SEDIBENG WATER

REGIONAL BULK INFRASTRUCTURE GRANT

FEASIBILITY STUDY

CONTENTS

CONTENTS

SECTION 1: STATUS QUO

1. PROJECT BACKGROUND

1.1. History of the development of the Namakwaland region

Historically, the development of the Namakwaland region was due to the natural occurrence of the element copper. The copper deposits of Namakwaland had long been used by the indigenous Nama people of the region and not long after their arrival at the Cape, the Dutch established that copper was available in some abundance to the north of their colony. In 1685 the Simon Van der Stel expedition sampled copper ore near the present day village of Carolusberg, but considering the fairly low grade of the samples, the remoteness and dryness of the area and that Namakwaland has no obvious natural harbours, establishing a mining operation was not considered feasible.

It was hence only in the early 19th century, after the British took control of the Cape, that interest in the copper deposits of Namakwaland was once again kindled, with travellers to the region reporting on possibilities for both mining and shipping of copper ore and the sampling of ore deposits with considerably higher yield than those assayed in the 17th century. After false starts in 1843 and again in 1846-47 mining began in earnest in 1854 in what is today called the Blue Mine which was located on the farm Springbokfontein around which the town of Springbok developed. Over 35 mining companies had been formed and one hundred mining licenses had been issued by 1855. By 1862 there were only two copper companies left - the Cape of Good Hope Copper Mining Company, and the Namakwaland Copper Company.

Within a short time sustainable mining operations developed at Okiep, Concordia, Spektakel and some-time later at Nababiep. Initially ore and later concentrate and copper from the smelters erected at the mines were transport by ox-wagon to Hondeklip Bay from whence they were shipped.

Mule train in Namakwaland hauling copper ore

ln the l860s a narrow gauge railway was built from the mines around Okiep to Port Nolloth which was developed as a port. A major problem for the railway operators as well as the mines was the lack of water to feed a steam locomotive. So, initially, the rail wagons were drawn by teams of mules. Early in 1878, the rail was upgraded for use by steam locomotives. Several options where experimented with such as the hauling of a water tender behind the locomotive to the introduction of special “condenser” locomotives. This railway line survived until 1945 when its owners sold most of the line as scrap, since by that time the copper that had been mined was traveling

southward by road to Bitterfontein from where it was transported by the South African Railways to the Cape Town harbour.

Mining activities in the area shut down during the copper slump of 1919. In 1927 Newmont Mining / American Metal Company, two American mining houses purchased the Namakwaland Copper Fields from the defunct Cape Copper Company and the Okiep Copper Company was formed in 1937 and started mining in 1940. In 1988 Newmont sold the Okiep Copper Company to Goldfields of SA who mined the Namakwaland copper fields until 1998 when they sold it to the present day owners Metorex (Pty) Ltd.

Springbok 1890

Metorex closed the last copper mining operations in Namakwaland in 2004 when the Nigramoep mine was closed. Namakwaland was known as the richest copper mining area in the world at the turn of the century.

The mine at Sprinbokfontein's name was shortened to "Sprinbok" in 1911 and a school and public library were opened. Water supply for the town was sourced from 3 municipal boreholes as well as 3 private boreholes until 1962. Due to lack of other resources, the municipality started purchasing water from the Okiep Copper Company who had several boreholes located in the Buffels River on the farm Spektakel. Since 1960's water for domestic use was severely restricted due to it being a scarce commodity.

The towns of Okiep, Nababeep and Carolusberg, located approximately 10km from Springbok were established as so-called "company towns" and controlled and serviced by the mining companies up to 1998 where after they were transferred to the administration of the Namkhoi Municipality.

The village of Steinkopf is situated approximately 50km north of Springbok. The settlement was founded by reverend Heinrich Schmelen of the London Missionary Society in 1818.

Remains of a Cornish Beam Pump in Okiep

Steinkopf was previously named called 'Tarrakois' which means 'a peculiar girl' and it was later renamed to commemorate Dr. Karl Steinkopf of London who donated money for the new missionary station. The station was transferred to the Rhenish Mission Society in 1840 when a new school and church was built and in 1934 the Dutch Reformed Church took control of the town. Water supply for Steinkopf was originally from a perennial spring which still flows today. The village population however grew to a point where demand exceeded the volume supplied.

The village of Concordia was established in 1863 as a station of the Rhenish Mission Society. It seems probable that its founding coincided with the opening of the copper mines by the Concordia Copper Mining Company. Very little is known about its original source of water.

In 1925, Mr Jack Carsten discovered the first diamond on the Namakwaland coastline on the farm “Kleyne Zee”. This property was then sold to the Cape Coast Exploration Company in 1928 when formal mining started. In 1942, Kleinzee was sold to the De Beers Consolidated Mines and this was

Mining at Kleinzee circa 1930

the official start of the company town Kleinzee. In 1981/82 the Springbok Regional Water Supply Scheme was extended from Nababeep to Kleinzee over a distance of 96km. One third of the cost of this pipeline was subsidized by the government and the balance paid by De Beers Consolidated Mining who also took responsibility for the construction of the pipeline.

Due to many years of drought, a report was tabled in 1970 to the then Minister for Water Affairs for a proposed water supply scheme for the Namakwaland region. The persistent water shortages occurred mainly due to the unreliability of groundwater in the area. In 1970, all mines as well as the town of Springbok were under severe water restrictions. The last time the Buffels River had come down in flood was in 1962 and accordingly, the water table dropped due to insufficient recharge. Rainfall at the time was determined to be between 127mm and 254mm per annum. Storage dams in nearby rivers where considered but due to the low rainfall and protracted droughts experienced, there were no rivers that flowed for any length of time and the idea was abandoned. Records indicate that the growth in the Springbok / Okiep / Nababeep area was in the order of 6 percent per year. Accordingly, a scheme was approved by government at an expected total cost of R6 million. The scheme was named the Springbok Government Regional Water Supply Scheme. Construction commenced in 1973/74 and the Water Treatment Plant was officially inaugurated in 1979.

After construction, the scheme was operated and maintained by the Department of Water Affairs for a period of more than 10 years. In 1982, the Springbok Water Board was established with board members being made up from representatives of the Okiep Copper Company, De Beers Consolidated Mines and the Springbok Municipality. The name of the water board was changed to the Namakwa Waterboard in 2007. By 2005 only 5 of the 8 board members were still serving and by 2010, only 3 members were remaining due to the closure of the mines.

In essence the scheme approved in 1970, with the exception of the extension to Kleinzee, is still the scheme in use today after some 38 years of service. In anybody’s terms, this was money well spent. Over the 38 year period, the Water Board has managed to deliver potable water to the Namakwaland communities in a sustainable fashion. However, since the year 2000, old infrastructure has been a serious issue for sustainability as well as the closure of the Okiep Copper Company’s mines in September 2004. Especially the latter happening left the region with a large number of unemployed consumers in the area. Since 2008, the large increases in the cost of ESKOM electricity and the continuous failure of infrastructure have impacted heavily on the scheme's financial stability and its ability to provide a sustainable supply of water to its service area. Accordingly, the Department of Water Affairs intervened and BVi Consulting Engineers were appointed by the Namakwa Water Board to assist them in managing the scheme. The last few years saw severe increases in the price of water to bring tariffs to a market related level and also to enable the water board to recover their direct costs. These measures have helped to increase the financial stability of the scheme, but the age and condition of the infrastructure remains a serious problem for sustainability.

In January 2010, the Minister of Water Affairs requested Sedibeng Water to conduct an assessment of the scheme's infrastructure with the view of taking over the administration, operations and maintenance as a whole. Since December 2010, interruptions of the water supply to the Springbok area have been rife with continuous occurrences of pipe failures leading to towns being without water for periods of up to 4 days. In October 2010, BVi Consulting Engineers were appointed by Sedibeng Water and the Department of Water Affairs to conduct a study of which the outcome was to provide a single technical solution to solve the infrastructure problems as well as increase the sustainability of the Namakwa Regional Water Supply Scheme.

1.2 Scope of the Feasibility Study

BVi Consulting Engineers were appointed to conduct a feasibility study on the Namakwa Regional Water Supply Scheme in October 2010. The scope of the feasibility study was to encompass the following major issues:

- Determine the current and future water demand for all towns and villages
- Liaise with all interested and affected parties in the region to determine future developments and associated water demands.
- Conduct an assessment of the current infrastructure condition
- Conduct a GAP Analysis to determine the difference between current and future needs
- Investigate and evaluate all possible water supply options
- Select a single technically feasible solution and develop a project scope for construction
- Calculate estimated capital requirements as well as the operating and maintenance costs
- Compile a Water Master Plan for the Namakwaland region

1.3 Existing water supply system

The Namakwa Regional Water Supply Scheme consists of the following major components:

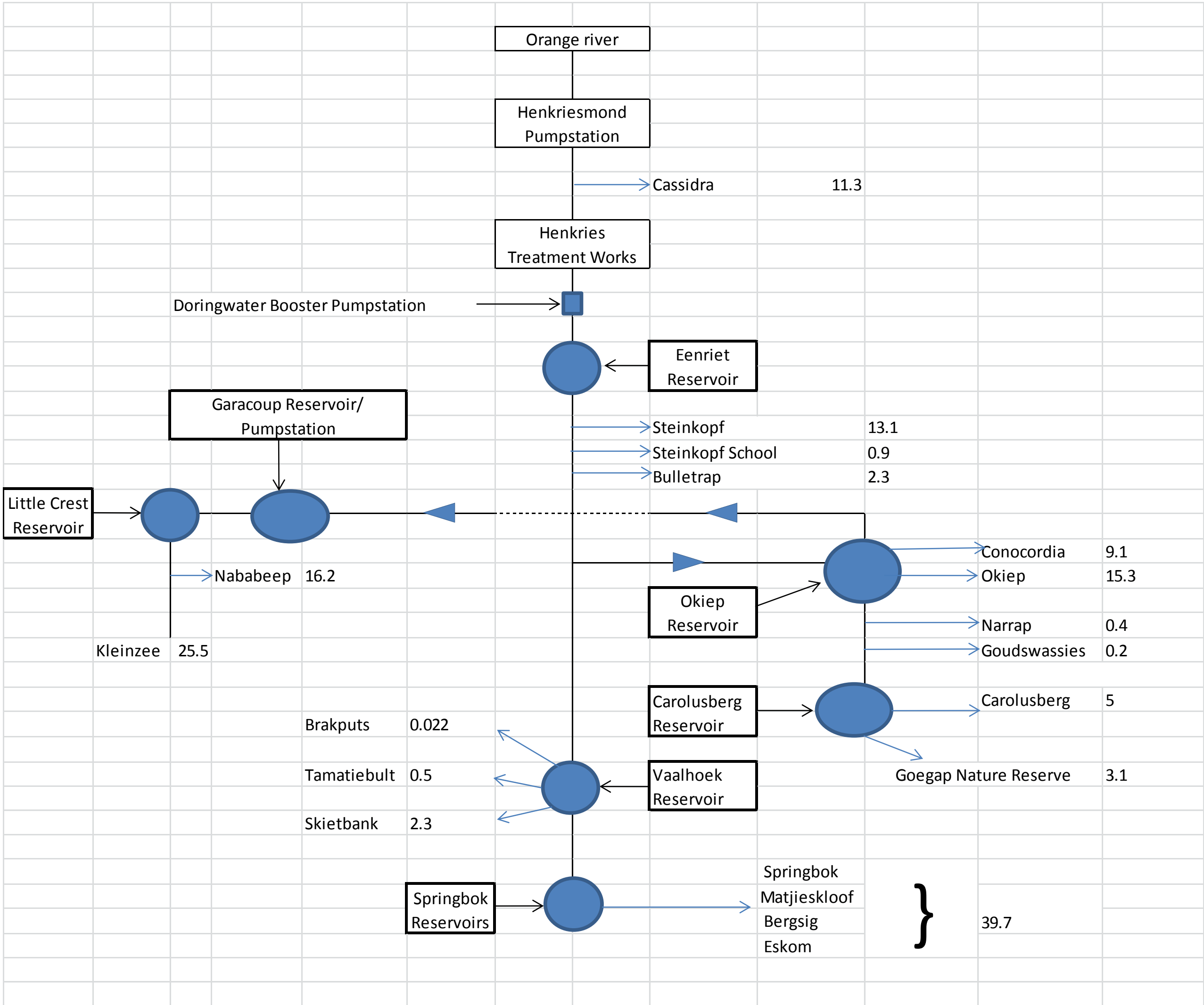
- River Pumpstation, gravity main and canal
- Henkriesmond pre-sedimentation facility, pump station and rising main
- Henkries Water Treatment Plant, Clear Water Pumpstation and rising main
- Doornwater Booster Pump Station and rising main
- Eenriet Reservoir
- Eenriet to Okiep Gravity Main
- Vaalhoek Reservoir
- Okiep Pumpstation, reservoir and rising mains
- Carolusberg Reservoir
- Concordia Reservoir
- Garagoup Reservoir, booster pump station and rising main
- Little Crest Reservoir and gravity main
- Kleinzee Gravity Main and reservoir

Each of the above are briefly discussed below in order to provide the reader with an overview of the extent, equipment installed and capacities of each component.

1.3.1 River Pumpstation

Raw water is abstracted from the left embankment of the Orange River at Henkries located approximately 120km north-northeast of Springbok. The raw water pump station consists of 4 number multistage axial flow pumps installed on an inclined reinforced concrete ramp structure. The water is abstracted from the Orange River and lifted approximately 20m vertically where it is discharged into an elevated concrete sump. The capacities of the raw water pumps are as follows:

Raw water pump no.1 :	90 liters per second
Raw water pump no.2 :	90 liters per second
Raw water pump no.3 :	90 liters per second
Raw water pump no.4 :	45 liters per second
Total capacity:	**315 liters per second** (22.7 Ml/day @ 20 hours pumping time)



Schematic Layout of the existing Namakwa Regional Water Supply Scheme

Gravity Main and raw water canal (km0.00 to km3.00)

The water then flows from the raw water sump under gravity into a 600mm diameter concrete pipe of 1.5km in length after which it discharges into a concrete-lined canal. The canal has a parabolic section with a top width of 750mm and is approximately 1.4km in length. This was most probably done to ensure that the supply of water was conveyed above the 1 in 50 year flood line. At maximum flow of 315 liters per second, the flow velocity in this pipe is **1.11m/s** which is still a safe velocity.

Electrical supply and switchgear

Electricity is supplied to the pump station by means of an overhead medium voltage supply line from ESKOM. The switchgear for all of the pumps are very dated and utilize the star-delta starting arrangement.

Condition of the Raw Water pump station and related infrastructure

The axial flow pumps have been modified extensively to avoid continuous maintenance costs. Typically, axial flow pumps have their drive motors located at the top of the delivery tubes with long extended spindles powering the impellors located in the lowest section of the pump. The spindle is then located inside the delivery tubes with a set of bearings. To avoid the continuous replacement of these locating bearings, the motors have now been moved down to the water edge and coupled directly to the lower section of the pump where the impellors are located. This has implications as any rise in the river level has the risk that the motors can be flooded. The axial flow pumps are quite badly corroded. The switchgear is very old and will need to be replaced as a matter of course to improve efficiency. The 600mm diameter gravity main from raw water pump station sump is not able to carry the full flow provided by the pumps. This is probably due to some 30 years of silt deposition in the pipeline. This pipe's routing is also of such a nature that it is partially submerged for some length of its route when floods occur in the Orange River. The raw water canal is in a reasonably good condition and according to the water board does not cause any problems.

Henkries River Pump Station

1.3.2 Henkriesmond pre-sedimentation plant and lifting pump station

The raw water canal discharges into a pre-sedimentation facility at Henkriesmond. This facility consists of two large pre-sedimentation tanks where a large portion of the settleable solids are removed from the stream. The raw water is dosed with a primary flocculent prior to entering the pre-sedimentation tanks to aid settling. Settled sediments can be discharged back to the Orange River by means of desludge valves and a piping arrangement. There is also access for mechanical removal of the sediment by means of a frontend loader.

The settled water is then abstracted from the pre-sedimentation tanks by a lifting pump station. The Henkriesmond pump station is equipped with 5 number Sulzer HPH 28-15 multistage pumps powered by High Voltage 3300V motors of 375kW and 225kW with capacities as follows:

Lift pump No.1	70 liters per second
Lift pump No.2	70 liters per second
Lift pump No.3	70 liters per second
Lift pump No.4	45 liters per second
Lift pump No.5	45 liters per second
Total capacity:	**300 liters per second** (21.6 Ml per day @ 20 hours pumping time)

Henkriesmond Booster Pump Station

Rising Main (km3.00 to km13.2)

The Henkriesmond pump station lifts the partially treated water through a vertical elevation of 216m over a distance of 10.2km where it discharges the water into the Henkries Water Treatment Plant inlet works. The water is conveyed through a 406mm diameter concrete lined steel rising main. The steel pipe is continuously welded and is laid approximately 1.00m deep in the ground. This section of pipeline runs through an area where severely saline soils occur. The level of salinity is of such an extent that the concrete valve chambers are showing signs of severe deterioration. Although the steel pipeline is protected from outside corrosion by a petrolatum based wrapping, problems with corrosion failures do occur from time to time. At maximum flow, the velocity through this pipe is **2.32m/s** which is already on the high side and risks such as transient surges can be greatly exaggerated at such velocities.

Electrical supply and switchgear.

Electrical supply is provided by an ESKOM 66kV overhead supply line and there is a substation adjacent to the Henkriesmond pump station. The incoming 66kV is stepped down to 3.3kV. All the Medium Voltage switchgear is outdated and fitted with oil-filled circuit breakers of which the spares are no longer available.

Henkriesmond Electrical Substation

Cooling Equipment

This facility was also previously equipped with an evaporative cooling system to lower ambient temperatures inside the pump station and switchgear rooms. The cooling system is totally dysfunctional and extreme temperatures are experienced inside the buildings.

Pump house and Buildings

The buildings at this facility have not been painted in years and a severe lack of maintenance is visible everywhere. The structures appear to be in a functional condition with the exception of some loose cladding appearing occasionally. Repainting and tidying up of the buildings is recommended.

1.3.3 Henkries Water Treatment Plant and Clear Water pump station

The Henkries Water Treatment Plant has a design capacity of some 18 Megaliters per day. It has however been mechanically equipped to produce only about 10 Megaliters per day. The plant is equipped with the following facilities:

- Inlet works and Chemical Dosing facility
- 3 x 22m diameter circular bridge-scraped clarifiers
- 10 x Rapid gravity sand filters with false floor drainage system
- Clear Water sump
- Clear Water pump station
  - Sulzer HP 28-15-25 6 stage delivering 70l/s each at 390m head
- Evaporative Cooling Equipment
- Chlorination plant

- Laboratory
- Utility Buildings
  - Stores building
  - Oil and fuel storage facilities
  - Workshop
- Personnel housing
- Electrical substation
- Rising Main

The water treatment plant was constructed with primarily reinforced concrete with the occasional brick masonry infill panels. The condition of the structures throughout the plant is still excellent even after some 30 years of use.

Each of the pertinent facilities is briefly discussed as follows:

Inlet Works and Chemical Dosing Facility

This facility it appears was initially designed to dose a flocculent in powder form. There are sufficient facilities available for storage of both lime and powdered flocculent such as alum. The facility is equipped with make-up tanks as well as dry powder feeders of which none are currently operational. Currently Sudfloc 3TL, which is a liquid polyelectrolyte, is dosed at the plant. There is no raw water flow meter available at the plant which makes the calculation of chemical dosages impossible. There is also a lime feeder in which a milk of lime solution can be made up and then pumped into a concrete silo adjacent to the dosing building from where the lime can be fed into the works by gravity. None of the above equipment is operational. Lime is occasionally fed into the raw water stream with a spade to correct the pH. The existing dosing equipment should be scrapped and replaced with new equipment as a matter of urgency. The building itself has been well designed and is structurally intact with sufficient hydraulic mixing capability to achieve the required flash mixing of chemicals. Provision has been made for future extensions to the treatment plant as the dosing facility can provide water to 5 clarifiers although only three were originally constructed.

Clarifiers

There are three clarifiers on the plant with a diameter of 22m each. They are typical Bateman type clarifiers with a central flocculation compartment and bridge-scraped sludge removal. The concrete structures appear to be still in good condition. The mechanical equipped has however suffered from a lack of maintenance with especially bridge drive-end gearboxes being in poor condition. Lack of maintenance is also evident on the overflow weirs where algae are growing profusely. There is also grass growing inside the flocculation chambers. Despite these issues, these 3 units are still functioning satisfactorily with the clarified water being of acceptable standard. Desludging is done manually once a day with the discharged sludge being conveyed to 3 number concrete sludge drying beds located below the water treatment plant. The frequency of desludging appears to be rather ad-hoc and not based on the quality of the raw water or solids loading of the plant. The drying beds appeared to be not in use during the visit to the plant. There is a lot of evidence suggesting that sludge and backwash wastewater is merely dumped.

Rapid gravity sand filters
The Henkries Water Treatment Plant is fitted with 10 rapid gravity sand filters of which only 6 are fully equipped mechanically. These filters are of the Degremont false floor design with a side channel feed–water inlet. This design allows for backwashing by means of an air-scour cycle, a combined air/water scour cycle and water only backwash cycle. It is uncertain whether it is being operated as such. Filters are operated as constant rate filters with water levels in the filters being controlled by a mechanical float valves. The condition and depth of the filter sand is poor and needs to be replaced as a matter of course. It is doubtful whether the required turbidities can be maintained with the current sand. These filters have dimensions of 5.80m x 3.20m x 2.60m which give them a **filtration rate of roughly 4m/h**. This rate is very low in comparison with modern gravity filters which have nominal rates of 10m/h and more. Given that only 6 of the 10 filters are operational, the filtration capacity is therefore only 60% utilized.

Clear Water Sump
Filtered water is collected in the Clear Water sump which has a storage capacity of 4.545 Megaliters. Clear Water is abstracted from this facility by the Clear Water Pump Station.

Clear Water Pump Station
The Clear Water pump station is submerged below the natural ground level in its entirety. It is a deep reinforced concrete structure housing the clear water high lift pumps, the air scour blowers and 2 dewatering pumps. Provision was originally made for six pumps, but only three where provided. The pumps used are Sulzer HP 28-15-25 6 stage pumps powered by 650kW 3300V motors delivering 70l/s each at 390m head.

The capacity of the Clear Water pump station is as follows:

Lift pump No.1	70 liters per second
Lift pump No.2	70 liters per second
Lift pump No.3	70 liters per second
Total capacity:	**210 liters per second** (15.2 Ml per day @ 20 hours pumping time)

The Clear Water pump station is also equipped with an overhead crane which appears to be operable. There is a Clear Water flow meter installed which was not operational during several visits to the plant. For all practical purposes, no measurement is done.

The electrical switchgear for this pump station is of a very old design and spare parts are extremely difficult to sources. Very few indication instruments on the switchgear are functional and this makes it very difficult to operate the plant optimally. At the rate at which electric motors are rewound and refurbished, it is doubtful whether the protection mechanisms such as overload and underload relays are still functioning. The age of the switchgear also seriously affects the efficiency of the pump station.

Cooling Equipment

This Henkries Water Treatment Plant is also equipped with an evaporative cooling system to lower ambient temperatures inside the pump station and switchgear rooms. The cooling system is totally dysfunctional and extreme temperatures are experienced inside the buildings. This influences negatively on the systems efficiency.

Chlorination Plant

Disinfection is conducted by the dosing of chlorine gas into the filtered water. The chlorination room consists of two rooms which are isolated from each other. The first is the so-called drum room which has space to accommodate a duty and standby 1 ton chlorine gas cylinders. Each of the cylinders is supposed to be on a scale to give an indication of the chlorine being consumed. None of the scales are operational. Only one chlorinator is currently functional and is already severely corroded and in need of urgent maintenance. The drum room doors where not locked and access to this extremely hazardous area was not controlled. The injectors and vacuum regulators where likewise in very poor condition. Safety equipment has been provided, but all chlorine gasmask canisters had expired which means that they are of no use. This section of the plant needs to be totally refurbished with a new system and new equipment.

Laboratory

The laboratory is currently very poorly equipped with a many of the instrumentation and equipment being outdated or in a state of disrepair. It is also doubtful whether the Namakwa Water Board has personnel which have the required qualifications and skills to utilize such a facility. Not even basic analysis such as Jar Testing, pH levels, free chlorine levels and turbidity measurements are currently taken. Subsequently, there is very little, if any, quality control of the potable water leaving the plant. Given the new legal requirements with regards to Blue Drop certification as well as the risks of delivering contaminated water to consumers, this situation leaves much to be desired.

Utility Buildings

At the water treatment plant, there are also general stores, an oil and fuel store and a workshop. Although the buildings are in a fair condition, they require some refurbishment. No evidence existed that any of these buildings were still in regular use.

Personnel Housing

There are 19 houses at the Henkries Water Treatment Plant for staff housing. These homes are in a terrible state of repair and require maintenance to make them livable. As Henkries is very isolated and more than 60km from the nearest town, it is a necessity to have decent accommodation for the operational staff at the plant. This situation urgently needs to be addressed.

Electrical Substation

There is an electrical substation located adjacent to the Henkries Water Treatment Plant which supplies its electrical power. This substation is maintained by ESKOM and appears to be in a good condition.

Rising Main(km13.20 to km32.4)

From the Henkries Water Treatment Plant, potable water is pumped with the Clear Water Pumps through a 406mm diameter concrete lined steel pipe to the Doornwater Booster Pump Station. The Clear Water Pumps pump a maximum of 210 l/s into this pipeline through a vertical elevation of 340m over a distance of 19.2km. A 12km section of this pipeline was replaced in 2005 due to continuous pipe failures. The new pipe section is no longer concrete lined but painted with an epoxy coating such as Copon or similar. This pipe section is currently in a fair to good condition with relatively few failures occurring. The velocity in this pipe at the current maximum flow equates to **1.62 m/s** which is marginally higher than the norm of 1.50m/s.

