotage of items such as air- and pressure control valves
- Lack of continuous preventative maintenance on installed equipment
- Lack of sufficient management of the groundwater resources

# 8 OPTIONS CONSIDERED TO ADDRESS THE OBJECTIVES

## 8.1 Philosophy and Criteria employed

The basic philosophy employed to solve the problem of firstly, supplying enough water to Calvinia, and secondly, supplying water of suitable quality, was to seek a source(s) that was able to be developed viably in terms of economy, sustainability of supply and having a suitable water quality for a 10-to-15-year horizon.

In addition, the solution should be such that it must be easy and affordable to operate and maintain, and this must be possible with the current resources available to the Hantam Municipality.

The following options were investigated:

**Option 1: Abstraction of surface water from the Doring River at Botterkloof Bridge**

**Option 2: Abstraction of surface water from the Doring/Tankwa Rivers confluence.**

**Option 3: Development of further groundwater sources at Kreitzberg and Northwest**

## 8.2 The Doring River

The Doring River is a semi-perennial river originating in the Hex River Mountains just north of Ceres in the Western Cape Province. The Doring River forms a critical part of the Olifants/Doring Water Management Area. The Olifants-Doring Catchment straddles the Northern and Western Cape Provinces and lies within the Namakwa, Central Karoo, Boland and West Coast District Municipalities.

The Doring sub catchment occupies the greater part of the total catchment area and drains the eastern slopes of the Cedarberg, the Swartruggens and the western Roggeveldberge – a more arid, summer rainfall area. The Doring River flows north east into the dry region to the east of the Cedarberg Mountains. It is joined by several small tributaries in its upper reaches. Along the first 150 km the river is naturally seasonal, but now flows for much of the year as a result of an interbasin transfer from Lakenvlei Dam near Ceres (DWAF 2004a). 150km from its source, the Doring River is joined by the perennial Groot River, and becomes a large, often-braided river which flows strongly in winter and maintains some flow for most of the year. Further downstream, it is joined by the seasonally-flowing Tankwa river which drains a large area of the Karoo, and by the seasonal Tra-tra River that drains the Cedarberg. After flowing through a deep gorge for about 60km, the Doring is joined from the west by the Biedou, Brandewyn and Koebee Rivers before entering the Olifants River just upstream of Klawer. The lower sections of the Doring stop flowing for periods of up to several weeks during the summer months, being reduced to a series of pools. The Doring River lies primarily in the E22, E21, E23, E24 and E40 drainage areas.

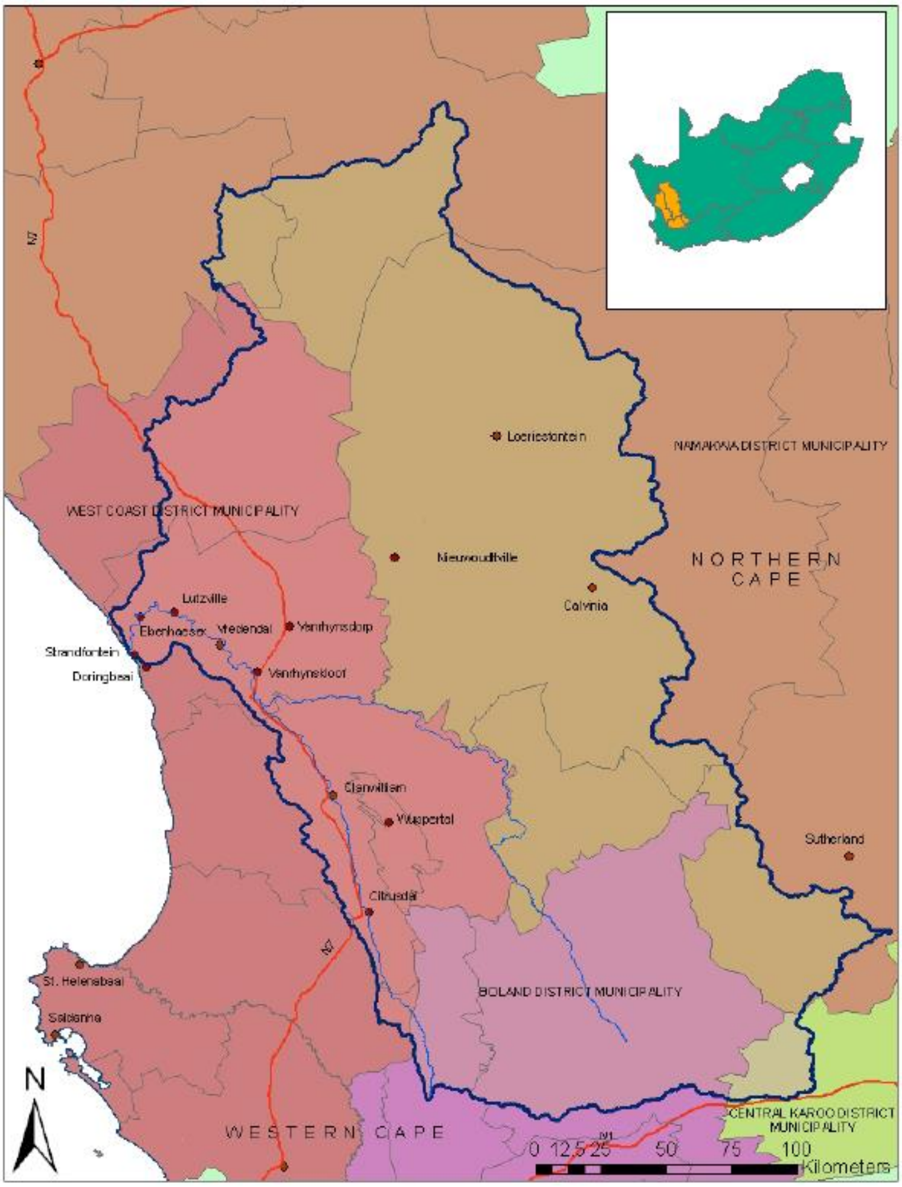



**Figure 27: Geographical location of the Doring River**

The Olifants River is the main river in the catchment, and is a perennial river which rises 280 km from the mouth at about 800 m altitude on the Witzenberg plateau - a winter rainfall area. The Olifants River, is highly developed with two regulating dams, namely the Clanwilliam Dam and the Bulshoek Dam, while the Doring River is not regulated at all and is basically in a pristine condition.

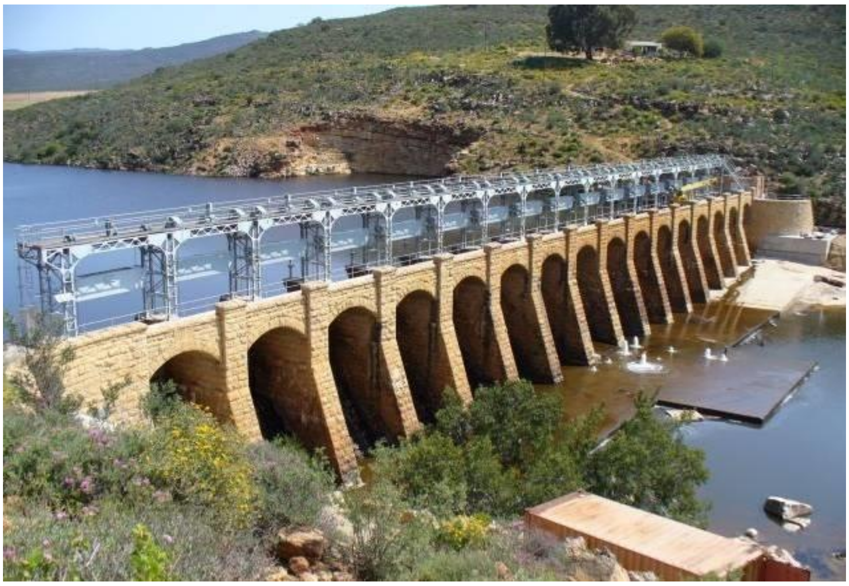


**Figure 28: Bulshoek Dam and Clanwilliam Dam on the Olifants River**

Given that the Doring River is the closest source of surface water to Calvinia, it was considered a viable option as future water source for the town. Although the Doring River is considered to be perennial, it does often stop flowing in summer months and is reduced to stagnant pools of water. Subsequently, the data of two gauging stations in the Doring River were obtained to determine whether there would be sufficient flow to supply water to Calvinia. Gauging Station E2H300 (Melkboom), is located approximately 7km upstream of the Olifants / Doring Rivers confluence at Klawer. This gauging station would therefore indicate the volumes of water that will flow into the ocean at the estuary, and could therefore be seen as the “surplus” water. The long-term data from this gauging station from 2009 to 2017 indicates that there is zero flow occurring every year between December and April, therefore most of the summer months.

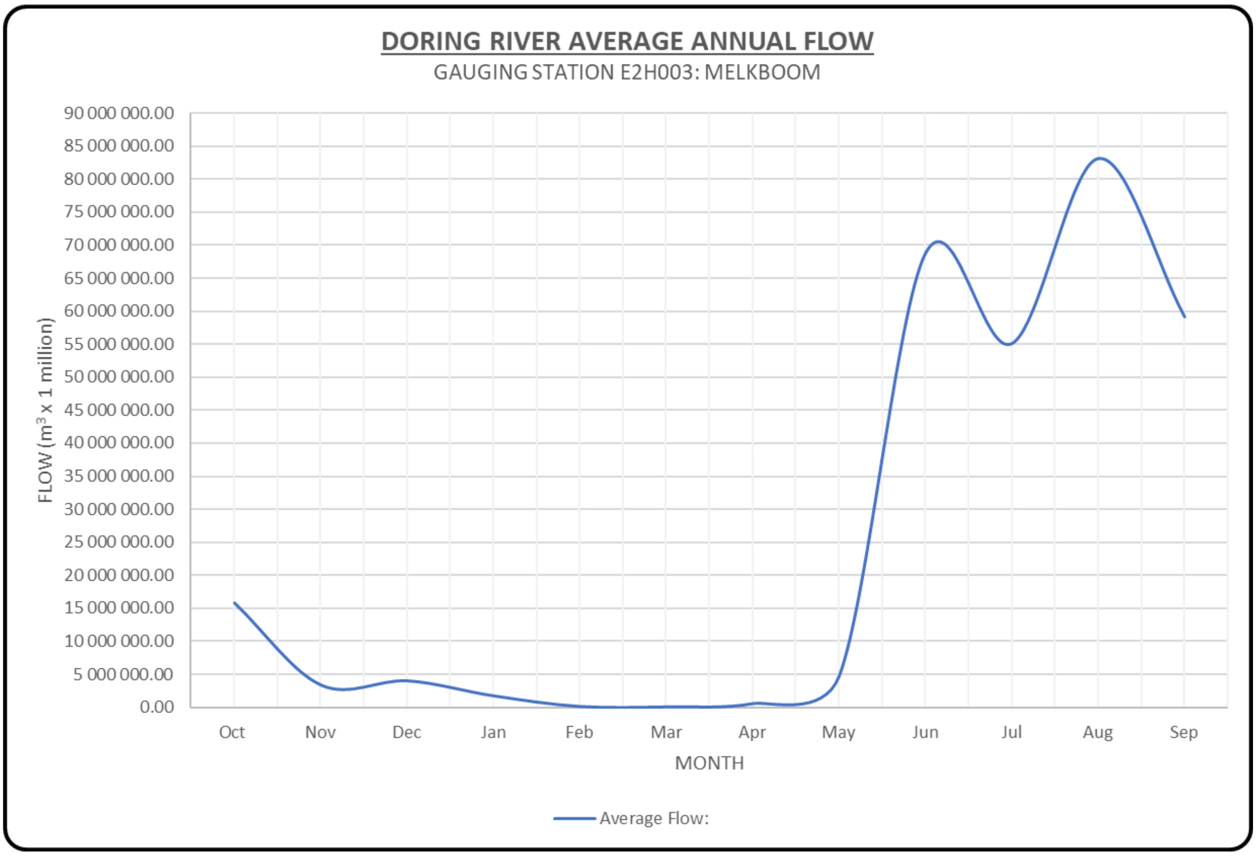



**Figure 29: Flow Data from the Doring River at Melkboom gauging station**

## 8.3 Literature Survey

The Olifants/Doring River Systems have been the focus of several studies and initiatives over several decades in the past that have focussed mainly on assessing the potential of the rivers and groundwater for water resource developments.

Most of these studies have to a greater or lesser extent also considered the impacts on the freshwater environment of proposed developments and in recent years the studies and projects have provided information that has contributed to the knowledge and understanding particularly of the resource protection aspects within the WMA. The focus of previous hydrological studies in the Olifants-Doorn WMA has been the Olifants-Doring system, which has been the subject of numerous studies at the quaternary level. The following could be considered the most important for this project:

- **The Olifants River System Analysis (ORSA) (BKS, 1990)** consisted of an assessment of the existing hydrology of the area upstream of Clanwilliam Dam and the extension of the hydrology to include the area down to Bulshoek Weir. This resulted in calibrated hydrology for the period 1920 to 1988 and a system configuration for the Upper Olifants River and ***calibrated hydrology for the period 1920 to 1990 for the Doring River***.

- **The Olifants/Doring River Basin Study (ORBS) (DWAF, 1998)** consisted of an investigation into the yields and cost of developing potential dam sites in the Olifants and Doring River basins. Part of this study included a review of irrigated areas and associated water requirements.

- **Western Cape Olifants/Doring River Irrigation Study (WORDRIS) (PGWC, 2001)** used the same sub catchments as the Olifants/Doring Basin Study to estimate the total irrigation demand.

- **Olifants-Doorn Water Management Area: Water Resources Situation Assessment (DWAF, 2002)** gives only an estimate of the total irrigated area for the upper Olifants River (i.e. above Bulshoek weir) of 107 km2 and associated demand of 80 millionm3/a. No hydrological analysis was undertaken.

- **The Olifants/Doring River Basin Study (Phase II) (DWAF, 2003)** investigated the potential raising of the Clanwilliam Dam.

- **The Olifants/Doring River Comprehensive Reserve determination study in 2006 for DWA** where a Comprehensive Reserve determination for six sites on the Olifants and Doring rivers was done, and this resulted in Environmental Water Requirements (EWRs) for a range of possible future conditions for the six sites and the Olifants estuary site;

- **Water Resource Classification System for the Olifants/Doorn Catchment in 2006.** The Comprehensive Reserve data was used to extrapolate EWRs to 46 nodes throughout the catchment as part of the proof of concept activities for the development of the Water Resource Classification System (WRCS).

- **The Classification of Significant Water Resources in the Olifants / Doorn Water Management Area (WMA 17)** Final inception Report May 2011 (BlueScience Consulting cc). This report served to investigate the water resources within the WMA and to follow a seven-step classification process during which the social, economic and environmental implications of different class scenarios and configuration in the catchment are investigated and the consequences communicated to the users and stakeholders in the catchment.

The outcome of the classification process provides a Management Class, Resource Quality Objectives and a Reserve requirement for rivers, estuaries, wetlands and aquifers within the study area.

## 8.4 Availability of Water in the Doring River

The 1998 study on Water Resource Development Options indicated that the Mean Annual Runoff of the Doring River was in the order of 500 million $m^3$/annum. Data measured at the confluence of the Doring and Olifants Rivers indicated a usable volume of **430 million $m^3$/annum** from the Doring River.

| Site | Natural runoff | | Present water use | | Nett runoff |
|---|---|---|---|---|---|
| | between sites | at site | between sites | to & at site | at site |
| **Doring River** | | | | | |
| Source | | 0 | | 0 | 0 |
| | 54 | | 19 | | |
| Leeuriver | | 54 | | 19 | 35 |
| | 181 | | 54 | | |
| Grootriver | | 235 | | 73 | 162 |
| | 21 | | 6 | | |
| Aspoort | | 256 | | 79 | 177 |
| | 92 | | 19 | | |
| Reenen | | 348 | | 98 | 250 |
| | 157 | | 10 | | |
| Melkbosrug | | 505 | | 108 | 397 |
| | 8 | | 1 | | |
| Melkboom | | 513 | | 109 | 404 |
| | 1 | | 2 | | |
| Confluence | | 514 | | 111 | 403 |
| | | | | | |
| **Site** | **Natural runoff** | | **Present water use** | | **Nett runoff** |
| | **between sites** | **at site** | **between sites** | **to & at site** | **at site** |
| **Olifants River** | | | | | |
| Source | | 0 | | 0 | 0 |
| | 32 | | 5 | | |
| Rosendaal | | 32 | | 5 | 26 |
| | 33 | | 0 | | |
| Visgat | | 64 | | 5 | 59 |
| | 89 | | 9 | | |
| Grootfontein | | 153 | | 14 | 139 |
| | 13 | | 0 | | |
| Keerom | | 167 | | 14 | 153 |
| | 265 | | 47 | | |
| Clanwilliam | | 431 | | 61 | 370 |
| | 77 | | 51 | | |
| Bulshoek | | 509 | | 112 | 397 |
| | 2 | | 120 | | |
| Confluence u/s of Doring | | 511 | | 232 | 279 |
| Doring River | 514 | | 113 | | |
| Confluence d/s of Doring | | 1 025 | | 348 | 683 |
| | 30 | | -30 | | |
| Estuary | | 1 055 | | 318 | 737 |

**Figure 30: Olifants / Doring Rivers Mean Annual Runoff (million $m^3$/annum)**

In **Report No. P WMA17/000/00/0203: Olifants /Doring Water Management Area: Overview of Water Resources Available and Utilization:2003 (BKS Consulting Engineers)** the available volume at the confluence of the Olifants River and the Doring River was calculated as being **221 million m$^3$/annum**. This is a significant volume of water available for utilization remaining in this system.

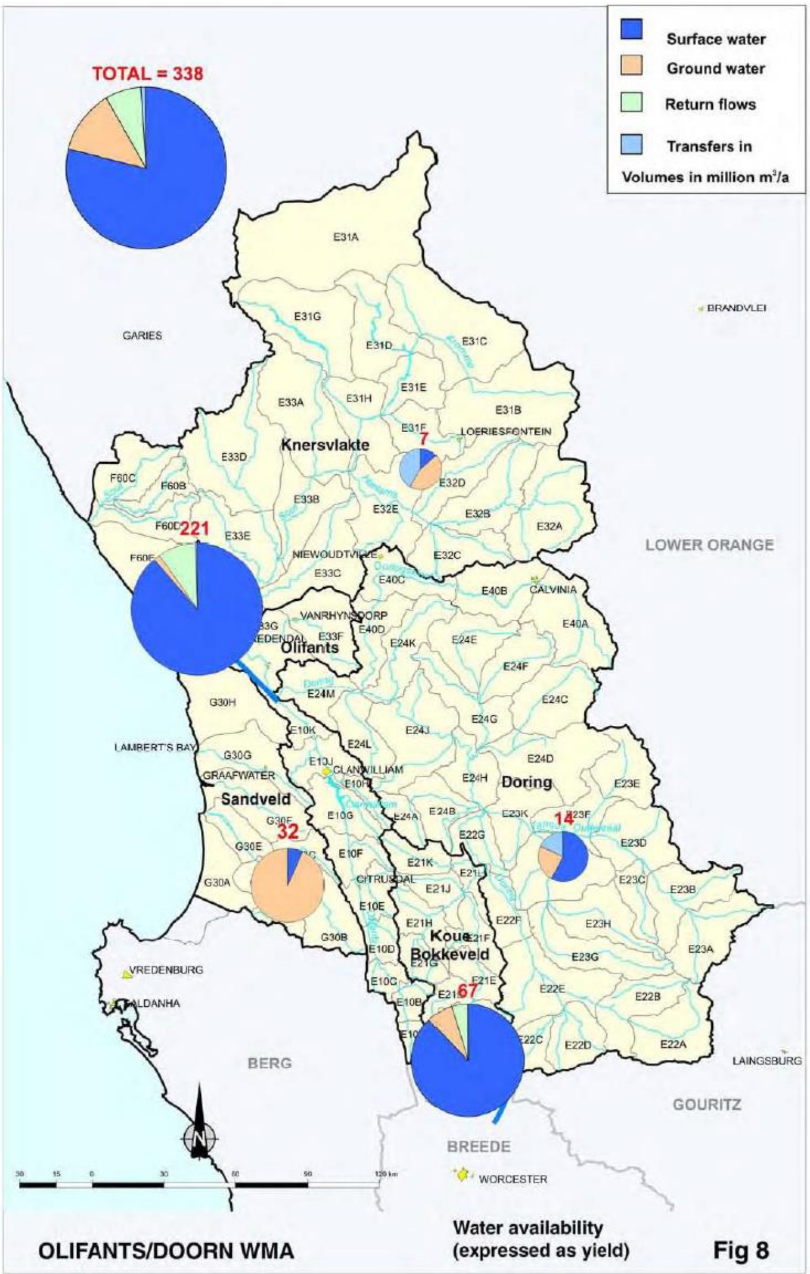



**Figure 31: Water availability from the Olifants / Doorn River system**

Given that Calvinia's annual requirement is currently at **473 000 m$^3$/annum** and a projected future demand at 2030 of **575 000 m$^3$/annum**. Given the available volumes in the Doring River system, it just makes sense to investigate the possibility of transferring water from this system to Calvinia where they are battling to sustain their water supplies year after year.

