PRINCE ALBERT MUNICIPALITY

TECHNICAL REPORT FOR THE UPGRADE OF THE KLAARSTROOM OXIDATION POND WASTEWATER TREATMENT SYSTEM (REVISION 2)

SUBMITTED BY :

Physical Address:	55 Bult Street UPINGTON 8800
Postal Address:	P O Box 1155 UPINGTON, 8800
Tel Number:	+27 54 337 6600
Fax Number:	+27 54 337 6699
E-mail:	gertm@bvinc.co.za
Enquiry:	G.H. Meiring

30 September 2018

Contents

TABLE OF FIGURES

LIST OF ANNEXURES

TECHNICAL REPORT FOR THE UPGRADE OF THE KLAARSTROOM OXIDATION POND WASTEWATER TREATMENT SYSTEM

1. BACKGROUND

The village of Klaarstroom is located adjacent to the N12 National Road between Beaufort West and De Rust at the northern end of Meiringspoort, about 60 km east of Prince Albert and 95 km north-west of Uniondale.

Figure 1: Locality Map of the Prince Albert Municipality

Klaarstroom resorts under the Prince Albert Local Municipality and has a population of approximately 600 persons. The village is located south of the N12 National Road and the existing wastewater treatment plant is located north of the N12. All wastewater from the village is pumped to the wastewater treatment plant.

2. EXISTING INFRASTRUCTURE

The village of Klaarstroom is fairly well serviced in terms of water, sewage, electricity and roads. The wastewater is collected at a central pump station in the village and then pumped through a 100mm diameter rising main over a distance of 800m to the wastewater treatment plant.

Figure 2: Existing Wastewater Pump Station and inlet to Anaerobic Pond

The existing wastewater treatment plant comprises only two ponds. The first pond is an anaerobic pond followed by a single facultative pond from where the final effluent is discharged into two 5000 liter tanks where the water is chlorinated.

A small pump abstracts the water from the tanks and then feeds a small sprinkler system (2 x sprinklers) located north of the existing plant where it is irrigated onto the veld. The design capacity of the pond system is given as 50m^3/day and it was constructed in 1970. Records indicate a measured daily flow with peaks of up to 80 m^3/day which is approximately 60% higher than the current design capacity.

The current disposal of effluent takes place by sprinkling the treated effluent in the veld from where it could eventually end up in the Groot River south of Klaarstroom. The existing wastewater treatment plant is located on the lower slopes of the Swartberg Mountains at the Great Karoo entrance to Meiringspoort. The current site has a medium to sharp slope in a southerly direction towards the N12 National Road. This is considered a good site for the wastewater works as well as its proposed extensions, as the natural slope assists in allowing gravity flow through the system and also decreases the volumes of earthworks required for construction of the pond embankments.

The existing septic tank has not been in use for many years and is structurally beyond repair. The current rising mains appear to be in reasonable condition with isolating valves in place to control the outlet flow.

Wes-Kaap Laboratorium dienste
Western Cape Laboratory Services
Market Mall No 5 . George
Sel: 071 688 4774
: jowater@jdsarc.co.za

ANALYSIS CERTIFICATE

Client	Prince Albert Municipality
Client Adress	Privatebag X 53 Prince Albert
Contact Person	J.Lech
Date of Sampling	11-Aug-15
Received at Lab	12-Aug-15
Date of Certificate	20-Aug-15
Tipe Sample	Waste water
Sample point	PRINCE ALBERT, KLAARSTROOM & LEEU GAMKA WASTE WATER