1.3.4 Doornwater Booster Pump Station

The water from the Henkries Water Treatment Plant's Clear Water Pump Station reaches the Doornwater Booster Pump Station at a pressure between 5 and 10 bar. The Doornwater Booster Pump Station is an in-line booster station with no reservoir or other storage capabilities. The Doornwater pump station has been provided with space for a possible 5 booster pump sets but is equipped with only 3 sets in parallel. Each pump set comprises a Sulzer 28-15-25 6 stage pump powered by a 650kW 3300V electrical motor.

Doornwater In-line Booster Pump Station

The capacities of the pump sets are as follows:

Booster pump No.1	70 liters per second
Booster pump No.2	70 liters per second
Booster pump No.3	70 liters per second
Total capacity:	**210 liters per second** (15.2 Ml per day @ 20 hours pumping time)

The delivery side of this pump stations pumps are fitted with actuated needle valves to enable the very slow and accurate increase of the line pressure as operating pressures can be as high as 50 bar. Reckless opening and closing of valves could lead to very serious transient pressure surges occurring, therefore these valves have been installed. Several of the valves are also out of commission or in some state of disrepair or partially stripped.

Rising Main(km32.4 to km49.3)
The Doornwater pump station boosts the pipeline pressure from 5 bar to 50 bar and lifts the potable water through a vertical elevation of 333m over a distance of 16.9km where it discharges the water into the Eenriet Reservoir located on Eenriet Mountain. The water is conveyed through a 406mm diameter concrete lined steel rising main. The steel pipe is continuously welded and is laid approximately 1.00m deep in the ground. This section of piping is also prone to continuous failure. The failures are possibly due to air pockets being trapped in the pipeline as air valves are located up to 1 kilometer or more apart. In addition to the above, corrosion is constantly causing the pipe wall to become thinner since the delamination of the concrete liner started roughly 10 years ago. This section of pipeline may need replacement in sections. The calculated velocity at the current maximum flow is also **1.62m/s** which is marginally high, but still acceptable.

The air valves, scour valves and isolating valves on this pipeline are in a serious state of disrepair. It is doubted whether many of these valves still function due to corrosion and lack of maintenance. Many of the valve chambers have been seriously damaged due to pipe failures washing away soil and undermining the chamber foundations. The inability of these valves to be operated during pipe failures lead to serious water losses as the point of failure cannot be properly isolated.

Electrical supply and switchgear
Electrical supply is provided by ESKOM and there is a substation adjacent to the Doornwater pump station. The substation is in a good condition and maintained by ESKOM. All the Medium Voltage switchgear is outdated and fitted with oil-filled circuit breakers of which the spares are no longer available. Very few of the indicators on the switchgear are still operational and will need to be replaced with more modern units.

Cooling Equipment
The Doornwater Booster Pump Station was also equipped with an evaporative cooling system to lower ambient temperatures inside the pump station and switchgear rooms. The cooling system is totally dysfunctional and extreme temperatures are experienced inside the buildings. This influences negatively on the systems efficiency and makes it almost unbearable to work there.

1.3.5 Eenriet Reservoir
The Eenriet Reservoir is located on the highest point of the water supply scheme. It serves to make the transition from rising main pipe line to gravity main pipeline and also serves to balance the flow variation due to fluctuating demand of the downstream users. The Eenriet Reservoir is a circular flat roofed concrete reservoir with a nominal capacity of 9 Megaliters. The reservoir is in a good condition and there are no visible leaks. The outflow from the reservoir is equipped with a mechanical bulk flow meter. The accuracy of this meter is questioned due to discrepancies with the flows recorded and actual sales to customers.

1.3.6 Gravity Main: Eenriet Reservoir to Vaalhoek Reservoir (km49.3 to km103.9)

The potable water is conveyed from Eenriet Reservoir to the Vaalhoek Reservoir at Okiep by means of a 520mm diameter concrete lined steel pipe. The pipes are of the longitudinal weld variety and the lengths are continuously welded together. This pipe is the main carrier of water to the following towns and villages:

- Steinkopf Village
- Steinkopf School
- Bulletrap Village
- Okiep Reservoir
- Nababeep
- Carolusberg
- Concordia
- Springbok
- Kleinzee

The condition of this pipe is precarious. **Since November 2010 it is failing almost weekly**. The weakest part of the pipeline being the 8km length between Bulletrap turn-off and the Rooiwinkel area just prior to Okiep. This is also geographically the lowest lying section of the pipe and subsequently experiences the highest pressures due to the difference in elevation. Pressures in excess of 35bar are commonplace under static conditions. To alleviate this problem, a pressure reducing valve was installed at Vrieskloof in 2005. This reduced the pressure by almost 10 bar and this measure extended the useful life of this section by another 5 years.

Typical pressure bursts occurring due to deterioration of the pipe wall thickness

The operational personnel have over time continuously been adjusting the pressure downward to prevent pipe failures and in the process have also destroyed the energy required to get sufficient flow through the pipeline. This section of pipe needs to be replaced as a matter of urgency to lengthen the lifespan of the existing system by at least 5 years or until an alternative feasible technical solution has been found. Currently, the pressure reducing valve is reducing the pressure to a downstream maximum of 9 bar. With this pressure, the minimum flow required to meet the current demand is only just passed through the pipe. This has the consequence that the Vaalhoek Reservoir is operated at a minimum level (below 10% of maximum storage capacity) and subsequently has almost no reserve capacity available when a pipe failure does occur. This leaves the supply area without water within 2 hours. Therefore it will be fair to say that at this point in time, the gravity main is the Achilles Heel of the total system.

1.3.7 Vaalhoek Reservoir

The Vaalhoek Reservoir is the final distribution reservoir in the supply system. The Vaalhoek Reservoir is a circular flat roofed concrete reservoir with a nominal capacity of 11.4 megaliters. The distribution to the 4 reservoirs in Springbok, Okiep, Brakputs, Tamatiebult and Skietbank all commence from this reservoir via 300mm diameter gravity main. The condition of the reservoir is good and it has many years of serviceable life remaining.

Vaalhoek Reservoir near Okiep

1.3.8 Okiep Pumpstation, reservoir and rising mains

Approximately 50km downstream from the Eenriet reservoir, the Okiep take-off is found. This take-off feeds water into the Okiep Reservoir located roughly 1km east of the gravity main. The pressure from the gravity main is sufficient to fill the Okiep Reservoir continuously. The Okiep reservoir is also a circular flat roof concrete reservoir with a nominal holding capacity of 4.5 megaliters. A large portion of the old mining town area of Okiep is supplied directly from the Okiep reservoir whilst the higher lying areas are supplied from the Vaalhoek reservoir.

The Okiep Pump Station is located adjacent to the Okiep Reservoir and is fitted with 2 Sulzer 18-8 HPL 8 stage pumps driven by 75kW motors pumping water to Carolusberg and Concordia via separate 150mm steel rising mains laid above ground on concrete plinths. In addition to the above, the pump station is also equipped with one 6 inch Sulzer 21-10 3 stage pump powered by a 45kW motor and one 8 inch Sulzer HPL 32-17 4stage pump driven by a 90kW motor. The latter two pumps supply water to the Garagoup Reservoir and pump station complex via 150mm and 200mm steel rising mains which eventually supply the towns of Nababeep and Kleinzee.
The Okiep pump station is old, but fairly well maintained. The electrical switchgear for the pumps is very old and outdated but still operational. The efficiency of these pump stations could probably be improved considerably.

Okiep Pump Station and Reservoir Complex

The capacities of the pumps are as follows:

Booster pump No.1	42 liters per second
Booster pump No.2	42 liters per second
Booster pump No.3	42 liters per second
Booster pump No.4	70 liters per second

Total capacity: **196 liters per second** (14.1 Ml per day @ 20 hours pumping time)

1.3.9 Carolusberg Reservoir

The Carolusberg Reservoir is the distribution reservoir for Carolusberg. This reservoir is a circular concrete reservoir covered with a galvanized sheeting roof. It has a nominal capacity of 4.545 megaliters. This reservoir supplies the Carolusberg village reticulation system.The condition of the reservoir is fair and it has many years of serviceable life remaining.

1.3.10 Concordia Reservoir

The Concordia Reservoir is the distribution reservoir for Concordia to the far right of the photograph. The reservoir to the left was constructed roughly 2 years ago. The original reservoir is a circular flat roofed concrete reservoir with a nominal capacity of 1.5 megaliters. From this reservoir water is fed via a gravity main to a complex of reservoirs known as the 3 Megaliter Reservoir and the new reservoir from where the village distribution network is fed. The condition of the reservoir is good and it has many years of serviceable life remaining.

1.3.11 Garagoup Reservoir, pumpstation and rising mains

Water is pumped from the Okiep Pump Station to the Garagoup Reservoirs across the Eenriet – Vaalhoek gravity main in a northwesterly direction by means of an FC pipe which is laid above and below ground. The Garagoup Reservoir Complex consists of two 500 m^3 concrete reservoirs located approximately 7.5km from Okiep. The Garagoup pump station is located adjacent to the two reservoirs and is equipped with 6 Sulzer multistage pumps driven by three 75kW motors, two 110kW motors and one 350kW motor respectively. The latter motor appears to be totally oversized and was probably a spare motor which the mine had in its stores when the previous motor failed. This is a very uneconomic means of operation.

Garagoup Pumpstation

and

Reservoir Complex

The capacities of the pumps are as follows:

Booster pump No.1	30 liters per second
Booster pump No.2	30 liters per second
Booster pump No.3	30 liters per second
Booster pump No.4	45 liters per second
Booster pump No.5	45 liters per second
Booster pump No.6	60 liters per second

Total capacity: **240 liters per second** (17.3 Ml per day @ 20 hours pumping time)

All six the pumps at Garagoup pump water through two above ground steel pipe lines utilizing Victaulic couplings. The pipes have diameters of 150mm and 200mm respectively. These pipes are in very poor condition with evidence of leaks at many places. Both pipes feed into the Little Crest

Reservoir located in the mountains above the town of Nababeep. Currently, the Water Board only operates the 350kW pump.

1.3.12 Little Crest Reservoir and Gravity Mains

The Little Crest Reservoir is the distribution reservoir for the towns of Okiep and Kleinzee. The Little Crest Reservoir is a circular flat roofed concrete reservoir with a nominal capacity of 4.545 megaliters. The condition of the reservoir is good and it has many years of serviceable life remaining. Water to Nababeep and Kleinzee are fed through two parallel above ground steel pipes with Victaulic couplings of 150mm and 200mm respectively. The 150mm pipe is the primary feeder into the Nababeep distribution network. There is however also a section of Nababeep that receives its supply from the 200mm diameter main. The 200mm diameter gravity main is also the primary feed pipe to the De Beers mining town of Kleinzee located 96km west of Nababeep. Both these pipelines also have frequent leaks and are in excess of 60 years old. Access to these pipes is also very difficult due to the mountainous terrain.

Typical leaks and failures occurring on the Nababeep gravity mains

1.3.13 Kleinzee Gravity Main and Reservoir

The mining town of Kleinzee's water is gravity fed from the Little Crest reservoir through a 200mm diameter steel pipe laid above ground, later reducing to a 150mm steel pipe over a distance of 96km. An inspections of this pipe revealed that it is still in very good condition with the De Beers mining personnel still maintaining it to a high level of reliability. This pipe terminates in a storage reservoir located approximately 12km from the town of Kleinzee inside the diamond mining area from where it feeds the town's distribution system. The Kleinzee Reservoir is a circular concrete reservoir with a nominal capacity of 6.125 Megaliters.

1.3.14 General Condition of the existing supply system

The primary problem on the complete system is **age and lack of extensive maintenance** over a long period of time. The main supply system is now in excess of 30 years old and has reached the end of its economic lifecycle. Before copper mining activities ceased in 1998, maintenance was primarily conducted by the personnel of the Okiep Copper Company as it was in their interest do so. Since the closure of the mines, the Namakwa Water Board has had neither the capacity in terms of personnel nor the financial resources to maintain the system to the required standard.

The current water supply crisis is mainly due to the continuous failure of the gravity main between Eenriet Reservoir and Okiep. Failures occur primarily due to the delamination of the pipe's concrete lining over the past 10 years and the resultant accelerated corrosion of the steel pipe wall. At the section between the Bulletrap turn-off and Rooiwinkel, the highest pressures occur and the pipe structure is no longer able to cope with the stresses involved.

Section cut off from a 520mm diameter steel pipe which recently failed.
Corrosion inside the pipe is severe with no evidence of any concrete lining remaining.
Wall thickness of the pipe is less than 2mm in the vicinity of the longitudinal weld.

The mechanical and electrical equipment at the main pump stations are in a poor condition due to age and lack of preventative maintenance. The maintenance that is being conducted is mainly breakdown maintenance and there is no program in place for scheduled activities. The lack of indication in terms of pressure and amperage as well as the motor protection devices make efficient operations very difficult and there is continuous risk of motor overloads, etc. The fact that many of the high voltage electrical motors have been rewound several times creates huge inefficiency with the resulting higher electricity costs.

The pump stations such as those at Okiep and Garagoup are equipped with 500V motors which are not a regular industry standard, but often used by mining houses. Replacement motors and spares for switchgear equipment are not freely available locally and this hampers repairs and fast reaction considerably.

All the steel pipes on both the main feeder system as well as those distributing water to smaller reservoirs are steel pipes which are in various stages of serious corrosion. Leaks and failures are the order of the day on a weekly basis. Also access to many of the distribution pipe lines is extremely difficult due to the lack of service roads and the mountainous nature of the topography especially around Springbok, Okiep and Nababeep.

Leaks on the Okiep – Garagoup steel rising mains

A major concern, which has a serious financial implication, is the lack of sufficient bulk flow metering. At the present point in time, the water board is unable to conduct a water balance or reconcile their water sales due to this issue. It is currently impossible to quantify losses due to desludging, filter backwashing, leakage or pipe failures by any means.

The control of the total scheme is currently done on an ad hoc basis as there is no telemetry system in place. Operators do not have real-time information with regards to flows, pressures, reservoir levels, pump parameters, etc. In our opinion, it is impossible to operate a system as complex and extended as the Namakwa Regional Water Supply Scheme without the aid of a telemetry system. All communications and switching of pumps is coordinated by telephone with the subsequent time lags and wastage of energy taking place when pumps are operated against closed or partially opened valves.

In general, the total system is in a poor condition posing a serious threat to the water security of the service area. Urgent remedial works are required to firstly lengthen the economic lifecycle of the system for at least another 5 years. Five years is a conservative estimate of the time required to either reconstruct the existing pipe line, or supply water from an alternate source.

2. STAKEHOLDERS INVOLVED IN THIS PROJECT

2.1 Namakhoi Municipality

The Namakhoi Municipality was formed after demarcation in 1999 and their administration now includes the following towns and villages: Springbok, Steinkopf, Okiep, Nababeep, Carolusberg, Concordia, Bulletrap, Kommagas, Buffelsrivier, Rooiwinkel, Gladkop, Goodhouse, Henkries, Vioolsdrift and Kotzeshoop. Of these villages, the following are fully dependent on water supplied from the Namakwa pipeline: Springbok, Steinkopf, Okiep, Nababeep, Carolusberg, Concordia and Bulletrap. Also the small communities at Henkries which work and reside on a date farm owned and operated by the Department of Agriculture are fully dependent on water from the system. The Namakhoi Municipality is the primary client of the water board and responsible for in excess of 80% of the board's income.

Discussions were held with the municipality's officials to determine what their future spatial development plans entail as well as where additional housing is planned. According to the Director: Technical Services, the municipality have quantified a current housing shortage of some 2 680 residential units. This is linked to future planning to develop a further **4050 residential stands** in both Springbok and the other surrounding towns.

The Namakhoi Municipality will be a major stakeholder in any projects involved with water supply for the area in the immediate future.

2.2 Namakwa District Municipality

The Namakwa District Municipality administrate a large area encompassing the following local municipal areas: Namakhoi Municipality (Springbok), Richtersveld Municipality(Port Nolloth), Hantam Municipality(Calvinia), Karoo Hoogland Municipality(Williston), Khai-ma Municpality (Pofadder) and Kamiesberg Municipality (Kamieskroon). The Namakwa District Municipality's offices are located in Springbok from where their region is administrated. Although, they are not direct clients or water users of the Namakwa pipe line system, they are still a stakeholder which must be kept up to date with regards to any developments of regional water supply.

2.3 Kleinzee Community

Kleinzee is a mining town belonging to the De Beers Consolidated Mine company which were primarily involved in the mining of alluvial diamonds on the Namakwaland West Coast. Mining operations have in the meantime ceased and the town is in process of being handed over to the Namakhoi Municipality. It is a well-developed town with approximately 2 750 inhabitants. Roughly 60% of the town's water is supplied by the Namakwa pipe line system. They are therefore a very dependent stakeholder for any projects concerning the system. They have an alternative groundwater source which is able to meet about 40% of the towns demand.

2.4 Department of Environmental Affairs and Tourism

The whole Namakwaland Region is a major tourist destination during the flower season which runs from roughly early August to end September annually. In addition to the flowers, the Namakwa Region is located on the main route (N7) between Cape Town and Namibia. The Richtersveld / Ais-ais Transfronteir Park is located in the region and has a huge amount of tourism potential.

In addition, the Namakwaland region is ecologically sensitive and needs to be carefully protected. This is of extreme importance ecologically and will need to be considered when any construction activities commence. As an Environmental Impact Assessment will need to be undertaken in the case of any activities with regards to the pipe line system, this government department is a major stakeholder and is able to influence the outcome of any projects derived from this study.

2.5 Department of Water Affairs

This national department is responsible for all things water related. They also have a serious stake in this project as they were firstly the original designer, constructor and owner of the water supply scheme. In addition to the above, they will be the major contributor of funds for any future remedial works as well as alternatives with regards to water supply to the Namakwa region.

2.6 Department of Agriculture

The Department of Agriculture operate a state-owned date farm near the Henkries Water Treatment Plant. They have indicated that they are interested in expanding their operations by a further 20 ha of date plantations in the near future. **For this expansion, a minimum of 20 000 m^3/ha of water is required per annum**. As they require raw water, it may be possible to incorporate their envisaged demand into future upgrades of the pipeline between Henkriesmond Pump station and the Henkries Water Treatment Plant. The families living on this farm are also dependent on the pipeline system for domestic water supply. There is also a possibility for the pipeline system to provide water to extensive stock farming activities taking place on communal land between Steinkopf and Springbok. The supply of water for stock watering could possibly be the catalyst for changing this area from a subsistence farming area to a commercial farming area. Consultation with this stakeholder is therefore important.

2.7 South African National Roads Agency

The South African National Roads Agency is a parastatal agency who administers and maintains the N7 National Road between Cape Town and Namibia. As the existing main supply pipe line runs parallel and crosses this road on several occasions, SANRAL will need to be included in any consultations to obtain wayleaves, etc. Currently, any infrastructures within 60m of the road centerline are required to have an official wayleave from SANRAL.

2.8 TELKOM

TELKOM is also a state owned corporation providing landline and cellular telecommunication services. TELKOM have landlines parallel to the existing pipe routes and will have to be communicated with for especially wayleaves, new and existing fiber optic cable routes, etc which may be affected by future construction activities.

2.9 ESKOM

ESKOM is the government owned electrical supply utility company providing electricity for all pump stations on the existing scheme. They own and maintain the substations located at several of the water supply facilities and also maintain the High Voltage power lines supplying these substations. Electricity is also the largest expense for the Namakwa Water Board and therefore a major factor in the system sustainability. ESKOM is an important stakeholder for this study as negotiations may need to be undertaken with them regarding **electricity rates** for the water board. In addition, ESKOM may also in future be a client of the Water Board with possibilities of establishing renewable energy type and other electrical power generation facilities in the area. Both Brazil and Schulpfontein on the Namakwa West Coast have been identified in 1994 as potential sites for the construction of conventional nuclear power stations.

2.10 De Beers Namakwaland Mines

Although De Beers have for all practical purposes ceased mining activities at Kleinzee and plan to cease activities at Koiingnaas within the near future, they have indicated that they wish to maintain their rights to their maximum water allocation at Kleinzee for the foreseeable future.

2.11 Metorex Mining Ltd

Metorex Mining Ltd is the current owners of the old Okiep Copper Company Mines. Although they currently have no immediate plans for reinstating any of the copper mining activities within the foreseeable future, they will need to be kept on board for the duration of this project.

2.12 Blastrite

Blastrite are a company specializing in the production and sales of shot blasting grit. They currently have an agreement whereby the old copper smelter slag dumps at Nababeep are being utilized to produce shot blasting grit. Their current operations are not water intensive and they receive only domestic water supply. If they in future should upgrade their existing small beneficiation plant at Nababeep, they may become an important stakeholder in this project.

2.13 Landowners adjacent to the project

Although most of the land along the existing pipe route is either communal grazing areas or part of the municipal commonage, these parties will need to be a part of any public participation process once envisaged future construction commences. A list of landowners is currently being compiled for record purposes.

3. OPPORTUNITY STATEMENT

3.1 Project Objectives

This study aims to find a single technical solution to secure the current and future supply of water to the town of Springbok and surrounds by means of piped surface water originating from the Orange River 120km to the north of Springbok. The purpose of the project is to provide a secure and financially sustainable future system for supplying fresh water suitable for human consumption by all possible means for a period of at least 20 years. This study therefore aims to show that the use of a pipe line, pump stations and related works to supply the required water to the Springbok and other areas is a feasible long term option which can be afforded, operated and maintained by the Namakwa Water Board / Sedibeng Water with future in-house resources.

3.2 Current circumstances requiring the need for this study

Since 2000 the Springbok supply area has been experiencing increasing water supply problems. These problems were primarily caused by the following:

- **Deterioration of the existing system components**.
  (Construction of the existing system commenced in 1973 and the system components have now reached the end of their designed economic lifecycle after 38 years of service.)

- **Hot and dry climate with very low rainfall and no potentially available groundwater sources.**
  (Average monthly rainfall in the region varies between 120mm and 254mm per annum. Rainfall in the region occurs mainly in winter whilst high water demands occur in the summer months. Exhaustive studies on groundwater potential in the entire region over many years have indicated that resources are extremely limited and not an option for secure supply.)

- **Population growth**
  (Population in the Namakhoi Municipality service area has increased from 44 250 persons in 2001 to 54 644 persons in 2007 and households have increased from 10 903 to 15 656 over the same period representing an increase of 4.4%)

- **Supply of free basic water and loss of job opportunities**
  (35,5% of the community relies on grants and state pensions for income; they are classified as indigent and therefore qualify for free basic water. This places enormous financial strain on the municipal water supply resources. In addition, more than 5 000 jobs were lost since 1998 when the Okiep Copper Company ceased mining activities. This has resulted in many people being without income but still requiring services to survive.)

- **Lack of potential resources to augment the current water supply**
  (Intensive investigations have shown that the potable groundwater resources in Namakwaland have reached maximum development and are not a feasible option to supply water in the volumes required.)

- **The current unsustainability of the existing supply system**
  (The current financial losses incurred have led to financial restraints which have impacted negatively on their operation and maintenance function. This study will attempt to find a solution to either improve the viability of the current system or to propose a new system which will achieve this.)

4. STRATEGIC FIT STATEMENT

4.1. National Water Resource Management Strategy

The Cabinet approved the National Water Resource Strategy on 1 September 2004. The strategy document describes how the developmental needs of South Africa will be met in spite of the fact that we are one of the 30 driest countries in the world. The purpose of the strategy is to ensure that the available water resources are utilized to meet the needs of the country's people by supporting equitable and sustainable social and economic development while ensuring that the water environment is adequately protected.

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.

Given the above, this project aims to find a means of securing the current and future water supply to the Springbok supply area, meets the strategic objectives of the National Water Resource Strategy in that it will aim to secure the water supply of several towns and villages in which there are a large portion of poor and previously disadvantaged persons residing.

4.2. Municipal Backlogs

The Nama Khoi Municipality who administers the Namakwa water supply area, as many others in the Northern Cape, are continually trying to decrease their backlogs in terms of housing, water supply, sanitation and electricity. Nama Khoi Municipality is fairly well off in terms of backlogs in that the water reticulation system currently can provide 97.4% of households in the municipality's service area with potable water to the RDP standard or better. The Municipal Demarcation Board's Capacity Assessment of 2009 revealed that 96.2% of all households have yard taps or in-house water supply while 1.1% have access to a communal standpipe system.

The sanitation in the area is of similar situation with 77% of all households having flush toilets draining either to a conservancy tank or to water borne reticulation system. The balance of the households is serviced by dry sanitation systems.

4.3. Service Quality

For the greater part of its administrative area, the Nama Khoi Municipality has a better than RDP level of service at all households. The Level of Service is however not the same in all towns and villages. Springbok, Okiep, Nababeep and so forth have higher service levels than for example the Vioolsdrif and Kotzeshoop villages.

4.4. Alignment with IDP and WSDP

The Nama Khoi Municipality has an active integrated development planning process in place and their last valid IDP was submitted in 2010. The Water Services Development Plan for this municipality is continuously updated and the last draft was submitted to DWA in 2010 for review. The provision of sufficient water to Springbok and related supply areas is listed as a priority in both the IDP and the WSDP.

5. EXISTING DATA

5.1. Population Data

Accurate population data for the various towns are extremely difficult to come by and the various sources utilized differ considerably. Since 1999 when demarcation took place, population data has been collected by ward population and not by town. For the purposes of this study, population data of the various towns and villages supplied by the Namakwa Regional Water Supply Scheme were collected from the following sources:

- The DWA Water Services National Information Service 2009
- Statistics SA Census 2001
- Statistics SA Census 2006
- Statistics SA Community Survey 2007
- Demographic Information Bureau

For the purposes of this study, the highest data figures for each town were taken from the various sources to ensure that a worst case scenario has been covered.