## 8.5 Option 1: Abstraction of Water from the Doring River at Botterkloof Bridge

### 8.5.1 Concept for the solution

Calvinia is located on the edge of the winter rainfall region, and if it receives sufficient winter rainfall, the Karee Dam is able to impound in the order of 900 000$m^3$ providing an annual yield of 370 000$m^3$/ annum. If the winter rainfall is below average, the above supply of water does not realize and the town is dependent on groundwater sources as an alternate supply.
Option 1 intends to provide water to Calvinia from the Doring River as a sustainable source of surface water. For this option, abstraction of water would take place at the Botterkloof Bridge. Our study has indicated that there is more than sufficient volume of water available from the Doring River to provide a long-term sustainable source as alternative.

A typical scenario would be that, should the rains fail to fill the Karee Dam by the end of July in any given year, the proposed solution would then be activated and a volume of 575 000$m^3$ would need to be pumped to Calvinia in a period of 90 days (before mid December) to fill the Karee Dam and sustain the town for a full year. The reason for this is that the availability of water in the Doring River declines sharply from mid-October. In January, the water in the Doring River is reduced to stagnant ponds. This means that infrastructure such as pumps and pipes would theoretically need to be sized to deal with a flow of:

**575 000$m^3$÷ 3 months÷ 30 days= 6 388$m^3$/day ÷ 20 hours = 319$m^3$/h = 90 litres / second**

If the pumping cycle could commence in May, and be extended to 5 months, instead of 3 months, the requirement would be as follows:

**575 000$m^3$÷ 5 months÷ 30 days= 3 833$m^3$/day ÷ 20 hours = 192$m^3$/h = 53 litres / second**

This while the annual average daily demand for Calvinia only equates to some **20 litres per second** on average.

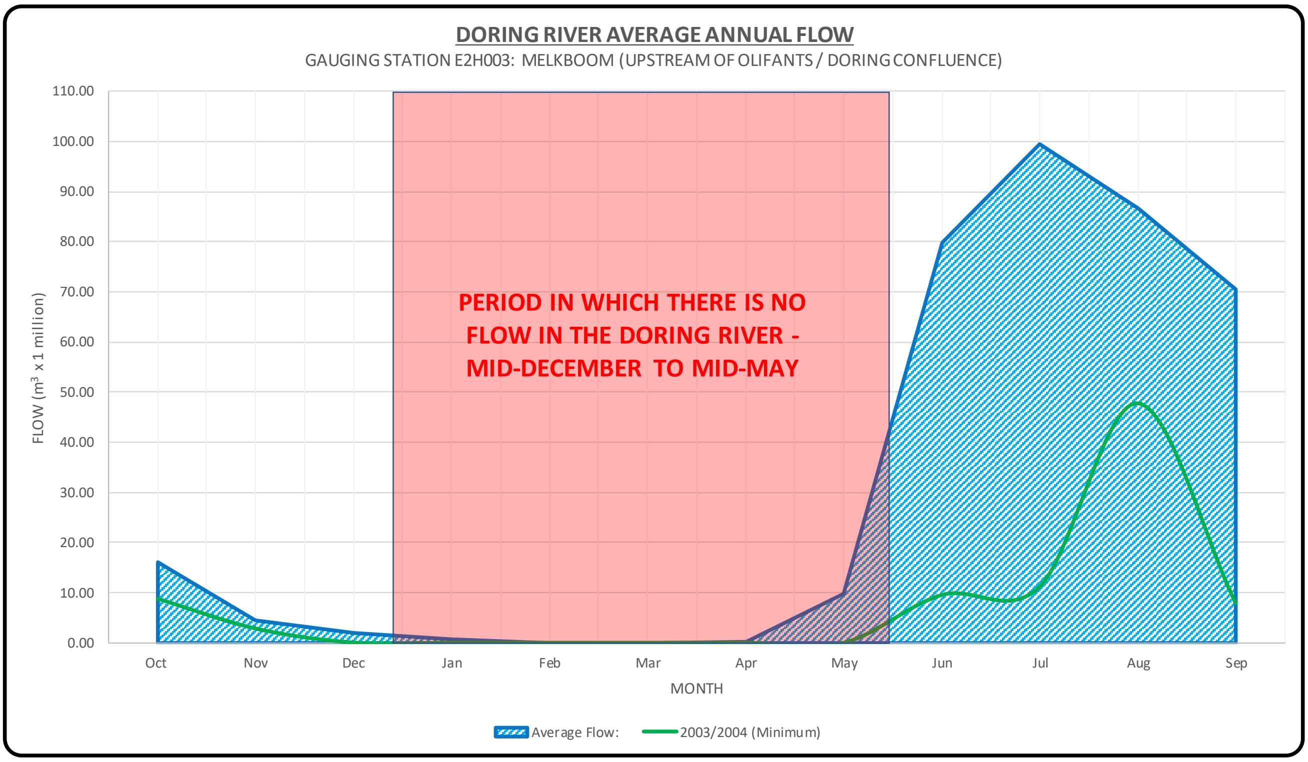
The fact that the period in which the water in the Doring River is available is limited between mid-April and mid- December annually is problematic, as it requires the need to oversize the infrastructure in order to transfer sufficient volume of water within the time available. In addition, the calculation done above, does not provide for any compensation of storage losses which will be incurred due to evaporation from the surface of the Karee Dam. This could be significant in volume.

**DORING RIVER FLOW DATA**

GAUGING STATION E2H003: MELKBOOM (UPSTREAM OF OLIFANTS / DORING CONFLUENCE)

( X 1 000 000 $m^3$)

| YEAR | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Tot Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000/2001 | 9.32 | 0.73 | 0.01 | 0.00 | 0.00 | 0.00 | 1.05 | 2.12 | 10.50 | 245.00 | 108.00 | 180.00 | 557.00 |
| 2001/2002 | 22.20 | 9.18 | 0.56 | 0.00 | 0.00 | 0.00 | 0.00 | 16.80 | 27.50 | 137.00 | 125.00 | 44.90 | 383.00 |
| 2002/2003 | 21.90 | 4.00 | 0.32 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 42.60 | 34.50 | 104.00 |
| 2003/2004 (Mir | 8.75 | 2.82 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.52 | 11.20 | 47.70 | 7.85 | 87.80 |
| 2004/2005 | 4.32 | 0.99 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 34.30 | 42.80 | 104.00 | 29.90 | 216.00 |
| 2005/2006 | 12.30 | 1.20 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 59.30 | 107.00 | 28.80 | 63.80 | 14.60 | 287.00 |
| 2006/2007 | 6.30 | 6.54 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 28.80 | 286.00 | 185.00 | 179.00 | 36.80 | 729.00 |
| 2007/2008 | 9.22 | 2.72 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 45.30 | 502.00 | 54.90 | 344.00 | 959.00 |
| 2008/2009 | 52.70 | 22.40 | 1.30 | 0.01 | 0.00 | 0.00 | 0.00 | 19.90 | 286.00 | 101.00 | 84.70 | 35.50 | 603.00 |
| 2009/2010 | 15.78 | 3.34 | 3.98 | 0.06 | 0.00 | 0.00 | 0.00 | 28.10 | 52.10 | 26.20 | 25.30 | 23.00 | 177.86 |
| 2010/2011 | 17.60 | 5.77 | 24.30 | 0.46 | 0.10 | 0.17 | 0.01 | 1.25 | 153.00 | 60.10 | 59.90 | 38.50 | 361.00 |
| 2011/2012 | 8.81 | 2.51 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 42.90 | 45.40 | 129.00 | 66.60 | 295.00 |
| 2012/2013 | 24.20 | 2.38 | 2.22 | 0.16 | 0.01 | 0.01 | 4.16 | 1.78 | 146.00 | 75.80 | 241.00 | 197.00 | 694.00 |
| 2013/2014 | 36.10 | 9.79 | 0.88 | 6.26 | 0.11 | 0.00 | 0.00 | 2.52 | 83.80 | 147.00 | 114.00 | 66.20 | 466.00 |
| 2014/2015 | 13.80 | 2.52 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.30 | 32.60 | 46.60 | 8.60 | 133.00 |
| 2015/2016 | 1.74 | 0.03 | 0.00 | 6.63 | 0.50 | 0.00 | 0.00 | 3.91 | 43.70 | 48.10 | 43.20 | 13.70 | 162.00 |
| 2016/2017 | 8.18 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.18 | 5.51 | 59.09 | 351.83 |
| **Average Flow:** | **16.07** | **4.55** | **2.02** | **0.82** | **0.04** | **0.01** | **0.31** | **9.70** | **79.76** | **99.60** | **86.72** | **70.63** | 386.26 |



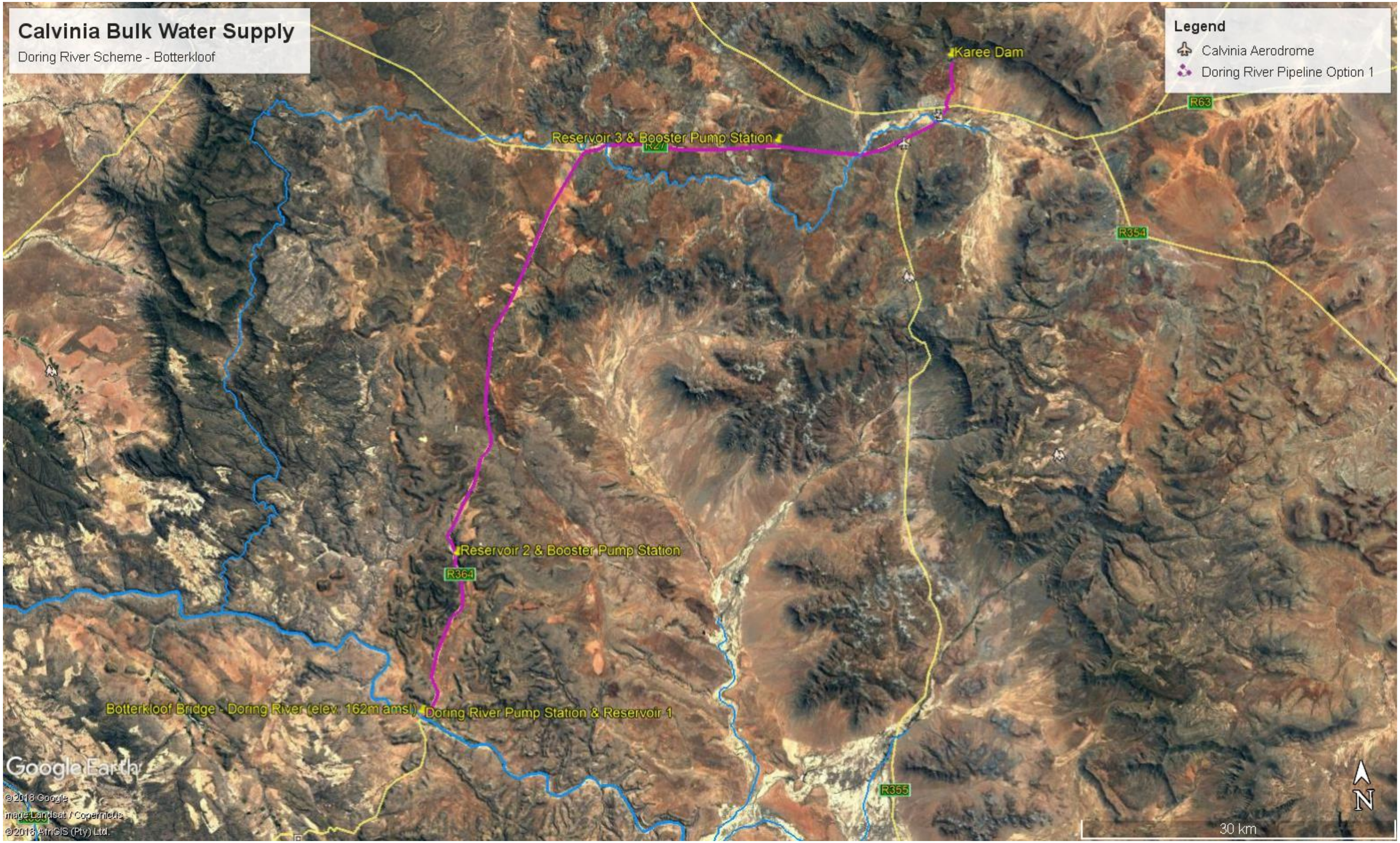



**Figure 32: Proposed Doring River Scheme layout from Botterkloof Bridge**

The alternative would be to store the water from the Doring River underground by means of ***Managed Aquifer Recharge***, or as a second alternative, ***to use the water directly*** from the Doring River and increase storage of Potable Water at Calvinia.

The fact that both the Doring River and the Karee Dam are dependent on winter rainfall, but Calvinia needs its larger portion of water during the hot summer months, makes storage inevitable. The question remains as to where to store the water and how much to store?

### 8.5.2 Physical Locations

The closest point at the Doring River from Calvinia is located at the Botterkloof Bridge on the R364. The R364 is the gravel road between the R27 Regional Route and Clanwilliam on the west side of the Cedarberg Mountains. The turn-off from the R27 is approximately 35km from Calvinia. The total distance from the Karee Dam at Calvinia to the Botterkloof Bridge on the Doring River is 101km. In addition to the above, the elevation of the surface of the Doring River is measured as 162m above Mean Sea Level, the elevation of the Full Supply Level of the Karee Dam is given as 1 050m above Mean Sea Level. This equates to a difference in elevation of 888m indicating that all water transferred from the Doring River, would need to be pumped.

**Figure 33: Botterkloof Bridge on the Doring River**

### 8.5.3 Required Infrastructure for this option

Water would need to be abstracted from the Doring River by a river pump station which would need to be suitably engineered to allow operation at varying water levels. This pump station **(RP)** would then abstract the water from the river and pump it through a set of course filters **(FS)** to remove the turbidity into a holding reservoir **(RES1)**. The filtration is required to remove any abrasives from the water. The elevated heads needed, require that multi-staged high-pressure pumps will be needed, and this type of pump is sensitive to course particles such as sand, etc, which would accelerate normal wear and tear dur to the abrasion in the pump components.
The size required for each holding reservoir would be in the order of ***4 hours storage*** to ensure that the whole system can operate at steady state conditions and not switch on and off unnecessarily. Frequent switching would greatly increase the risk of transient surges and subsequent pipe failures at the extreme pressures the system is operating at.

A first booster pump station **(BP1)**, located in close proximity to the Botterkloof Bridge, would then elevate the water through 500m over a distance of 17km to a second holding reservoir **(RES 2)**.
A second booster pump station **(BP2)** would then elevate the water from this point through an elevation of 500m over a distance of 61km to a holding reservoir **(RES3)** located on a high point at elevation 1 010m aMSL. Water could then either flow by gravity for a distance of 12km where a fourth holding reservoir and booster pump station would be required, or as alternative, it could already be pumped from the fourth reservoir directly to the Karee Dam discharge point for storage. The latter would comprise a booster pump **(BP3)** capable of pumping through an elevation of 66m over a distance of 23 km. This pump station would be located in the vicinity of the Calvinia Airfield.

Typically, the pipelines between Booster Pump Station I and Booster Pump Station 3 would all have a pressure rating of Class 60 or higher where they start off. For a flow of 53 litres per second, a 350mm diameter pipeline would be required. If a flow of 90 litres per second is considered, a 450mm diameter pipeline would be required. For costing purposes, we have assumed that the pipeline would be a 350mm diameter ductile iron pipe capable of dealing with 60 bar pressure.

Although there is already electrical power available at the Botterkloof Bridge site, powerlines would need to be constructed to each of the booster pump stations. An additional powerline from Botterkloof to Booster Pump Station 2 would be 61km in length. A powerline from Calvinia to Booster Pump Station 3 would be 23km in length. Therefore, a total of 84km of 11kV powerline would be required.

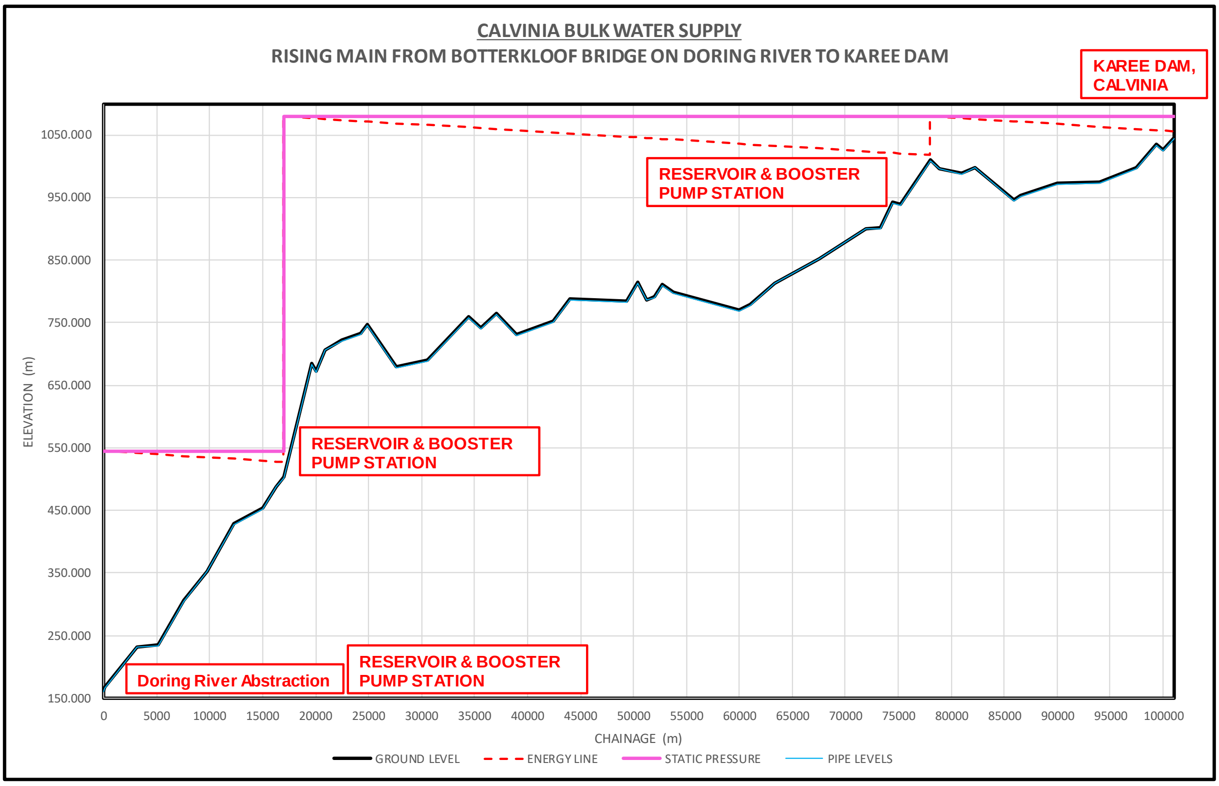



**Figure 34: Hydraulic profile for the Botterkloof to Karee Dam Pipeline**

### 8.5.4 Summary of Required Infrastructure for the Botterkloof Bridge option

1. River Abstraction Pump Station on raft or ramp (2 x Pumps 60 litres/second @ 25m)
2. Pipeline from River Pump Station to Filtration Plant and Reservoir: 250m x 500mm dia CL 9
3. Filtration Plant: 200 $m^3$/h capacity
4. Holding Reservoir 1: 800 kilolitre (Steel or Concrete)
5. Booster Pump Station 1: 2 x Pumps: 53 l/s @ 378m
6. Pipeline from Booster Pump Station 1 to Holding Reservoir 2: 17 000m x 350mm dia DIP CL60
7. Holding Reservoir 2: 800 kilolitres (Steel or Concrete)
8. Booster Pump Station 2: 2 x Pumps: 53 l/s @ 577m
9. Pipeline from Booster Pump Station 2 to Holding Reservoir 3: 61 000m x 350mm dia DIP CL60
10. Holding Reservoir 3: 800 kilolitres (Steel or Concrete)
11. Booster Pump Station 3: 2 x Pumps: 53 l/s @ 80m
12. Pipeline from Booster Pump Station 3 to Karee Dam: 23 000m x 350mm dia uPVC CL9
13. Construction of 11kV Powerline x 84km
14. Telemetry System

### 8.5.5 Cost Estimate for Doring River Option 1: Botterkloof to Karee Dam

A cost estimate of the capital requirement for this option was calculated and summarized in the table below. The Capital requirement for this option runs to **R340 889 081 – 09**.

| | |
|---|---|
| **PRELIMINARY AND GENERAL COSTS** | R 37 518 335.86 |
| **RAW WATER ABSTRACTION PUMPSTATION:** | R 1 254 799.00 |
| **RAW WATER RISING MAIN** | R 469 400.00 |
| **WATER FILTRATION PLANT** | R 5 222 521.00 |
| **STORAGE RESERVOIRS (800 kl) X 3** | R 6 267 000.00 |
| **BOOSTER PUMPSTATIONS X 3** | R 12 090 000.00 |
| **RISING MAIN:** | R 167 347 976.00 |
| **ELECTRICITY SUPPLY** | R 2 655 000.00 |
| SUBTOTAL | **R 232 825 031.86** |
| CONTINGENCIES: 10% | R23 282 503.19 |
| ESCALATION: 9% | R20 954 252.87 |
| SUBTOTAL: | **R277 061 787.91** |
| PROFESSIONAL FEES & DISBURSEMENTS | R 19 363 500.00 |
| SUBTOTAL: | **R296 425 287.91** |
| VAT @ 15% | R44 463 793.19 |
| **TOTAL PROJECT COST:** | **R340 889 081.09** |

**Figure 35: Summary of Capital Costs for Option 1**

In addition to the Capital Cost, the annual Operations and Maintenance Costs were calculated using the following assumptions:

| | |
|---|---|
| Maintenance Cost for Pipelines: | 1% of construction value |
| Maintenance Cost for Mechanical Equipment: | 4% of construction value |
| Maintenance Cost for Electrical Powerlines and Switchgear: | 4% of construction value |

Operational costs are calculated using the direct expenses for Electrical energy at an ESKOM Rate of R1.3575 / kW.h as found in the latest Tariff Tables for rural areas. The operational cost for personnel was taken as R500 000-00 per annum and includes salaries and transport.