accredate	Quality parameters	Test Method	WCPALG-009 Leeu Gamka		WCPAKS-009 Klaarstroom		WCPAPA-015 Prince Albert		STANDARDS			
			Rou Inkomend	Uitvloei	Rou Inkomend	Uitvloei	Rou Inkomend	Uitvloei	To 50 m³/dag	50-500 m³/dag	Special Standaard	General standaard
SM	Ammonia (N)	HACH Method 10031 NH3 – N Salicylate method	280	130	220	130	180	190	N.S	N.S	2	6.0
SM	COD (CSB) (mg/l)	HACH Method 8000 Reactor Digestion Method	695	315	505	225	545	550	<5000	<400	30	75
SM	Conductivity(mS/m)	WTW LF330 Direct measurement	265	194	129	186	98	100	<200	<200	100	150
SM	Nitrate (N)	8171NO3 – N Cadmium Reduction Method							N.S	N.S	1.5	15.00
SM	Nitrite (N)	HACH Method 8507NO2 – N Diazotization Method		0.11		0.29		0.09	N.S	N.S	1.5	15.00
SM	Ortho-phosfate (P)	HACH Method 8114 PO4³ Molybdovanadate Method		21		23		100.5	N.S	N.S	N.S	10.00
SM	pH	HANNA HI8424 Direct measurement	8.38	7.73	7.68	8.47	7.4	7.7	N.S	6.0-9.0	5.5 - 7.5	5.5 - 9.5
SM	Suspended Solids (mg/l)	HACH Method 8158 Gravimetric Method		186		148		88	N.S	N.S	10	25
	Feacal Coliforms (per 100ml)	Membrane Filtration		4300		7600		150	100 000/100 mL	100 000/100 mL	0	1000/100 mL

Comments

LEEU GAMKA:

Effluent comply with irrigation standard

KLAARSTROOM:

Effluent comply with irrigation standard

PRINCE ALBERT :

Effluent comply with irrigation standard

This report relates only to received samples. No responsibility can be accepted for the use of results.

Methods	Parameters preceded with SM are adapted from the standard methods
Instrument Calibration	Instrument calibration are done daily with appropriate standards

Bacteriological	Outeniqua Laboratory services	NLA Lab code yj4pk.	Z Scores	Heterotrophic Plate Count *cfu/ml*		Sep-14	0.14
				Total Coliform Count *cfu/100ml*		Sep-14	0.2
				Faecal Coliform Count *cfu/100ml*		Sep-14	-0.02
				Escherichia coli Count *cfu/100ml*		Sep-14	-0.08
Chemical analysis	Western Cape Laboratory Services	SABS Lab. Code B 211	Z Scores	Group 1	Heavy metals	Jan 14	0.85
				Group 2	Nutrients	May. 14	1.44
				Group 3	Major constituents	Jun-14	0.84

Authorized by: Johan Jacobs Laboratory Manager
Western Cape Labpratory Sevices

Figure 3: Analysis of Klaarstroom WWTP Treated Effluent

An analysis of the treated effluent dated August 2015 indicates that the current effluent is basically non-compliant with all the important parameters. The Total Suspended Solids on the final effluent is very high at 88mg/l and far exceeds the allowable minimum of 25mg/l. Similarly, the COD and Ammonia levels are much higher than the allowable limits. It is therefore clear that the Klaarstroom WWTP is both hydraulically (flow) overloaded, as well as organically (chemical load) overloaded.