Town / Village	Population 2009	Households 2009
Springbok	10 298	2 315
Nababeep	6 056	1 460
Okiep	5 246	1 306
Concordia	6 946	1 798
Carolusberg	959	275
Steinkopf	8 439	2 143
Bulletrap	1 130	308
Kleinzee	3 304	1 891
TOTAL	**42 378**	**11 496**

When the Census population data for the whole of the Nama Khoi Municipality is considered, the population growth can be derived.

Municipality	Population (Census 2001)	Population (Census CS 2007)	Growth Percentage over past 6 years	Growth Percentage per annum
Nama Khoi Municipality	44 750	54645	22%	3.66%
	Households (Census 2001)	**Households (Census CS 2007)**	**Growth Percentage over past 6 years**	**Growth Percentage per annum**
Nama Khoi Municipality	10 903	15 656	43.6%	7.2%

The figure of 3.66% corresponds well with the 4% per annum growth that the municipal IDP for both Nama Khoi Municipality and the Namakwa District Municipality has calculated.

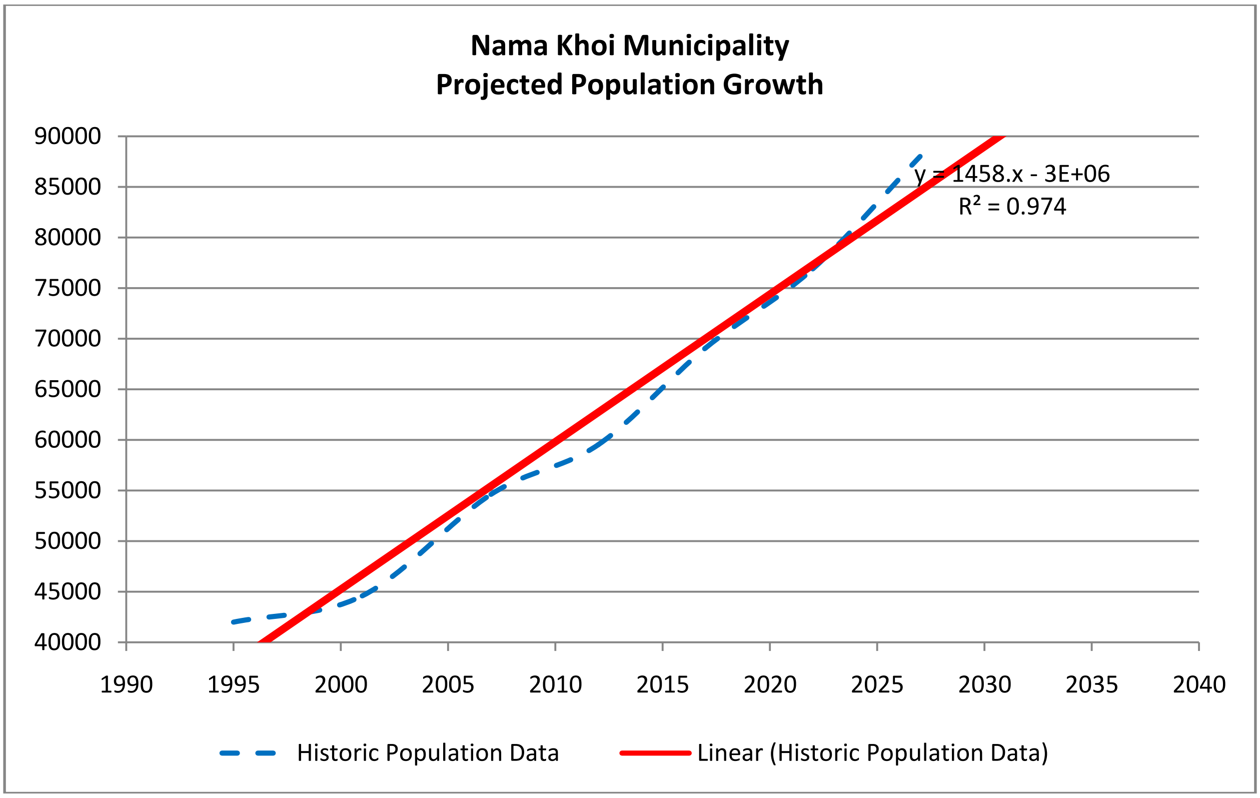
From the above data it is clear that there is definite population growth in the area. It is however uncertain as to what is stimulating this growth. After the closure of the Okiep Copper Company in

1998 and the end of mining operations in 2004, there are very little industries that employ large numbers of people. Especially Springbok is only driven by being a service center for the towns and communities in the vicinity.

If one considers that the 1970 population for some of these towns were as follows:

Town / Village	1970 Population	2009 Population	Percent Growth per annum
Springbok	3530	10 298	3.26%
Nababeep	10 200	6 056	-1.04%
Okiep	2 700	5 246	2.42%
Concordia	1 450	6 946	9.72%
Carolusberg	1 300	959	-0.67%
Steinkopf	2 400	8 439	6.45%
TOTAL:	**22 580**	**37 944**	**1.74%**

If this calculated growth figure is accepted and data from the population statistics are plotted, future growth figures can be projected as follows:



This calculation projects that should the historic growth rate be maintained, this area's population could be approaching the 90 000 persons mark by the year 2030.

5.2. Household and Per capita Income

The Nama Khoi Municipal area supports three important economic sectors, namely Agriculture, Tourism and Mining. The Okiep Copper Co. provided many job opportunities for a large amount of people in the previous years but since 1998, these opportunities have declined rapidly in this sector. The agriculture sector is characterized by cattle and game-farming as well as irrigation along the banks of the Orange River. Tourism is mainly seasonal in nature and does not provide as much sustainable employment.

According to the 2001 census data there are 21 311 Females and 20 690 Males in Nama Khoi Municipality. Twenty six percent of the population has some degree of Secondary Education with 4% obtaining a Higher education and 3% not attending any Education institution.

The majority of the population has a household income of between **R19 201 - R 38 400**. Sixty nine households earn more than R614 401 - R1 228 800 per annum and **1531 households earn no income at all.** An alarming number of **61% don’t earn any form of personal income** and are dependent on social grants such as pensions, disability allowances, child welfare grants and guardianship grants. The majority of the people in the area earn between R401 - R800 per month.

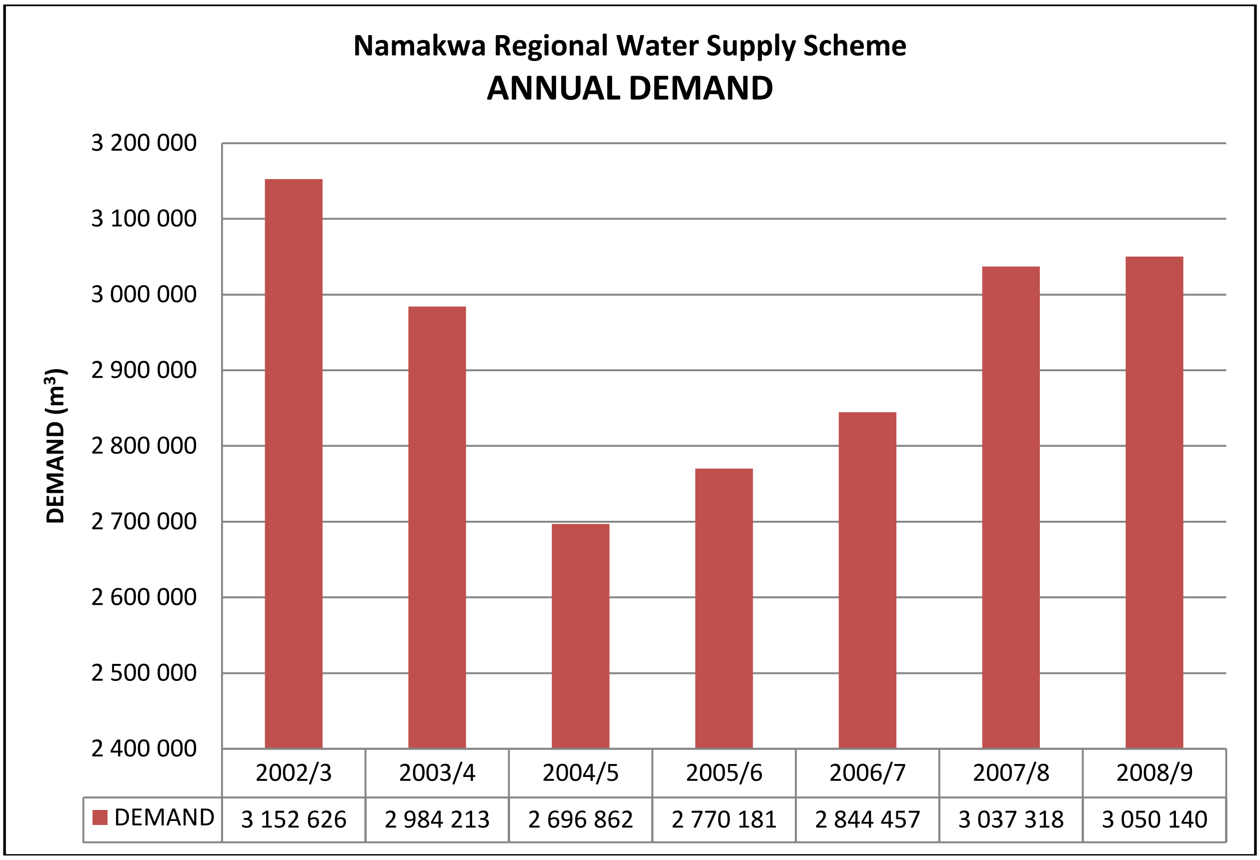
In terms of employment the data indicates that 27.5% of people are employed, 13.7% of people are unemployed and 29.2% of people are not economically active.
(Social Impact Assessment Eskom : Kudu Transmission Line : Strategic Environmental Focus May 2006)

These facts have a major impact on the ability of the communities serviced by the Namakwaland Regional Water Scheme to pay for their services. This also impacts heavily on the Nama Khoi Municipality and they will need to re-assess this situation continuously in order to keep their indigent register up to date.

National Government subsidizes local municipalities with a social grant known as the Equitable Share. This grant is based on the municipal indigent register and comprises a subsidy per capita to pay for Free Basic Water and electricity services of indigent people. It is therefore of utmost importance that municipalities keep this register current to avoid delivering services of which the cost cannot be recovered.

5.3 Water Demand

The water demand calculations for the Namakwa Regional Water Supply Scheme are based on historic sales records for the last 7 years. The graphic presentation below indicates the annual bulk demand pattern for this period.



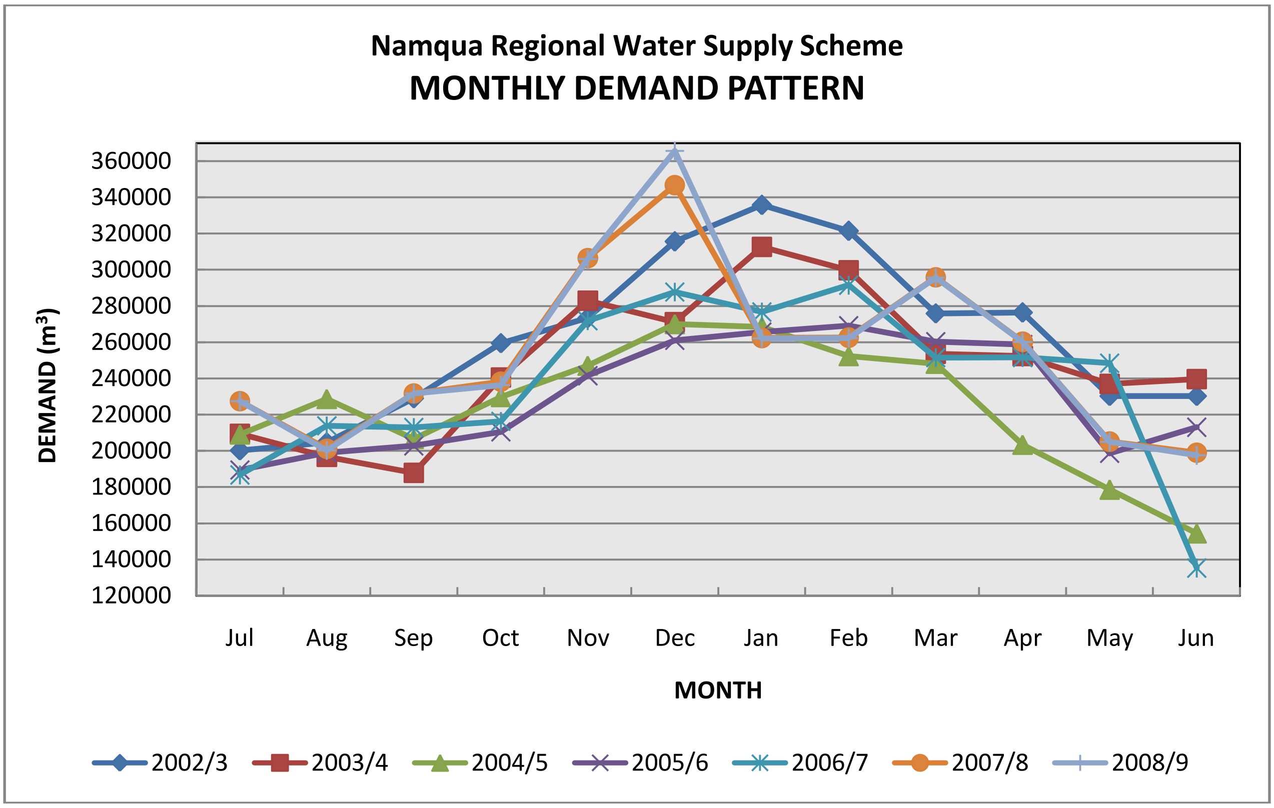
The above indicates that since 2002 the demand had declined from 3 152 626m^3 per annum to a low point in 2004 of 2 696 862m^3. Since 2004, the demand has steadily increased again to a high of 3 050 140m^3 per annum in 2008/9.

The sharp decline since 2002/3 was probably due to the rapid closure of the copper mining industry which had been on-going since 1998. The last copper mining activities at Nigramoep closed down in 2004. Before the closure of the mines, the inhabitants of the mining towns did not pay for water themselves. All domestic water was paid by the mining company and supplied to the mine employees free of charge. When the mines closed, the remaining inhabitants had to pay for water themselves and this led to more efficient and declining use of water to kerb household expenditure.

The growth since 2004 is difficult to explain, but probably due to the normal expansion of the towns and the drive by national government to provide housing.

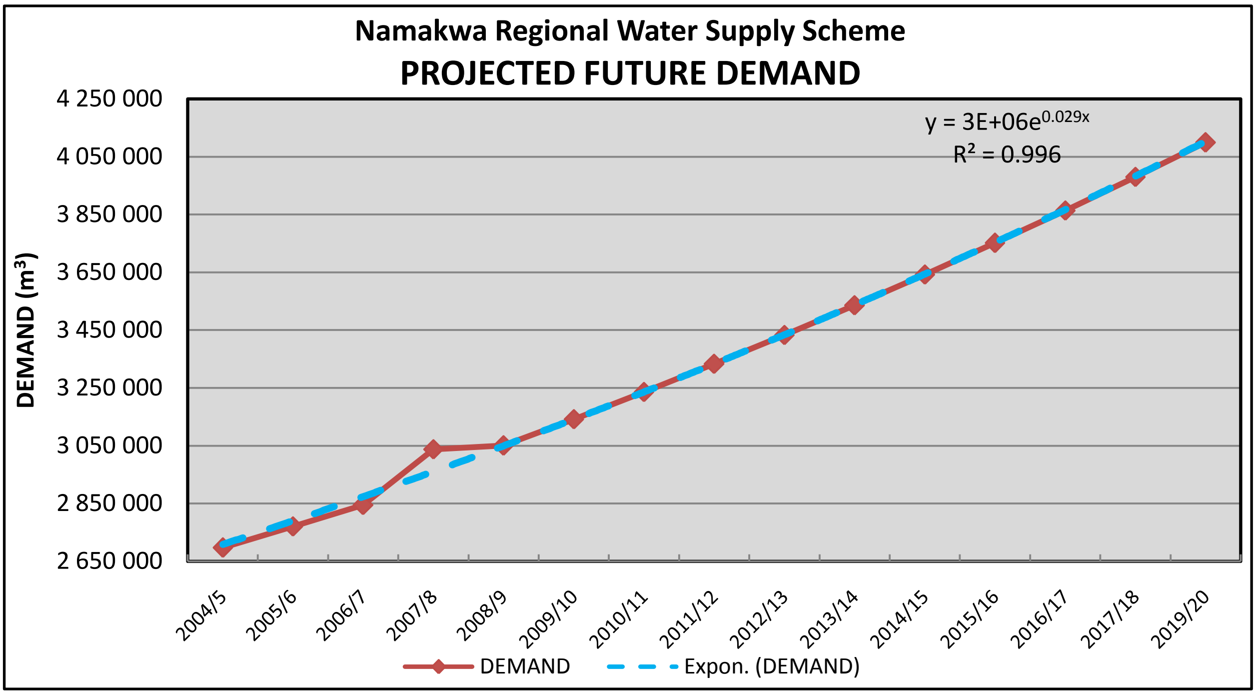
In accordance with the population growth of roughly 3% per annum, the water demand has followed a growth of 2.72% increase per annum from 2004 to 2007. Then a sharp 6.78% increase from 2005 to 2006 and has then remained fairly stable with small decreases and increases of ±0.5%.

The following graph shows the monthly demand patterns for the same period.



This graph indicates that peak monthly demands occur in the hot summer months of December and January after which the demand decreases sharply as the winter months approach.

An exponential growth curve was fitted to the data received from the Namakwa Water Board to project the future demand for the supply area for a future period of 10 years.



When the above projection is quantified, the demand figures envisaged can be calculated as follows:

YEAR	DEMAND	GROWTH
2004/5	2 696 862.00	
2005/6	2 770 181.00	2.72%
2006/7	2 844 457.00	2.68%
2007/8	3 037 318.00	6.78%
2008/9	3 050 140.00	0.42%
2009/10	3 141 644.20	3.00%
2010/11	3 235 893.53	3.00%
2011/12	3 332 970.33	3.00%
2012/13	3 432 959.44	3.00%
2013/14	3 535 948.22	3.00%
2014/15	3 642 026.67	3.00%
2015/16	3 751 287.47	3.00%
2016/17	3 863 826.10	3.00%
2017/18	3 979 740.88	3.00%
2019/20	4 099 133.11	3.00%

The current data indicates that the 2009/10 demand equates to an **average flow of 96,7 liters per second.** If the peak demand is considered, the average flow increases to a peak of **141.1 liters per second.** These flows indicate a peak factor of **1.46** which is experienced in the months of December, January and February.

Should a 15 year design horizon be considered, an average demand of **150.7 liters per second** will be required by 2025 with **a peak flow of 220 liters per second** during summer months.

5.4 Per Capita consumption

Given that the population statistics are a fair reflection of the true population, the per capita consumption of the consumers in the supply area equates to an average of **220 liters per capita per day**. When this per capita consumption is analyzed for each of the major supply areas, it is clear that the peak events have a major impact on the per capita figure as the majority of the areas have a per capita consumption of **less than 100 liters per person per day** which is commensurate with the income profile of these towns.

Town / Village	2009 Population	Peak Monthly Demand (m^3)	Peak Per Capita Consumption (litre/capita/day)	Average Monthly Demand (m^3)	Average Per Capita Consumption (litres/capita/day)	Peak Factor
Springbok	10298	109662	355	78714	255	1.39
Nababeep	6056	41941	231	28724	93	2.48
Okiep	5246	39756	253	25552	83	3.05
Concordia	6946	23655	114	10414	34	3.35
Carolusberg	959	7975	277	5998	19	14.58
Steinkopf	8439	33947	134	22883	74	1.81
Average:			**227**		**93**	**2.44**

The town of Springbok is the exception, but this is also where the concentration of the more affluent section of the population resides. In addition, Springbok often experiences pipe failures in their network which could have a significant impact on the town's water demand. Like many municipalities in South Africa, Springbok's reticulation network consists of primarily fiber-cement pipes which are reaching an age where failures occur more frequently especially in the colder winter months.

5.5 Demand Management

Water Conservation and Demand Management for the scheme as well as at the Namakhoi Municipality is managed very poorly. There are very few water flow meters on the system as a whole which makes it impossible to quantify losses.

For example, there is currently no working raw water or clear water flow meter at the Henkries Water Treatment Plant. This means that there is no record whatsoever of the losses incurred due to backwashing and desludging.

At the outlet of the Eenriet Reservoir there is a mechanical flow meter that measures the water entering the gravity main. This meter is very old and the accuracy thereof is questionable as a simple water balance calculation shows that during some months, the quantity of water sold to consumers exceeds the total quantity passing through the Eenriet flow meter. This occurs even during periods of high occurrence of pipe failures when large volumes of water are lost and do not reach the consumers. An example of this occurred in August 2010 when the bulk water meter reading at Eenriet was recorded as being 214 439 kiloliters while the total of the consumer meters read equated to a value of 218 437 kiloliters. There are also discrepancies in the monthly consumer readings which indicate that they are either not read correctly or that the meters may be faulty.

5.6 Current Water Pricing Structure

As noted elsewhere, during the period that the copper mines where still active in the region, consumers at the mining towns received water for free as the mining company paid for the water. Since the mine has closed down, consumers had to pay their own water and the tariffs have increased drastically since 2004 in order for the Namakwa Water Board to meet their obligations. The table below indicates the cost of water to consumers over the last 3 years.

Year	2008 / 2009	2009/2010	%Increase	2010/2011	% Increase
Raw Water	R1.47	R2.54	**72%**	R3.64	**43%**
Potable Water	R3.68	R6.37	**73%**	R9.14	**43%**

A further increase of 10% is envisaged for the 2011 / 2012 financial year which will bring the cost of potable bulk water to **R10.07 per kiloliter**. Given that this is the cost at which water is sold to the bulk customer, i.e. the Namakhoi Municipality, the end-user will end up paying even more as the municipality's distribution, operation and maintenance costs, etc. still need to be added to this tariff. The primary driver behind the large increases is the cost of electricity which over the last 4 years has increased significantly. ESKOM increased tariffs in April 2008 with 14% and in July 2008 with 34, 2%. In 2009 the cost of electricity increased again by 31, 3%. Given that all water supplied by the Namakwa Water Board is pumped using electric motors, it is clear that **the increase in energy cost is a major driver behind the significant increase in the cost of the water delivered to the consumer.**

5.7 Current Financial Situation

When looking at the annual audited financial statements for the last 3 to 4 years, it is clear that the Namakwa Water Board is in serious trouble. They have not been able to meet their obligations or generate any profit since 2007.

The latest financial statements indicate that the board is **operating at a net loss of some R1.25 million per month**. This situation has called for drastic measures and is one of the reasons that the tariffs have increased sharply over the same period. The increase in water tariffs have therefore been necessary to ensure that the income from water sales balances the cost of operating and maintaining the infrastructure thereby ensuring that the service can still be delivered.
Although the increase in tariffs have gone some way in helping to alleviate this situation, the continued pipe line failures and accompanying loss of large volumes of water ***(to which value such as treatment and energy costs have already been added)*** during such failures has continued to have a serious effect on the financial viability of the current infrastructure to be sustainable. It will therefore be a major part of this study to investigate how energy and operational efficiency can be improved to increase the long term financial sustainability of the Namakwa Regional Water Scheme.

This dire financial situation has also lead to the Water Board being unable to finance any desperately needed capital expenditure to replace failing infrastructure which in turn is seriously influencing their ability to deliver a sustainable service.

5.8 Water Quality Data

The Namakwa Water Board has no historical records of water quality data other than monthly biological analysis for *E.coli* bacteria. Grab samples were taken of the raw water from the Orange River at Henkries, settled water at Henkriesmond Pre-sedimentation Facility, Final Water from the Henkries Water Treatment Plant and also from a household tap in Springbok for analysis. The results of this once-off analysis are as follows:

Sample Marked :	Springbok Potable Water	Henkries WTP Final Potable Water	Henkries PS Pre Settled Water	Henkries River PS Oranjerivier Raw Water	SANS 241 – 2006 (Drinking Water)		
					Class I (Recomm. Operational Limit)	Class II (Max. Allow. for Limited Duration)	Class II Water Consumption Period, [a] max.
pH (at 25°C)	8,01	8,22	8,29	8,24	5.0-9.5	4.0-10.0	No Limit [c]
Conductivity (at 25°C) (mS/m)	33,9	35,2	35,7	36,3	<150	150-370	7 years
Turbidity (NTU)	3,4	0,87	24,7	91,4	<1	1-5	No Limit [d]
Langelier Saturation Index	-0,02	0,25	0,32	0,26	-	-	-
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	

Colour (as Pt)	2	<1	6	5	<20	20-50	No Limit [b]
$CaCO_3$ Precipitation Potential					-	-	-
Total Alkalinity (as $CaCO_3$)	128	140	144	140	-	-	-
Total Hardness (as $CaCO_3$)	121	128	132	134	-	-	-
Calcium Hardness (as $CaCO_3$)	54,8	58,3	56,5	58,0	-	-	-
Calcium (as Ca)	21,9	23,3	22,6	23,2	<150	150-300	7 years
Magnesium Hardness (as $CaCO_3$)	66,0	69,3	75,4	76,3	-	-	-
Magnesium (as Mg)	16,1	16,9	18,4	18,6	<70	70-100	7 years
Potassium (as K)	0,77	0,77	0,77	1,3	<50	50-100	7 years
Zinc (as Zn)	0,06	<0,01	<0,01	<0,01	<5.0	5.0-10.0	1 year
Chloride (as Cl)	22,2	24,2	24,2	24,2	<200	200-600	7 years
Fluoride (as F)	0,14	0,17	<0,10	0,28	<1.0	1.0-1.5	1 year
Sulphate (as SO_4)	22,0	25,0	28,0	31,0	<400	400-600	7 years

Total Dissolved Solids	340	350	350	360	<1000	1000-2400	7 years
Ammonia Nitrogen (as N)	<0,15	<0,15	<0,15	<0,15	<1.0	1.0-2.0	No Limit d
Nitrate & Nitrite Nitrogen (as N)	0,61	0,50	0,56	0,71	<10	10-20	7 years
Nitrate Nitrogen (as N)	<0,08	<0,08	<0,08	<0,08	-	-	-
	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	
Iron (as Fe)	**200**	100	**700**	**4720**	<200	200-2 000	7 years b
Manganese (as Mn)	<40	<40	<40	60	<100	100-1 000	7 years
Aluminium (as Al)	120	<14	**880**	**4360**	<300	300-500	1 year
a	The limits for the consumption of Class II water are based on the consumption of 2 litres of water per day by a person of mass 70 kg over a period of 70 years.						
b	The limits given are based on aesthetic aspects.						
c	No primary health effect – low pH values can result in structural problems in the distribution system.						
d	These values can indicate process efficiency and risks associated with pathogens.						