## Maintenance Cost (annual)

| | | COST: | TOTAL: |
|---|---|---|---|
| 4% on Mechanical Equipment: | | | |
| Value: | R 18 567 320.00 | R 742 692.80 | |
| 1% on Pipelines | | | |
| Value: | R 167 817 376.00 | R 1 678 173.76 | |
| 1% on Powerlines | | | |
| Value: | R 2 655 000.00 | R 26 550.00 | |
| | | | **R 2 447 416.56** |

## Operational Cost (annual)

| | | |
|---|---|---|
| Electricity consumption | R 6 342 707.20 | |
| Salaries of Operating Staff: | R 500 000.00 | |
| Sub-total: | | **R 6 842 707.20** |
| TOTAL O&M COSTS | | R 9 290 123.76 |
| VAT @ 15% | | R 1 393 518.56 |
| **Annual Estimated Costs of Operation and Maintenance:** | | **R 10 683 642.32** |
| **Annual Volume of water produced:** | **575000 $m^3$** | |

### Estimated Unit Cost of Water: R 18.5802 per $m^3$

The above calculation equates to an annual Operations & Maintenance Cost of **R10 683 642-32** of which **R 6 342 707.20 or 59.4% is for electrical energy** to elevate the water from 162m Above Mean Sea Level to an elevation of 1 046m Above Mean Sea Level where Calvinia is located. The unit cost is calculated using the maximum demand that the scheme is designed for and the annual Operations and Maintenance Costs. The unit cost for water for this option is calculated to be R18-58 per kilolitre without the Hantam Municipality's mark-up. This is approximately 140% higher than what consumers in the Hantam Municpality are currently paying for water.

**In the opinion of the Engineer, this project is technically possible to execute, but NOT economically feasible for the community of Calvinia.**

## 8.6 Option 2: Abstraction of surface water from the Doring/Tankwa Rivers confluence.

### 8.6.1 Concept for the solution

Calvinia is located on the edge of the winter rainfall region, and if it receives sufficient winter rainfall, the Karee Dam is able to impound in the order of 900 000m$^3$ providing an annual yield of 370 000m$^3$/ annum. If the winter rainfall is below average, the above supply of water does not realize and the town is dependent on groundwater sources as an alternate supply.

Option 2 intends to provide water to Calvinia from the Doring River as a sustainable source of surface water. For this option, abstraction of water would take place just downstream of the confluence of the Doring and Tankwa Rivers. Our study has indicated that there is more than sufficient volume of water available from the Doring River at this point to provide a long term sustainable source as alternative.

Again, a typical scenario would be that, should the rains fail to fill the Karee Dam by the end of July in any given year, the proposed solution would then be activated and a volume of 575 000m$^3$ would need to be pumped to Calvinia in a period of 150 days (before mid December) to fill the Karee Dam and sustain the town for a full year.

The reason for this is that the availability of water in the Doring River declines sharply from mid-November. By January, the water in the Doring River is reduced to stagnant ponds. This means that infrastructure such as pumps and pipes would theoretically need to be sized to deal with a flow of:

575 000m$^3$÷ 5 months÷ 30 days= 3 833m$^3$/day ÷ 20 hours = 192m$^3$/h = **53 litres / second**

This, while the annual average daily demand for Calvinia, only equates to some 20 litres per second on average. The fact that the period in which the water in the Doring River is available is limited between mid-April and mid- November annually, is problematic, as it requires the need to oversize the infrastructure in order to transfer sufficient volume of water within the time available. In addition, the calculation done above, does not provide for any compensation of storage losses which would be incurred due to evaporation from the surface of the Karee Dam. This could be significant in volume.

The alternative would be to store the water from the Doring River underground by means of ***Managed Aquifer Recharge***, or as a second alternative, ***to use the water directly*** from the Doring River and increase storage of Potable Water at Calvinia.

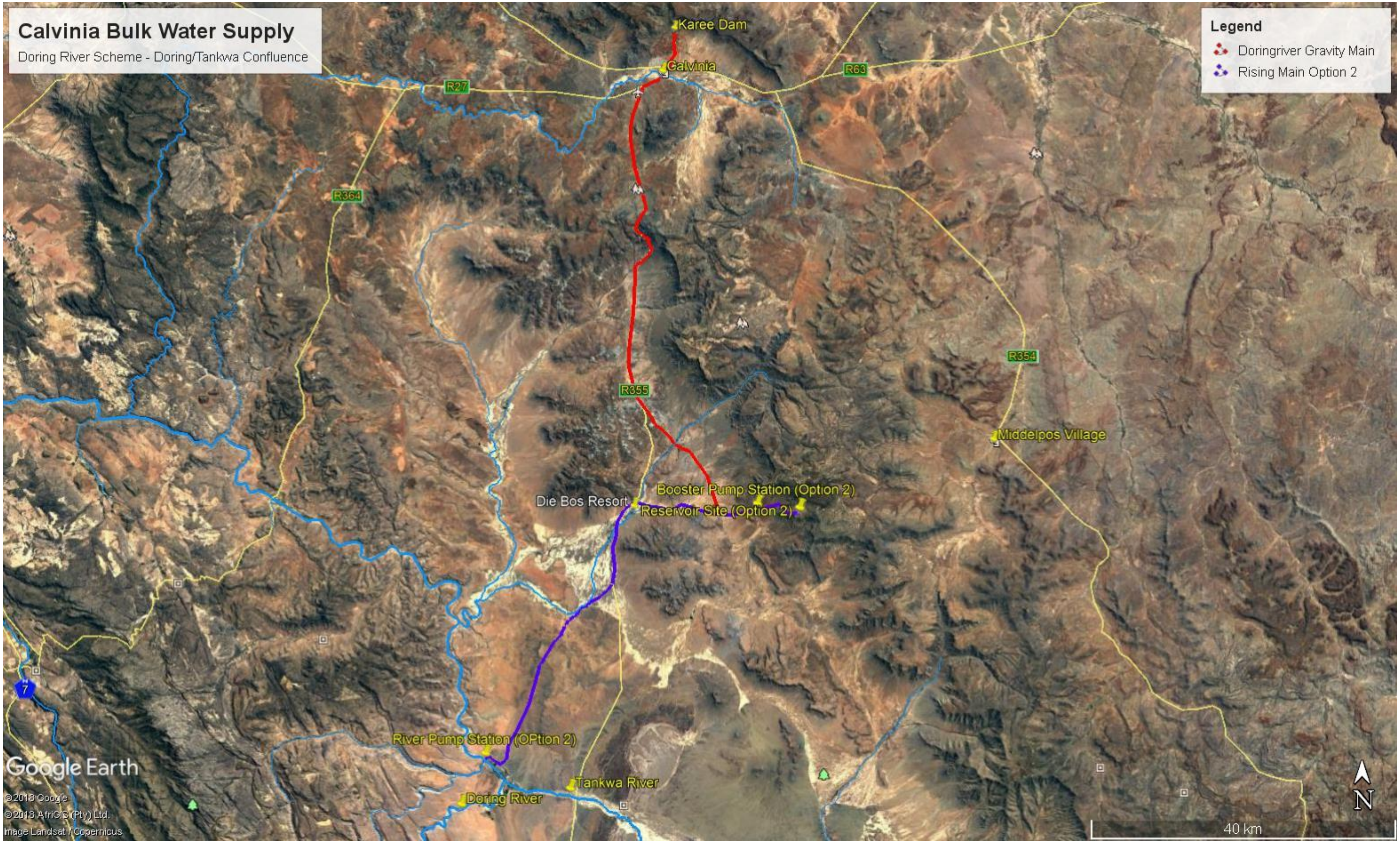



**Figure 36: Proposed Layout of Option 2 from the Doring / Tankwa Confluence**

### 8.6.2 Physical Locations

This location was chosen for two reasons, i.e. the availability of sufficient water from the Doring River, and secondly due to the elevation above sea level. This point, just downstream of the confluence of the Doring and Tankwa Rivers, is in excess of 100m higher than the site at Botterkloof. In addition, there is high terrain (elevation greater than 1200m aMSL) in the vicinity which lends itself to possible gravity flow to Calvinia located at 1046m aMSL. The idea is therefore, to abstract water from the Doring River, elevate it to a high level reservoir near the Bos Resort, and then have gravity flow to Calvinia with a pipeline along the R355 road. It is proposed that the reservoir be located at an elevation of at least 1150m aMSL to ensure that gravity flow can take place.

**Figure 37: Doring River near to the Tankwa confluence**

### 8.6.3 Required Infrastructure for this option

Water would need to be abstracted from the Doring River by a river pump station which would need to be suitably engineered to allow operation at varying water levels. This pump station **(RP)** would then abstract the water from the river and pump it through a set of course filters **(FS)** to remove the turbidity into a holding reservoir **(RES1)**.

The filtration is required to remove any abrasives from the water. The elevated heads needed, require that multi-staged high-pressure pumps will be needed, and this type of pump is sensitive to course particles such as sand, etc, which would accelerate normal wear and tear due to the abrasion in the pump components.

The size required for each holding reservoir would be in the order of ***4 hours storage*** to ensure that the whole system can operate at steady state conditions and not switch on and off unnecessarily. Frequent switching would greatly increase the risk of transient surges and subsequent pipe failures at the extreme pressures the system is operating at.

A first booster pump station **(BP1)**, located in close proximity to the River Pump Station, and would then elevate the water through 540m over a distance of 64km to a second holding reservoir **(RES 2)**.

A second booster pump station **(BP2)** would then elevate the water from this point through an elevation of 450m over a distance of 3km to a holding reservoir **(RES3)** located on a high point at elevation 1 250m aMSL. Reservoir 3 would have a storage for at least 7 days in case any of the pumping systems where to fail. This equates to a reservoir capacity of 12 Megaliters. From here, water could then either flow by gravity through a 250mm diameter Ductile Iron pipeline, using the reduction in diameter to reduce the pressure, for a distance of 59km into a break pressure tank.

It is required to break this pressure to avoid excessive pressures in the pipeline when the valve at Karee Dam is closed. Without the Break Pressure Tank, pressures at Karee Dam would elevate to 38 bar. When the pressure is reduced, the maximum pressure at the Karee Dam valve would be only 4 bar, making the construction a lot more economical. From the Break Pressure Tank, the water would flow under gravity to the Karee Dam through a 300mm diameter uPVC Class 9 pipe for a distance of 25km, where it can be discharged to the Karee Dam for storage.

Typically, the pipelines between River Pump Station and Booster Pump Stations would all have a pressure rating of at least Class 60 or higher where they start off. For a flow of 53 litres per second, a 350mm diameter pipeline would be required.

Although there is already electrical power available at the Doring / Tankwa Rivers confluence site, powerlines would need to be constructed to each of the booster pump stations. An additional powerline from the River Pump Station to Booster Pump Station 2 would be 61km in length, plus another 3km to power Booster Pump Station 3. Therefore, a total of 70km of 11kV powerline would be required.

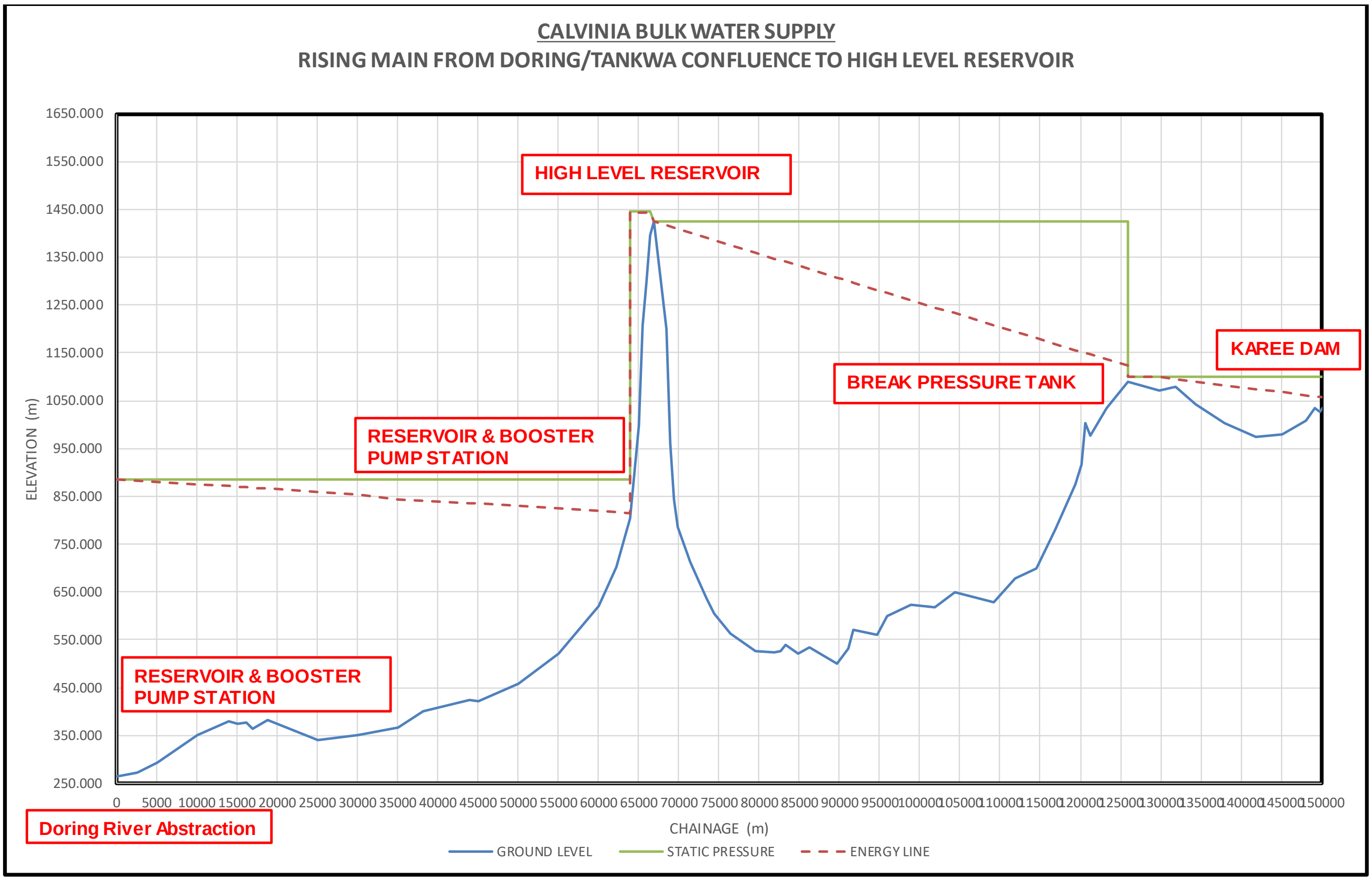



**Figure 38: Hydraulic profile of the Doring/Tankwa confluence option (Option2)**

### 8.6.4 Summary of Required Infrastructure for the Botterkloof Bridge option

15. River Abstraction Pump Station on raft or ramp (2 x Pumps 60 litres/second @ 25m)
16. Pipeline from River Pump Station to Filtration Plant and Reservoir: 500m x 500mm dia CL 9
17. Filtration Plant: 200 $m^3$/h capacity
18. Holding Reservoir 1: 800 kilolitres (Steel or Concrete)
19. Booster Pump Station 1: 2 x Pumps: 53 l/s @ 540m
20. Pipeline from Booster Pump Station 1 to Reservoir 2: 61 000m x 350mm dia DIP CL60
21. Holding Reservoir 2: 800 kilolitres (Steel or Concrete)
22. Booster Pump Station 2: 2 x Pumps: 53 l/s @ 577m
23. Pipeline from Booster Pump Station 2 to Holding Reservoir 3: 61 000m x 350mm dia DIP CL60
24. Holding Reservoir 3: 800 kilolitres (Steel or Concrete)
25. Booster Pump Station 3: 2 x Pumps: 53 l/s @ 450m
26. Pipeline from Booster Pump Station 3 to High-level Reservoir: 3 000m x 350mm dia DIP Cl.40
27. High Level Reservoir: 10 Megalitres (concrete) to have 7 days storage
28. Gravity Main from High Level Reservoir to Break Pressure Tank: 59 000m x 250mm DIP Cl60.
29. Concrete Break Pressure Tank: 400 kilolitres (Steel or Concrete)
30. Gravity Main from Break Pressure Tank to Karee Dam: 25 000m x 300mm dia. uPVC Cl.9
31. Construction of 11kV Powerline x 70km
32. Telemetry System

### 8.6.5 Cost Estimate for Option 2: Doring/Tankwa Rivers Confluence to Karee Dam

A cost estimate of the capital requirement for this option was calculated and summarized in the table below. The Capital requirement for this option runs to **R 468 414 650.93**.

| | |
|---|---|
| **PRELIMINARY AND GENERAL COSTS** | R 51 465 162.79 |
| **RAW WATER ABSTRACTION PUMPSTATION:** | R 1 254 799.00 |
| **RAW WATER RISING MAIN** | R 938 800.00 |
| **WATER FILTRATION PLANT** | R 5 222 521.00 |
| **STORAGE RESERVOIRS (800 kl) X 2** | R 4 178 000.00 |
| **HIGH LEVEL STORAGE RESERVOIR (10 MEGALITER)** | R 28 490 677.00 |
| **BREAK PRESSURE TANK: (400 KILOLITER)** | R 1 445 500.00 |
| **BOOSTER PUMPSTATIONS X 3** | R 12 090 000.00 |
| **RISING MAIN:** | R 106 158 634.00 |
| **GRAVITY MAIN: HIGH LEV RESERVOIR TO BP TANK** | R 80 366 804.00 |
| **GRAVITY MAIN: BREAK PRESSURE TANK TO KAREE DAM** | R 28 846 760.00 |
| **ELECTRICITY SUPPLY** | R 2 389 000.00 |
| SUBTOTAL | **R 322 846 657.79** |
| CONTINGENCIES: 10% | R32 284 665.78 |
| ESCALATION: 9% | R29 056 199.20 |
| SUBTOTAL: | **R384 187 522.77** |
| PROFESSIONAL FEES & DISBURSEMENTS | R 23 129 565.00 |
| SUBTOTAL: | **R407 317 087.77** |
| VAT @ 15% | R61 097 563.17 |
| **TOTAL PROJECT COST:** | **R468 414 650.93** |

**Figure 39: Estimated Capital Cost required for Option 2**

In addition to the Capital Cost, the annual Operations and Maintenance Costs for Option 2 were calculated using the following assumptions:

| | |
|---|---|
| Maintenance Cost for Pipelines: | 1% of construction value |
| Maintenance Cost for Mechanical Equipment: | 4% of construction value |
| Maintenance Cost for Electrical Powerlines and Switchgear: | 4% of construction value |

Operational costs are calculated using the direct expenses for Electrical energy at an ESKOM Rate of R1.3575 / kW.h as found in the latest Tariff Tables for rural areas. The operational cost for personnel was taken as R500 000-00 per annum and includes salaries and transport.