This analysis shows that the water improves significantly in quality after treatment when it leaves the Henkries Water Treatment plant as a water **complying to SANS 241-2006 Class 1** water. There is some contamination taking place as the turbidity in the Springbok distribution network is considerably higher than at the treatment plant. This may be due to the pipe failures on both the Namakwa Scheme pipe lines as well as the failures in the Springbok distribution systems which do occur fairly frequently. In general, the quality of water met the required specification for this sample. The Langelier Saturation Index indicates a positive precipitation potential which should be maintained. The water is chlorinated at Henkries Treatment Plant, but no measurements were taken in the reservoirs to determine what residual levels were maintained.

It is however a concern that no historic analysis records were kept of even basic water quality parameters. It is suggested that control samples be sent to an independent SANAS accredited laboratory at least on a monthly basis. This is also a requirement for the Blue Drop system which is a water quality management system initiated by the Department of Water Affairs.

6 ASSUMPTIONS

6.1 Current and Future Demand Growth

Water demand is calculated using the Department of Water Affairs & Forestry RDP Rural Water Supply Design Criteria Guidelines (1997):

(a) Daily usage allowed for:	60 liters per person per day
(b) Conveyance losses:	10%
(c) Summer peak factor:	1.5
(d) Municipal usage:	10%
(e) Commercial and industrial usage:	10%
(f) Total Demand required:	(60 + 10%) x 1.5+10%+10% = 120 liters/c/day

With the above calculation in mind, the historic consumption data from the Namakwa Water Board equates to a peak per capita consumption of 227 liters per day while the average consumption is only 93 liters per capita per day. This indicates that the accepted peak figure provided by the Department of Water Affairs is probably too low.
Given that the Northern Cape has a dry arid climate with summer temperatures sometimes reaching in excess of 35^{o} Celcius, it is acceptable that peak factors of 1.8 and 2.0 do occur. Accordingly, the demand calculation should be adjusted to reflect this phenomenon.

(a) Daily usage allowed for:	60 liters per person per day
(b) Conveyance losses:	10%
(c) Summer peak factor:	1.9
(d) Municipal usage:	10%
(e) Commercial and industrial usage:	10%
(f) Total Demand required:	(60 + 10%) x 1.9+10%+10% = 151 liters/c/day

When this figure is applied to the existing population and the tourist population that visit the region, the total demand for the Namakwaland Regional Water Supply Scheme equates to:

Current Population	Visiting Tourist Pop.	Total Population	Per capita consumption	Total Demand / day	Total Annual Demand
42 378	12 000	54 378	151	8 211 078	2 997 043 kl/y

The demand calculated above compares favorably with the current historic consumption figures which show an annual consumption in the order of **3 000 000 kiloliters per annum**.

Historic population data obtained shows that there is a slow but definite growth in the region's population. With population growth averaging between 3.6% per annum for the town of Springbok to -0.6% per annum for the village of Carolusberg. On average, population growth can be taken as being 2.72% for the Namakwa Water Board supply area. If the worst case scenario is taken as a growth of **3% for a 20 year horizon**, it means that the population will grow to:

90 000 persons by the year 2030

whom will require a calculated peak water supply of:

5 781 600 kiloliters of water per annum.

For the purpose of this study, these figures will be assumed for the calculation of pipe sizes, etc.

6.2 Current and Future Water Resources

The supply area of the Namakwa Regional Water Supply Scheme is located from the Orange River south to Springbok and west to Kleinzee located on the Atlantic coast. This area comprises three distinct topographic zones. The area stretches from the sandy coastal lowlands (Sandveld) to the mountainous central Kamiesberg escarpment (Hardveld), and to the eastern plateau of Bushmanland.

The Kamiesberg higher lying regions are drained by a large number of ephemeral streams and small rivers. There are **no perennial rivers in the area** except the Orange River to the north and all other rivers have been classified as being non-perennial, falling in the Lower Orange Water Management Area and extending across Quaternary catchments D82D, F30A-C-D-E-G, F40E-F-G, F50A-E-F and F60A.

Climate

The climate in the west of the study area, or Succulent Karoo parts, is characterized by relatively reliable, although minimal (50 – 400 mm/a) winter rainfall (>60% arriving between May and September). The east of the region lies in the Nama-Karoo and despite receiving similar total annual rainfall this comes predominately in late summer (February-April) as violent thunderstorms and can be highly variable when and where it falls. The presence of the cold Atlantic Ocean in the west not only moderates temperatures throughout Namakwaland (mean summer temperature 30°C), but also provides additional sources of moisture in the form of coastal fog and heavy dew experienced in winter months.

However, this rainfall pattern is likely to change, as the effects of global climate change lead scientists to the conclusion that the entire Succulent Karoo will most likely experience increased temperatures. It is projected that a 2°C increase in temperature in the area will lead to a 10% reduction in rainfall – a significant loss in an area that is already severely water restricted. This decrease in rainfall is projected to result in a 35% decrease in livestock carrying capacity over the coming 200 years. (Mukheibir and Sparks, 2005).

Given the above natural background, the supply of water in this region is limited to the following options:

a. Groundwater
b. Desalinated sea water
c. Surface water from the Orange River

Given that groundwater options are limited as shown by leading hydrogeological studies conducted over many decades in the region and the cost of desalinating sea water before any distribution can take place is already exorbitant at R8-29 per kiloliter, the only sustainable source of water remaining to be exploited, is the Orange River some 120km north of the supply area. ***It therefore remains that the Orange River will be the future source of water for this region***.

The question as to how to supply it to where it is required and what will be required in terms of capital infrastructure to make it a feasible option is the remaining challenge.

Accordingly, the above mentioned options will be discussed in detail to investigate their feasibility as possible water sources.

SECTION 2 : GAP ANALYSIS

7. GOALS & OBJECTIVES OF THE NAMAKWA REGIONAL WATER SUPPLY SCHEME

The 1970-71 White Paper tabled for the Minister of Water Affairs stated the following:

"…the proposed building of a regional water supply scheme as a Government water work to supply the town of Springbok, the Okiep Copper Mine and with its mining townships of Okiep, Nababeep and Carolusberg, the towns of Steinkopf and Concordia with water from the Orange River."

Today this still holds true, except that the mining town of Kleinzee was added to the supply area in the 1980's and that the "scheme" is no longer a subsidized "Government water work". Accordingly, the goal and objective of the Namakwa Regional Water Supply Scheme must now be formulated to read as follows:

"The goal and objectives of the Namakwa Regional Water Supply Scheme being to supply, on a continuous basis, potable water of the desired quality and quantity to the towns of Springbok, Okiep, Nababeep, Carolusberg, Steinkopf, Bulletrap, Concordia and Kleinzee at an affordable tariff in the most sustainable and efficient manner possible. This is to be achieved by managing the efficient operation of the infrastructure, regular and disciplined maintenance and tight financial control based on accepted industry practices. "

Now an analysis needs to be conducted to investigate whether these goals and objectives are achieved and if not, to identify the factors hindering their delivery. These factors will then need to be addressed in such a manner as to eventually achieve the goals and objectives set out in the above statement.

Factors hindering the achievement of the goals & objectives

Item	Hindrance	Current State	Desired State	GAP/Action Reqd
1	Continuous failure of the 520mm ø gravity main from Bulletrap for 5km south.	Complete loss of concrete lining, severe internal corrosion, weekly failures	Pipe must be capable to convey water at a pressure of at least 35bar to ensure Vaalhoek Reservoir can be kept full.	**Replace this section of pipe as a matter of urgency.**
2.	Failure of the Raw Water Pump Station at Henkries to supply sufficient raw water to the system.	Pumps fail due to high wear rates during periods of flooding. Pumps are very old and spares need to be manufactured every time a failure occurs. Long lead times for spares delivery.	Pumps must be capable of delivering raw water continuously under all river conditions at a rate of at least 300 l/s.	**Replace existing axial flow pumps with either rail mounted centrifugal pumps or supported submersible pumps of sufficient capacity. Variable speed drives can save energy by reducing flow in winter.**

Item	Hindrance	Current State	Desired State	GAP/Action Reqd
3.	Continuous failure of the 406mm ø rising main downstream of Doornwater booster pump station due to air entrapment and corrosion.	This section of pipe fails sporadically leading to downtime and inability to supply water.	This section of pipe needs to be replaced to ensure continuous duty at 50 bar pressure to ensure that Eenriet Reservoir is continuously supplied.	Replace approximately 17km of pipe and analyze air valve spacing and transient pressure surges. Soil resistivity testing required to check for external corrosion. Install corrosion protection measures such as cathodic protection, etc.
4.	Sporadic failure of high pressure pumps and HV motors at both Henkriesmond and Henkries WTP.	There is continuously either 1 or 2 pumps not operational at these two installations. This leads to reduced pumping capacity and inability to supply water continuously.	Replace all high pressure booster pumps and motors with units of increased efficiency.	Investigate availability in the market of pumps and motors with high efficiency able to provide the required duty and replace existing units.
5.	Sporadic failure of electric drive motors at pump stations	During the past few years several of the high voltage motors have failed for various reasons.	New HV motors and matched high efficiency switchgear suitable for continuous use.	**Replace all obsolete electrical switchgear and replace all motors at pump stations which have been rewound**.
6.	Sporadic failure of the 406mm ø rising main pipeline between Henkriesmond and Henkries WTP.	This section of pipe fails sporadically due to both internal and external corrosion leading to downtime and inability to supply water. Soil in this area is very saline.	This section of pipe needs to be replaced to ensure continuous duty to ensure that Henkries WTP is continuously supplied.	**Replace approximately 11km of pipe and analyze air valve spacing and transient pressure surges. Soil resistivity testing required to check for external corrosion. Install corrosion protection measures such as cathodic protection, etc.**
6.	Lack of monitoring of pipeline pressures, reservoir levels and pump and motor parameters allows failures to occur.	There is no telemetric monitoring of any remote installations such as reservoirs, pipeline pressures, flows, etc.	Sufficient instrumentation and telemetric monitoring facilities to ensure full control of the complete system from a single point.	Supply and install full instrumentation such as flowmeters, pressure transducers, level sensors integrated to a radio telemetry system allowing full control and early warning of problems to the control facility.

Item	Hindrance	Current State	Desired State	GAP/Action Reqd
7.	Lack of quality control at the Henkries Water Treatment Plant and Henkriesmond Pre-sedimentation facility.	There is currently very little quality control undertaken at these facilities in terms of chemical dosing, continuous turbidity monitoring, chlorine dosing, production rates, loss management, etc.	Sufficient operational procedures and measuring devices available to ensure optimum chemical dosing, water loss management and quality control of water production.	Supply and install the required instrumentation to enable the necessary control to be put in place.
8.	Lack of efficient management of the system as a whole. Lack of preventative maintenance. Inability to recover outstanding debtors, inability to service financial obligations.	There is very little supervision and accountability for things that go wrong and failure to take action to ensure continuous operation.	Supervision and various levels. Preventative maintenance plan and schedule in place. Financial management system and debt recovery system in place.	Establish transparent management systems and provide competent supervision at several levels to ensure accountability.

From the above shortened analysis, it is clear that the primary hindrance for preventing the water board from attaining their stated goals is the failing infrastructure of the complete system. This and the inability of the water board to be financially viable over the past 8 years has led to the repair and replacement of infrastructure to be left behind. Given that the "normal" design life of this type of infrastructure is 30 years and that the majority of the current infrastructure is already in excess of 37 years old and even older around the towns of Nababeep and Okiep, it is clear that a significant capital investment will be required to firstly refurbish the infrastructure and secondly to put in place strict management and operational supervision to ensure that provision is made for maintenance and timely replacement of failing equipment in future.

A primary consideration which stood out in this analysis is the matter of ***efficiency*** of equipment. Considering that the majority of the operational budget is spent in paying ESKOM, the replacement of all electrical drive units, pumps, switchgear and pipelines must be very carefully considered. The minimization of energy requirements must be a major priority in the selection of such equipment. Similarly, the initial capital cost saving of a smaller pipeline diameter must be weighed up against the continuous escalation of energy costs in future. A life cycle cost analysis will be conducted to find the optimum diameter.

8. UNCERTAINTIES

8.1. Possible Obstructions/Limitations

The only obstruction and/or limitation of major note for the envisaged project is the cost required to either refurbish the current system or to provide a new supply system from elsewhere.

Neither the Namakwa Water Board or as a secondary consideration, the Namakhoi Municipality have the customer/revenue base necessary to enable them to recover the capital costs and interest associated with a project of this scope.

In addition, neither of these institutions even have the financial security nor co-lateral available to secure a loan from a commercial financial institution**. This has held true since the inception of the original project in 1971 when it was recommended in the original White Paper that the tariff for the water be subsidized by 20% as the cost of the water in Springbok by far exceeded that paid in other parts of South Africa.**

Given that current (2010/11) tariffs are exceeding R10-00 per kiloliter, which is already expensive; it will not be possible for this project to be sustainable if the capital cost is to be redeemed by the Namakwa Water Board. It is our opinion that even if the complete capital cost for this project is provided as a grant, consideration will need to be given to the possibility of a tariff subsidy in future.

The Orange River is the only sustainable source of water in this region that remains for exploitation and water is an absolute requirement for any sustainable future development of the region. The problem is however that this water is in excess of 100km from where it is required and will require a major capital investment as well as a **possible continuous future subsidy** to bring it to the consumers where it is required.

9. STRATEGIC RISKS

9.1. Primary risks

- The economic growth potential of the entire region will be severely impacted if not enough potable water is available to sustain the community and current industries. Especially Springbok, which is the only major town in the region and acts as a service center for the surrounding smaller villages as well as being the hub of the Namakwa tourist industry will be severely inhibited.

- Public health in general will be negatively affected if insufficient potable water is available to sustain life and ensure efficient sanitation in the towns. There is currently a drive by the Department of Co-operative Governance, Human Settlements and Traditional Affairs to provide waterborne sewer systems for all communities. Without sufficient water this will not be possible and could lead to failing public health.

- The Namakwaland is one of the most unusual environmental biomes in the world. This biome is a biodiversity hotspot with the greatest biodiversity and the highest concentration of succulent plants of any of the world's arid regions. There are more than 5,000 plant species in this biome, including more than a third of all the succulent species in the world. Approximately 40% of the biome's plant species are endemic and 18% are threatened. The biome also has diverse invertebrate and reptile species, some of which are endemic. An estimated **100,000 tourists** visit Namakwaland every year to see this anomaly. 65% of these visitors are South

African and 35% are from other countries. The government has identified tourism as a means to improve the region's economy, and tourism in this area has been actively promoted through marketing. If there is not sufficient water provided to sustain this influx of tourists each year, the economy of the region, which is already battling, will suffer even more.

9.2. Operational risks of the project

The primary operational risk of the project is limited to the following:

- If **poor management** of the completed system were to continue in future, the sustainability of the project will be severely impacted.
- Limitations on the **continued sustainable supply of electricity** by ESKOM in future are a major operational risk that could be provided for in the form of standby generators.
- The **cost of energy** is a major operational risk which will need to be addressed continuously by maintaining and improving the efficiency of the system.
- If only **partial refurbishment** of the existing infrastructure is done, the continued failure of the next weakest section of the infrastructure could again impact on the sustainability of the water supply.
- The affordability of water could lead to **consumer resistance** which may also in the future impact negatively on the income of the water board and could jeopardize continued operations and maintenance activities.

SECTION 3: POSSIBLE SOLUTIONS

10. OPTIONS TO ADDRESS THE OBJECTIVES

10.1. Philosophy and Criteria employed

As there is no alternative in terms of the water source, the philosophy used in developing a solution to address the objectives for this proposed project are based on finding a solution which is as efficient as possible to reduce the energy input required by the system and secondly, to make the proposed solution as financially sustainable as possible. The design guidelines of the Department of Water Affairs & Forestry: RDP Rural Water Supply Design Criteria Guidelines: 1997 have been used to determine current and future demand for this project.

In addition to the above, the proposed solution should be developed in such a way as to make it easy and cost effective to operate and maintain. This entails such issues as selecting simple mechanical equipment for which spares and service support are locally available on a long term basis.

The management and operation of the entire system will need to be scrutinized and adjusted to ensure that efficient maintenance is able to be done on a continuous basis to ensure the sustainability of the project in future.

An optimization process will need to be followed to make sure that initial capital cost is not the only criteria employed when seeking a long-term sustainable solution.

Water Conservation and demand management measures will need to be employed as a matter of urgency and this will include a campaign launched at the end users of the water so that they are able to understand the limitations and cost of the systems.

Solid engineering principles are to be employed throughout this process.

10.2. Cartage of Water

The cartage of water in large quantities for domestic use is not possible in this case. Firstly, the required quantities will make such a process exorbitantly expensive and secondly, the communities that need to be served are far apart which will require a fleet of vehicles to service them in such a manner. This is therefore not considered a feasible solution and is subsequently abandoned.

10.3. Groundwater Resources

Groundwater studies in the Namakwaland region have been ongoing for many decades. BVi Consulting Engineers appointed Messrs SRK Consulting to conduct an assessment for the potential of using groundwater to supply or augment supply to the towns and villages covered by the Namakwa Regional Water Supply Scheme. *(SRK Consulting: Report No.427711, March 2011)*

The geology of the area is underlain by a variety of metamorphic and igneous rocks of the Namakwa Metamorphic Complex consisting largely of granite, gneiss, metaquartzite, basic volcanic and intrusives comprising among others the Little Namakwaland Suite, the Richtersveld Suite and the Vioolsdrift Suite.

Alluvial deposits mainly occur along rivers and valleys. These deposits are usually only a few metres thick consisting of brownish grey, coarse-grained sand, silt, gravel and clay.

Folds, joints and brecciated fault and shear zones are common structural features in this tectonic province. The area is one of structural complexity and numerous faults displace and duplicate strata. Intensive folding is also present in many localities. These geological structures form important water-bearing features in the area and are referred to as secondary or fractured-rock aquifers. The major fault zones in the area have a predominantly northwest-southeast, north-south or northeast-southwest orientation. Prominent north-south to north-northwest trending faults, consisting of well brecciated zones dipping in an easterly direction, control valley development.

Shear zones varying from a few centimeters to several kilometres in thickness, occur. The shear zone at Paulshoek is the most prominent at approximately 2 km in width and consists of foliated, fine-grained, pink gneiss. Another prominent shear zone cuts through the middle of the area south of Nourivier. However, these shear zones are not very good water-bearing sources since the foliation is very compact limiting the recharge and abstraction.

Joints and joint systems occur frequently and have proved to be good water-bearing sources. The joint systems become compact with depth and only small amounts of water may be abstracted. These systems are only recharged seasonally.

When the baseline hydrogeology is considered, it is found that groundwater is largely confined to certain zones within structural features such as faults and lineaments. The groundwater level throughout the study area usually varies between 10 m and 50m below surface. Most boreholes are sub-artesian although artesian boreholes do occur in the Leliefontein area.

The predominant aquifer types found are the primary or intergranular aquifers, represented by alluvial deposits along river courses and valleys. These deposits consist of medium to coarse grained sand and clay of a few metres thick. A number of wells are developed in these deposits and the owners report that they deliver a fairly constant yield. However, due to the limited extent and thickness of these aquifers, it is not expected that large scale abstraction would be feasible.

The secondary aquifers are represented by the brecciated faults and joint systems that occur in the crystalline gneiss and granitic rocks. These aquifers are more extensive and capable of yielding more sustainable quantities of water. Most of the smaller towns and villages in Namakwaland obtain their water supplies from such aquifer types.

Historic monitoring records indicate that yields from boreholes vary between 0,3 litres per second to about 3.5 litres per second. The quantities are therefore very small.

Parsons and Conrad (1998) classify the study area as being a poor to minor aquifer. However, this classification is over a regional area and conditions may vary locally.

Aquifer vulnerability is determined by evaluating the following seven parameters (DWAF, 2005), namely:

- Depth to groundwater;
- Recharge;
- Aquifer medium;
- Soil media;
- Topography;
- Impact on vadose zone; and
- Hydraulic conductivity.

Aquifer vulnerability is defined as the likelihood of contamination reaching a specified position in the groundwater system after being introduced at a point above the uppermost aquifer. The higher lying areas are predominantly of medium low to low vulnerability. Where the fractured rock aquifer is located west of Nababeep and east of Buffelsrivier the aquifer is shown as being of high to very high vulnerability.

Groundwater quality in the area varies considerably with the salinity measured between 70 and 300 milliSiemens per meter. The DWA Water Quality Guidelines for Domestic use indicate that water with a salinity between 70 and 150 milliSiemens per meter is suitable for long-term human consumption. Above 150mS/m, the water may be used for a period of up to 7 years and then safety becomes marginal.

Similarly, the occurrences of high concentrations of fluoride occur in groundwater throughout the study area. Levels exceeding 1.5mg/l were found in groundwater throughout the study area. This water can only be used for periods up to 1 year where after health risks become quite serious. Fluoride levels in drinking water higher than 1.5 mg/ℓ may cause multidimensional health problems, including not only mottling of teeth and dental fluorosis but also several neurological disorders. At such elevated levels, the removal of excessive fluoride through defluoridation, or desalination, must be considered.

Ground Water Resource Potential

The percentage mean annual recharge (mm/a) from rainfall is very low throughout the area. It ranges from 0.05 % in catchment F30D, which has a mean annual precipitation of 213 mm/a, to 1.31 % in catchment F50E, which has a mean annual precipitation of 218 mm/a. There are two parameters used to evaluate groundwater potential, namely:

- The ***Utilisable Groundwater Exploitation Potential*** or UGEP, is the parameter that refers to the volume of water that may be abstracted from a groundwater resource which may ultimately be limited by anthropogenic, ecological and/or legislative considerations, which ultimately comes down to a management decision that may reduce the total volume of groundwater available for development.
- Potable Groundwater Exploitation Potential or PGEP, which is an estimate of the mean annual volume of groundwater available for development for domestic supply purposes.

The table below summarizes the potential for groundwater at the towns in the study area.

Town	Quater-nary Catchment	Mean Annual Precipitation (mm / a)	Mean Annual Recharge from rainfall (%)	Utilizable Groundwater Exploitation Potential (m^3/a/catchment)		Potable Groundwater Exploitation Potential (m^3/a/catchment)	
				Wet Periods	Dry Periods	Wet Periods	Dry Periods
Steinkopf	F30E	238	0.09%	322 804	282 144	136 913	119 623
Bulletrap	F30E	238	0.09%	322 804	282 144	136 913	119 623
Okiep	F30E	238	0.09%	322 804	282 144	136 913	119 623
Nababeep	F30E	238	0.09%	322 804	282 144	136 913	119 623
Carolusberg	F30C	136	0.83%	947 415	691 624	205 608	150 863
Concordia	D82D	145	0.18%	643 604	536 447	129 280	107 709
Springbok	F30D	213	0.05%	272 935	257 697	71 670	67 764
Kleinzee	F30G	158	0.30%	12 138	0	3 222	0

From this table it is therefore clear that utilizing groundwater as a primary source has considerable risk. Besides the fact that annual rainfall in the applicable catchments is relatively low, the geology limits the mean annual recharge from rainfall dramatically with none of the areas having a recharge percentage exceeding 0.83%. In addition to the above, the possible exploitable volumes decrease by as much as 30% during dry periods making groundwater very risky as a sustainable supply option for the towns in question.

Subsequently, the availability of groundwater at each of the above towns is discussed briefly as follows:

Steinkopf
Although there is a potential for exploitation from 3 existing boreholes of an estimated volume of 44 400m^3 per annum, the salinity from this source is marginal to poor (95 - 330mS/m). The fluoride concentrations range from 0.5mg/l to 2.3mg/l, making the quality for domestic use risky without further treatment. The aquifer at Steinkopf is currently under-utilized.

Bulletrap
This aquifer is stable and has the potential for exploitation of some 11 892m^3/annum. Again, the quality of the water is poor with salinity ranging from 170 -290mS/m and fluoride concentrations between 2.5mg/l and 3.2mg/l. Water cannot be utilized without additional treatment.

Okiep
There is no sustainable groundwater source available at Okiep. The last known abstraction from local boreholes was before 1946.

Nababeep

There is no sustainable groundwater source available at Nababeep. The last known abstraction from local boreholes was before 1946. Water was supplied from the Spektakel Aquifer between 1947 and 1981.

Carolusberg

There are no known production boreholes at this town and the potential for possible exploitation is very low.

Concordia

There are no known production boreholes at this town and the potential for possible exploitation is very low.

Springbok

There are currently no available production boreholes at Springbok. The last known local boreholes exploited for domestic water supply were abandoned in 1962. From 1962, water was purchased from the Okiep Copper Company who pumped water from the Buffelsrivier and sold it to the municipality up to 1979. The potential for further groundwater exploitation at Springbok is very low.

Kleinzee

Although Kleinzee do utilize groundwater, the water quality is saline and is blended with freshwater from the Namakwa Pipe Line. Further groundwater exploitation is possible, but not without additional treatment such as desalination.