## Maintenance Cost (annual)

| | | COST: | TOTAL: |
|---|---|---|---|
| 4% on Mechanical Equipment: | | | |
| Value: | R 18 567 320.00 | R 742 692.80 | |
| 1% on Pipelines | | | |
| Value: | R 216 310 998.00 | R 2 163 109.98 | |
| 1% on Powerlines | | | |
| Value: | R 2 389 000.00 | R 23 890.00 | |
| | | | **R 2 929 692.78** |

## Operational Cost (annual)

| | | |
|---|---|---|
| Electricity consumption | R 7 204 918.96 | |
| Salaries of Operating Staff: | R 500 000.00 | |
| Sub-total: | | **R 7 704 918.96** |
| TOTAL O&M COSTS | | R 10 634 611.74 |
| VAT @ 15% | | R 1 595 191.76 |
| **Annual Estimated Costs of Operation and Maintenance:** | | **R 12 229 803.50** |
| **Annual Volume of water produced:** | **575000 $m^3$** | |

**Estimated Unit Cost of Water:** **R 21.2692 per $m^3$**

The above calculation equates to an annual Operations & Maintenance Cost of **R12 229 803-50** of which **R 7 204 918.96 or 58% is for electrical energy** to elevate the water from 267m Above Mean Sea Level to an elevation of 1 424m Above Mean Sea Level to the High-Level Reservoir. This elevation is required so that gravity flow to Calvinia is possible.

The unit cost is calculated using the maximum demand that the scheme is designed for and the annual Operations and Maintenance Costs. The unit cost for water for this option is calculated to be R21-27 per kilolitre without the Hantam Municipality's mark-up. This is approximately **175% higher** than what consumers in the Hantam Municpality are currently paying for water.

**In the opinion of the Engineer, this project is technically possible to execute, but NOT economically feasible for the community of Calvinia for the foreseeable future.**

## 8.7 Option 3: Groundwater exploration and augmentation of existing groundwater sources

The Hantam Municipality has over the past summers of 2016 and 2017 suffered severely due to drought conditions. This had the result that the municipality were forced to implement Level 4 water restrictions in all its towns including Calvinia. The situation also led to the Minister of Cooperative Governance, Human Settlements and Traditional Affairs declaring the Namakwa Region as a Drought Disaster Area.

Given the above, funds were provided by the National Disaster Management Centre for finding additional water sources and providing emergency infrastructure for specifically Calvinia. In addition to the above, reasonable winter rains fell in May and June 2018 which assisted in both catchment of water in the Karee Dam at Calvinia as well as recharging the groundwater levels.

Calvinia is currently supplied with water from two primary sources. The first source is the Karee Dam which is able to impound approximately 920 000$m^3$ of water and has a yield of 370 000$m^3$ per annum. During years of average rainfall (244mm per annum), the dam is able to supply water for approximately 270 days in a year. After the good rains experienced in May and June 2018, the dam level stood at 68% at the end of July 2018. Currently, the Karee Dam level is at 20% which should provide sufficient surface water until April 2019 if no further rains occur. During the winter rainfall season of 2019, virtually no rains fell within the Karee Dam catchment, forcing the Hantam Municipality to already start using their groundwater resources before the summer months. This situation does not bode well, as it places strain on the existing ground water before the hotter season has even commenced.

Calvinia's current secondary source of water is from the Old Wellfield, consisting of seven production boreholes of which 6 are used for supplying the town. The maximum supply from the existing boreholes is limited to 55$m^3$/h, while the summer demand for Calvinia is in the order of 65$m^3$/h. In addition to the above, the Calvinia Northern Wellfield was also recently developed and equipped, consisting of an additional 5 boreholes. The maximum supply from these boreholes in a normal rainfall year is 8 liters per second or 28.8 $m^3$/h. This therefore brings the supply to a total of 83.8 $m^3$/h or 2011 $m^3$/day.

In normal years, this should be sufficient, as the period during which the town is dependent on groundwater is usually of short duration. If rains however do not fall timeously, as is the case currently, the water supply from the boreholes is found wanting. Subsequently, a major effort was conducted in May 2018 to find additional groundwater sources. Messer's' GEOSS was appointed by BVi to conduct the hydrogeological work required to site new boreholes.

### 8.7.1 Exploration: Hydrocensus, Identification of Drill Sites, Drilling, Yield Testing

The geohydrological study commenced in March 2018, and was conducted using the following information in order to identify higher potential areas for groundwater exploration;

1. National Ground water archive (NGA)
2. 1: 50 000 and 1: 250 000 Geological Maps
3. South African airborne magnetic data
4. Lineament maps provided by the CGS
5. Climatic data for the region.
6. Previous reports (Private and government sector)

The study was stipulated to target areas either owned by municipality or government initially and then private owned land. Previous reports/literature indicated that groundwater is generally located within alluvial channels, dolerite dykes or dolerite sills.

The above-mentioned data was collated into a Geographical information system (GIS) software package. Five areas of interest were identified which met the criteria of geological structures, and sufficient recharge/rainfall. The Nature reserve located 1 km north of Calvinia was re-assessed for groundwater potential and the re-drilling of existing abandoned/dilapidated boreholes.

A study area previously identified by SRK Consulting (Report No: 345429/4), 18 km to the north-east of Calvinia on a farm known as Renosterhoek was also assessed for groundwater potential. The SRK report identified the area as a potential area for groundwater exploration, however, GEOSS reassessed the area and data. Based on GEOSS assessment the area was classified as a low priority due to changes in climatic data and limited information pertaining to aquifer yield potential. The following areas where considered viable for assessment from the existing information available:

1. Renosterhoek Farm (SRK study area)
2. Ceres Karoo area / Kruitberg (Study area 1)
3. Keiskie/ Keiskie road (Study area 2)
4. Downes (study area 3)
5. North-west region along the R355 (Study area 4)

6. Nature reserve (Re-drilling of existing boreholes)
7. De Vlok farm (Study area 5)

The 1:250 000 and 1:50 000 geological maps were also used where possible, to increase the level of geological detail used in understanding target areas. The geological maps used in conjunction with aerial imagery were used to conduct lineament and fault mapping at site specific scales, to more closely define target areas. These target areas were then compared to the available groundwater information surrounding them, to obtain estimate outcomes and expectations of groundwater exploration in these sites.

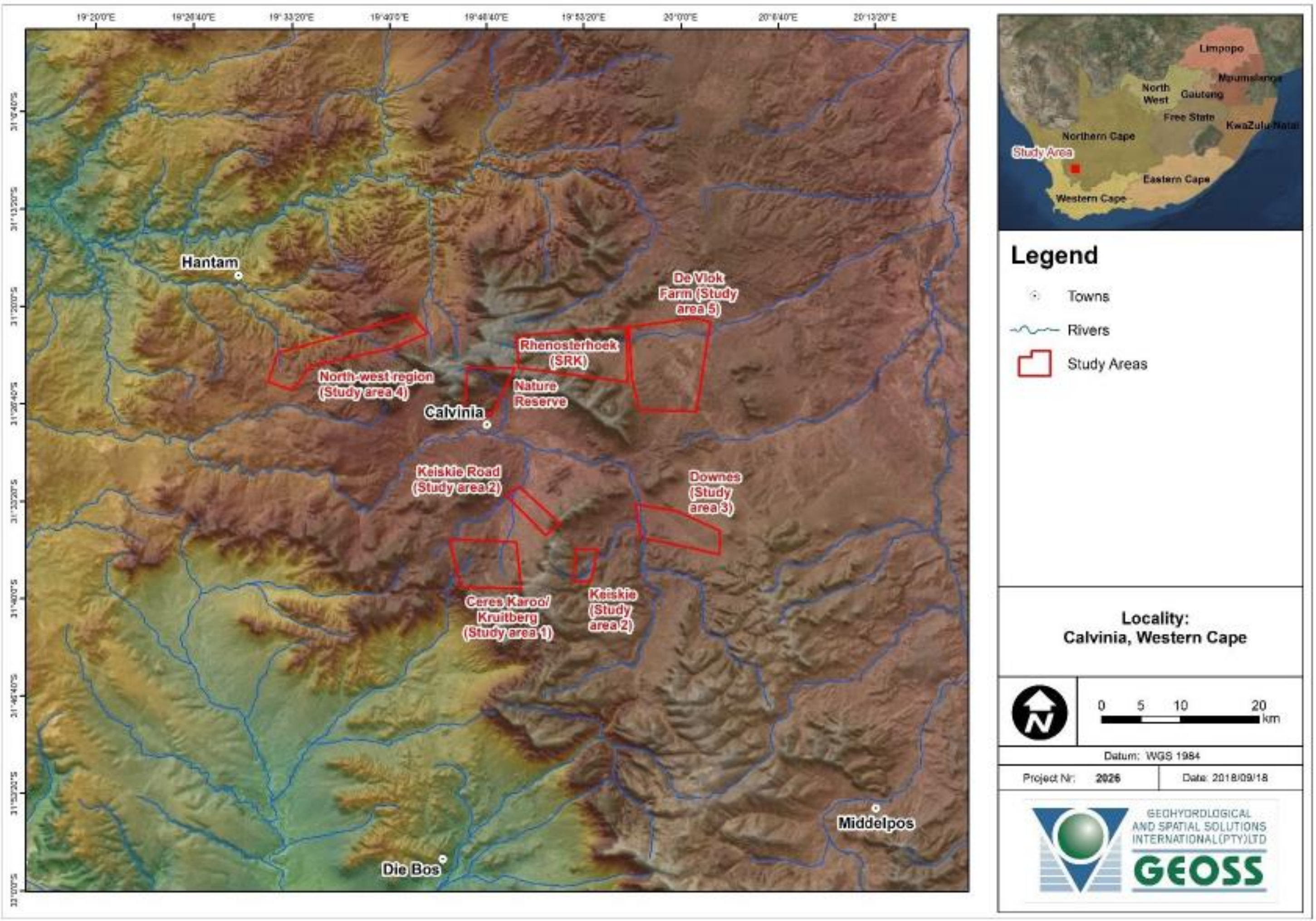



**Figure 40: Study areas identified for groundwater exploration**

Once the desktop study targets had been identified, field work was completed to finalise the exploration drill sites. The field work took the form of onsite structural verification (field geology), where the target structures were visible at surface. In areas where the target structures were covered by alluvium, geophysical techniques were used to further define the exploration drill sites.

Electromagnetic geophysical techniques were used, the method is a non intrusive and rapid for covering large areas. the geophysical survey was undertaken using a CMD-DUO Electromagnetic conductivity meter which measures the ground conductivity of the subsurface.

In general, the ground conductivity measured has a direct correlation with formation porosity and groundwater salinity; i.e. if porosity of the formation or groundwater salinity increases, this will be reflected as a higher ground conductivity measurement (Telford et al, 1990).

*Access to two of the study areas were limited by the private land owners. Renosterhoek Farms' owner refused access to the land. The second target area Downes, GEOSS was allowed access to conduct geophysical and structure mapping work. However, the Land owner stipulated that he does not want drilling to take place on his land.*

Exploration drilling for new water sources commenced in May 2018 in the Calvinia district and some 44 borehole sites where identified and sited. Of these, 31 boreholes were drilled from March 2018 to August 2018. Of these 31 boreholes, 13 sites were considered successful having an exploitable quantity of water with acceptable or treatable quality. The complete geohydrological report, *GEOSS Report No. 2018/10-18* is attached as annexure to this study document.

The newly drilled boreholes where then yield tested to determine sustainability and the results are listed in the table below.

| Site | Latitude (WGS84) | Longitude (WGS84) | Abstraction Rate (L/s) | Pump Depth (m) |
|---|---|---|---|---|
| Cal_DV1 | -31.455414 | 19.773937 | 5 | 150 |
| Cal_DV3 | -31.430694 | 19.788300 | 0.8 | 150 |
| Cal_DV4 | -31.411629 | 19.775115 | 1 | 100 |
| Cal-S2-3 | -31.651334 | 19.801571 | 1.3 | 35 |
| Cal-S2-4 | -31.650359 | 19.801047 | 4 | 150 |
| Cal_S2_10 | -31.617462 | 19.744726 | 15 | 80 |
| Cal_Nat5 | -31.435236 | 19.784485 | 4.3 | 178 |
| Cal_Nat6 | -31.451284 | 19.770548 | 1.5 | 100 |
| Cal_Phase3_6 | -31.357725 | 19.691500 | 2 | 96 |
| Cal_Phase3_4A | -31.401169 | 19.556679 | 15 | 70 |
| Cal_Phase3_9 | -31.632714 | 19.756781 | 15 | 96 |
| Re-Drill 39602 | -31.372864 | 19.970834 | 4.5 | 79 |

**Figure 41: Sustainable Yield results for New Boreholes drilled at Calvinia**

A total sustainable yield of **69.4 litres per second** was calculated after the pump testing. Water samples were taken from all the newly drilled boreholes and analysed for water quality. The following water quality analysis chemistry results were returned for these four boreholes.

| Sample Marked : | Cal_DV1 | Cal_DV3 | Cal_DV4 | Cal-NAT5 | Cal-NAT6 | CalS2-3 | CalS2-4 | CalS2-10 | Cal-Ph3-4 | Cal-Ph-3-6 | Cal-Ph-3-9 | Cal-39602-redrill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| pH | 8.39 | 9.59 | 8.32 | 8.18 | 7.36 | 9.22 | 9.83 | 7.39 | 7.45 | 9.45 | 8.55 | 8.09 |
| Conductivity (mS/m) | 54.5 | 49.5 | 73.5 | 45 | 60.5 | 70.5 | 74 | 127 | 173 | 48.5 | 75.5 | 175 |
| Turbidity (NTU) | 2.1 | 2 | 10.3 | 0.37 | 0.13 | 8.8 | 7.2 | 0.37 | 82 | 0.6 | 0.18 | 0.52 |
| | | | | | | | | | | mg/L | | |
| Total Dissolved Solids | 361 | 327 | 495 | 265 | 381 | 474 | 488 | 823 | 1354 | 377 | 553 | 1381 |
| Sodium (as Na) | 86 | 76.1 | 116 | 70.8 | 53.5 | 125 | 127 | 108 | 95.7 | 77.1 | 77.9 | 160 |
| Potassium (as K) | 0.73 | 0.52 | 1.4 | 0.68 | 0.67 | 1.2 | 1 | 2.9 | 6.2 | 0.63 | 2.8 | 2.3 |
| Magnesium (as Mg) | <1.1 | <1.1 | 6.4 | 1.7 | 18.9 | <1.1 | <1.1 | 28 | 92.7 | <1.1 | 20.1 | 58.3 |
| Calcium (as Ca) | 5 | 3.4 | 16.2 | 6.7 | 41.6 | 2.8 | 0.43 | 97 | 130 | 5.7 | 31.8 | 80.2 |
| Chloride (as Cl) | 66.4 | 89.9 | 60.7 | 41.7 | 36.6 | 58.1 | 66 | 188 | 96.9 | 96.2 | 98.1 | 307 |
| Sulphate (as SO4) | 19 | 4.3 | 7.9 | 6.6 | 27.2 | 10 | 5.5 | 100 | 616 | 4.4 | 18 | 118 |
| Nitrate& Nitrite (as N) | <0.20 | <0.2 | 0.24 | <0.20 | <0.2 | 0.26 | 0.22 | <0.2 | <0.2 | <0.20 | <0.20 | 2.1 |
| Fluoride (as F) | 3.3 | 6.8 | 3.1 | 5.1 | 1.3 | 3.6 | 7.2 | 1.6 | 1.5 | 3.4 | 1.8 | 0.91 |
| Manganese (as Mn) | <0.019 | <0.019 | 0.037 | <0.019 | 0.067 | <0.019 | <0.019 | <0.019 | 1.005 | <0.019 | <0.019 | <0.019 |
| Iron (as Fe) | 0.08 | 0.083 | 0.175 | <0.024 | <0.024 | 0.294 | 0.296 | <0.024 | 22.4 | 0.027 | 0.053 | <0.024 |
| Copper (as Cu) | 0.016 | 0.014 | 0.015 | <0.006 | <0.006 | 0.015 | 0.016 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Zinc (as Zn) | 0.02 | 0.007 | 0.01 | 0.003 | 0.003 | 0.006 | 0.006 | 0.003 | 0.004 | <0.001 | 0.006 | 0.003 |
| Arsenic (as As) | 0.167 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Cadmium (as Cd) | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

**Figure 42: Water quality analysis results for new boreholes at Calvinia**

The water quality parameters highlighted in blue indicate that the quality is acceptable, while green is classified as being applicable to a Class I water and yellow a Class II water. Parameters highlighted in RED or PURPLE are considered to be problematic for human consumption, either as being aesthetically not acceptable or presenting a health issue.
Physical issues such as turbidity are not a problem, as the water is filtered as a matter of course. Issues such as fluoride are however a serious problem, and not easy to treat.

Basically, all the water analysed from the new boreholes have a serious fluoride problem varying from marginal at 1.6mg/l to serious at 7.20mg/l. The limit for fluoride concentration acceptable for human consumption is at 1.5mg/l. Beyond this concentration, serious health issues can be caused.

The salinity of most of the boreholes was within acceptable levels for human consumption. Only two boreholes have severe salinity and could still be utilized for blending with fresher water. Six of the boreholes had water of excellent quality in terms of salinity, which is quite rare for the area in question.
A single borehole had elevated levels of arsenic, which is also treatable, and could be removed in the same process envisaged for removing fluoride.

Of these new boreholes, Boreholes CAL_DV_1 has since been equipped and is able to deliver 3 litres per second, Borehole CAL_NAT_5 has been equipped and is able to deliver 4 litres per second, and Borehole CAL_NAT_6 has also been equipped and is able to deliver 1.5 litres per second. This equates to an additional 28.8 $m^3/h$ which is available for use. The water from the new boreholes is currently used in conjunction with the water from the existing wellfield, thereby delivering a blended water to the residents of Calvinia which is marginal with respect to fluoride concentration, but that is what is available, and fluoride will not have a significant effect when used for short periods of time.

**Figure 43: Borehole CAL_NAT_6 equipped for use at Calvinia**

The recent completion of the Calvinia North Wellfield, will then bring the water available from the groundwater supply for Calvinia to a total of **83.8 $m^3/h$** which is more than the current peak summer demand, if the water levels in all the existing boreholes remain at acceptable levels during the summer. In 2018, with no rains falling to provide recharge, the delivery from the existing boreholes declined to **38 $m^3/h$** due to declining water levels in the boreholes.

In summary, a **total additional sustainable yield of 69.4 litres per second** was achieved with this exploration effort. This is approximately 3 times the Average Annual Demand for Calvinia (18 litres per second), without considering the existing production boreholes.

Overall, the fluoride concentration of all the boreholes is a concern (of varying degrees) and should be addressed before significant water production begins. Inn selecting the boreholes to be developed, the following factors were considered:

1. Sustainable yield
2. Salinity
3. Proximity of borehole to existing or proposed new infrastructure

With the exception of Borehole CAL_DV_3, all the boreholes have useful quantities of water to contribute. In terms of salinity, only Boreholes CAL_PH3_4 and Borehole G39602 exceed the allowable limit of 1200mg/l. The remaining nine boreholes all have acceptable quality and quantities to contribute with the exception of their fluoride concentrations.

In terms of proximity to existing infrastructure such as pipelines, all of the new boreholes located within the Akkerendam Nature Reserve (Calvinia North Wellfield) are in relatively close proximity to the Calvinia Water Treatment Plant, from where water is supplied to the town. These boreholes have recently been permanently equipped and connected to the Calvinia Water Treatment Plant.

The remaining boreholes are all far from town, with the Kreitzberg boreholes being the furthest at 31km away, but located at an elevation which allows the water to flow under gravity to Calvinia. Typically, the borehole pumps would just lift the water to ground level, enter the gravity main and could then flow to Calvinia.

The Northwest boreholes, that is BH CAL_PH3_6 and CAL_PH3_4A, are located 33.5km from the Calvinia Water Treatment Plant and located in a hollow, which requires pumping all the way using a rising main.

Borehole G39602, is located to the Northeast and is 16.5km from the existing rising main between the Deon Vlok borehole and the Calvinia Water Treatment Plant. This borehole could deliver a quantity of 4.5 litre per second, but is the most saline of the successful boreholes.

Given the above, it is proposed that only Borehole G39602 be disqualified, as the quality and distance involved for a single borehole is excessive.

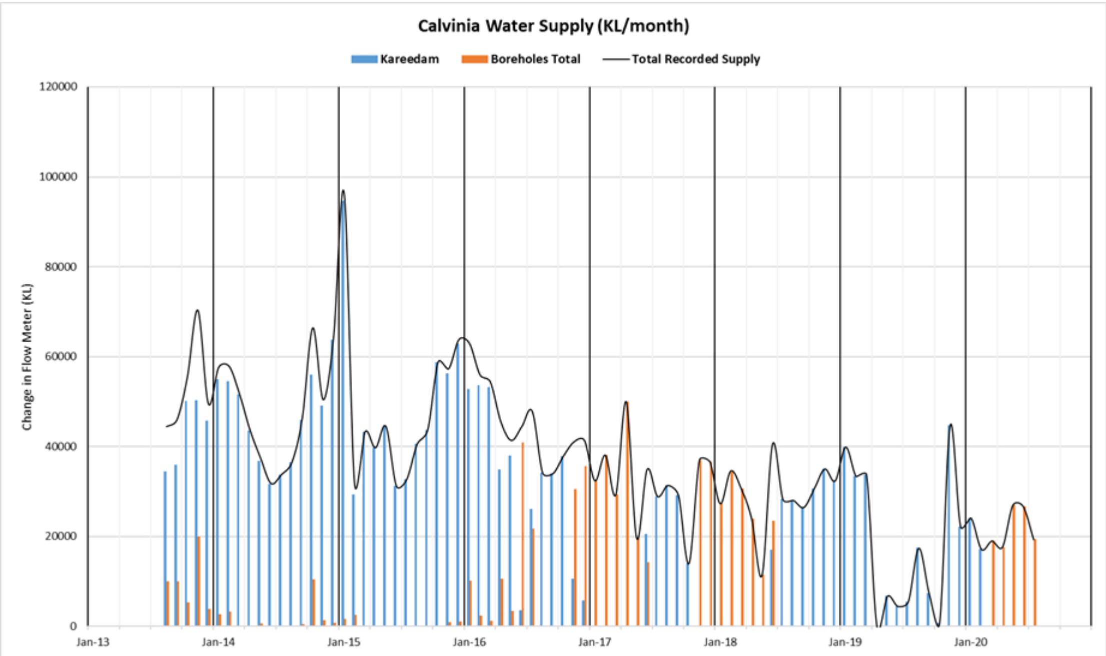
This decision the leaves us with **65 litres per second**, which is still more than sufficient to address the water demand of the town.

### 8.7.2 Assessment of the Firm Yield potential of the new boreholes

The new boreholes have been pump-tested in accordance with SANS 10299_4-2003 and initial assessments of the maximum potential yields of the boreholes indicated that up to 65 liters per second, or 5.616 Megaliters per day could be abstracted without dropping water levels below the main water strike depths.

However, due to our experience with the sustainability of borehole yields at both Loeriesfontein and Brandvlei, a decision was taken to look at the Calvinia borehole yields a bit differently. Subsequently, we undertook a study to determine Firm Yield estimates (varying between 50 – 65 % of long-term recharge expectations) to assess a more realistic potential yield for these boreholes. This has led to an exercise whereby the tested abstraction rates and abstraction periods were reduced so as to be **within 50 to 75% of the Firm Yields** calculated for delineated Groundwater Resources Units at each borehole and wellfield. These calculations were approached as follows:

The water supply to the town of Calvinia as monitored through monthly measurements of flow meters by the Hantam Municipal staff is shown in Figure 10. The supply has been split into the volume from the Karee Dam (blue bars) and the cumulative volume from any boreholes in operation (orange bars) for that month. The sum of these two has been indicated with the black line. This indicates that monthly demand ranges from ~40 000 $m^3$/month to 60 000 $m^3$/month (15 – 25 L/s continuous supply) depending on the time of year, availability of water and the implementation of water restrictions. The current mean daily demand is 1724.9 $m^3$/day and the 20-year projected demand increases to 1944.2 $m^3$/day (or a continuous supply of 20 L/s and 22.5 L/s respectively).



From this, it is clear that while there is some overlap in use, the Karee Dam and the current boreholes are mostly used in seasonal rotation. The majority of rainfall occurs mostly during the months of May – August. Therefore, the supply from the Karee Dam is most reliable towards the end of this period and in the following months, before peak evaporation occurs in December and January. An annual schedule of groundwater abstraction from the 20 application boreholes grouped in their clusters and wellfields is provided in the tables below.

| Month | Water supply (m³) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Golf_course_BH | Witwal_BH | Sandgat_3_BH | Sandgat_4_BH | Sandgat_5_BH | Breccia_BH | Re-Drill 39602 | Deon_Vlok_BH |
| January | 5356.8 | 4017.6 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 16070.4 |
| February | 4838.4 | 3628.8 | 2419.2 | 1935.4 | 4838.4 | 0.0 | 8467.2 | 14515.2 |
| March | 5356.8 | 4017.6 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 16070.4 |
| April | 5184.0 | 3888.0 | 2592.0 | 2073.6 | 5184.0 | 0.0 | 9072.0 | 15552.0 |
| May | 5356.8 | 4017.6 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 16070.4 |
| June | 5184.0 | 3888.0 | 2592.0 | 2073.6 | 5184.0 | 0.0 | 9072.0 | 15552.0 |
| July | 5356.8 | 0.0 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 0.0 |
| August | 5356.8 | 0.0 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 0.0 |
| September | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| November | 5184.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15552.0 |
| December | 5356.8 | 4017.6 | 2678.4 | 2142.7 | 5356.8 | 0.0 | 9374.4 | 16070.4 |
| **Total (m³/a)** | **52 531.2** | **27 475.2** | **23 673.6** | **18 938.9** | **47 347.2** | *0** | **82 857.6** | **12 5452.8** |

| Month | Water supply (m³) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cal_DV1 | Cal_DV3 | Cal_DV4 | Cal_Nat5 | Cal_Nat6 | Cal_Phase3_4a | Cal_Phase3_6 |
| January | 4017.6 | 2142.7 | 2142.7 | 5356.8 | 4017.6 | 5356.8 | 26784.0 |
| February | 3628.8 | 1935.4 | 1935.4 | 4838.4 | 3628.8 | 4838.4 | 24192.0 |
| March | 4017.6 | 2142.7 | 2142.7 | 5356.8 | 4017.6 | 5356.8 | 26784.0 |
| April | 3888.0 | 2073.6 | 2073.6 | 5184.0 | 3888.0 | 5184.0 | 25920.0 |
| May | 4017.6 | 2142.7 | 2142.7 | 5356.8 | 4017.6 | 5356.8 | 26784.0 |
| June | 3888.0 | 2073.6 | 2073.6 | 5184.0 | 3888.0 | 0.0 | 25920.0 |
| July | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| August | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| September | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| November | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5184.0 | 25920.0 |
| December | 4017.6 | 2142.7 | 2142.7 | 5356.8 | 4017.6 | 5356.8 | 26784.0 |
| **Total (m³/a)** | **27 475.2** | **14 653.4** | **14 653.4** | **36 633.6** | **27 475.2** | **36 633.6** | **209 088.0** |

| Month | Water supply (m³) | | | | | |
|---|---|---|---|---|---|---|
| | Cal_S2_10 | Calvinia-CeresRd_BH | Cal-Phase3_9 | Cal-S2-4 | Cal-S2-3 | Monthly Totals |
| January | 8035.2 | 5356.8 | 8035.2 | 5356.8 | 3481.9 | 125 081.3 |
| February | 7257.6 | 4838.4 | 7257.6 | 4838.4 | 3145.0 | 112 976.6 |
| March | 8035.2 | 5356.8 | 8035.2 | 5356.8 | 3481.9 | 125 081.3 |
| April | 0.0 | 0.0 | 0.0 | 5184.0 | 3369.6 | 100 310.4 |
| May | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 94 815.4 |
| June | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 86 572.8 |
| July | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24 909.1 |
| August | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24 909.1 |
| September | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| November | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 51 840.0 |
| December | 0.0 | 0.0 | 0.0 | 5356.8 | 3481.9 | 103 654.1 |
| **Total (m³/a)** | **23 328.0** | **15 552.0** | **23 328.0** | **26 092.8** | **16 960.3** | **850 150.1** |

In order to evaluate the sustainable volume of groundwater that can be abstracted from the aquifers for the application boreholes and properties, the **Aquifer Firm Yield Model** (AFYM) was utilised (WRC, 2012). The model uses a single cell “Box Model” approach and makes use of a critical management water level, below which aquifer storage levels cannot be drawn down, to provide estimates of aquifer firm and assured yields. The “Box Model” approach is schematically presented below.

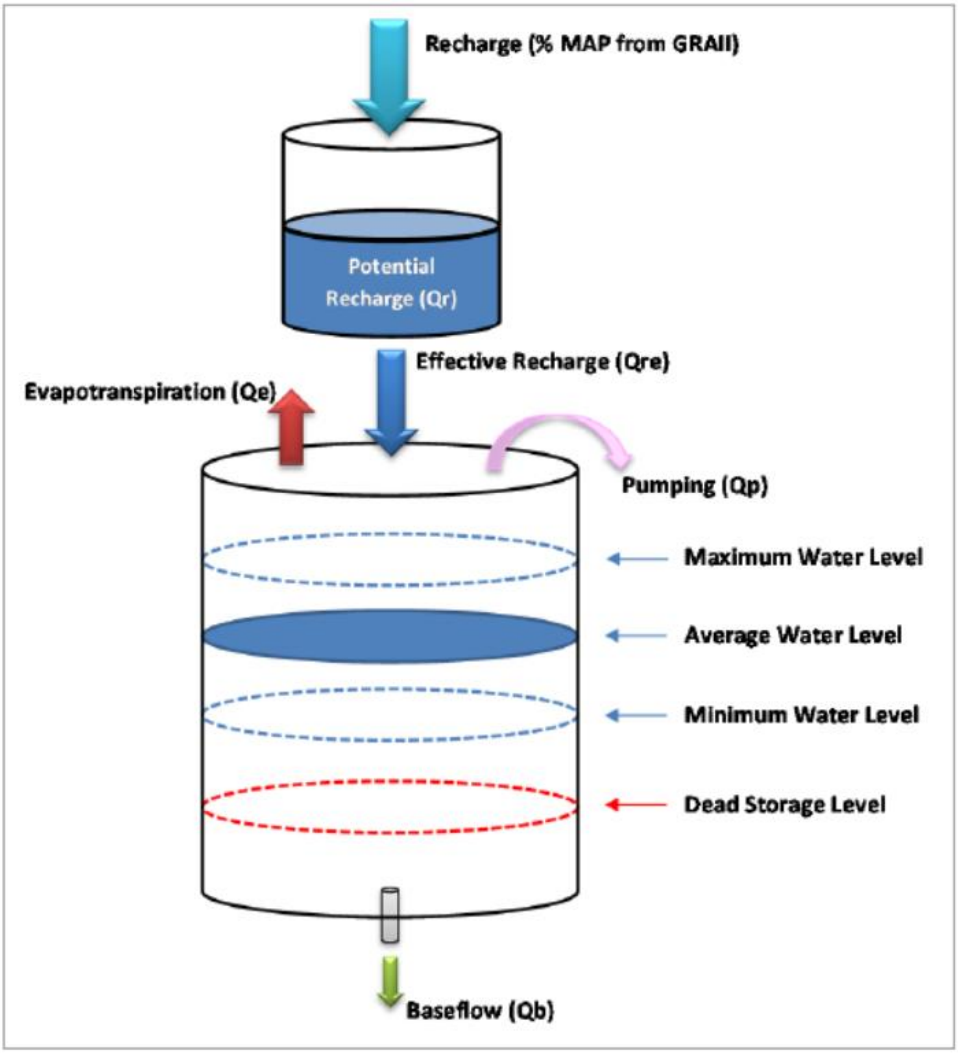



**Figure 44: The "Box Model"aapproach**

An evaluation was completed using the Aquifer Firm Yield model (WRC, 2012). The Input parameters used for the catchment are the default values presented in WRC (2012). These are taken from datasets like WR2005 (e.g. rainfall data) (Middleton and Bailey, 2008) and GRAII (e.g. specific yield and recharge (%MAP)) (DWAF, 2005), and others generated during the WRC (2012) (e.g.recharge threshold and riparian zone (% catchment area)). The parameters for quaternary catchments E40A, E40B, E32A, E32C, E24F and D58B are presented in Figure 45 below.

| Parameter | E40A | E40B | E32A | E32C | E24F | D58B |
|---|---|---|---|---|---|---|
| Groundwater Level (mbgl) | 11.7 | 9.5 | 10.3 | 11.8 | 15 | 11 |
| Max Drawdown (m) | 5 | 5 | 5 | 5 | 5 | 5 |
| Specific Yield | 8.34E-4 | 8.3E-4 | 8.3E-4 | 8.3E-4 | 1.004E-3 | 7.93E-4 |
| Firm Yield (L/s) | 93.7 | 69.7 | 83 | 38.7 | 36.3 | 32.7 |
| Firm Yield (L/s/km²) | 0.0996 | 0.0985 | 0.0743 | 0.0606 | 0.0623 | 0.0289 |
| Recharge % | 2.1 | 2 | 1.8 | 1.3 | 1.6 | 1 |
| Recharge Threshold (mm) | 10 | 10 | 9 | 9 | 8 | 7 |
| MAP (mm) | 235.7 | 240.7 | 206.5 | 227.2 | 192.4 | 162.8 |
| Hydrological MAR (mm) | 7.9 | 8.5 | 3.4 | 4.7 | 7.2 | 1 |
| Hydrological MAE (mm) | 1940 | 1945 | 2020 | 1950 | 1895 | 2100 |
| Baseflow: Default (Mm³/a) | 4.54 | 8.09 | 0 | 0 | 3.95 | 3.81 |
| ET Model | Linear | Linear | Linear | Linear | Linear | Linear |
| ET Extinction Depth (m) | 2 | 2 | 2 | 2 | 1 | 1 |
| Riparian Zone (%) | 2.9 | 2.6 | 3.5 | 4.8 | 2.5 | 2 |

**Figure 45: Hydrogeological parameters for the relevant Quarternary catchments (WRC,2012)**

The Aquifer Firm Yield Model was run, and the Aquifer Firm Yield was determined - the results of which, are presented below in Figure 46.

| Name | Q (L/s) | Q (m³/month) | Q (m³/a) |
|---|---|---|---|
| E40A | 93.7 | 242870.4 | 2 956 947.12 |
| E40B | 69.7 | 180 662.4 | 2 199 564.72 |
| E32A | 83 | 215 136 | 2 619 280.80 |
| E32C | 38.7 | 100 310.4 | 1 221 279 |
| E24F | 36.3 | 94 089.6 | 1 145 541 |
| D58B | 32.7 | 84 758.4 | 1 031 933.52 |

**Figure 46: Results of the Aquifer Firm Yield model**

For this study area there are clear geological features such as contacts between dolerite intrusives and sedimentary layers, as well as mapped faults that enable the definition of more localised aquifers (i.e., Groundwater Resource Units (GRUs)). Nine individual GRUs have been delineated as part of this assessment within the study area. They are complex and discussed separately below. Figure 48 provides a geological map of the boreholes and GRUs with the positions of two cross sections provided, to help illustrate the conceptual hydrogeological and recharge mechanisms of the area.

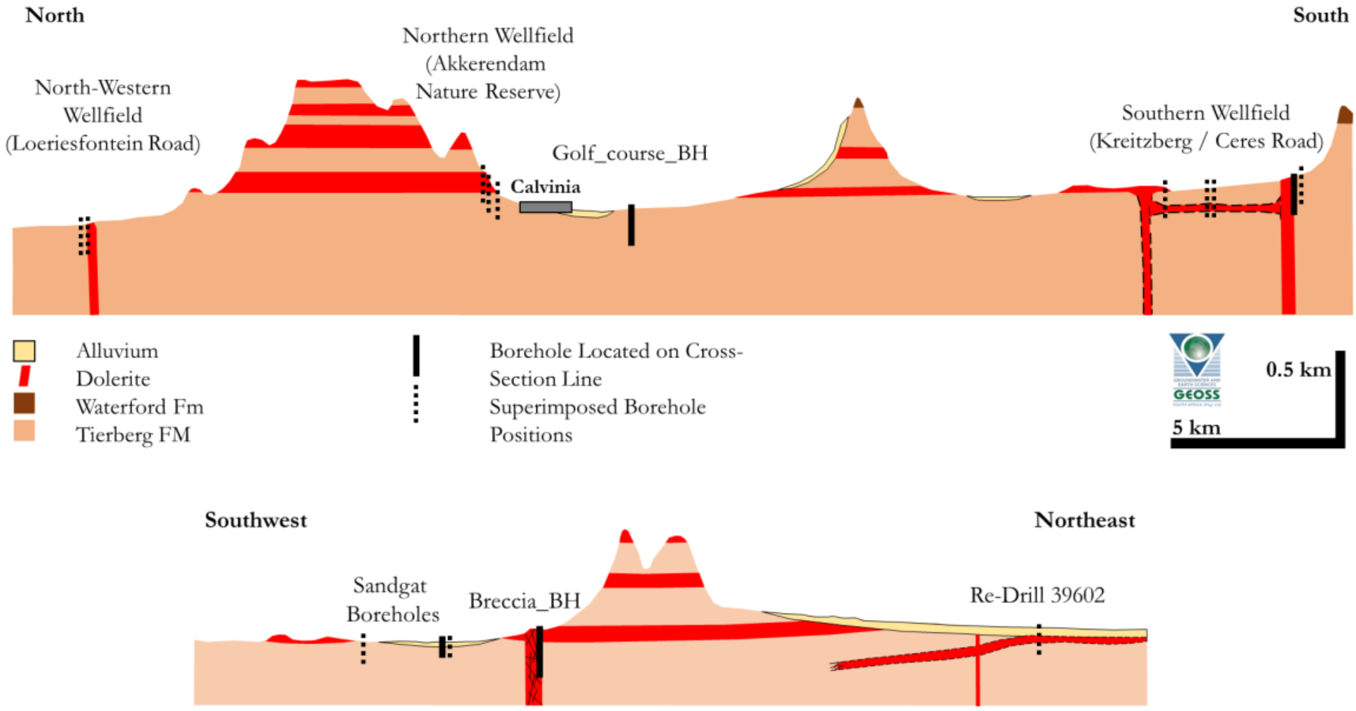



**Figure 47: Schematic of conceptual geological sections**

### Calvinia Borehole Cluster 1 (Old Boreholes) – GRUs

The six old boreholes within Cluster 1 are not all located within a single GRU, which delineates the area within which direct vertical recharge can contribute towards replenishing groundwater abstracted from the borehole(s). The Golf_course_BH and Deon_Vlok_BH each have their own GRU. The Witwal_BH shares a third GRU with the Northern Wellfield boreholes, while the three Sandgat boreholes share a fourth GRU.

***Golf_course_BH*** (979 mamsl) is located 0.6 – 1.1 km south of the Oorlogsrivier, along the R27 towards Niewoudtville and is drilled into the fractured rock aquifer (Tierberg Formation), reaching a depth of 225 m. The recharge to the GRU for this borehole has been delineated towards the southern topographical high (Rebunieberg, 1657 mamsl), away from the Oorlogsrivier channel. This is conservative and due to the depth of the borehole, the GRU may well extend further west, and potentially north as well. The GRU does cross two minor dolerite sills at 1065m and 1330m, however these are unlikely to limit vertical recharge to the GRU as they outcrop against the northern facing slopes of Rebunieberg where they are cross cut by drainage channels towards the Golf_course_BH. The delineated GRU has an extent of approximately 24.6 $km^2$ and is predominantly in quaternary catchment E40B. Using the GRAII recharge values (2.0 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 118 424.4 $m^3/a$ for the GRU. The firm yield of the GRU is calculated to be **76 483.2 $m^3/a$**, which is estimated to be 64.6 % of the total recharge to the GRU.