From the above, it is clear that the potential for further groundwater exploitation is severely limited. In addition, the larger towns such as Springbok, Okiep and Nababeep have no potential whatsoever. The only possible usable volumes being at Steinkopf and Bulletrap which are also located far from where the water is needed and are between the Orange River and Springbok which means a pipeline will pass them in any case.

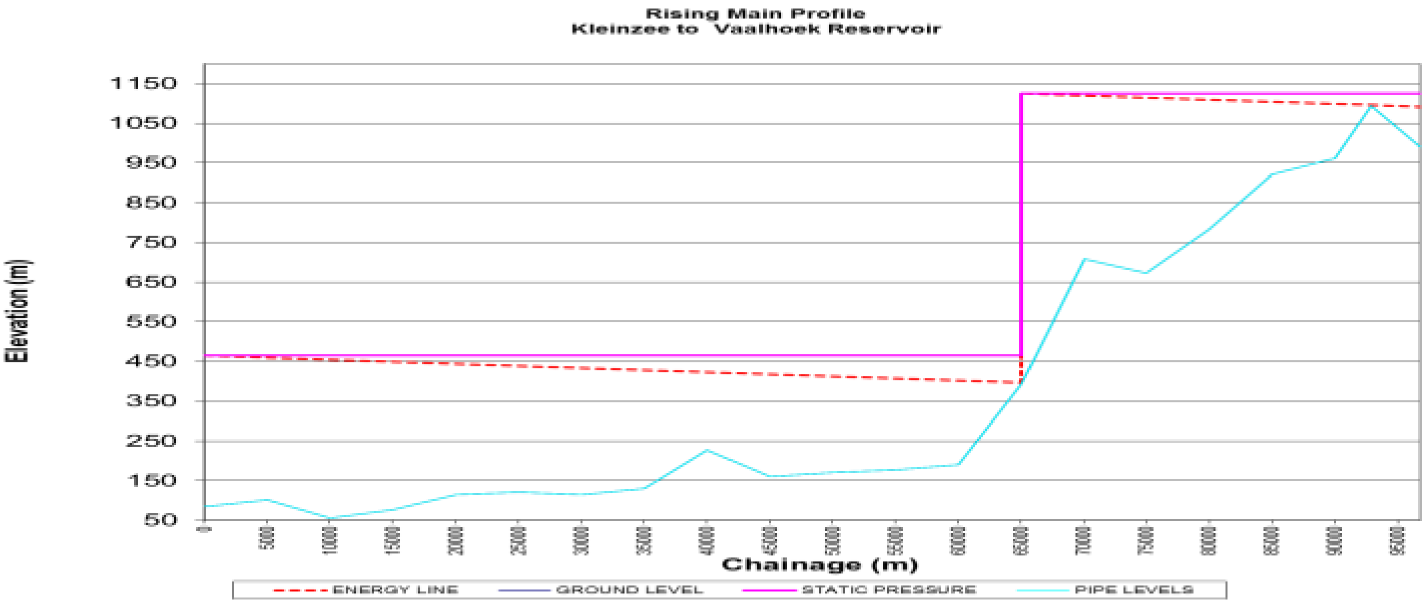
Subsequently, further investigations of utilizing groundwater as a source for the Namakwa Regional Water Supply Scheme were abandoned.

10.4. Desalination of seawater at Kleinzee and new rising main to Springbok

The use of desalinated seawater for domestic purposes has in recent years become more viable as the cost of reverse-osmosis membranes has declined considerably. Therefore, the use of desalinated seawater for this project is also an option which has been investigated.

The mining town of Kleinzee is located 80km directly west of Springbok on the Atlantic Ocean. The difference in elevation between the proposed point of abstraction and the Vaalhoek Reservoir at Okiep is 987m with a peak to be crossed which has an elevation of 1023m. This implies that at least two high lift booster pump stations will be required to supply the treated water to the Vaalhoek Reservoir. In addition, a gravity main will be required from Okiep to supply Steinkopf and Bulletrap which are respectively located 40km and 20km north of Okiep. Steinkopf is located at an elevation of 831m and Bulletrap at an elevation of 800m while the Vaalhoek Reservoir's top level is at 989m. The pipeline between Okiep and Steinkopf could then be considerably smaller than the existing 520mm diameter main of the existing system.

<u>Layout and locality of proposed Desalinated Seawater Pipe Line from Kleinzee</u>



For this option to be practical, the following infrastructure will need to be developed:

i. Abstraction beach well points equipped with submersible pumps
ii. 700mm Diameter sea water rising main of 5.07km in length
iii. Sand filtration and microfiltration system
iv. Biocide chemical dosing system
v. Sea Water Reservoir with a capacity of 7.5 Megaliters
vi. Reverse Osmosis desalination water treatment plant with a nominal capacity of 1 260m^3/h.
vii. Stabilization and disinfection dosing system (pH correction and Chlorine)
viii. Final Product Water Reservoir with a capacity of at least 9 Megaliters
ix. Booster Pump Station No.1 with a capacity of 220 liters per second @ 40bar
x. Rising Main No.1 : 600mm ø pipe line 65km long
xi. Booster Pump Station No.2 with a capacity of 220 liters per second @ 70 bar
xii. Rising Main No.2: 600mm ø pipe line 31.8km long
xiii. Discharge in the existing Vaalhoek Reservoir
xiv. New 200mm ø Rising Main from Vaalhoek to Steinkopf 42km long with an off take at Bulletrap

Energy Efficiency of proposed system:
If a calculation is made of the energy requirement to pump the water from Kleinzee to Vaalhoek using the proposed peak flow of 220 liters per second and a total elevation of 926m that needs to be overcome, assuming an efficiency of 85%, the energy requirement is **in excess of 2.35 MW**.

Assuming that pumping takes place for 20 hours per day at a current rate of 52,3c/kW.h, the total energy cost for this system then equates to **R8 976 526.10 per annum or R1.55 per kiloliter** of water pumped.

Desalination of seawater on the West Coast of South Africa normally takes place at a pressure of 65bar with a recovery rate of around 60%. This is at a salinity of 37 000 mg/l at a temperature of 11⁰ Celcius. This is therefore a further energy cost that will influence the final cost of potable water negatively. Given that the RO membranes need to be replaced every 3 to 5 years, replacement of the high pressure pumps and other mechanical equipment due to the highly corrosive environment created by seawater, the cost of desalinated water quickly escalates to an amount of **R6-93 per kiloliter**.

When this is added to the energy cost required to transfer the water from Kleinzee to Vaalhoek, a price of **R8-48 per kiloliter** is calculated before any operational costs, maintenance costs on the high lift pump stations or pipelines is even taken into account.
These facts indicate that although the option of using desalinated seawater from Kleinzee is technically possible, it is not yet cheaper than the costs being incurred with the current system.

Estimated Cost:

Summary of Project Cost (Estimated)	
PRELIMINARY & GENERAL COSTS	R 84 071 072.33
SEA WATER ABSTRACTION FROM WELLPOINTS:	R 58 547 990.00
SEAWATER RISING MAIN	R 8 446 620.00
SEAWATER RESERVOIR 7.5Ml	R 9 425 375.00
WATER PURIFICATION PLANT	R 160 015 347.77
FINAL PRODUCT WATER RESERVOIR 9 Ml	R 11 257 485.00
BOOSTER PUMPSTATION No.1	R 3 812 800.00
RISING MAIN No.1:	R 135 019 482.00
BOOSTER PUMPSTATION No.2	R 3 806 083.33
RISING MAIN No.2:	R 74 008 990.64
GRAVITY MAIN FROM VAALHOEK RESERVOIR TO STEINKOPF:	R 39 518 951.75
ELECTRICITY SUPPLY	R 5 662 525.00
Sub-total:	**R 593 592 722.82**
Contingencies: 10%	R 59 359 272.28
Escalation: 9%	R 53 423 345.05
Professional Fees and disbursements:	R 46 868 978.31
Total:	**R 753 244 318.47**
VAT @ 14%	R 105 454 204.59
TOTAL ESTIMATED EXPENDITURE:	**R 858 698 523.06**

Subsequently, this option is not investigated any further.

10.5. New pipeline from the Orange River at Pelladrift via Aggenys

The Pelladrift Water Board has been in existence since 1980. This water board was established to primarily supply water to the Black Mountain Mine and the village of Aggenys, some 53km from the abstraction point at Pelladrift on the Orange River, and also to the Khai-ma Municipality who buys water from the Water Board for Pella Village and the town of Pofadder.

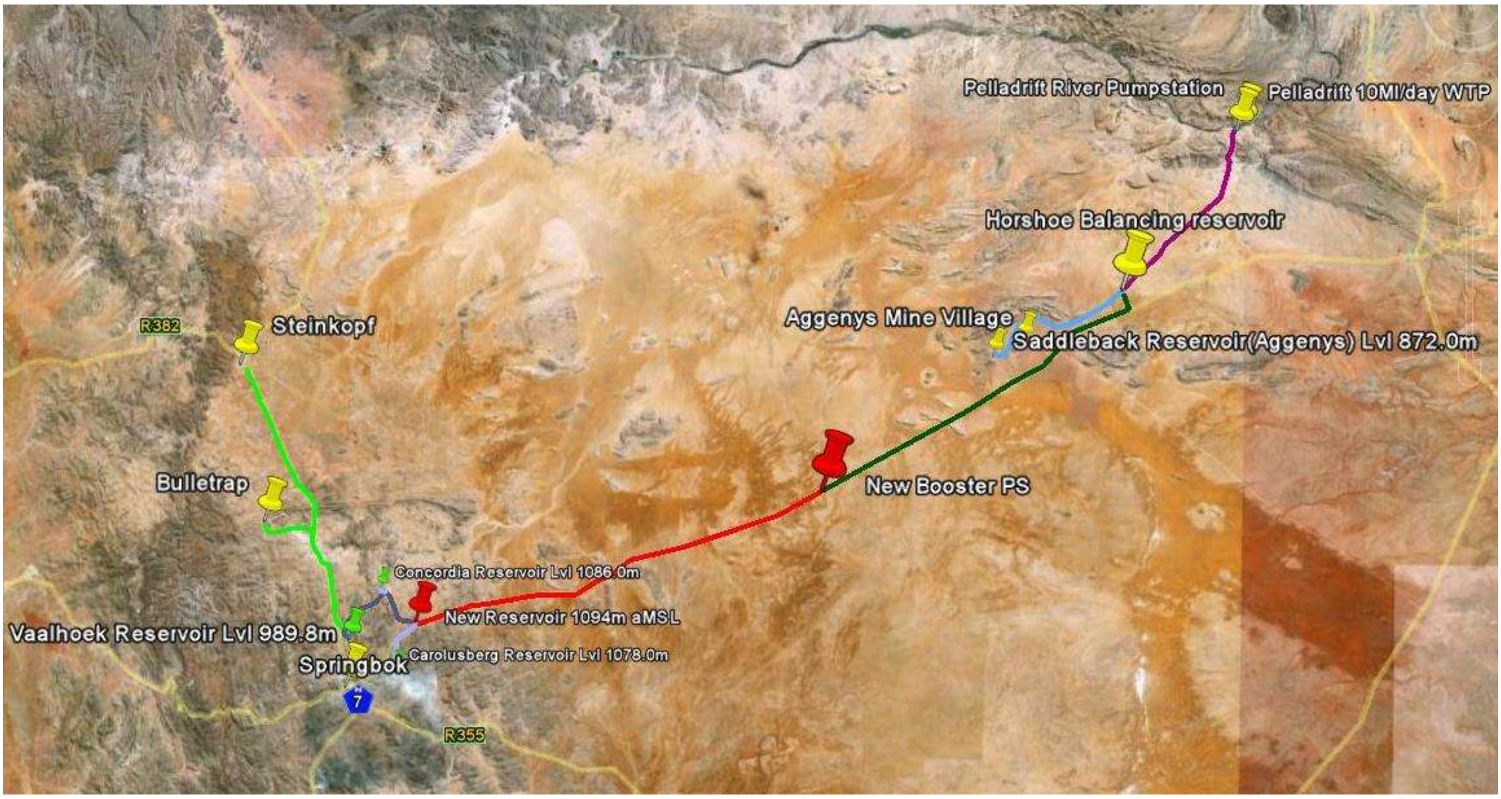
The existing system comprises the following major components:

- Raw water abstraction pump station at Pelladrift
- 400mm dia. Raw water rising main (981m)
- Pelladrift Water Treatment Plant (nominal capacity of 12 Ml/day)
- High lift Booster Pump Station (approximately 135 l/s at 80 bar)
- Clear Water Rising Main from Pella WTP to Horseshoe Reservoir (400mm ø epoxy coated steel approx.29,3km)
- Clear Water Gravity Main from Horseshoe Reservoir to Saddleback Reservoir (400mm ø and 350mm ø Fiber-cement pipes approx. 22.7km)
- 200mm Diameter ductile iron rising main from Pelladrift WTP to Pofadder Booster Pump Station and then a second rising main to the municipal reservoir in Pofadder.
- Off take from the rising main to Pella Village.

The complete system is operated and maintained by the Pelladrift Water Board with financial support and technical maintenance conducted by the personnel from the Black Mountain Mine at Aggenys. Despite its age, this system is still in a very good condition and currently able to meet the demand for which it was designed.

Aggeneys is located approximately 100km east – northeast of Springbok adjacent to the N10 National Road between Springbok and Pofadder. The Black Mountain Mine recently changed ownership from Anglo American to an Indian mining group named Verdanta. This sale included the mining rights to the proposed zinc deposits located at Gamsberg some 10km from Aggenys. There are now suggestions that the development of Gamsberg Mine is to take place within the near future. If this should occur, then the capacity of the Pelladrift Scheme will need to increase to a capacity of some 44 Megaliters per day.

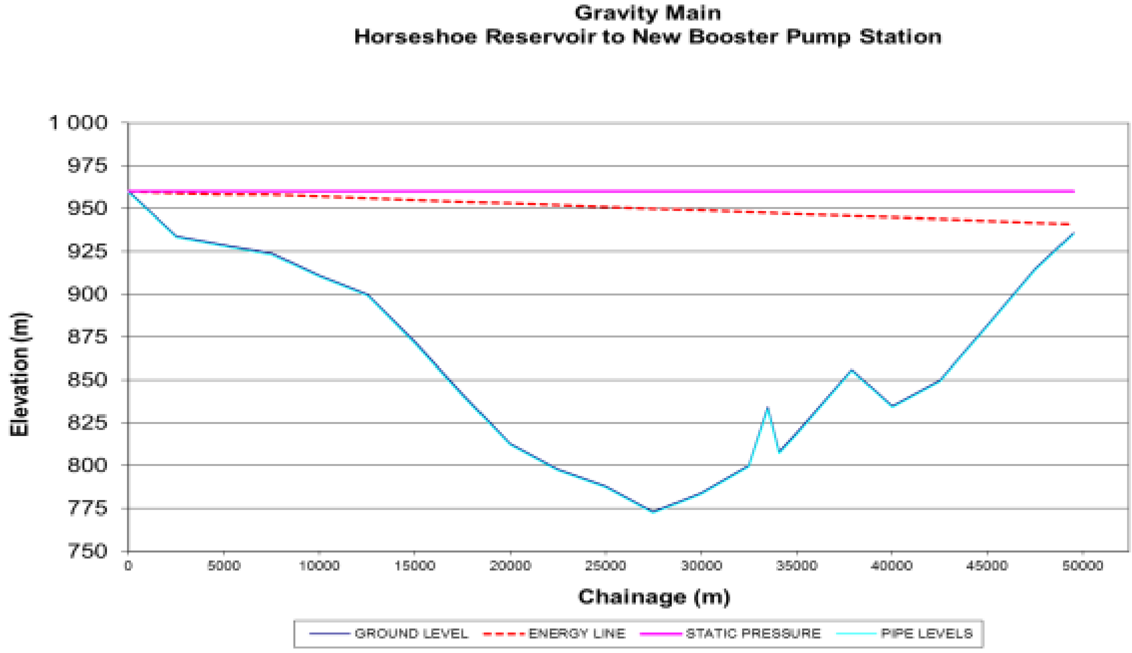
The above therefore presents an opportunity for supplying water from Pelladrift to the Vaalhoek Reservoir at Okiep. Accordingly this option is investigated to see if it is technically possible and also to test the sustainability thereof.



Proposed Layout

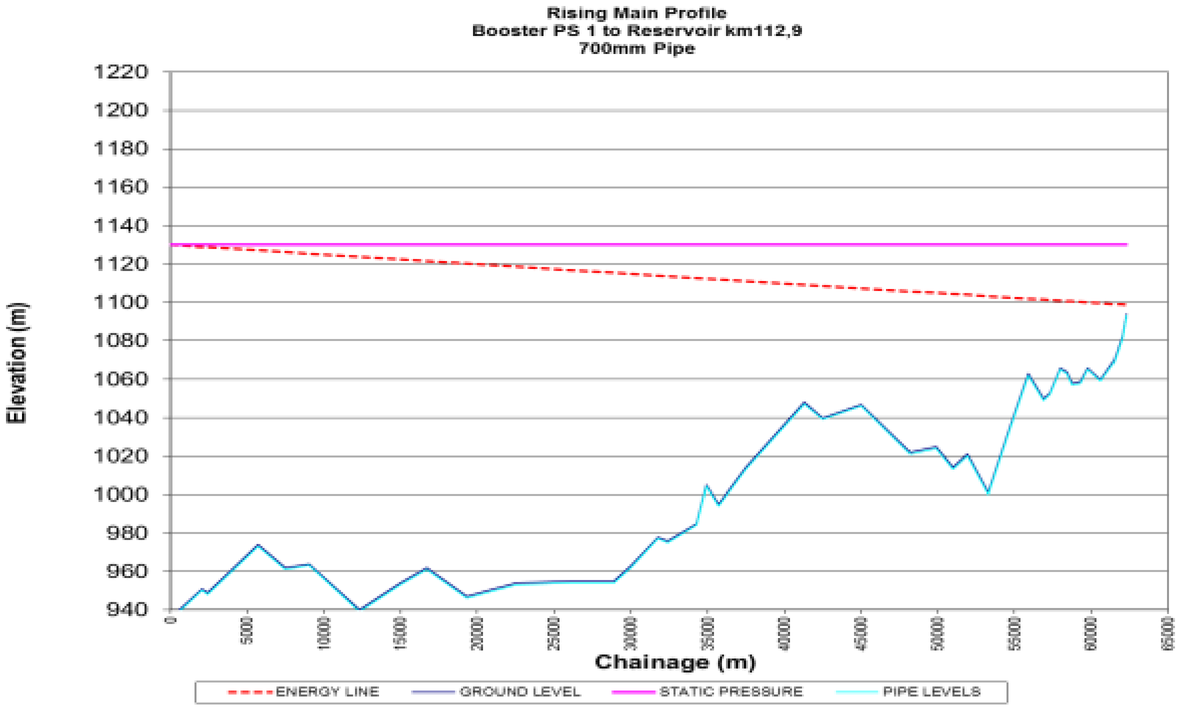
It is proposed that a pipe line could be constructed from the Horseshoe Reservoir located approximately 22.7km northeast of Aggenys, to Vaalhoek Reservoir in Okiep. In order for this scheme to work, the following major components are required:

i. Upgrading of the Pelladrift Raw Water Pump Station from 135 l/s to a capacity of 360 l/s.
ii. Upgrading of the Pelladrift Raw Water Rising Main from 400mm ø to a pipe line of 600mm ø.
iii. Upgrading of the Pelladrift Water Treatment Plant from its current 12 Megaliters per day to a capacity of 30 Megaliters per day.
iv. Upgrading of the Pelladrift Booster Pump Station from 135 l/s to a capacity of at least 360 l/s.
v. Upgrading of the Pelladrift Potable Water Rising Main from a 400mm ø pipeline to a 600mm ø pipeline over a distance of 29.3km pumping at a head of 721m.
vi. Construction of an additional new storage reservoir at the existing Horseshoe Reservoir with at least 12 hours storage capacity. An estimated size of 5 megaliters is suggested.
vii. Construction of new 700mm diameter potable water Gravity Main from Horseshoe Reservoir to a new Booster Pump Station located approximately 49,5km west from Horseshoe adjacent to the N10 national road.



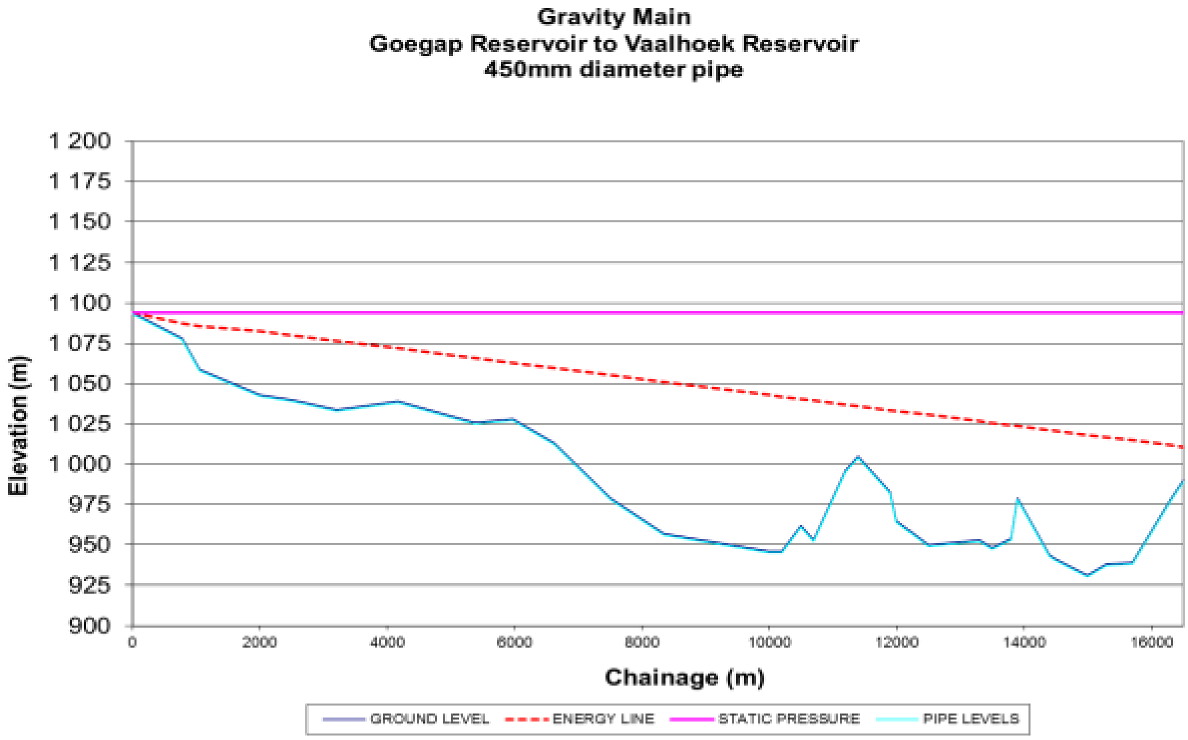
viii. Construction of an in-line booster pump station at km49,5 west of Horseshoe Reservoir.

ix. Construction of a 700mm diameter Rising Main 62,4km long from the Booster Pump station to a new reservoir located at km112,9 from Horseshoe Reservoir.



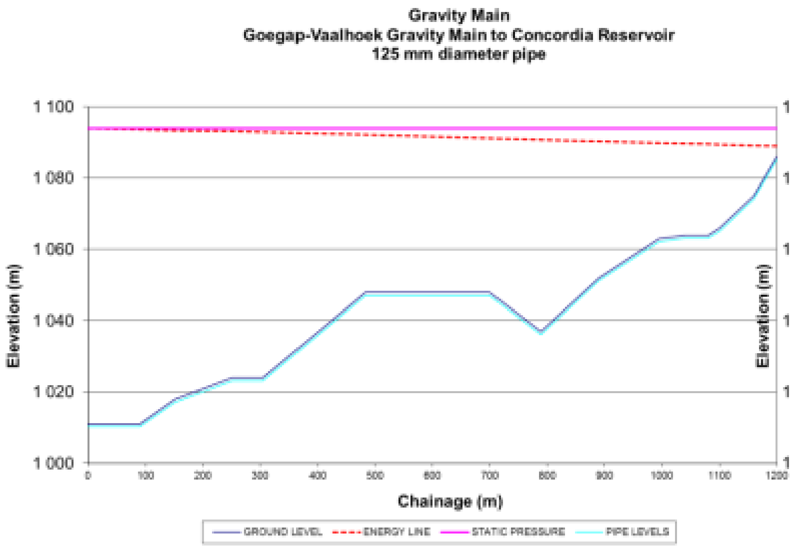
x. Construction of a second balancing reservoir with 1.5 Megaliter capacity at km112,9 (approximately 13km from Springbok) near the Goegap Nature Reserve.

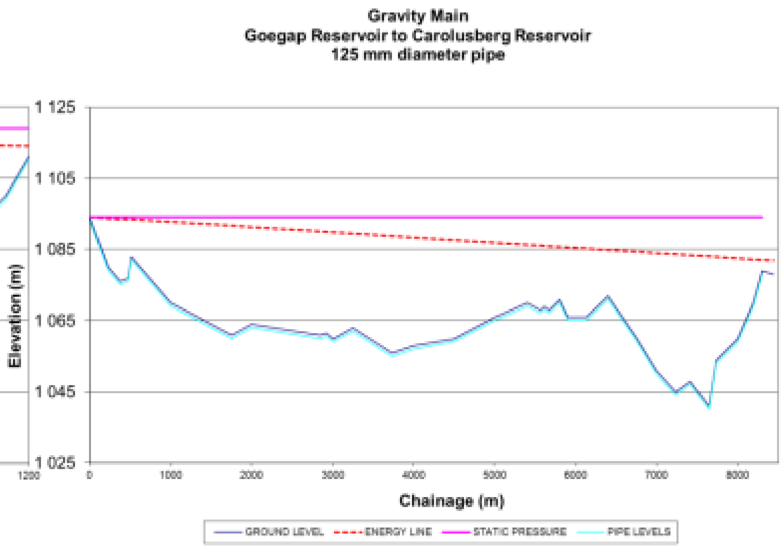
xi. Construction of a new 450mm diameter Gravity Main 16,5km long from the Goegap reservoir at km112,9 to feed the existing Vaalhoek Reservoir.



xii. This arrangement will also allow a 125mm diameter gravity main feed connection delivering 9.1 l/s to the Concordia Reservoir of 1,2km in length and a 125mm diameter gravity main feed connection to the Carolusberg Reservoir of 8.5km in length delivering 5 l/s.

xiii. New 200mm ø Rising Main from Vaalhoek to Steinkopf 42km long with an off take at Bulletrap.