***Deon_Vlok_BH*** (1083 mamsl) is located 17.5 km east of Calvinia along the R27 and is drilled into the fractured rock aquifer (Tierberg Formation), reaching a depth of 250 m. Drilling in 2018 north of this site indicates the presence of two dipping dolerite sills in the area between depths of 30 – 200 mbgl. Dolerite sill outcrops are also evident at elevations above Deon_Vlok_BH towards the northwest and south. The recharge to the GRU for this borehole has been delineated as reaching northwest to the topographical high (eastern tip of Hantamsberg, 1570 mamsl), south towards the Pramberg koppie (1375) and east towards alluvial deposits, which likely drain into the Tierberg Formation layers.

The delineated GRU has an area of approximately 66.9 $km^2$ and is predominantly in quaternary catchment E40A. Using the GRAII recharge values (2.1 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 331 134.9 $m^3/a$ for the GRU. The firm yield of the GRU is calculated to be **210 228.7 $m^3/a$**, which is estimated to be 63.5 % of the total recharge to the GRU.

**Witwal_BH** (1005 mamsl) is located 2.7 km northeast of Calvinia along the southern slopes of the Hantamsberg and is drilled into the fractured rock aquifer (Tierberg Formation), reaching a depth of 193m. The GRU for this borehole includes the Northern Wellfield boreholes and has been delineated as reaching north and west to the topographical high (Hantamsberg, 1600 mamsl) and south towards the alluvial deposits and drainage channel of the Oorlogskloofrivier (970 mamsl).

The delineated GRU for these boreholes has an extent of approximately 72.7 $km^2$ and is predominantly in quaternary catchment E40B. Using the GRAII recharge values (2.0 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 349 977.8 $m^3/a$ for the GRU. The firm yield of the GRU is calculated to be **226 029.7 $m^3/a$**, which is estimated to be 64.6% of the total recharge to the GRU.

***Sandgat_3_BH, Sandgat_4_BH and Sandgat_5_BH*** (1007, 1006 and 1005 mamsl respectively) are located 8.5 – 10.5 km east of Calvinia, south of the R27. Sandgat_3_BH and Sandgat_4_BH and are 15 and 59 m deep respectively and the mapped geology of the area is alluvial sand deposits. Sandgat_5_BH is 198m deep and drilled into the fractured rock aquifer (Tierberg Formation), which can be seen outcropping on site. The recharge to the GRU for these boreholes has been delineated as reaching northeast across the R27 to the dolerite outcrops (1050 mamsl) south of Breccia_BH, east to include the Tierberg outcrop in which Sandgat_5_BH is drilled and bounded by the Vlakfontein se Rivier drainage channel towards the Pramberg koppie (1375) and east towards alluvial deposits, which likely drain direct vertical recharge into the Tierberg Formation layers. The delineated GRU has an extent of approximately 38 km$^2$ and is predominantly in quaternary catchment E40A. Using the GRAII recharge values (2.1 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 188 088.6 m$^3$/a for the GRU. The firm yield of the GRU is calculated to be **119 412.4 m$^3$/a**, which is estimated to be 63.5 % of the total recharge to the GRU.

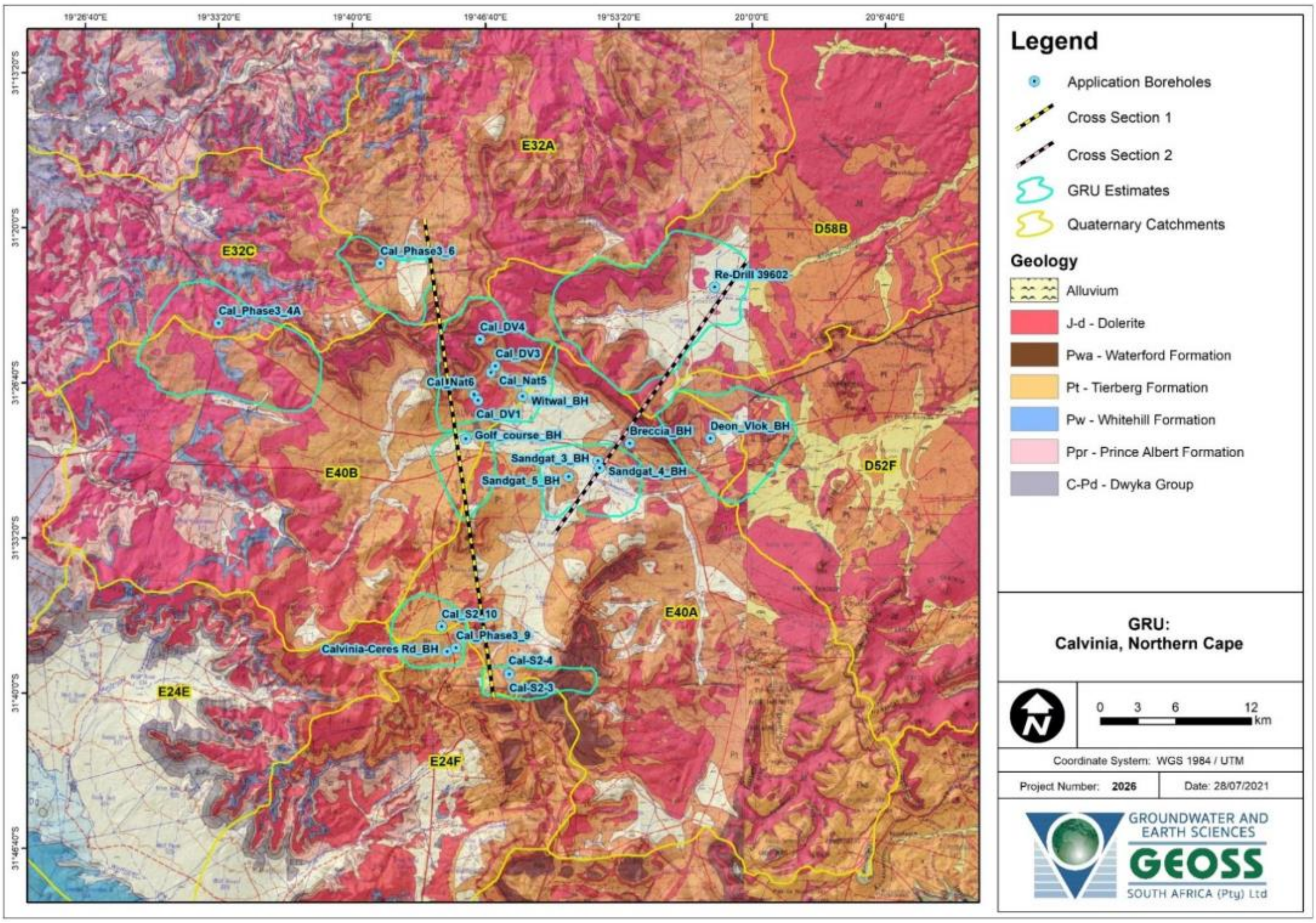



**Figure 48: Position of Calvinia GRU's**

**Calvinia Borehole Cluster 2 (Existing Boreholes) – GRUs**

Two boreholes within Cluster 2 are not within a single GRU. The borehole Re-Drill 39602 has an individual GRU described below.

***No GRU has been defined for the Breccia_BH as during the test pumping of this breccia pipe (WRC, 2002) it was deducted that this borehole penetrates a bounded groundwater compartment and thus a larger Groundwater Resource Unit for recharge and firm yield calculations is not applicable. A recharge rate of 9320 m$^3$/a was estimated from the 3 years required to replenish the water levels as a result of removing 28 800 m$^3$ in a week. The firm yield and recharge to this borehole is thus not an applicable concept.***

***Re-Drill 39602*** (1080 mamsl) is located 21.5 km northeast of Calvinia, on the other side of the Hantamsberg and is drilled 150 m deep into Tierberg Formation, intruded by dolerite from 31 – 70 mbgl and with the water strike intersected at 47 – 50 mbgl. The recharge to the GRU for this borehole has been delineated towards the western topographical high of quaternary catchment D58B (Hantamsberg, 1530 mamsl) and generally follows disconnected mapped outcrops of dolerite around the north, east and south. However, this is conservative and due to the depth of the water strike in the dolerite the GRU may well extend further south and east.

The delineated GRU has an extent of approximately 124 km$^2$ and is in quaternary catchment D58B. Using the GRAII recharge values (1.0 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 201 872 m$^3$/a for the GRU. The firm yield of the GRU is calculated to be **113 128 m$^3$/a**, which is estimated to be 56 % of the total recharge to the GRU.

**Calvinia Northern Wellfield (Akkerendam Nature Reserve) – GRU**

The five new boreholes within the Northern Wellfield are all located within a single GRU. These boreholes are ***Cal_DV1, Cal_DV3, Cal_DV4, Cal_Nat5 and Cal_Nat6*** and are located within the Akkerendam Nature Reserve, north of Calvinia. The boreholes are drilled into the Tierberg Formation and intrusive dolerites, reaching depths of 160 – 207 m. The GRU for these boreholes has been delineated as reaching north and west to the topographical high (Hantamsberg, 1600 mamsl) and south towards the alluvial deposits and drainage channel of the Oorlogskloofrivier (970 mamsl).

The delineated GRU for these boreholes has an area of approximately 72.7 km$^2$ and is predominantly in quaternary catchment E40B. Using the GRAII recharge values (2.0 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 349 977.8 m$^3$/a for the GRU. The firm yield of the GRU is calculated to be **226 029.7 m$^3$/a**, which is estimated to be 64.6% of the total recharge to the GRU.

**Calvinia North-Western Wellfield (Loeriesfontein Road) – GRUs**

The two new boreholes which form the North Western Wellfield are located within separate GRUs.

***Cal_Phase3_6*** (907 mamsl) is located 14 km northwest of Calvinia, between Perdekop and Toringskop and is drilled into a fractured aquifer along a 20 km long west-east dyke intruded into the Tierberg Formation. The borehole depth is 112 mbgl with the main water strike at 92 mbgl. The recharge to the GRU for this borehole has been delineated by topographical drainage towards the dyke from both the north (Toringskop, 1430 mamsl) and south (Perdekop, 1660 mamsl). This is conservative and may well extend further east along the Tierberg Formation south of the dyke. The GRU does cross minor dolerite sills which are unlikely to limit vertical recharge to the GRU as they outcrop against the slopes of Perdekop and Toringskop where they are cross cut by drainage channels towards Cal_Phase3_6.

The delineated GRU has an extent of 30.4 km$^2$ and is in quaternary catchment E32A. Using the GRAII recharge values (1.8 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 112 996.8 m$^3$/a for the GRU. The firm yield of the GRU is calculated to be **71 239 m$^3$/a**, which is estimated to be 63 % of the total recharge to the GRU.

***Cal_Phase3_4A*** (895 mamsl) is located 22 km northwest of Calvinia along the R355 Loeriesfontein Road and is drilled into a large dolerite sill, intrusive into the Whitehill and Tierberg Formations. Two regional faults of 20 km and 6 km respectively are also mapped in the area. The borehole depth is 79mbgl with dolerite from 30-79 mbgl underlying shale and a main water strike at 71 mbgl. The recharge to the GRU for this borehole has been delineated by topographical drainage towards two regional faults from both the northwest and southeast. Considering the extent of these two faults, this is conservative and may well extend further east along the 6 km fault and southwest along the 20 km fault.

The delineated GRU has an extent of approximately 69.7 km$^2$ and is predominantly in quaternary catchment E40B. Using the GRAII recharge values (2 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 478 030.2 m$^3$/a for the GRU. The firm yield of the GRU is calculated to be **308 731.1 m$^3$/a**, which is estimated to be 64.6 % of the total recharge to the GRU.

**Calvinia Southern Wellfield (Kreitzberg / Calvinia Ceres Road) – GRUs**

The five new boreholes within the Southern Wellfield are located within two separate GRUs. These boreholes are Cal-S2-3 (1161 mamsl) and Cal-S2-4 (1155 mamsl) in one GRU, and Cal_S2-10 (1089 mamsl), Cal_Phase3_9 (1076 mamsl) and Calvinia-Ceres Rd_BH (1067 mamsl) in a another GRU. The wellfield is 20 km south of Calvinia, along the R355 towards Ceres.

The boreholes ***Cal-S2-3*** and ***Cal-S2-4*** are drilled in the Tierberg Formation shales which are baked and fractured locally by two $90^{o}$ intersecting dykes in north-south and west-east orientations. The two boreholes are drilled to depths of 122 and 187 m respectively. The GRU for these two boreholes has been delineated as extending south to the topographical high (Kelderberg, 1510mamsl) and east towards the Waterford Formation capped Keiskie Berge (1520 mamsl).

The delineated GRU for these two boreholes has an extent of approximately 19.7 $km^2$ and is predominantly in quaternary catchment E40A. Using the GRAII recharge values (2.1 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 97 509.1 $m^3$/a for the GRU. The firm yield of the GRU is calculated to be **61 905.9 $m^3$/a**, which is estimated to be 63.5% of the total recharge to the GRU.

The three boreholes ***Cal_S2_10, Cal_Phase3_9 and Calvinia-Ceres Rd_BH*** are drilled into Tierberg Formation shales and dolerite intrusives, to depths of 117, 152 and 52 m respectively. The main water strikes of the two newly drilled boreholes which have drill logs were in a 60-70 m thick dolerite intrusive layer. Thus, the GRU for these three boreholes has been delineated based on the surrounding dolerite outcrop, which forms a localised basin delineation of topographical highs of 1120 mamsl in the south, east and west, and 1090 mamsl to the north.

The delineated GRU for these two boreholes has an extent of approximately 27.7 $km^2$ and is predominantly in quaternary catchment E40A. Using the GRAII recharge values (2.1 % of MAP), the direct vertical recharge (minimum recharge volume) is calculated to be 137 106.7 $m^3$/a for the GRU. The firm yield of the GRU is calculated to be **87 045.4 $m^3$/a**, which is estimated to be 63.5% of the total recharge to the GRU.

### 8.7.3 Comparison of Sustainable Yield vs Aquifer Firm Yield Model

| Current Production - Old Wellfield | Sustainable Yield (l/s) | Annual Yield ($m^3$/annum) | Aquifer Firm Yield Model ($m^3$/annum) | Aquifer Firm Yield Model (l/s) | Difference (percentage) | Safety Factor Required |
|---|---|---|---|---|---|---|
| Golf_course_BH | 2.5 | 78 840 | 52 531 | 1.67 | -33% | 3 |
| Witwal_BH | 6 | 189 216 | 27 475 | 0.87 | -85% | 2 |
| Sandgat_3_BH | 1.2 | 37 843 | 23 674 | 0.75 | -37% | 3 |
| Sandgat_4_BH | 0.8 | 25 229 | 18 939 | 0.60 | -25% | 5 |
| Sandgat_5_BH | 3 | 94 608 | 47 347 | 1.50 | -50% | 3 |
| Breccia_BH | 2.5 | 66 096 | | 0.00 | | |
| Deon_Vlok_BH | 16 | 504 576 | 125 453 | 3.98 | -75% | 2 |
| **Total:** | 32 | 996 408 | 295 419 | 9.37 | -70% | 2 |

| Current Production - New Wellfields | Sustainable Yield (l/s) | Annual Yield (m3/annum) | Aquifer Firm Yield Model (m3/annum) | Aquifer Firm Yield Model (l/s) | Difference (percentage) | Safety Factor Required |
|---|---|---|---|---|---|---|
| Calvinia-Ceres Rd_BH | 2 | 63 072 | 15 552 | 0.49 | -75% | 2 |
| Cal_DV1 | 5 | 157 680 | 27 475 | 1.74 | -83% | 2 |
| Cal_DV3 | 0.8 | 25 229 | 14 653 | 0.93 | -42% | 3 |
| Cal_DV4 | 1 | 31 536 | 14 653 | 0.93 | -54% | 2 |
| Cal-S2-3 | 1.3 | 40 997 | 16 960 | 1.61 | -59% | 2 |
| Cal-S2-4 | 4 | 126 144 | 26 093 | 2.48 | -79% | 2 |
| Cal_S2_10 | 15 | 473 040 | 23 328 | 2.97 | -95% | 2 |
| Cal_Nat5 | 4.3 | 135 605 | 36 634 | 2.32 | -73% | 2 |
| Cal_Nat6 | 1.5 | 47 304 | 27 475 | 1.74 | -42% | 3 |
| Cal_Phase3_6 | 2 | 63 072 | 36 634 | 2.79 | -42% | 3 |
| Cal_Phase3_4A | 15 | 473 040 | 209 088 | 13.22 | -56% | 2 |
| Cal_Phase3_9 | 15 | 473 040 | 23 328 | 2.97 | -95% | 2 |
| Re-Drill 39602 | 4.5 | 141 912 | 82 858 | 3.95 | -42% | 3 |
| **Total:** | 71.4 | 2 251 670 | 554 731 | 38.12 | -75% | 2 |

If the pump-tested Sustainable Yields for the Calvinia boreholes are compared to the Aquifer Firm Yields as calculated using the "Box Model", it is quite clear that the ***low rainfall, together with the very low recharge rates*** for the catchments in the Calvinia area have a major impact on the sustainability of the groundwater resources. See Annexure J for detailed calculations in this regard.

When this situation is then exposed to drought conditions, the risk of declining water tables multiplies exponentially.

This calculation correlates with our previous experiences in Loeriesfontein and Brandvlei, where the pump-tested sustainable yields could not reliably be achieved, even in the short term. At Loeriesfontein, 9 boreholes were developed and equipped in 2018. Today only 5 of the original boreholes are still producing water.
Similarly, at Brandvlei, we equipped 13 boreholes in 2020, and today only 6 of them are still producing water sustainably.

If we did not approach the use of groundwater at these two towns, **using a Safety Factor of at least 3**, we would have run out of options to supply these towns very quickly. The past year has not produced much summer rainfall or winter rainfall for the Calvinia area, and the season ahead is forecast to be similar.

It is therefore paramount, that **all the boreholes as listed be developed and equipped** to allow options for use when the sustainability of the groundwater becomes a limiting factor. We trust that this exercise will sufficiently demonstrate the need to have a large safety margin when supplying Karoo towns with groundwater as the sole source of water.

### 8.7.4 Fluoride removal from water

The high concentrations of fluoride (8mg/l) in the recently found, as well as the existing Calvinia water, are worrying as this constituent has long term health effect in terms of tooth enamel staining and is especially hazardous for children up to seven years of age.

Dental fluorosis is considered as a cosmetic effect only. However, in the Northwest Province of South Africa, dental fluorosis has resulted in cases of psychological trauma.
Many of the inhabitants in areas where high fluoride levels occur have demanded that their teeth be extracted and replaced with dentures (Mothusi, 1995; Rudolph et al, 1995).

**Figure 49: Typical illustration of severe dental fluorosis**

In addition to the cosmetic trauma, there is ample proof, that both acute and chronic dosages of excessive fluoride, are detrimental to health with skeletal problems, kidney disorders, depressed thyroid activity and interference with immune system functioning being widely studied.

Typically, potable water should not contain more than 1.0mg/l of fluoride. At this level it is beneficial. When concentrations are between 1.0mg/l and 1.5mg/l, there is already risk of mottling of dental enamel, but no other health effects.

Above concentrations of 1.5mg/l mottling and tooth damage will affect most continuous users of the water. Above 3.5mg/l, severe tooth damage is inevitable in especially infants' temporary and permanent teeth. Above 4mg/l, the threshold for chronic health affects is reached and from this concentration upwards, fluoride will cause skeletal trauma in the form of skeletal fluorosis.

The levels of fluoride from both the new and the existing boreholes at Calvinia are all in the 1.6 mg/l to 8.0mg/l range. This indicates a definite possibility for the occurrence of tooth defects due to long term usage. Although these values exceed both the recommended 1.0mg/l threshold, as well as the upper limit for domestic drinking water of 4.0mg/l.

Given that this water is what is available as a source of drinking water, the water should be treated to remove the excess fluoride. Fluoride can be removed with the following processes, should its concentration prove to be detrimental:

- Adsorption in a bed of activated alumina
- Removal by means of ion exchange columns
- Removal by means of membrane processes such as reverse osmosis and electrodialysis

All these processes incur an operational expense and produce a waste stream which needs to be dealt with in an environmentally acceptable manner. The process widely recognized as the most cost effective in terms of operational cost, is the activated alumina process.

### 8.7.5 Activated Alumina process

The fluoride removal unit proposed will be based on an ion exchange technology utilizing activated alumina media with a nominal treatment capacity of 75m$^3$ per hour. The Fluoride Removal Plant will be fed with water which has passed through a set of Sand Filters.

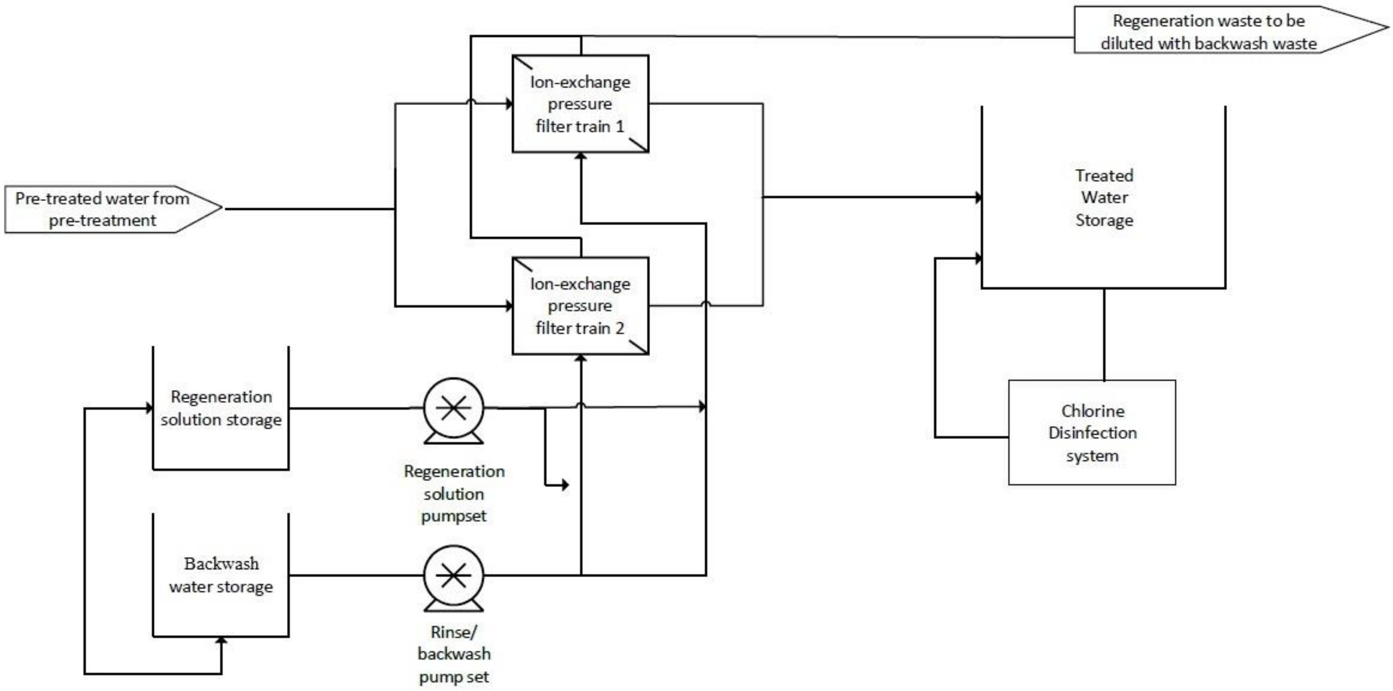



**Figure 50: Process and instrumentation diagram for Activated Alumina Process**

The fluoride plant will typically comprise the following components to be housed inside a building:

1. Four (4) number down flow epoxy coated carbon steel Pressure Vessels in which Activated Alumina contact will take place. To be utilized as Duty and Standby units when one vessel requires regeneration. The two sets of vessels are to be operated in parallel.
2. Provision for Feedwater pH control using Sulphuric Acid fed into Feedwater pipeline by means of a metered chemical dosing pump (1 Duty + 1 Standby).
3. Sulphuric Acid Day Tank complete with filling, abstraction and flushing pipework.
4. Provision for media regeneration by means of up flow Caustic Soda (1% concentration) contact with the media in the contact vessels.
5. Caustic Soda to be dosed using metered chemical dosing pumps (1 Duty + 1 Standby) abstracting solution from a suitably sized Day Tank complete with filling, abstraction and flushing pipework.
6. Provision for neutralization of the media after Caustic Soda contact using diluted Sulphuric Acid.

7. Provision of a Clean Water Rinsing cycle after Regeneration Cycle and before Production cycle recommences.
8. Provision of Bulk Chemical Storage Tanks for Caustic Soda and Sulphuric Acid complete with transfer pumps for each to the respective Day Tanks.
9. Piping for Feedwater, Caustic Soda dosing, Sulphuric Acid Dosing, delivery of Treated Water to Existing and New Reservoirs.
10. Supply and installation of all required instrumentation such as flow meters, online pH meters, online Fluoride meters, online Electrical Conductivity meters which will be used for control loops to completely automate the fluoride removal and regeneration of the media.
11. A complete package type plant mounted on one or more skids will be constructed in controlled conditions and then connected to the supply and delivery piping of the Calvinia Water Treatment Plant.

Activated alumina is regarded as one of the best available technologies for the removal of fluoride from water. AA is a granular highly porous material consisting, mainly, of aluminium oxide ($AlO_3$). Fluoride removal is obtained through ion-exchange, where a fluoride ion is exchange for an aluminium ion.
The efficiency of the process is pH dependent with the best results obtained at pH 5.5. The pH of the feed water is adjusted with 0.5% $H_2SO_4$, or sulphuric acid. After the removal of the fluoride, sodium hydroxide (NaOH) is dosed to increase the pH to neutral (pH 7) prior to delivery to the storage reservoir.

Once breakthrough of fluoride occurs, the media must be regenerated. Regeneration is done with sodium hydroxide (NaOH), which is pumped through the vessels in the opposite direction as during normal flow. This is followed by neutralization of the media with sulphuric acid ($H_2SO_4$), which is again pumped in the top to bottom direction. This is followed by a clean water rinse through the media. All three these cycles have a waste component, which is discharged to a set of evaporation ponds for disposal. The waste disposed consist of a liquid, and when the water has evaporated, the remaining solids will consist of sodium sulphate, aluminium sulphate and sodium fluoride salts. No special containment or handling is required for these materials.

For this application, two sets of two ion exchange columns are recommended (2.4 x 5.0 m). The two columns ensure continuous operation, allowing one bed to be operated while the other one is being regenerated. Fluoride effluent concentrations of <1.5 ppm can be expected.

Regeneration will be required after 1400 operational hours (roughly 2 months). Based on the loading capacity lost with each regeneration, the media for a single column will have a life-span of ±8 months. A long run cycle is, thus, preferred due to the loss in capacity of the media following each regeneration. It should be noted that the capacity lost with each regeneration is subject to the regeneration process and the composition of the feed water treated. Optimisation of the regeneration process is therefore a necessity.

**Figure 51: Typical Activated Alumina fluoride removal plant**

### 8.7.6 Infrastructure required to utilize this option

To secure the medium to long term sustainability of water supply to Calvinia, the following new infrastructure will need to be developed:

1. Equipping of 6 new boreholes at Calvinia
    - (Kreitzberg x 4 boreholes delivering 35.3 l/s)
    - (Northwest x 2 boreholes delivering 17 l/s)
2. Refurbishment of 6 existing boreholes at Calvinia to ensure full potential is reached.
3. Construction of a new 200mm diameter uPVC Gravity Main pipeline from Kreitzberg to the Calvinia Water Treatment Plant over a distance of 31km.
4. Construction of a new 160mm diameter uPVC Rising Main from the Northwest boreholes to the Calvinia Water Treatment Plant over a distance of 33km.
5. Construction of a new 1.5 Megalitres concrete storage reservoir to maintain a 48hour reserve for the town of Calvinia.

6. Construction of a 20 litres per second Activated Alumina fluoride removal facility at Calvinia to render the water quality safe for long-term future use.
7. Construction of 3 x 1000$m^2$ evaporation ponds at the Calvinia Water Treatment Plant to discharge the waste product from the Fluoride Treatment Plant.
8. Construction of a new 11kV mains power supply line to each of the wellfields with a total length of 60km in length.
9. Supply and installation of a telemetry system to enable control of the boreholes and reservoir levels from the Calvinia municipal offices.
10. Purchase of tools and equipment to enable the municipality to effectively operate and maintain the proposed new system.

We are of the opinion, that this investment would provide a sustainable supply of water to Calvinia for at least a 20-year horizon. The fact that surplus water is available, allows the intermittent use of boreholes and also allows the existing boreholes to be used less frequently, thereby enhancing the chances of recharge and recovery, and the longer-term sustainability of the system.

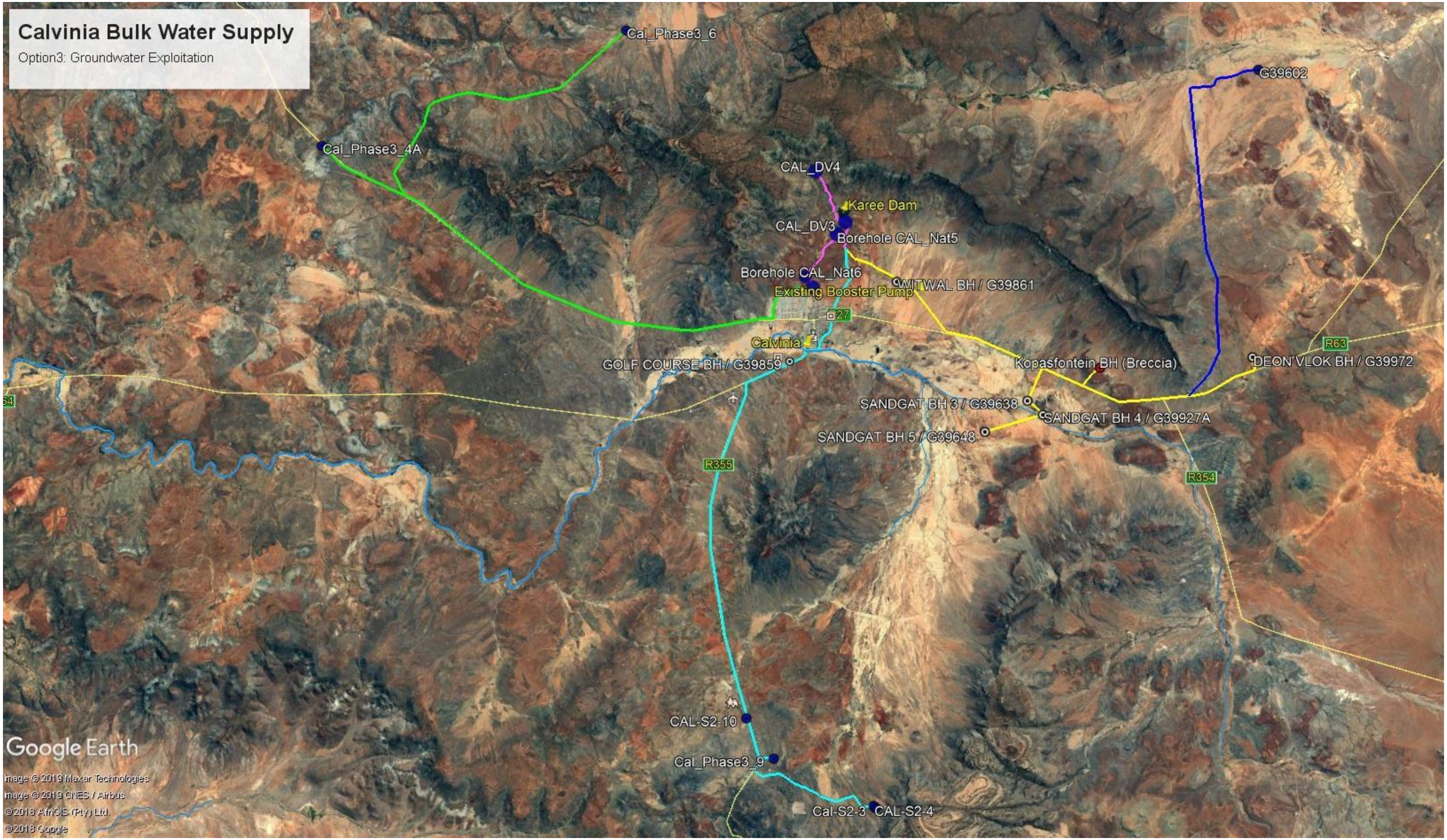



**Figure 52: Proposed Layout for Calvinia Bulk Water Supply Option 3 - Groundwater exploitation**

### 8.7.7 Cost Estimate for Option 3: Further exploitation of Groundwater sources

A cost estimate of the capital requirement for this option was calculated and summarized in the table below. The Capital requirement for this option runs to **R 178 956 388.63**.

**SUMMARY OF COSTS FOR CALVINIA GROUNDWATER EXPLOITATION**

| | |
|---|---|
| **PRELIMINARY AND GENERAL COSTS** | R 19 519 736.25 |
| **DEVELOPMENT AND EQUIPPING OF BOREHOLE PUMP STATIONS** | R 3 174 132.24 |
| **COLLECTOR PIPELINES BETWEEN BOREHOLES & CALVINIA WTP** | R 58 584 615.75 |
| **FLUORIDE REMOVAL ACTIVATED ALUMINA PLANT (CALVINIA)** | R 14 540 173.00 |
| **NEW 1.5MEGALITER CONCRETE STORAGE RESERVOIR** | R 3 750 000.00 |
| **TELEMETRY SYSTEM** | R 5 254 940.29 |
| **ELECTRICITY SUPPLY** | R 14 955 000.00 |
| **ENVIRONMENTAL REQUIREMENTS** | R 1 818 548.00 |
| **SUBTOTAL** | **R 121 597 145.53** |
| CONTINGENCIES: 10% | R12 159 714.55 |
| ESCALATION: 6.5% | R7 903 814.46 |
| **SUBTOTAL:** | **R141 660 674.54** |
| PROFESSIONAL FEES & DISBURSEMENTS | R 13 953 576.44 |
| SUBTOTAL: | **R155 614 250.98** |
| VAT @ 15% | R23 342 137.65 |
| **TOTAL PROJECT COST:** | **R178 956 388.63** |

**Figure 53: Capital requirement for the exploitation of Groundwater sources at Calvinia**

In addition to the Capital Cost, the annual Operations and Maintenance Costs for Option 3 were calculated using the following assumptions:

| | |
|---|---|
| Maintenance Cost for Pipelines and Civil Works: | 1% of construction value |
| Maintenance Cost for Mechanical Equipment: | 4% of construction value |
| Maintenance Cost for Electrical Powerlines and Switchgear: | 4% of construction value |

Operational costs are calculated using the direct expenses for Electrical energy at an ESKOM Rate of R1.3575 / kW.h as found in the latest Tariff Tables for rural areas. The operational cost for personnel was taken as R500 000-00 per annum and includes salaries and transport.

**Maintenance Cost (annual)**

| | | COST: | TOTAL: |
|---|---|---|---|
| 4% on Mechanical Equipment: | | | |
| Value: | R 17 714 305.24 | R 708 572.21 | |
| 1% on Pipelines & Civil Works | | | |
| Value: | R 62 334 615.75 | R 623 346.16 | |
| 1% on Powerlines | | | |
| Value: | R 20 209 940.29 | R 202 099.40 | |
| | | | **R 1 534 017.77** |

**Operational Cost (annual)**

| | | | |
|---|---|---|---|
| Electricity consumption | | R 1 248 720.48 | |
| Salaries of Operating Staff: | | R 500 000.00 | |
| Sub-total: | | | **R 1 748 720.48** |
| TOTAL O&M COSTS | | | R 3 282 738.25 |
| VAT @ 15% | | | R 492 410.74 |
| **Annual Estimated Costs of Operation and Maintenance:** | | | **R 3 775 148.99** |
| **Annual Volume of water produced:** | **575000 $m^3$** | | |

**Estimated Unit Cost of Water:** **R 6.5655 per $m^3$**

The above calculation equates to an annual Operations & Maintenance Cost of R 3 775 148.99 of which R 1 248 720.48 or 39.5% is for electrical energy to elevate the water from the depth of the boreholes to the Calvinia Water Treatment Plant inlet works. The unit cost is calculated using the maximum demand that the scheme is designed for and the annual Operations and Maintenance Costs. The unit cost for water for this option is calculated to be **R6-57 per kilolitre** without the Hantam Municipality's mark-up. This compares favourably with what consumers in the Hantam Municipality are currently paying for water.

In the opinion of the Engineer, this project is technically possible to execute, and also **economically feasible** for the community of Calvinia.

## 8.8 Summary of Options investigated during the feasibility study.

The options investigated during the feasibility investigation for the improvement of bulk water supply to Calvinia, are summarized as follows:

| NO. | OPTION INVESTIGATED | CAPITAL COST | UNIT COST | COMMENTS |
|---|---|---|---|---|
| 1 | **Abstraction of surface water from the Doring River at Botterkloof Bridge** | **R 340 889 081.09** | **R 18.5802** | Not sustainable, Unit Cost excessive due to elevation difference and distance from source. |
| 2 | **Abstraction of surface water from the Doring/Tankwa Rivers confluence** | **R 468 414 650.93** | **R 21.2692** | Not sustainable, Unit Cost excessive due to elevation difference and distance from source |
| 3 | **Development of further groundwater sources at Kreitzberg and Northwest** | **R 178 956 388.63** | **R6.5655** | **Unit cost acceptable and compares well with current tariffs for water.** |

In all cases above, the interest and redemption costs for the capital expenditure was not included in the calculation of the unit cost of water. The unit cost was purely based on the operation and maintenance cost for a period of one year.

From the above, it is clear that the further development of groundwater and the development of the new wellfields at Kreitzberg, Northwest area and in the Akkerendam Nature Reserve is the most feasible and sustainable option from those investigated.

It must however be kept in mind that groundwater development is heavily dependent on rainfall and as such needs to be managed very carefully to ensure its sustainability. If this management is not done diligently, and the rainfall again stays away for 5 years, the town of Calvinia may end up in the same situation they are in now.

It is of utmost importance that a competent person collects and evaluates the borehole data such as the static water levels, the volumes abstracted, any changes in quality along with climatic data such as rainfall on at least a 3 monthly basis for the duration of this project's expected life to ensure its sustainability.

## 8.9 Life Cycle Cost Analysis

Life-cycle cost analysis is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain an asset, when each is equally appropriate to be implemented on technical grounds. LCCA takes into account all the user costs such as the initial capital cost, costs related to future activities, including future periodic maintenance and operational costs such as electricity consumption. All the costs are usually discounted and totaled to a present-day value known as net present value (NPV).