Energy Efficiency of proposed Pelladrift system:

If a calculation is made of the energy requirement to pump the water from Pelladrift to Vaalhoek using the proposed peak flow of 220 liters per second and a total elevation of 1126m that needs to be overcome, assuming an efficiency of 85%, the energy requirement is **in excess of 2.86 MW**.

Assuming that pumping takes place for 20 hours per day at a current rate of 52,3c/kW.h, the total energy cost for this system then equates to **R10 915 300.64 per annum or R1.89 per kiloliter** of water pumped.

Estimated Cost:

Summary of Project Cost (Estimated)

UPGRADE PELLADRIF RAW WATER ABSTRACTION PUMPSTATION:	R 4 125 860.00
UPGRADE RAW WATER RISING MAIN	R 1 950 800.00
UPGRADE PELLADRIFT WATER PURIFICATION PLANT	R 18 835 122.00
ADDITIONAL CLEAR WATER RESERVOIR (2 ML)	R 2 089 000.00
UPGRADE CLEAR WATER RISING MAIN	R 52 444 738.04
CONSTRUCTION OF NEW 5 ML RESERVOIR AT HORSESHOE SITE	R 6 250 055.00
NEW GRAVITY MAIN FROM HORSESHOE TO BOOSTER PUMP STATION:	R 112 146 506.00
BOOSTER PUMPSTATION No.1	R 3 812 800.00
NEW RISING MAIN TO GOEGAP RESERVOIR:	R 141 440 175.00
NEW GOEGAP RESERVOIR	R 2 062 500.00
NEW GRAVITY MAIN FROM GOEGAP RESERVOIR TO VAALHOEK RESERVOIR	R 21 097 276.20
NEW GRAVITY MAINS TO CONCORDIA AND CAROLUSBERG RESERVOIRS	R 6 187 135.50
GRAVITY MAIN FROM VAALHOEK RESERVOIR TO STEINKOPF:	R 37 392 961.75
ELECTRICITY SUPPLY	R 7 437 525.00
Sub-total:	**R 417 272 454.49**
Contingencies: 10%	R 41 727 245.45
Escalation: 9%	R 37 554 520.90
Professional Fees and disbursements:	R 31 963 774.00
Total:	**R 528 517 994.84**
VAT @ 14%	R 73 992 519.28
TOTAL ESTIMATED EXPENDITURE:	**R 602 510 514.12**

Discussion:

The primary problem with this option is that the current system at Pelladrift is already operating at maximum capacity and is due for an upgrade in any case. This means that any additional water that is required from this system will require major capital investment to increase the capacity of the existing infrastructure to provide a flow of at least 360 liters per second.

There is a possibility that the Pelladrift Scheme will need to be upgraded in the near future if the Gamsberg Mine near Aggeneys is to be developed. It may then be feasible to piggyback onto this development and just provide the capital for the pipeline from Horseshoe Reservoir to Springbok.

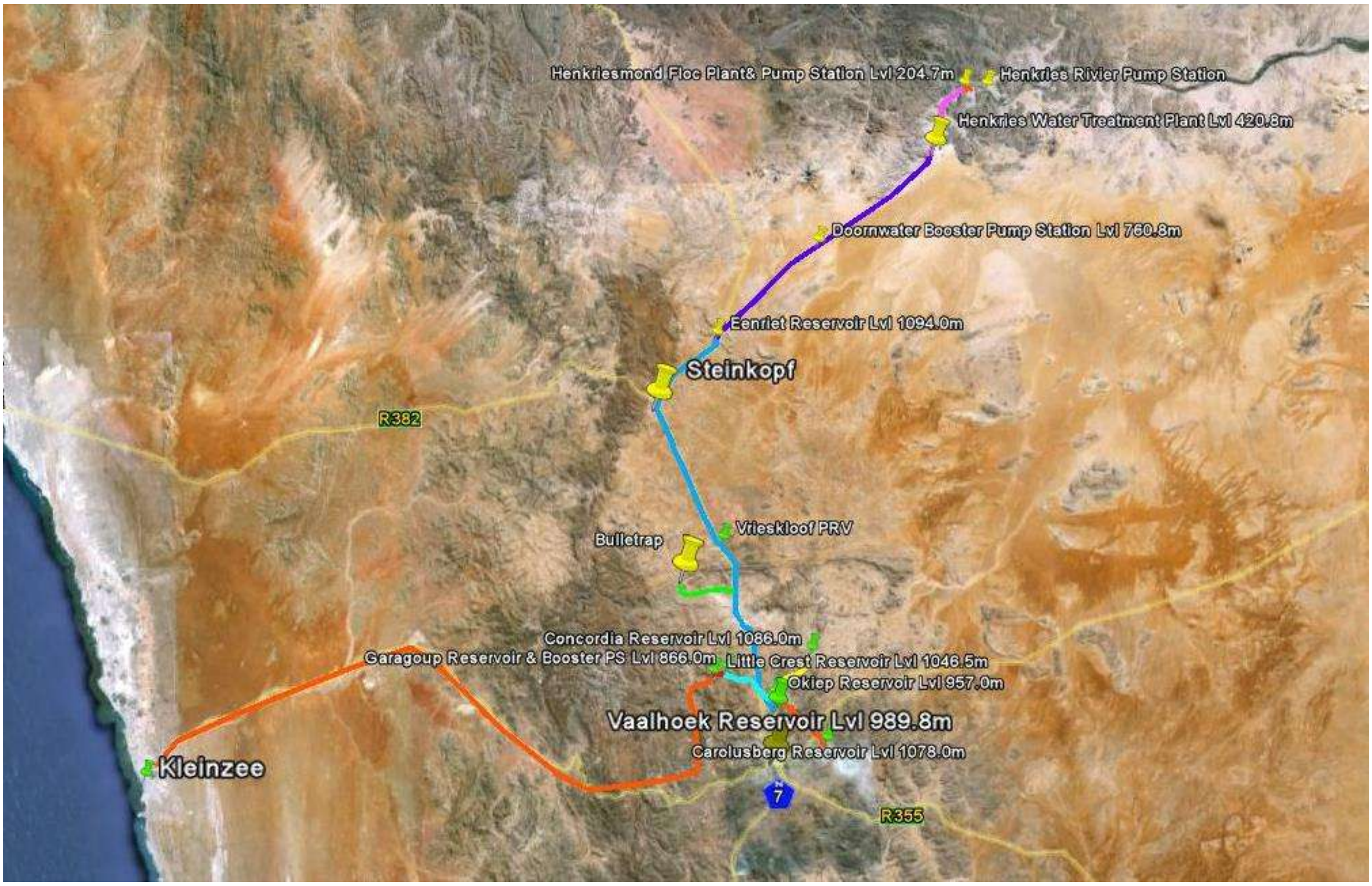
At this point in time however, the Pelladrift Scheme is fully utilized and there is no surplus capacity available. Should it be decided to use this option for supplying water to the Springbok area, Sedibeng Water would be liable for all the upgrading costs of the Pelladrift Water Board in addition to the costs of the new pipeline between Horseshoe Reservoir and Springbok.

Due to the additional costs required to upgrade the existing Pelladrift infrastructure to supply sufficient water for both Black Mountain Mine and the Springbok area, this option is not feasible. It is however technically possible and the movements of Messrs Vedanta with regards to the Gamsberg development should be the carefully observed in the short term. If the construction of the new mine commences before the end of 2012, this option may be the most economic.

10.6. Upgrade of existing pipeline from the Orange River with possible variations

The only other option remaining for the supply of water to the Springbok region is to upgrade the existing Namakwa Regional Water Supply Scheme to extend its life by another 20 years. Given that the existing infrastructure is already in excess of 30 years old and the pipe lines and pump stations are now beyond their useful lifecycle.

In addition, future water demand requirements dictate that all major components must be increased in terms of capacity in any case. Again, the point of departure will be a demand of 220 liters per second which is the 20 year projected peak demand for the current supply area.



The existing components of this system have been described in detail in Section 1.3 of this study. In the following paragraphs, details will be limited to addressing the necessity of replacing the current problematic components as well as their required size for future demand.

Components recommended for upgrading:

After extensive investigations and consideration of various options, it is recommended that the following components of the existing system be upgraded as follows:

- **Raw Water Pump Station**

  It is recommended that the existing Mono axial flow pumps and switchgear at this pump station be scrapped and replaced. It is suggested that 3 number new end suction centrifugal pumps be mounted on steel trolleys running on tracks to allow movement up and down the existing reinforced concrete ramp structure due to changes in the level of the Orange River. It is suggested that these pumps have a capacity of at least 150 liters per second each with a total delivery of 450 liters per second provided. Typically, each pump will require a 55kW motor for this duty.

Typical examples of pumps on a trolley configuration

Each pump to be equipped with a variable speed drive allowing more flexibility in terms of low flow periods in winter and also increased efficiency in terms of electrical consumption. In addition, electronic variable speed drives allow for optimal power factor correction leading to maximum electrical efficiency. All low voltage electrical motors must be of the high efficiency type allowing optimum use of electrical energy. The existing steel switchgear enclosure must be refurbished and fitted with a dedicated air conditioning system to ensure constant efficiency.

These pumps deliver raw water into a concrete sump which serves as a header tank for the existing 600mm diameter concrete raw water gravity main and feed canal. To optimize the use of the new pumps, it is suggested that an ultrasonic level sensor be employed to control the variable speed drives of the pump motors to ensure that the water level inside the concrete sump is maintained at a constant level. If the water level in the sump drops, a second pump will be started and both pumps will then run at a lower speed which will increase systematically if the water level in the sump continues to drop. This process will be repeated until a point is reached where the supply from the pumps are able to maintain the water level constantly.

All pumps to have a specific speed as close as possible to 50 ensuring the best possible efficiency. In addition to the above, the manufacturer of the pump is to be selected based on the suppliers track record of having continued availability of spares for at least 20 years and having accredited service agents within a radius of 400km of Springbok to ensure reliable and prompt service in outlying areas as primary selection criteria.

This system will require a dedicated steel rising main for each pump fitted with a series of vertical T-Pieces to allow connection of the pump to the rising main at 2m vertical elevation intervals.

This pump station must be fitted with full instrumentation such as:
-Oil temperature sensors
-Bearing temperature sensors
-Mechanical seal failure sensors
-Delivery pressure transducers
-Motor bearing temperature sensors
-Motor winding protection sensors
-Electromagnetic flow meter and local data logger/recorder

All of the above to be relayed to a computerized SCADA system located at the Henkries Water Treatment Plant by means of radio telemetry. All pumps must be able to be started and stopped remotely by means of the telemetry system.

- **Henkriesmond Booster Pump Station and Pre-sedimentation facility**

It is recommended that the existing Sulzer pumps be scrapped and replaced with new multistage ring section pumps and new 3.3kV high efficiency motors. It is suggested that the pumps be upgraded as follows: 3 x 100 l/s pumps and 2 x 50 l/s pumps. This combination will allow more flexibility in terms of varied pumping capacity while providing sufficient standby capacity (100% redundancy). Again it should be a requirement that spares are to be available for at least 20 years and that an approved agent must be available within a 400km radius of Springbok.

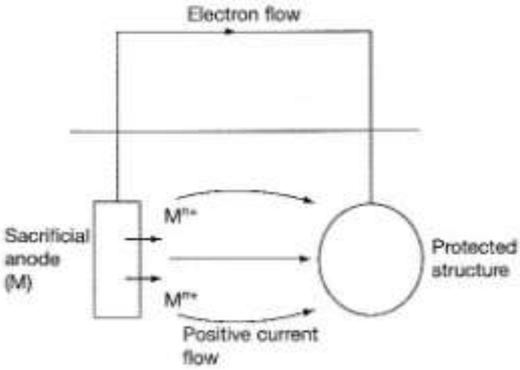
All switchgear at this pump station are also to be scrapped and replaced with either variable speed drives or electronic soft starters fitted with fixed capacitors for power factor correction. The latter may be preferable as these pumps generally operate at a constant load.

Provision is also to be made to refurbish / replace the existing pipe work inside the pump station. In addition, a new chemical dosing facility is to be provided to ensure effective coagulant dosing prior to the existing pre-sedimentation ponds. A provisional sum is also to be allowed for attention to the buildings such as repair of broken windows, repainting and refurbishment / replacement of the evaporative cooling system.

Typical modern switchgear panel with electronic softstarters vs existing obsolete switchgear.

- **Rising Main between Henkriesmond and Henkries Water Treatment Plant**

  Although this section of pipeline currently does not fail that often, this section of the pipeline runs through an area where the soil is highly corrosive and external corrosion is a serious problem. In addition, this pipe will need to be upgraded in terms of the required future capacity. It is proposed that this section of 406mm diameter pipeline be replaced with at least a 600mm diameter pipe. Said pipe to be fitted with a cathodic protection system to ensure a design life of at least 30 years.



Schematic presentation of cathodic protection system

  In simple terms the pipeline requiring corrosion protection is rendered cathodic (negative) and the circuit is completed with a sacrificial anodic (positive) component. Current flows from the anode to the cathode thereby preventing the oxidation (corrosion) of the pipe material. Before any decision in this regard is taken, a complete soil resistivity survey of the pipe route will need to be done to determine the potential for corrosion.

- **Henkries Water Treatment Plant & potable water pump station**

  The treatment plant is probably the single component on the Namakwa Regional Water Scheme that is in the best condition. Physically, the structures are sound and have many more years of useful life. In terms of capacity, the treatment plant will need to be upgraded to a future capacity of at least 16 Megaliters per day. This will entail the commissioning of the 4 filters which were never equipped with mechanical equipment as well as the construction of an additional 22,5m diameter clarifier complete with mechanical equipment.

  In addition, it is suggested that all the existing equipment be refurbished, i.e. replacement of filter media, overhauling of blowers and backwash pumps, upgrading of the chemical dosing equipment inclusive of the chlorine dosing equipment. The automation of the filter level control and backwashing cycles should also be considered.

The backwashing cycles at the plant are completely manual which leads to excessive clean water losses. It is suggested that the existing false floor filtration system be upgraded to provide a more aggressive backwash at a rate of at least $60m^3/m^2/h$. In addition, the backwash system should be upgraded to a combined air-water scour system. Typically, such a cycle starts the backwash cycle with a 2 minute duration air only scour, followed by a 2 minute duration air-(50% of full rate) water cycle and then finishes with a water only cycle of roughly 3 to 5 minutes duration. The existing filter design is equipped with a side overflow backwash spillway which is an effective design and should be retained.

Typical filter surface at Henkries WTP

Unfitted spare filter at Henkries WTP

The Potable Water Pump Station at the water treatment plant should be upgraded to have 3 x 100 l/s pumps fitted with variable speed drives. This combination will allow more flexibility in terms of varied pumping capacity while providing sufficient standby capacity (100% redundancy). Again it should be a requirement that spares are to be available for at least 20 years and that an approved agent must be available within a 400km radius of Springbok.

Provisional sums should also be allowed for the following:

- Flow proportional chemical dosing system
- Instrumentation such as a raw water and clear water flow meters
- Ultrasonic level sensor for the clear water sump
- Telemetry and SCADA system
- Renovations such as painting and repairs to the building and surrounds
- Cleaning out of the existing waste water collection drying beds

Henkries WTP Potable Water Pump Station

- **Rising Main between Henkries Water Treatment Plant and Doornwater Booster Pump Station**

  This pipeline is currently also a 406mm diameter continuously welded steel pipe. A section of roughly 12 kilometers in length has been replaced about 5 years ago. The replacement pipe was not lined with cement mortar, but coated with an epoxy on the inside. Again, the size of this pipe needs to increase to at least a 600mm diameter pipe for the required future capacity. In addition, all air release valves should be replaced and the quantity increased to have an air valve at at least every 500m. The current spacing for air valves is anything between 1km and 1.5km which is insufficient to release dissolved air and also to suck air into the pipe when column separation occurs at pump switch-off.

- **Doornwater Booster Pump Station**

  It is recommended that the existing Sulzer pumps be scrapped and replaced with new multistage ring section pumps and new 3.3kV high efficiency motors. It is suggested that the pumps be upgraded as follows: 3 x 100 l/s pumps fitted with variable speed drives. The variable speed drives can be linked to the water level of the Eenriet Reservoir. It is suggested that these pumps be set up to to allow full speed pumping until the reservoir level reaches 80% of full service level where after the variable speed drives will begin to slow the pumps down progressively until 95% of the level is reached when they will switch off. This has the advantage that very little if any waterhamer will occur, as the velocity of the water column is reduced gradually over a period. In addition, this system will prevent damage to and protect mechanical equipment such as reflux valves, etc. This combination of pumps will allow more flexibility in terms of varied pumping capacity while providing sufficient standby capacity (100% redundancy). Again it should be a requirement that spares are to be available for at least 20 years and that an approved agent must be available within a 400km radius of Springbok.

Doornwater Pumpstation

All switchgear at this pump station is also to be scrapped and replaced with either variable speed drives for improved power factor correction.

Provision is also to be made to refurbish / replace the existing pipe work inside the pump station. A provisional sum is also to be allowed for attention to the buildings such as repair of broken windows, repainting and refurbishment / replacement of the evaporative cooling system.

- **Rising Main between Doornwater Booster Pump Station and Eenriet Reservoir**

Although this pipeline does fail occasionally, it is currently still reliable. It should however also be upgraded to at least a 500mm diameter pipeline to provide sufficient capacity for future demand. In addition, all air release valves should be replaced and the quantity increased to have an air valve at at least every 500m. The current spacing for air valves is anything between 1km and 1.5km which is insufficient to release dissolved air and also to suck air into the pipe when column separation occurs at pump switch-off.

- **Eenriet Reservoir**

This reservoir currently is in a very good condition. It is suggested that as a minimum, a provisional sum be allowed for cleaning out the reservoir of all sludge and accumulated debris and for a thorough inspection of all joint seals. Mechanical equipment such as valves and flow meters should be replaced. An ultrasonic level sensor and telemetry outstation should be provided to relay the reservoir water level to Doornwater for booster pump control, to both Henkries Water Treatment Plant and Springbok for monitoring purposes.

- **Gravity Main between Eenriet Reservoir and Vaalhoek Reservoir**

This component is currently the Achilles Heel of the total system. It should be replaced in total with a pipe of similar diameter. The current pipe is a continuously welded steel pipe of 512mm inside diameter. It is suggested that the complete line be replaced with a pipe of 500mm nominal diameter. Similarly, the pressure reducing valve located at Vrieskloof at chainage 26 491m be retained to reduce the pressure with at least 50m. The maximum pressure that the pipe will then be required to deal with between Vrieskloof and Vaalhoek Reservoir is 30bar.


Typical pipe failure on the Eenriet to Vaalhoek gravity main

As on the other pipelines, all air release valves, isolating valves and scour valves should be replaced and the quantity of the air release valves increased to have an air valve arrangement at least every 500m. The current spacing for air valves is anything between 1km and 1.5km which is insufficient to release dissolved air and also to suck air into the pipe when column separation occurs in the case of a rapid valve opening or closing.

The replacement of pipelines will need to occur whilst the existing pipeline is to remain operational and this will be a major challenge. The idea at this point in time is to either construct the new pipe line above ground on concrete pedestals, or to lay a temporary bypass pipeline from air valve chamber to air valve chamber, remove the existing pipe from its trench and lay the new pipe in the same trench on the same route. Due to the topography and existing infrastructure such as roads and power transmission lines, there are very limited options available for rerouting the pipeline. The nature of the geotechnical soil conditions is such that extensive blasting would be required should a new trench need to be excavated. Besides the exorbitant costs for such an exercise, it would require that the new pipeline be routed quite far from the existing route to prevent damage to the existing pipeline during blasting operations. The condition of the existing pipeline is such that any such shocks imposed on it may cause it to fail with resulting lack of water for the consumers.

There is also the option of laying this pipe above ground. It does however have certain environmental as well as aesthetic impacts if this route is followed. In addition, measures would need to be taken to combat vandalism.

Typical Above Ground Installation of a 600mm diameter pipeline and air-valve arrangement

- **Vaalhoek reservoir**

This reservoir currently is in a very good condition. It is suggested that as a minimum, a provisional sum be allowed for cleaning out the reservoir of all sludge and accumulated debris and for a thorough inspection/replacement of all joint seals. Mechanical equipment such as valves and flow meters should be replaced. An ultrasonic level sensor and telemetry outstation should be provided to relay the reservoir water level to Doornwater for booster pump control and to both Henkries Water Treatment Plant and Springbok for monitoring purposes.

- **Rising Main between Okiep Reservoir to Little Crest Reservoir via Garagoup Booster Pump station to Nababeep.**

It is suggested that this system be completely abandoned and that a new 300mm diameter rising main be constructed from Rooiwinkel to Nababeep. This proposed new pipe can be directly connected to the Eenriet – Vaalhoek gravity main utilizing the excess pressure to lift the water over an elevation of roughly 190m through a distance of approximately 11km. This option will require a new reservoir in Nababeep for storage and also for balancing the flow to Kleinzee. The route, hydraulic design and tender documentation for this work has been completed and tenders received. Appointment of the contractor is imminent.

This option now eliminates two very old pump stations, two reservoirs and approximately 9km of pipeline in a very poor condition with a resulting future energy and maintenance savings.

- **Gravity Main between Vaalhoek and Springbok**

The feed pipe from the Vaalhoek Reservoir at Okiep to the Springbok bulk system is currently a 350mm fiber-cement pipe with an internal diameter of 340mm and 8 367m long. It is still hydraulically capable of delivering the current as well as projected future flows. Fiber-cement pipes are however no longer manufactured and the availability of couplings and spare pipes is problematic. It is suggested that this pipe be replaced in future with a 350mm diameter pipe using either uPVC or ductile iron as pipe material. This section of the total scheme is currently still serviceable and is therefore not an urgent priority. The cost of replacement has however been included in the estimate as funds will be required for replacement in the near future.

- **Okiep Reservoir**

This reservoir does in fact not supply water to Okiep, but acts as a balancing reservoir for the Okiep Pump Station which currently pumps water to Nababeep, Kleinzee, Carolusberg and Concordia. When the new gravity main to Nababeep is complete, the pumps at Okiep will only supply water to Concordia and Carolusberg. . It is suggested that as a minimum, a provisional sum be allowed for cleaning out the reservoir of all sludge and accumulated debris and for a thorough inspection/replacement of all joint seals. Mechanical equipment such as valves and flow meters should be replaced. An ultrasonic level sensor and telemetry outstation should be provided to relay the reservoir water level to both Henkries Water Treatment Plant and Springbok for monitoring purposes.

- **Okiep Pumpstation**

This pumpstation was not originally a part of the Namakwa Regional Water Supply Scheme as designed by Water Affairs. The pumpstation was constructed and operated by the Okiep Copper Company and is at least 20 years older than the bulk supply scheme. Water was originally supplied from boreholes at Spektakel and the Buffelsrivier and then pumped to Okiep from where it was then distributed. It is suggested that the two pumps pumping water to Nababeep via Garagoup Booster Pump Station be scrapped as soon as the new gravity main to Nababeep has been completed. The two pumps pumping water to Concordia and Carolusberg must be replaced and two additional pumps of similar capacity provided as standby units. All switchgear at this pump station must be scrapped and replaced with new motor control centers equipped with electronic soft starters and capacitor banks for power factor correction. The current electrical supply to this pump station is 500V which is a mining standard. The existing transformer should be scrapped and replaced with a 400V unit. The capacity of this pump station should remain unchanged as there is very little future growth envisaged for these two villages.

- **Rising Main from Okiep to Concordia**

This pipe line is currently a 150mm steel pipe line lay partially above ground and partially submerged. It is in a very poor condition and should be replaced.

- **Concordia Reservoir**

It is suggested that as a minimum, a provisional sum be allowed for cleaning out the reservoir of all sludge and accumulated debris and for a thorough inspection/replacement of all joint seals. Mechanical equipment such as valves and flow meters should be replaced. An ultrasonic level sensor and telemetry outstation should be provided to relay the reservoir water level to both Henkries Water Treatment Plant and Springbok for monitoring purposes. The galvanized metal roof must be replaced and made bird and insect proof. The security fence must be replaced.

- **Rising Main from Okiep to Carolusberg**

This pipe line is currently a 150mm steel pipe line lay partially above ground and partially submerged. It is in a very poor condition and should be replaced.

Carolusberg Reservoir

- **Carolusberg Reservoir**

It is suggested that as a minimum, a provisional sum be allowed for cleaning out the reservoir of all sludge and accumulated debris and for a thorough inspection/replacement of all joint seals. Mechanical equipment such as valves and flow meters should be replaced. An ultrasonic level sensor and telemetry outstation should be provided to relay the reservoir water level to both Henkries Water Treatment Plant and Springbok for monitoring purposes. The galvanized metal roof must be replaced and made bird and insect proof. The security fence must be replaced.

Estimated Cost:

Summary of Project Cost (Estimated)

PRELIMINARY & GENERAL COSTS	R 49 896 165.09
UPGRADE HENKRIES RIVER PUMPSTATION	R 5 369 795.00
UPGRADE HENKRIESMOND PRE-SEDIMENTATION FACILITY AND PUMPSTATION	R 11 852 391.00
REPLACE EXISTING RISING MAIN: HENKRIESMOND TO WTP	R 23 617 735.69
REFURBISH AND UPGRADE HENKRIES WATER TREATMENT PLANT	R 34 412 744.00
REFURBISH CLEAR WATER PUMPSTATION AT WTP	R 6 222 811.00
UPGRADE CLEAR WATER RISING MAIN FROM WTP TO DOORNWATER PS	R 41 988 000.81
REFURBISH DOORNWATER BOOSTER PUMP STATION	R 12 118 811.00
UPGRADE CLEAR WATER RISING MAIN FROM DOORNWATER TO EENRIET RESERVOIR	R 28 273 056.00
REFURBISH EENRIET RESERVOIR	R 1 084 266.00
REPLACE CLEAR WATER GRAVITY MAIN FROM EENRIET RESERVOIR TO VAALHOEK RESERVOIR	R 101 462 276.50
REFURBISH VAALHOEK RESERVOIR	R 1 159 266.00
REPLACE CLEAR WATER GRAVITY MAIN FROM VAALHOEK RESERVOIR TO SPRINGBOK	R 9 525 551.15
NEW RISING MAIN FROM ROOIWINKEL TO NABABEEP	R 10 636 312.50
REFURBISHMENT OF THE OKIEP PUMP STATION COMPLEX	R 3 940 511.00
REPLACE CLEAR WATER RISING MAIN FROM OKIEP PUMP STATION TO CONCORDIA RESERVOIR	R 4 447 001.92
REPLACE CLEAR WATER RISING MAIN FROM OKIEP PUMP STATION TO CAROLUSBERG RESERVOIR	R 5 171 938.97
REFURBISH CONCORDIA RESERVOIR	R 559 266.00
REFURBISH CONCORDIA RESERVOIR	R 559 266.00
INSTALL NEW TELEMETRY SYSTEM FOR COMPLETE SCHEME	R 1 683 330.00
Sub-total:	**R 353 980 495.62**
Contingencies: 10%	R 35 398 049.56
Escalation: 9%	R 31 858 244.61
Professional Fees and disbursements:	R 46 662 795.00
Total:	**R 467 899 584.79**
VAT @ 14%	R 65 505 941.87
TOTAL ESTIMATED EXPENDITURE:	**R 533 405 526.66**

Energy Efficiency of the existing system

If a calculation is made of the ***current*** energy requirement to pump the water from the Orange River abstraction point to Eenriet Reservoir using the proposed peak flow of 220 liters per second and a total elevation of 923m that needs to be overcome, and assuming an efficiency of 85%, the energy requirement is **3.17 MW**. ***This is the requirement for a 406mm diameter pipe.***

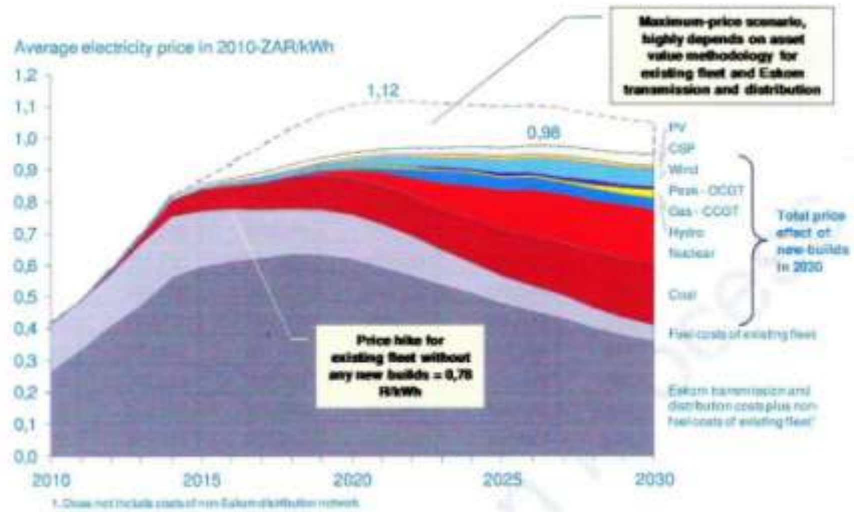
Assuming that pumping takes place for 20 hours per day at a current rate of 52,3c/kW.h, the total energy cost for this system then equates to **R 12 084 381.69 per annum or R2.09 per kiloliter** of water pumped.

If all the rising mains on this system were to be upgraded as proposed above to be as follows:

Henkriesmond to Henkries WTP : 600mm dia.
Henkries WTP to Doornwater PS: 600mm dia.
Doornwater PS to Eenriet reservoir: 500mm dia.

Theses upgrades will result in energy savings equating to **R 2 597 957-87** per annum. The saving is primarily brought about by the lower velocity through the larger pipe with resulting decreased friction losses. This saving should now be offset against the increased capital cost of laying the larger pipe to check if the proposal is financially feasible.

Given that the lifecycle costs of a pump station are generally considered in the following ratio:
Capital Cost: 10%
Maintenance Cost: 5%
Energy Cost: 85%
The estimated life cycle for the new refurbishments is 20 years and energy costs are set to increase from the current 52,3c per kW.h by 28% per annum over the next 3 years and then level off at a worst case scenario of R1.12 per kW.h in 2021 as per the ESKOM IRP 2010-2030 Final Report. After 2021, ESKOM expects that increases will be in accordance with the inflation rate. It would therefore be prudent to seriously consider any means of alleviating this continuous long-term energy cost.



SECTION 4: EVALUATION OF POTENTIAL SOLLUTIONS

11. VALUE DRIVERS AND TRADE-OFFS

11.1. Capital Costs of the Project

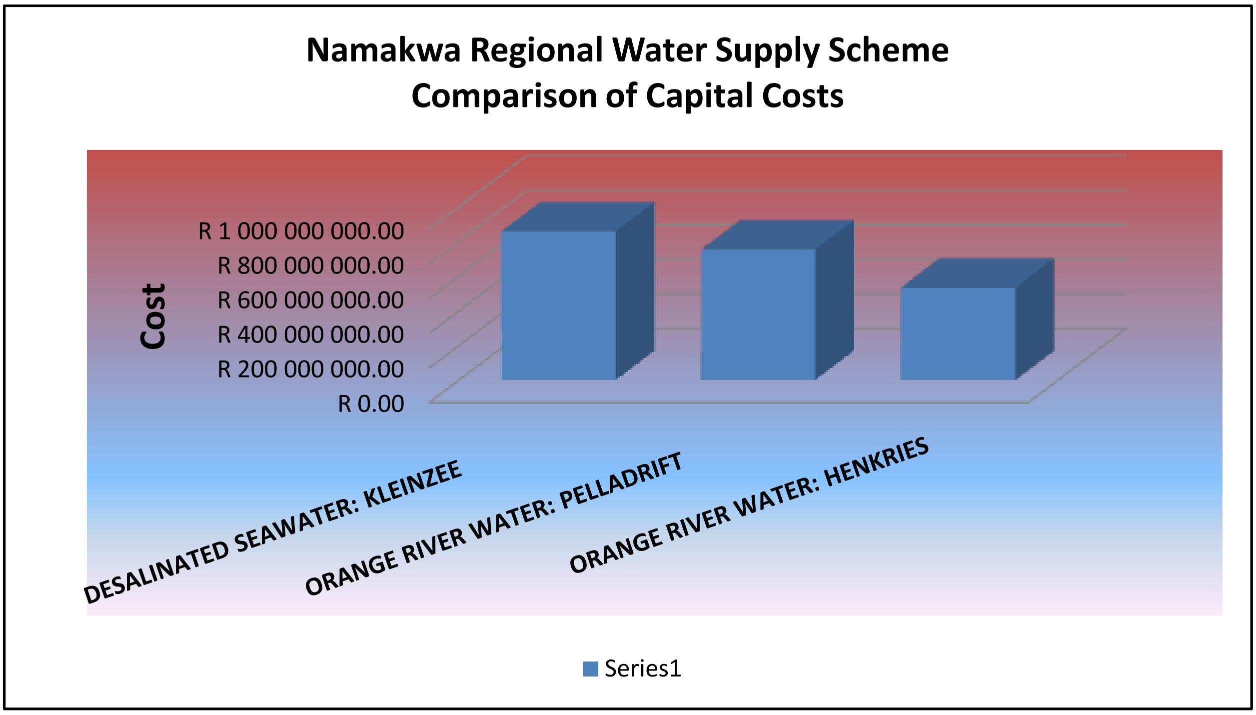
The capital cost required for the 3 options investigated are as follows:

Description:	OPTION 1 DESALINATED SEAWATER: KLEINZEE	OPTION 2 ORANGE RIVER WATER: PELLADRIFT	OPTION 3 ORANGE RIVER WATER: HENKRIES
Capital Cost:	R 858 698 523.06	R 754 243 611.73	R 533 405 526.66

These costs include 10% contingencies, 9% for escalation as these will all be multi-year projects.

This costs also includes professional fees and disbursements in accordance with the Guideline Scope of Services and Tariff of Fees for Persons Registered in terms of the Engineering Profession Act (2000) (Act No.46 of 2000) as published in Government Gazette No.33892 of 3 December 2010.

From the above, it is clear that the refurbishment of the existing system is less capital intensive than the other two options investigated. The Refurbishment of the Namakwa Regional Water Scheme as it is now, pumping Orange River water from Henkries is some R220 million rand less expensive than the option of supplying water from Pelladrift and some R325 million rand cheaper than establishing a new scheme pumping desalinated seawater from Kleinzee on the west coast.



11.2. Production Cost of Water

This project is sized to deliver a potential total volume of 5 781 600 m^3 per annum. This volume is based on a total delivery of 220 l/s for an operating period of 20 hours per day. The production cost of the water is calculated from the volume produced and the estimated operational, maintenance and energy costs for each of the options investigated.

Operational Costs

The operational cost was calculated for each option covering the following items:

OPERATIONAL COST DESCRIPTION	DESALINATED SEAWATER FROM KLEINZEE (New System)	ORANGE RIVER WATER FROM PELLADRIFT (New system)	ORANGE RIVER WATER FROM HENKRIES (Refurbish existing system)
Admin Cost	R 2 500.00	R 2 500.00	R 2 500.00
Bank Charges	R 45 000.00	R 45 000.00	R 45 000.00
Chemicals	R 4 266 000.00	R 450 000.00	R 450 000.00
Computers	R 20 000.00	R 20 000.00	R 20 000.00
Insurance	R 300 000.00	R 300 000.00	R 300 000.00
Vehicle expenses	R 450 000.00	R 450 000.00	R 345 000.00
Occupational Health	R 7 500.00	R 7 500.00	R 7 500.00
Stationary	R 45 000.00	R 35 000.00	R 25 000.00
Protective Clothing	R 25 000.00	R 15 000.00	R 15 000.00
Repairs & Maintenance: Buildings	R 20 000.00	R 20 000.00	R 20 000.00
Repairs & Maintenance: General	R 30 000.00	R 30 000.00	R 30 000.00
Salaries & Wages	R 7 500 000.00	R 6 000 000.00	R 5 000 000.00
Skills Development Levy	R 75 000.00	R 60 000.00	R 40 000.00
Telephone & Fax	R 140 000.00	R 140 000.00	R 140 000.00
Employee transport	R 85 000.00	R 75 000.00	R 60 000.00
UIF	R 97 500.00	R 78 000.00	R 65 000.00
Laboratory Costs: Water analysis	R 60 000.00	R 60 000.00	R 60 000.00
Water Extraction Levy		R 800 000.00	R 800 000.00
TOTAL OPERATIONAL COST/ANNUM:	**R 13 168 500.00**	**R 8 588 000.00**	**R 7 425 000.00**

Maintenance Costs

The maintenance costs for each option were calculated using the following industry norms:

- 1% of the capital value of Civil infrastructure per annum
- 4% of the capital value of Mechanical Equipment per annum
- 1% of the capital value of Pipelines per annum
- 1% of the capital value of Electrical Power Distribution lines per annum

The 3 options investigated returned the following values:

MAINTENANCE COST DESCRIPTION	DESALINATED SEAWATER FROM KLEINZEE (New System)	ORANGE RIVER WATER FROM PELLADRIFT (New system)	ORANGE RIVER WATER FROM HENKRIES (Refurbish existing system)
4% on Mechanical Equipment:	R 9 047 288.84	R 1 070 951.28	R 1 946 501.16
0.5% on Civil Infrastructure/Buildings	R 47 126.88	R 52 007.78	R 141 172.82
1% on Pipelines	R 2 569 940.44	R 3 866 271.02	R 2 251 218.74
1% on Power & Electrical	R 56 625.25	R 74 375.25	R 240 446.28
TOTAL MAINTENANCE COST/ANNUM:	**R 11 720 981.41**	**R 5 063 605.33**	**R 4 579 339.00**

From the table it is again obvious that the existing Henkries option has returned the most favourable values. This may not correlate with the current situation at experienced by the water board, but it must be taken into account that these calculations are based on the ideal situation, i.e. new pumps, high efficiency switchgear and larger diameter pipes leading to less friction and reduced costs.

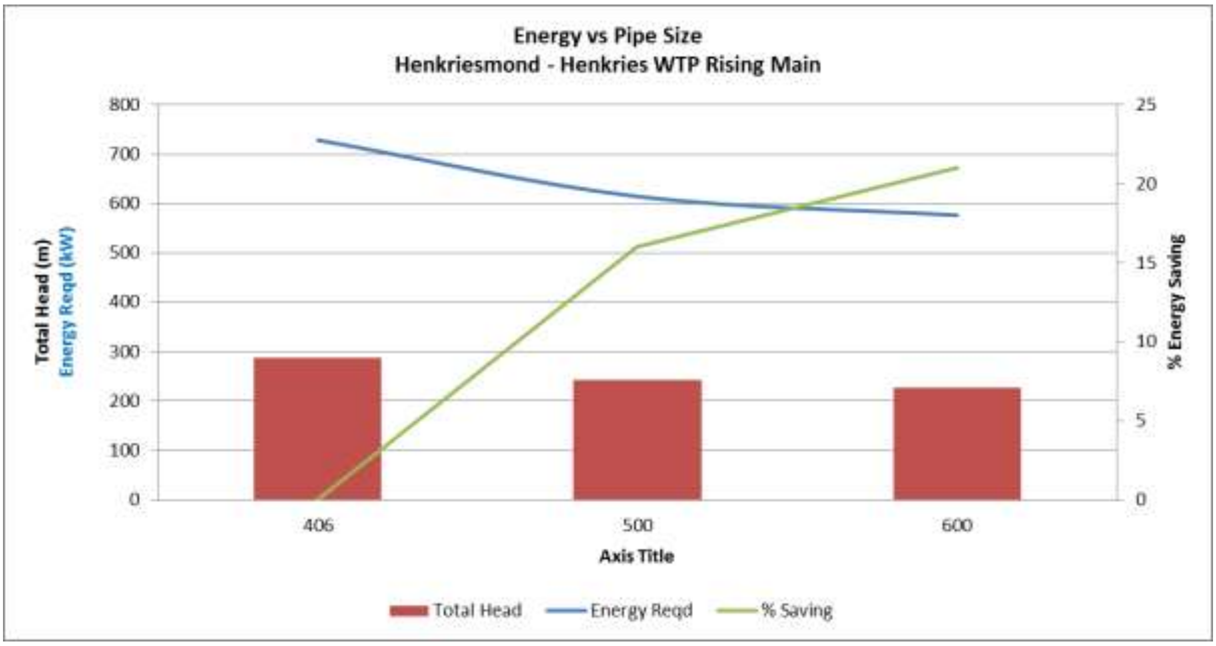
Energy Cost:
The energy costs calculated for this study were calculated using the following assumptions:

- An energy cost of R0.523 per kW.h
- An escalation in energy cost of 25,8% per annum up to 2012 and then a linear increase up to 2021 when ESKOM expects a tariff peaking at R1-21 per kW.h where after increases will be expected to follow the inflation rate.
- An expected efficiency of 85% was assumed given that all switchgear, motors and pumps will be replaced with higher efficiency units than is now the case.
- All calculations were conducted for Total Head which includes static head as well as the friction for the optimally sized pipe diameter.
- It was assumed that systems will be operated for a total of 20 hours per day.

The 3 options investigated returned the following values:

ENERGY COST DESCRIPTION	DESALINATED SEAWATER FROM KLEINZEE (New System)	ORANGE RIVER WATER FROM PELLADRIFT (New system)	ORANGE RIVER WATER FROM HENKRIES (Refurbish existing system)
Electricity	R 24 160 949.00	R 10 915 300.64	R 9 189 791.30

An energy optimization exercise for the pipe diameter of the Henkries option was conducted to determine a pipe size where the energy is most efficiently utilized. As a rule of thumb, it was decided that friction losses should not exceed 10% of the static head. The results of this exercise are displayed in the following series of graphs:

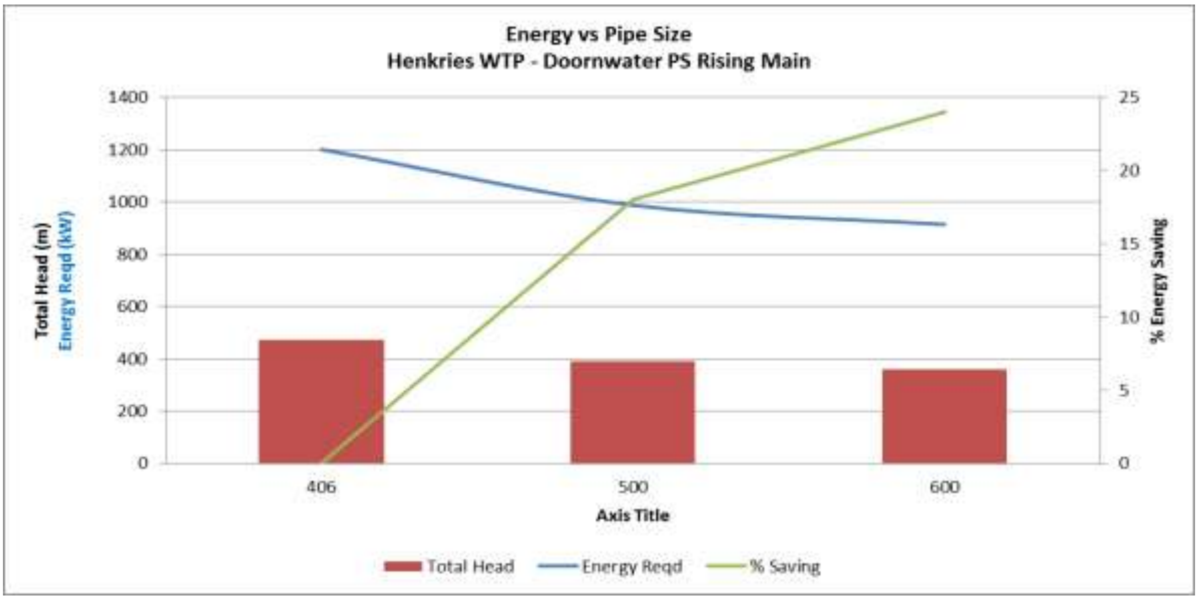


Henkriesmond – Henkries WTP Rising Main

The current pipe is a 406mm diameter pipe. At the new proposed flow of 220 l/s, the flow velocity in this pipe will be 1.70m/s. The static head is 216.1m. With a 406mm diameter pipe, the friction head is 71.5m which equates to a Total Head of 287.6m. The annual energy cost for this pumpstation is then R 2 782 141.46 per annum. By changing this pipe diameter to 600mm, the velocity reduces to 0.78m/s and the total head reduces by 60m which results in an annual energy saving of **R 581 632.36 or 21%.**

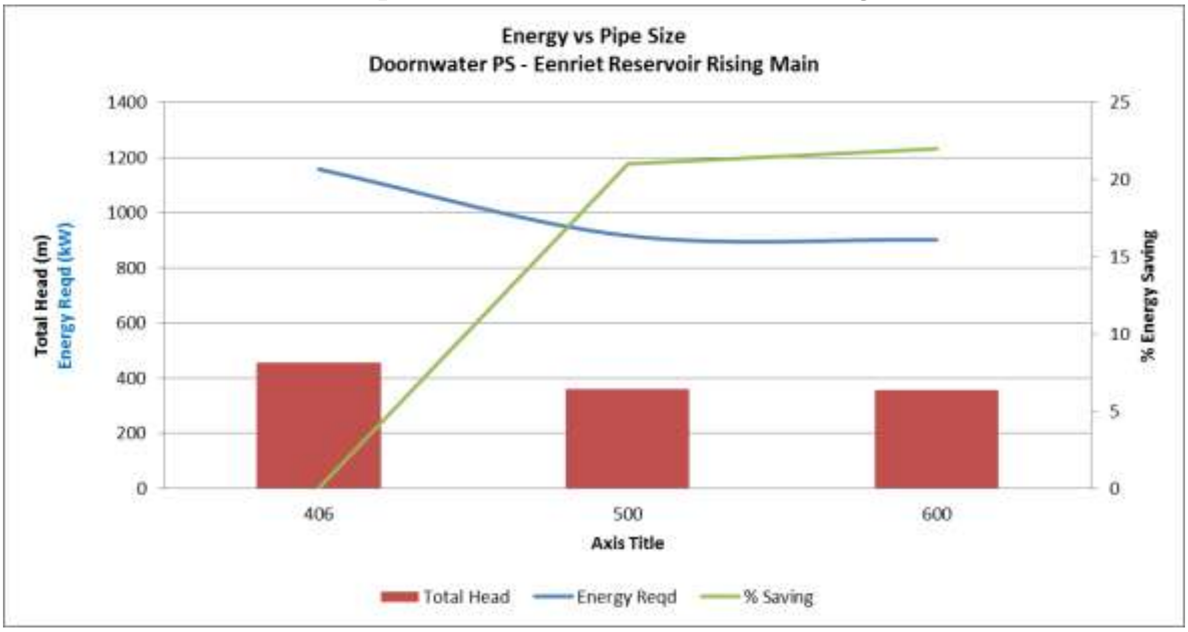
Similar calculations were conducted for the other rising mains with the following results:

Henkries WTP – Doornwater Booster Pump Station Rising Main:



The reduction in total head for this section, when changing the diameter from the current 406mm diameter to a 600mm diameter pipe, equates to 113m and results in a potential saving to the value of **R1 095 407.61 or some 24%.**

Doornwater Booster Pump Station – Eenriet Reservoir Rising Main:

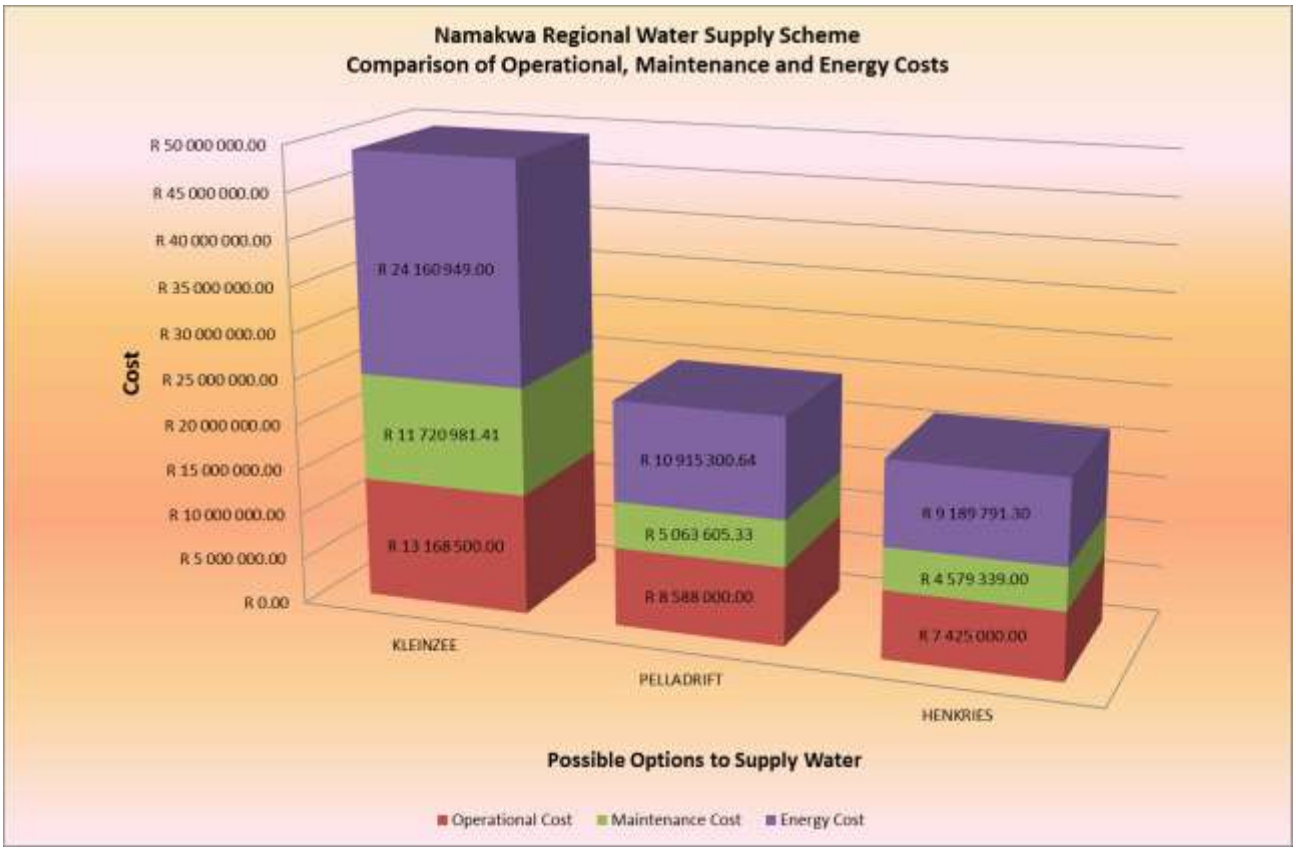


The difference in saving between a 500mm diameter pipe and a 600mm diameter pipe for this section of pipeline is very small due to the shorter length of the pipe. It was therefore decided to use a 500mm diameter pipe for this section as it is significantly cheaper than the larger pipe and realizes almost the same percentage of saving. The reduction in total head for this section equates to 90m and results in a potential saving to the value **of R 920 917.90 or some 21%.**

From the above, the production cost of potable water for each of the options can be calculated as follows:

ENERGY COST DESCRIPTION	DESALINATED SEAWATER FROM KLEINZEE (New System)	ORANGE RIVER WATER FROM PELLADRIFT (New system)	ORANGE RIVER WATER FROM HENKRIES (Refurbish existing system)
Operational Cost	R 13 168 500.00	R 8 588 000.00	R 7 425 000.00
Maintenance Cost	R 11 720 981.41	R 5 063 605.33	R 4 579 339.00
Energy Cost	R 24 160 949.00	R 10 915 300.64	R 9 189 791.30
Total:	R 49 050 430.41	R 24 566 905.97	R 21 194 130.30
Water Volume: (kl/annum)	5 781 600	5 781 600	5 781 600
Cost per kiloliter(excl capital):	**R 8.48**	**R 4.25**	**R 3.67**

When this is presented graphically on a 100% percentage graph, it is clear that the refurbished Henkries option remains the most beneficial solution.