If the Life Cycle Cost for each of the options for water supply to Calvinia is analyzed over a period of 30 years, and using an interest rate of 5% per annum, which is comparable to the average inflation rate, the results of the calculation are as follows.

| Year | Doring River Option 1 (R x million) | | Doring River Option 2 (R x million) | | Groundwater Option 3 (R x million) | |
|---|---|---|---|---|---|---|
| 0 | R | 340.89 | R | 468.41 | R | 178.96 |
| 1 | R | 352.08 | R | 481.22 | R | 182.91 |
| 2 | R | 363.79 | R | 494.63 | R | 187.05 |
| 3 | R | 376.06 | R | 508.67 | R | 191.38 |
| 4 | R | 388.90 | R | 523.37 | R | 195.92 |
| 5 | R | 402.35 | R | 538.77 | R | 200.67 |
| 6 | R | 416.43 | R | 554.89 | R | 205.65 |
| 7 | R | 431.18 | R | 571.77 | R | 210.86 |
| 8 | R | 446.62 | R | 589.45 | R | 216.32 |
| 9 | R | 462.79 | R | 607.96 | R | 222.03 |
| 10 | R | 479.72 | R | 627.34 | R | 228.01 |
| 11 | R | 497.45 | R | 647.63 | R | 234.28 |
| 12 | R | 516.02 | R | 668.89 | R | 240.84 |
| 13 | R | 535.45 | R | 691.14 | R | 247.71 |
| 14 | R | 555.81 | R | 714.44 | R | 254.90 |
| 15 | R | 577.12 | R | 738.84 | R | 262.43 |
| 16 | R | 599.44 | R | 764.39 | R | 270.32 |
| 17 | R | 622.81 | R | 791.14 | R | 278.58 |
| 18 | R | 647.28 | R | 819.15 | R | 287.22 |
| 19 | R | 672.91 | R | 848.48 | R | 296.28 |
| 20 | R | 699.74 | R | 879.20 | R | 305.76 |
| 21 | R | 727.84 | R | 911.36 | R | 315.69 |
| 22 | R | 757.26 | R | 945.04 | R | 326.08 |
| 23 | R | 788.06 | R | 980.30 | R | 336.97 |
| 24 | R | 820.32 | R | 1 017.23 | R | 348.37 |
| 25 | R | 854.10 | R | 1 055.90 | R | 360.30 |
| 26 | R | 889.47 | R | 1 096.39 | R | 372.80 |
| 27 | R | 926.51 | R | 1 138.78 | R | 385.89 |
| 28 | R | 965.29 | R | 1 183.18 | R | 399.59 |
| 29 | R | 1 005.90 | R | 1 229.66 | R | 413.94 |
| 30 | R | 1 048.42 | R | 1 278.34 | R | 428.97 |

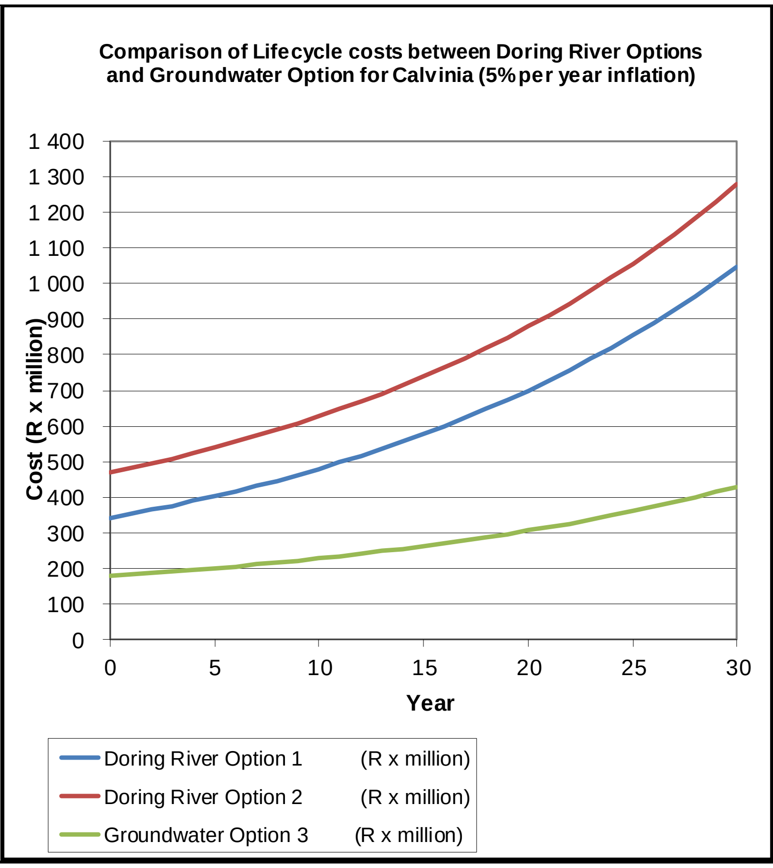



**Figure 54: Life Cycle Cost analysis**

From the above it is clear that the total cost of ownership over a period of 30 years for both Option 1 and Option 2 exceed R1 billion over 30 years, while the total cost of ownership for Option 3 only claculates to R428 million. This calculation does not take into account the rising cost of electricity, which will probably exceed 5% per annum over the next 10 years! The unit cost per kilolitre (capital costs included) over the 30-year period will amount to **R24-87 /kl**.

From the above, it is clear that the further development of groundwater and the development of the new wellfields at Kreitzberg and the Northwest area is by far the most feasible and sustainable option from those investigated. Not only does this option have the lowest initial capital input, but in terms of operational costs, and unit cost of water, it is orders of manatude cheaper than the options of bringing surface water to Calvinia from the Doring River.

It must however be kept in mind that even groundwater development is dependent on rainfall and as such needs to be managed very carefully to ensure its sustainability. If this management is not done diligently, and the rainfall again stays away for 5 years, the town of Calvinia may end up in the same situation they are in now.

It is of utmost importance that a competent person collects and evaluates the borehole data such as the static water levels, the volumes abstracted, any changes in quality along with climatic data such as rainfall on at least a 3 monthly basis for the duration of this project's expected life to ensure its sustainability.

# 9 VALUE DRIVERS AND TRADE-OFFS

## 9.1 Capital Costs of the Project

The current estimate for the capital requirements for the proposed project equates to a value of **R 178 956 388.63**. This cost is inclusive of 10% contingency, an allowance of 6.0% for cost escalation, professional engineering fees and 15% VAT.

## 9.2 Production Cost of Water

The new portion of this project has the potential to produce a total volume of 850 150 $m^3$ per annum. This is based on an operating period of 24 hours per day. The projected future requirement (2030) for Calvinia is 575 000$m^3$. The new sources are therefore able to provide 1.47 times the projected future need.

Together, the completed scheme could theoretically produce a potential yield in excess of 3 million $m^3$/ annum which is substantially more than the projected future demand of 575 000$m^3$ per annum. It must however be understood that this is a groundwater scheme which needs to be carefully managed in accordance with climatic factors, rainfall and borehole water levels.

The production cost of the water supplied by the project is calculated from the volume required by 2030 and the estimated annual operational and maintenance costs.

The estimated operational and maintenance costs equate to a value of **R3 775 148.99** per annum which is not exorbitant given that the source is 30km away.

Using these values, the estimated current production costs of the water produced by this project calculates to a value of **R6-57 per kilolitre**.

When compared with the current consumer rates in the Hantam Municipality for a consumer using 20kl per month, it is clear that the cost of this water is in line with the current rates.

It is uncertain from what basis the current rates of the Hantam Municipality are calculated or whether they are merely adjusted by a fixed percentage each year. It would be in the best interest of the Hantam Municipality to go through an exercise of zero-based costing for their various water supply systems before they adjust their tariffs in future.

The primary cost driver in the cost of water is the cost of electricity. Electricity makes up approximately **33.08% of the Operational Cost** and will probably increase substantially each year as ESKOM rates increase. This means that approximately R2-17 of the cost of each kilolitre of water is due to electrical energy costs.

Given that the town of Calvinia has been subjected to severe restrictions over the past 4 years (since November 2015), this cost is a small price to pay for the basic human right to have a sustainable supply of drinking quality water available on a constant basis.

## 9.3 Product Quality

Although the boreholes to be used as production boreholes are not saline, almost all of them do have elevated fluoride levels varying between 1.6mg/l and 8.0mg/l. This quality issue will be addressed by providing treatment to remove fluoride by means of activated alumina at the proposed new treatment plant to be located at the Calvinia Water Treatment Plant.

Treatment at the proposed plant will consist of an ion exchange process which is operated much in the same way as what a water softener is operated. It consists of contact vessels filled with activated alumina over which the water passes at a rate of 2-3 litres per minute. The activated alumina lasts several months before regeneration is required. Regeneration is done with caustic soda and sulphuric acid.

Water must be chlorinated prior to passing through the activated alumina to prevent accumulation of bacteria inside the defluoridation vessels. After removal of the fluoride, the water is pumped directly to the storage reservoirs. This treatment will be sufficient to curb most of the aesthetic and health related issues to be found in the groundwater.

## 9.4 Monetary Value of Health Benefits

The primary health benefits derived from this project are sanitation related. Without water, sanitation becomes a serious problem in any town. Most of Calvinia's households are provided either with a conservancy tank to which a flush toilet is connected, or to a waterborne sewer reticulation system. Without water to flush toilets, these systems become a foul-smelling mess and subsequently, a public health risk. It would be possible to quantify this enormous social benefit by studying the effects of not having water and recording the occurrence of diseases such as gastro enteritis, diarrhoea, etc.

The community of Calvinia has for many years been exposed to marginal water quality from their existing boreholes, of which medium salinity, hydrogen sulphide gas and high levels of fluoride, are the main issues. There is however not a large prevalence of fluorosis in spite of this. Fluoride ingested at the correct quantities is beneficial to dental health. Above concentrations of 1.5 mg/litre, it does however become problematic especially in small children.

## 9.5 Socio-Economic Benefits

Gains from improved water supply and drinking quality water sources benefit indigent persons the most. Improved water quality is crucial to any production process where worker health is critical for increased productivity. Interventions to reduce poverty and to bolster economic growth will be more effective if they implicitly include measures to improve people's health and livelihood systems as well as resilience of economies to rainfall variability.

Calvinia is primarily a service centre for the extensive stock farming industry practiced in the region. Many of the male inhabitants are farm hands and only return to the town during weekends. So, the primary socio-economic benefit lies in the improved health of the women and children. Children who are not ill can attend school more often leading to improved development of human capital.

In addition, agricultural support industries such as abattoirs will benefit greatly from improved quality as a well as sustainable supply enabling them to increase their production as well as product quality.

Calvinia also has several guesthouses which serve the hospitality industry. Without water, it is almost impossible for establishments such as these to ply their trade. An improved water supply would therefore greatly benefit this sector.

## 9.6 Proposed Breakdown of Funding for the Project

Taking into consideration the funding rules of the Regional Bulk Infrastructure Grant, it is estimated that this project be funded as follows:

Percentage of Indigent Households benefitting: **70.0%** (Census 2011)

Estimated Project Cost: **R 178 956 388.63**

**Counter funding calculation:**

| Indigents | Population 2030 | Indigent population | Indigent users 2030 | Water use per day in litres | $m^3$ per day | Supply in $m^3$/day 2030 | % social component |
|---|---|---|---|---|---|---|---|
| Calvinia | 13908 | 27.5% | 3820 | 125 | 549 | 1575.0 | 34.87% |
| ***Subtotal*** | ***13908*** | | ***3797*** | | ***549*** | | ***34.87%*** |
| Non-indigents | 10088 | 100.00% | 10111 | 25 | 291 | 1575.0 | 18.46% |
| ***Subtotal*** | | | ***13908*** | | ***840*** | | ***53.32%*** |
| **Associated users** | **2011** | **Growth pa** | **Users 2030** | | | | |
| Schools (day) learners | 1519 | 2.00% | 2067 | 20 | 48 | 1575.000 | 3.02% |
| Schools (boarding) | 450 | 2.00% | 619 | 140 | 100 | 1575.000 | 6.33% |
| Hospital beds | 33 | 0.50% | 47 | 300 | 16 | 1575.000 | 0.50% |
| Clinic outpatients | 14570 | 0.50% | 19478 | 20 | 1.23 | 1575.000 | 0.08% |
| Community hall seats | 375 | 1.00% | 105 | 90 | 11 | 1575.000 | 0.69% |
| Crèche learners | 580 | 2.00% | 131 | 20 | 3 | 1575.000 | 0.19% |
| ***Subtotal*** | | | | | | | **10.81%** |
| ***Total social component*** | | | | | | | **64.13%** |
| ***TOTAL COST OF PROJECT:*** | | | | | | | **R 178 956 388.63** |
| ***RBIG CONTRIBUTION TO COVER SOCIAL COMPONENT:*** | | | | | | | **R 114 759 236.17** |
| ***CO-FUNDING REQUIRED FROM HANTAM MUNICIPALITY:*** | | | | | | | **R 64 197 152.46** |

This calculation is based on the rules of the Regional Bulk Infrastructure Grant rules with one deviation. The per capita consumption allowed for by RBIG equates to 80 litres per capita per day.

However, when one calculates the required water demand, the norm in South Africa is 125 litres per capita per day for rural areas. These figures have a huge effect on the calculation of counter funding required by the municipalities. If the demand is calculated at 125 litres per capita per day, the counter funding calculation must use the same figure. Likewise, the demand at 125 litres per capita differs considerably from the demand calculated at 80 litres per capita per day.

Calvinia has an indigent sector of 27.46% of the population. If the demand and allowable consumption for indigents is kept the same, the **counter funding is calculated at 35.87% of the project cost**.

At this percentage of the Capital Costs, Hantam Municipality will **not be able to afford the counter funding** required for this project. They can only contribute a maximum of 15%, which could be recovered from the VAT on the project which can be reclaimed, and ringfenced to be used to fund the project counterfunding.

The funding breakdown, in accordance with the adjusted RBIG rules therefore equates to the following:

| | |
|---|---|
| Estimated Project Cost: | R 178 956 388.63 |
| Municipal counter funding required: | R 64 197 152.46 |
| **Funding from Regional Bulk Infrastructure Grant:** | **R 114 759 236.17** |

Hantam Municipality is unable to fund this project if their contribution exceeds 15% of the capital cost. The only possibility for assistance in this regard, is for them to apply that this project be declared a “Presidential Project” similar to what happened with the Namakwa Regional Water Supply Scheme in Springbok many years ago.

The original scheme in Sprinbok was fully funded by the national government in 1974, and originally belonged to the Namakwa Water Board, but only serves the Namakhoi Municipality. To this day, Namakhoi Municipality has not made a contribution of a single cent towards the capital cost.

On their own, Hantam Municipality will not be able to fund this project. If they do not get funding for the full project in the form of an RBIG grant of at least 85% of the capital cost, their only other option is to construct the project in various smaller phases utilizing the WSIG program, where counterfunding is not a requirement. If the latter option is followed, the project **will cost approximately 29% more**, as there will need to be several procurement processes, multiple establishments of contractors, and of course over time the cost of the project will increase.

These calculations are all based on an estimate, which estimate is based on costs of recently completed projects of similar nature, quotations from specialist suppliers and the engineers' experience.

The fact of the matter is that the devaluation of the South African Rand, the slow growth of the national economy and the annual price hikes by ESKOM makes rural water supply projects extremely expensive.

South Africa, and particularly the Northern Cape Province, is a dry, water scarce area where water is required to be conveyed over long distances to provide small numbers of people with water at great expense, which is often not practically recoverable by municipalities.

***In spite of these challenges, the people in Calvinia are guaranteed the same basic rights to sufficient drinking water as all other citizens in South Africa.***

# 10 STAKEHOLDERS INVOLVED IN THIS PROJECT

## 10.1 Calvinia Community

The Calvinia Community are the primary beneficiaries of this project. Calvinia is a marginal community with 23.70% of the residents classified as indigent. Although they are a relatively marginal community with limited ability to pay for services, they still have the basic right to sufficient water of suitable quality.

It is estimated that some 60 temporary job opportunities will be created by this project for at least 18 months. There will also be a need for at least 4 permanent positions at the proposed new fluoride treatment plant to operate the system efficiently.

## 10.2 Hantam Local Municipality

Hantam Local Municipality is the administrative local authority in whose area the proposed project is to be implemented. Hantam Municipality are responsible for the towns of Calvinia, Brandvlei, Nieuwoudtville, Loeriesfontein and the villages of Middelpos and Swartkop near Verneukpan.

The Hantam Municipality have appointed BVi Consulting Engineers for the execution of implementation. See letter of appointment from Hantam Municipality attached as Annexure.

The Hantam Municipality is the only formal institution directly involved in this project. The Municipal Manager has signed an undertaking wherein the Municipality endeavours to take ownership of the project as well as committing to budget for the Operational and Maintenance Costs for this project in their annual budget.

Signed documentation in this regard is attached as Annexure.

## 10.3 Namakwa District Municipality

The Hantam Local Municipality falls within the administrative area of the Namakwa District Municipality which has it's seat in Springbok. As the project is located within their administrative area, the Namakwa District Municipality is an Interested and Affected Party to the project.

## 10.4 Northern Cape Department of Environment and Nature Conservation

This provincial department is responsible for the issue of the Record of Decision regarding the Environmental Impact Assessment and therefore an important stakeholder to this project.

## 10.5 Department of Water and Sanitation

This department is responsible for the granting of the Water Use Licenses applicable to this project as well as a primary funder of the project through the Regional Bulk Infrastructure Grant program.

## 10.6 Northern Cape Department of Roads, Transport and Public Works

Department of Roads, Transport and Public Works has jurisdiction over the R355 Regional Road between Loeriesfontein and Calvinia, as well as public road R354 between Calvinia and Ceres.. As it is proposed that the pipe line be laid parallel to these roads inside the road reserves of these two roads, this department is an important stakeholder in this project.

## 10.7 Telkom

Although Telkom has services adjacent to the R353 Regional Road and R354 road, these services are in a state of disrepair and have been abandoned. As it is envisaged that excavation activities will take place in close proximity to this infrastructure, it is proposed that they be notified as an Interested and Affected Party.

## 10.8 Landowners affected by the project

There are 3 private landowners affected by this project. The project is crosses 3 privately owned properties and this requires negotiation for access to boreholes, as well as future registration of pipeline servitudes in the favour of Hantam Municipality.

# 11 DEVELOPMENT OF GROUNDWATER AT CALVINIA: OUTSTANDING ISSUES

## 11.1 Survey and Investigation

The positions of all the new boreholes were determined by the geohydrologists, but they have not been surveyed. Similarly, the positions of all the connecting pipelines between the boreholes and the Calvinia WTP have not been surveyed and mapped for final design.

## 11.2 Environmental Issues

This project is subject to a Basic Assessment Review in terms of the National Environmental Management Act, 1988 (Act No.107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014 as amended in 2017 because of the following proposed listed activities:

**<u>Activity</u>: (According to Government Notice No. 386):**

**1(k)** the bulk transportation of water, in pipelines;

**1(n)** the off-stream storage of water, including dams and reservoirs, with a capacity of 50 000 m$^3$ or more;

1. The transformation or removal of indigenous vegetation of 3ha or more;

The Environmental Assessment Practitioner and environmental specialists for the required studies as well as the public participation process for this project still need to be appointed

A positive **Record of Decision** for this project is required from the Department of Environment and Nature Conservation before this project can be implemented.

## 11.3 Water Use Licensing

Water Use License Applications for the 12 new boreholes need to be prepared to legalize these sources. Applications will be based on the tested and calculated 24-hour abstraction yields for each individual borehole. These applications must be submitted to the Department of Water and Sanitation before they can be legally utilized.

## 11.4 Way leaves and Consent Applications

The primary way leave that is required is from the Northern Cape Department of Roads, Transport and Public Works. This application still needs to be submitted.

## 11.5 Risk Review

Technically this is not a complicated project. The only technical challenge will be to get the fluoride removed from the water to deliver water that poses no health risk for the population. The only other factors that restrict the commencement of the project are the financial magnitude thereof and the availability of funding.

The use of groundwater as source to supply the population of a town is always a risk. The reason for this being that the availability of ground water is dependent on the recharge of the aquifer which is again dependent on climatic factors such as rainfall. The sustainability of the project therefore remains a concern although careful management of groundwater resources over the long-term can reduce this risk significantly.

The Hantam Municipality is fully committed to supplying sufficient water of acceptable quality to all its residents including those in Calvinia. The Hantam Municipality has also committed itself to the project in terms of ownership, operations and maintenance and counterfunding, given that the counter funding can be reduced to 15% instead of the required 35.07%. If this is not acceptable, this project will either need to be phased to reduce the annual counter funding, or, the project will need to source alternative means of financing the project other than the RBIG program.

The only remaining risk is therefore the availability of primary funding. Should funding not be forthcoming, the residents of Calvinia will continue to be subject to severe water restrictions in future as has been the case since February 2016, and will continue to bear the public health risks and damage to the local economy associated with the lack of sufficient water for drinking and sanitation.

# 12 ASSESSMENT OF STUDY RESULTS

This study has indicated that the development of the new boreholes at Calvinia and the construction of a new water supply pipelines for the supply of drinking water to Calvinia is feasible. Analysis of the operational and maintenance costs has indicated that unit costs to supply water to Calvinia as proposed are similar to current municipal rates for water. Water supply from the Doring River will not be feasible in the near future due to the distance from Calvinia and also the large difference in elevation requiring abnormal pumping heads and related energy requirements.

It is however also true that the whole Hantam Municipality has uniform water tariffs for all residents irrespective of where they reside. The Municipality would do well by conducting a study to determine the “real” cost of water in each of the towns within its jurisdiction before the next budget process commences. There is certainty that such an exercise will show that the current water tariffs are most likely too low and that the calculated unit cost for Calvinia is well within the actual cost for the Municipality as a whole.

The fact that above normal amounts of fluoride have been ingested for a long time by the residents of Calvinia is not an acceptable situation. The fact that there is no viable alternative water source for Calvinia other than the Karee Dam and further exploitation of groundwater sources, puts the Hantam Municipality in an impossible position. The removal of fluoride from water is problematic, but can be removed using an ion exchange process utilizing activated alumina. The current levels of fluoride are above the limits of what humans can consume safely and should be removed from the water stream.

In short, given sufficient funding, this project is do-able in terms of technical possibility, economical feasibility and social benefit to be derived.

GH MEIRING Pr TECH ENG
BVi CONSULTING ENGINEERS (NORTHERN CAPE) (PTY) LTD

AUGUST 2021