11.3 Life Cycle Cost Analysis:

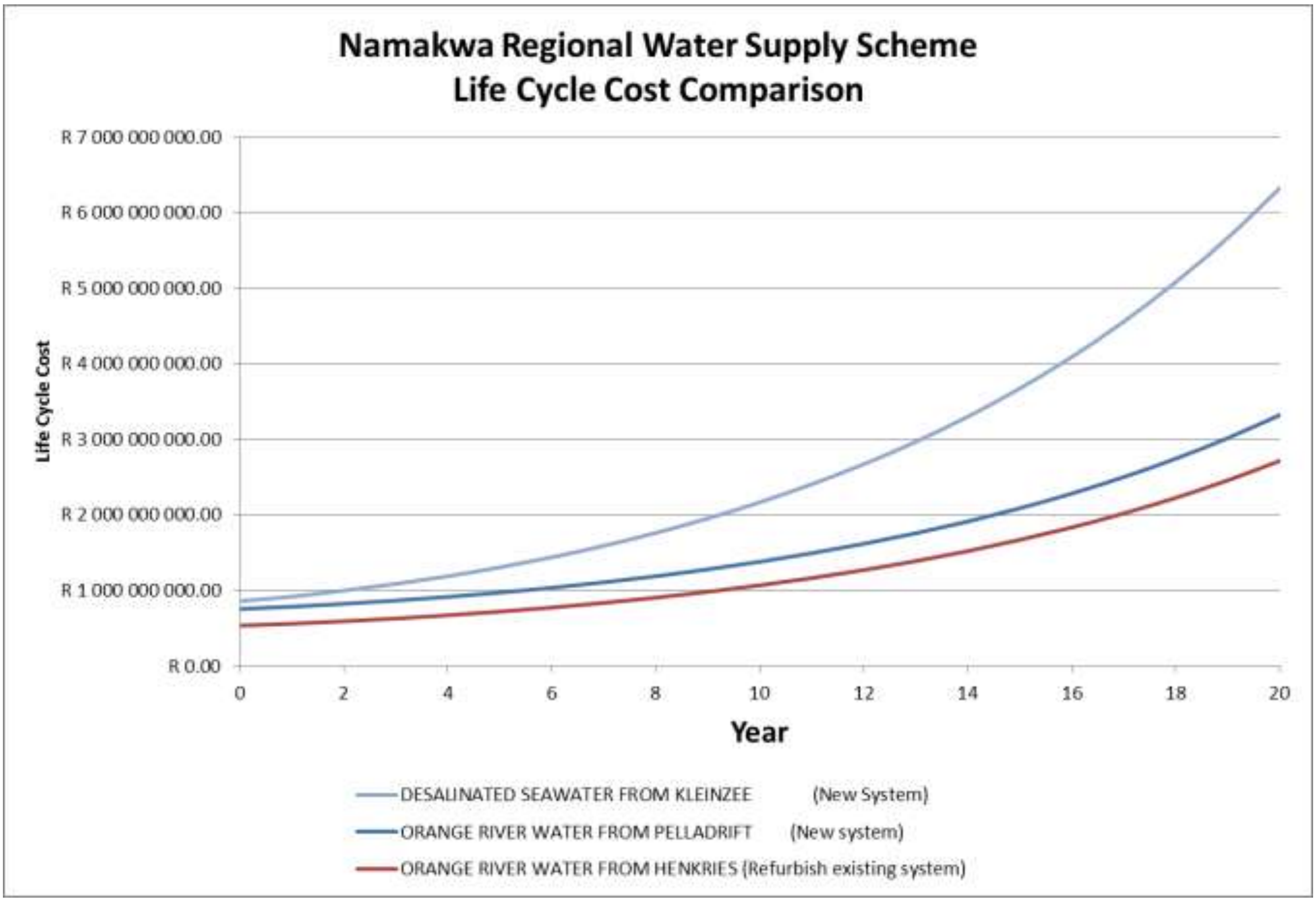
The Life Cycle Cost of a project is defined as :

"***The sum of all recurring and one-time (non-recurring) costs over the full life span or a specified period of a system. It includes purchase price, installation cost, operating costs, maintenance and upgrade costs, and remaining (residual or salvage) value at the end of ownership or its useful life***."

This analysis was conducted for this proposed project on all 3 options. The following assumptions were used during calculation:

Inflation Rate:	6%
Return period:	20 years
Escalation rate for O&M:	6%
Escalation rate for electricity:	As per ESKOM projection

The analysis returned the following result:



From this analysis it is clear that the refurbishment of the existing Henkries option to supply water to the greater Springbok area is the most beneficial in the long term. The reason for this being primarily the lower capital cost and the more efficient use of energy.

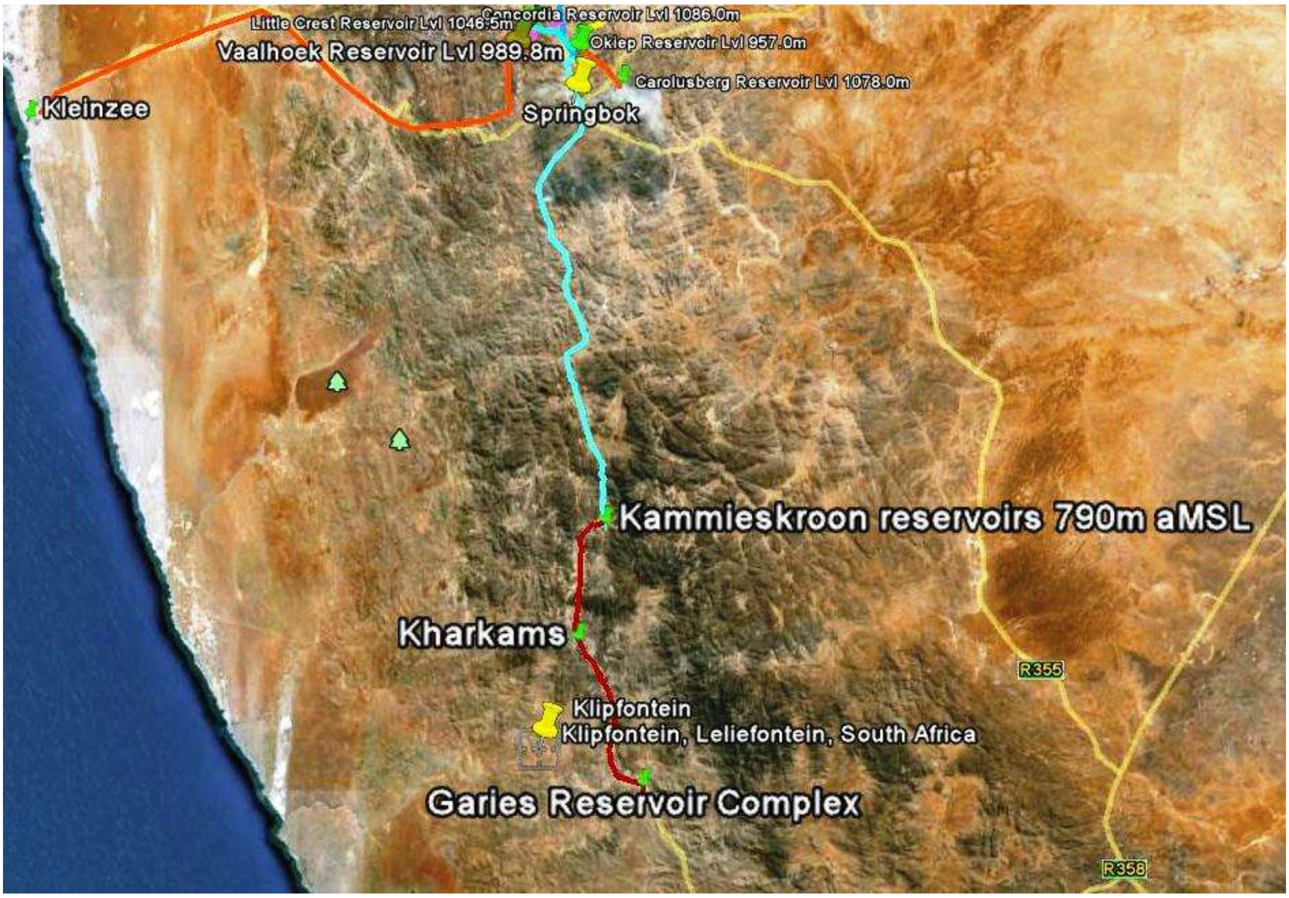
Based on the above calculations and financial analysis of the various options considered, it is recommended that the existing system, pumping water from the Orange River at Henkries be retained and refurbished as proposed.

11.4 Possible Expansions:

As an additional means of making the scheme as a whole more sustainable, the customer base or supply area could be expanded.

Southern Expansion:

The system could be expanded to the south to supply water to the towns of Kharkams(1700 pax), Kammieskroon(949 pax), Klipfontein(560 pax) and Garies(1 250). The demand for these 4 villages equates to an additional 10 liters per second which could easily be supplied from the proposed upgraded system. To make this possible, it will entail the construction of a new gravity main of 124km in length with offtakes to each of the above towns/villages' reservoirs. The first section from Vaalhoek to Kammieskroon would be a 250mm diameter pipe some 77km in length with two pressure control valves required.



The second section, from Kammieskroon to Garies is required to convey 7.5 liters per second. This section will comprise a 200mm diameter pipeline some 47km in length with off takes at Kharkams, Klipfontein and Garies.

This extension will cost an additional **R 142 358 076-29** over and above the suggested upgrades to the main system.

Western Expansion:
There is also a possibility of extending the scheme further west by supplying Port Nolloth(5172 pax) and McDougals Bay(1408 pax) from an offtake at Steinkopf. Such an extension will require a 250mm pipeline some 80km in length as well as 3 balancing reservoirs and could be done at an estimated cost of **an additional R55 million** over and above the proposed upgrades to the existing system. The biggest problem being the excessive pressures encountered below the escarpment where the coastal plain starts. This option requires some 550 000m^3 per annum or 20 liters per second. The proposed expansion as described in this document will be able to provide this quantity without problems.

The expansion above will therefore require an additional capital cost of **R197 358 075-29** to expand the customer base by some 11 039 persons who will buy an additional volume of **608 414m^3 per annum** at a rate of R3.67 / m^3, which will provide an annual income of another **R2 232 879.38** per year. The greatest advantage of this extension being that there is no additional energy required to supply water to these areas as they are all able to be supplied by gravity.

The only problem being to find the additional capital required to pay for the extensions. The extensions to Garies and Port Nolloth will not be economical if the capital is to be included in the price of the water, but if the additional capital is provided as a grant, the additional income provided by the extended system can help to pay for the energy costs on the existing system.

11.5. Product Quality

Raw water from the Orange River is currently still of a fairly good quality, although this is declining from year to year. As the water to be abstracted is in the Lower Orange River, all upstream pollution will impact on the quality of the raw water. It is especially the increase in salinity due to large areas of irrigation upstream and the increasing occurrence of algae outbreaks that poses a severe threat to the water quality.

The Henkries Water Treatment Plant is able to treat the raw Orange River Water to SANS 241 Class 0 or Class I standard quite easily. It is envisaged that with the dosing of a suitable single polyelectrolyte and disinfection with chlorine, the water could be treated to the required standard. An additional treatment with lime stabilization will provide a positive precipitation potential and help to avoid corrosion of the pipelines when the alkalinity balance is occasionally upset.

11.6. Socio-Economic Benefits

Water is the primary driver behind quality of life as well as all economic activity. The primary beneficiaries of an improved supply of water and water quality are the indigent community. Villages such as Concordia, Carolusberg, Nababeep, Okiep and to a lesser extent Springbok, are mainly inhabited by indigent persons. Improved supply of water is crucial to any production process as well as public health. Improved public health leads to increased worker productivity and benefits the regional economy in general.

The entire Namakwaland is a major tourist hub in the Northern Cape. During the past flower season, many guesthouses and other tourism driven institutions were very badly affected by the continuous water shortages every time the existing system fails. Failure of the water supply system also has a severe cost impact on local industries as well as the risk that public health can be severely affected. All these factors impact on the economy of an already strained region.

The implementation of this project, due to it's scope and character, will be conducted over several financial years and will create job opportunities for many people during the construction phase.

Without a sufficient and sustainable supply of good quality water, the future of this region is doomed. It is therefore of utmost importance that the people of the Namakwa region's constitutional right to water be brought to fruition as soon as is practically possible.

SECTION 5: PROJECT SOLUTION SELECTED AND IMPLEMENTATION PLAN

12. PIPE LINE FROM THE ORANGE RIVER : TECHNICAL DETAILS

12.1. Scope of the Works

In order for this project to be implemented, the following projects need to be initiated:

Project 1
New Rising Main from Rooiwinkel to Nababeep
Upgrading of the Raw Water Pump Station
Estimated Cost: ***R 16 006 10-50***

Project 2
Replace Clear Water Gravity Main from Eenriet Reservoir to Vaalhoek Reservoir with a new 500mm diameter pipeline.
Estimated Cost: ***R 101 462 276-50***

Project 3
Upgrade Henkriesmond Pre-sedimentation facility and pump station.
Replace Rising Main from Henkriesmond to Henkries WTP with a 600mm diameter pipeline
Refurbish and upgrade Henkries Water Treatment Plant
Refurbish Clear Water Pump Station at Henkries WTP
Replace Rising Main from Henkries WTP to Doornwater Pump Station with a new 600mm diameter pipe.
Estimated Cost: ***R 118 093 681-69***

Project 4
Refurbish Doornwater Booster Pump Station
Replace Rising Main from Doornwater Pump Station to Eenriet Reservoir with a new 500mm diameter pipeline.
Refurbish Eenriet Reservoir
Refurbish Vaalhoek Reservoir
Replace Gravity Main from Vaalhoek Reservoir to Springbok
Install new Telemetry system for complete scheme
Estimated Cost: ***R52 685 014-15***

Project 5
Refurbishment of the Okiep Pump Station Complex
Replace the Clear Water Rising Main to Concordia
Replace the Clear Water Rising Main to Carolusberg
Refurbish Concordia Reservoir
Refurbish Carolusberg Reservoir
Estimated Cost: ***R14 677 983-89***

The estimates above exclude 14% VAT and professional fees.

12.2. Survey and Investigation

It is proposed that a complete survey be conducted of all the pipe line routes as soon as possible. This is required to verify existing information as well as to obtain accurate ground levels and levels of existing infrastructure.

In addition, it is recommended that a detailed soil resistivity survey be conducted to ascertain the corrosion potential of the soil for the full length of all pipelines. This will enable the engineer to take an informed decision with regards to the external corrosion protection required for the proposed pipelines.

It is also recommended that a full geotechnical investigation be conducted over all pipe line routes to determine the soil formation to be expected. The approach to the replacement of these pipelines will be dictated by this survey. If a new trench is to be excavated, it will need to be conducted in such a manner that the existing pipeline must remain operational throughout construction. Alternately, a bypass pipe could be lay above ground from air-valve chamber to air-valve chamber to ensure continued supply of water whilst the existing pipe is excavated and removed from the existing trench.

12.3. Environmental Issues

This project is due for a full environmental impact assessment. The project is located in Namakwaland which is an ecologically sensitive biome and will require extreme care and strict control over activities during construction. In addition, the area to be disturbed, the diameter of the proposed pipes and the volume of water to be conveyed dictate that an assessment be done in any case.

A suitably experienced environmental consultant should be appointed for this with extreme urgency, as the obtaining of the Record of Decision to commence with construction will take anything between 9 months to a year to be obtained.

12.4. Water Use Licensing

The existing water allocation for the Namakwa Regional Water Supply scheme will need to be increased by at least 2 million cubic meters per annum. For this to happen, a new Water Use License application will need to be submitted to the Department of Water Affairs as soon as possible. Approval of such applications can take anything from 2 to 3 years after submission.

12.5. Way leaves and Consent Applications

The proposed construction works will impact on the N7 national road between Springbok and the Namibian border at Vioolsdrift. Any activities taking place within 60m on either side of the road centerline are subject to an approved way leave from SANRAL. It is suggested that this process begin immediately by scheduling a meeting with the SANRAL

Regional Manager in Cape Town to inform him of the pending works and to clarify any concerns that they may have.

In addition to the above, both ESKOM and TELKOM will need to be approached for way leaves as the pipe route crosses their services occasionally.

12.6. Proposed Project Schedule

It is envisaged that this project will take between 4 and 5 years to complete as an absolute minimum. Given that the environmental process needs to be completed before any construction can commence, it is doubtful whether any major construction will take place before late in 2012.

A major restriction on any scheduling is the availability of funding for this project. The current approved funding on the 3 year MTEF is as follows:

2010/11	R 17 000 000-00
2011/12	R 41 000 000-00
2012/13	R103 000 000-00
TOTAL:	R161 000 000-00

The required funding is proposed to be as follows:

Year 1	R 25 000 000-00
Year 2	R172 000 000-00
Year 3	R200 000 000-00
Year 4	R112 000 000-00
Year 5	R 25 000 000-00
TOTAL:	R534 000 000-00

Once the funding schedule has been finalized, or at least a commitment has been received to this effect, the works can be more accurately scheduled.

12.7. Risk Review

There are basically two primary risks associated with this project.

- Lack of funding
- Failure of the water supply to the Springbok area

A lack or delay in funding will severely increase the pressure on the water board to deliver water to its supply area sustainably. In addition, every year that passes increases the probability as well as the frequency that a pipe failure will occur with resultant water shortages in the various towns. The proposed replacement of the 5km section where 80% of the failures occur will be a stopgap measure at best as the pipe will just fail at the next weakest point.

It is therefore imperative that sufficient funding be found to finance the construction of this project. The possibility of finding supplemental funding from the private sector must be pursued with similar urgency by all parties involved. The fact that this project cannot supply water sustainably if the funds are to be borrowed makes this an enormous challenge for both government as well as the private sector companies involved.

13. IMPLEMENTATION READINESS STUDY

This section of the study strives to prove that the project is ready for implementation and that all criteria required by the rules of the Regional Bulk Infrastructure Grant program have been examined and attended to.

13.1. Strategic and Planning Issues

This project is slightly different from the norm seeing that the project is being implemented by the Sedibeng Water Board and not the Namakhoi Municipality. The Namakhoi Municipality are however the Water Services Authority in the supply area of this project and have therefore taken it up in both their Integrated Development Plan as well as in their Water Services Development Plan as a major priority.

This project is also aligned with the Northern Cape Provincial Growth & Development Strategy policy document which has been set up until 2014. Especially the three primary sectors of Tourism, Agriculture and Mining are applicable for this project.

The Namakhoi Municipality currently has in excess of 75% of its households fitted with household water connections and roughly 73% of the households have a full waterborne sanitation services. It is only the much smaller villages in the area that still rely on single boreholes for water supply and have dry sanitation systems or septic tank systems installed.

This project is of extreme strategic importance to the supply area. Studies have proven that this project provides the only sustainable source of water for the whole area. Without water, life is not possible and the chances of economic development less than zero. Springbok, the major town in the area is a major service center for tourism as well as the mining and agricultural industries. Without sufficient water, the town will cease to exist.

The implementation of this project will increase the level of service in all the towns involved and could stimulate economic growth. The last 10 years, the supply of water has severely hampered especially the tourism industry due to guesthouses and accommodation facilities being without water and having to decline proposed bookings from tourists.

The cost of refurbishing the existing Namakwaland Regional Water Supply Scheme is high. Higher than the communities in the supply area could ever hope to afford. The majority of the people in the supply area battle to make their daily existence and will **not** be able to make a contribution towards the capital required for the project.

The study has indicated that if the technical proposals made are implemented, there is a good possibility that water could be delivered cheaper than what is currently the case due to major electricity savings by improved efficiency.

The Namakhoi Municipality is **not** able to provide any counter funding for capital expenditure on this project. Sedibeng Water, who have taken over the scheme since July 2011, are a water board who do not operate on a profit generating basis, but merely cover their operational and maintenance expenses. Subsequently, there is no counter funding available for this project from the current institutions involved.

13.2. Social Criteria

The Namakhoi Municipality has a total population of 54 644 persons residing in some 15 707 households (Community Survey 2007). The full municipal area is however not served by this project.

The following population figures for the supply area are applicable:

Town / Village	Population 2009	Households 2009
Springbok	10 298	2 315
Nababeep	6 056	1 460
Okiep	5 246	1 306
Concordia	6 946	1 798
Carolusberg	959	275
Steinkopf	8 439	2 143
Bulletrap	1 130	308
Kleinzee	3 304	1 891
TOTAL	**42 378**	**11 496**

Of the above some 68% of the population or 29 000 people are classified as being indigent in that they earn less than R1 040-00 per month or are totally dependant on government grants for their subsistence. Therefore, some 7 800 households will be benefitting directly from this project in the sense that they will be receiving Free Basic Water from this project.

In addition to the above, it is envisaged that at least 100 temporary jobs will be created during the construction of the first phase of this project. The duration of the first phase is expected to be between 12 and 14 months.

The distances and elevations over which this water needs to be conveyed from the source to the supply area lend it to higher than normal water tariffs. This fact makes the affordability of water, especially for the poorer people, problematic. The current tariff of R9-14 per kiloliter is high, but necessary to ensure that the water board is able to conduct the required maintenance to ensure continued supply. The implementation of the new project must have an impact on this tariff within the next 3 to 5 years to improve its affordability.

The project will have a major impact on public health improvement as water shortages, as experienced the past 10 years, impact negatively on water borne sanitation systems.

There are also several schools and old age homes that will benefit from this project for similar reasons. The major schools affected are:

No.	School Name	Location

	Primary Schools	
1	BUFFELSRIVIER VGK PRIMÊRE SKOOL	SPRINGBOK
2	BULLETRAP VGK PRIMÊR	SPRINGBOK
3	CAROLUSBERG PRIMÊRE SKOOL	SPRINGBOK
4	CONCORDIA PRIMÊRE SKOOL	SPRINGBOK
5	DE HOOP PRIMÊRE SKOOL	SPRINGBOK
6	DR. IZAK VAN NIEKERK PRIMÊRE SKOOL	SPRINGBOK
7	FERDINAND BRECHER PRIMÊRE SKOOL	STEINKOPF
8	GOODHOUSE NGK PRIMÊRE SKOOL	SPRINGBOK
9	HENKRIES (NGK) PRIMÊRE SKOOL	STEINKOPF
10	HOLY ROSARY RK PRIMÊRE SKOOL	OKIEP
11	J.J. LAMBERT PRIMÊRE SKOOL	SPRINGBOK
12	LAERSKOOL KLEINZEE	KLEINZEE
13	MATJIESKLOOF RK PRIMÊRE SKOOL	SPRINGBOK
14	ROOIWAL (VGK) PRIMÊRE SKOOL	STEINKOPF
15	SACRED HEART (RK) PRIMÊRE SKOOL	NABABEEP
16	SPRINGBOK PRIMÊRE SKOOL	SPRINGBOK
17	ST. CYPRIANS PRIMÊRE SKOOL	NABABEEP
18	VIOOLSDRIF N.G.K. PRIMÊRE SKOOL	STEINKOPF
19		
	Secondary Schools	
1	CONCORDIA SEKONDÊRE SKOOL	CONCORDIA
2	HOËRSKOOL NABABEEP	NABABEEP
3	HOËRSKOOL NAMAKWALAND	SPRINGBOK
4	KHARKHAMS SEKONDÊRE SKOOL	SPRINGBOK
5	OKIEP HIGH/HOËR SKOOL	OKIEP
6	S.A. VAN WYK SEKONDÊRE SKOOL	SPRINGBOK
7	ST. ANNA SEKONDÊRE PRIVAATSKOOL	SPRINGBOK
8	STEINKOPF SEKONDÊRE SKOOL	STEINKOPF

In addition to the schools, there are some 22 community health clinics that will benefit from this project by receiving a constant supply of treated potable water.

In terms of socio-political support, all the community's affected by water shortages the past years are fully supporting this project. This includes the councilors and community leaders of both the Namakhoi Local Municipality and the Namakwa District Municipality.

13.3.Economic Criteria

13.4. Technical Criteria
13.5. Institutional Criteria
13.6. Financial Criteria
13.7. Legal Criteria
13.8. Sustainability Criteria
13.9. Overview

13. ANNEXURES

ANNEXURE A
Locality Map of proposed project

ANNEXURE B
Groundwater Study Report

ANNEXURE C
Schematic of existing water supply system

ANNEXURE D
Option 1: Desalination of seawater at Kleinzee

ANNEXURE E
Option 2: Pipeline from the Orange River at Pelladrift

ANNEXURE F
Option 3: Upgrade and refurbish of Henkries Pipeline

REFERENCES