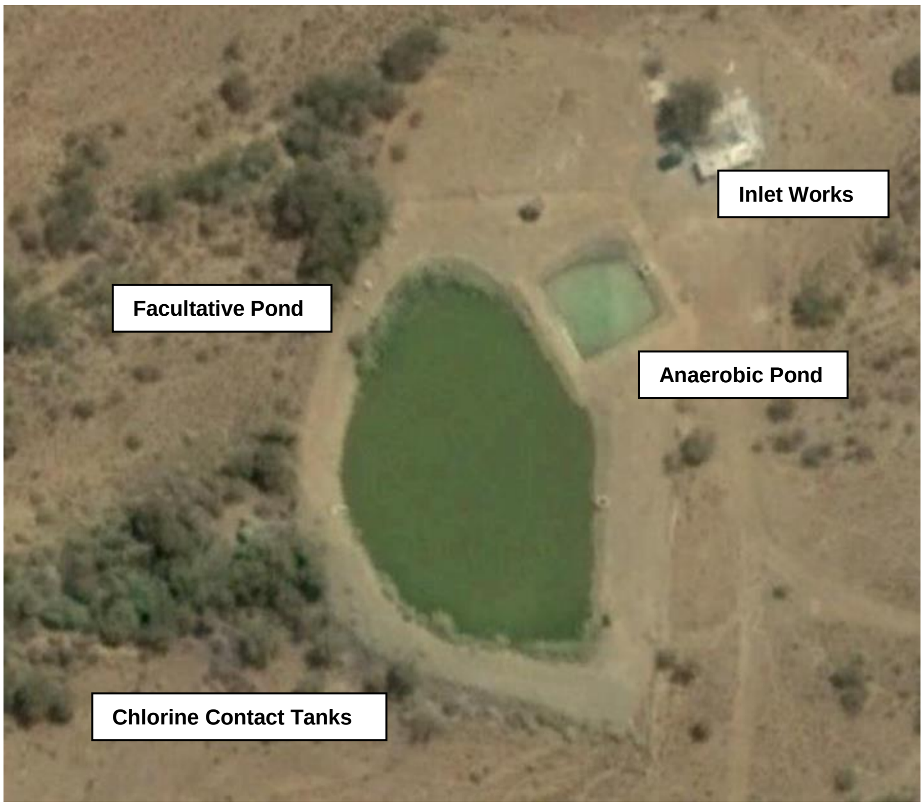


Figure 4: Existing Klaarstroom Oxidation Pond System

3. PROPOSED IMPROVEMENTS TO THE OXIDATION POND SYSTEM

BVi Consulting Engineers' brief was to provide a proposal for the upgrade of the oxidation pond system to increase the capacity and improve the quality of the Final Effluent.

Given the population of approximately 600 persons living in the village, a theoretical calculation was conducted to determine the approximate daily flow expected at the treatment plant. This takes into account a population growth of 0.5% per annum over a period of 20 years.

A flow was calculated using a per capita run-off of 100 liters per person per day, a peak factor of 1.8 and the possibility of 15% storm water infiltration. This calculation returned an Average Dry Weather flow of **61m^3/day or 0.71 l/s**. The Peak Wet Weather Flow was calculated to be **127m^3/day or 1.47 l/s**.

Figure 5: Chlorine contact tanks for treated effluent

Figure 6: Existing Septic Tank structurally very unsound; not used

3.1. PROPOSED SCOPE OF WORKS FOR UPGRADE

Typically, when a treatment plant is designed, the inlet works is designed to accommodate the peak flow and the remainder of the plant process units is designed for the Average Dry Weather Flow.

Given the existing layout of the plant and the analysis results of the Final Effluent received, , it is proposed that the existing plant be converted to a system comprising conventional oxidation ponds with a single horizontal flow reedbed in series, followed by a storage pond.

The following components are proposed:

1. Construct a new Inlet Works to provide for screening, dual grit removal channels and flow measurement.

2. The existing old septic tank (approximately 23 m^3) has a retention period of less than 24 hours. In addition, it is in a very poor structural condition and no longer in use. It is therefore suggested that both this tank be omitted from the process and demolished upon completion of the new works.

3. As the depth of the current single anaerobic pond is unknown, and the volume thereof probably completely filled with sludge, it is suggested that two new anaerobic ponds are constructed. The

anaerobic ponds are suggested to have a combined retention period of 24 hours. This should be sufficient to break down the organic fraction (COD) of the wastewater by at least 50%. Dimensions of 5.5m x 5.5m x 3.5m depth are suggested for each pond. The incoming wastewater is to enter the dual ponds at floor level and are to be operated in parallel. Only the primary ponds are to be lined with an HDPE Lining to prevent seepage of raw sewage into the water table below.

4. The existing facultative pond (large pond) is to be refurbished and reshaped to encourage plug flow to have final dimensions of 58m x 30m x 1.20m deep. The area is approximately the same as what the existing pond is at the moment. A total retention period of 25 days is provided for. The provision of oxygen by means of algal photosynthesis and wind action allows the ammonia to be nitrified and converted to nitrates and nitrites in this pond.

5. The existing anaerobic pond is to be modified and reshaped to create a new secondary aerobic pond with dimensions of 38m x 15m x 1.00m deep.

6. Construction of a 2nd secondary aerobic pond of 38m x 15m x 1.00m deep. Each of the secondary ponds to provide a retention period of 5.5 days or a total of 11 days.

7. Construction of a single Horizontal Flow Reed Bed with dimensions of 60m x 20m x 0.60m deep for polishing of the final effluent and to facilitate denitrification. Denitrification is achieved by allowing the nitrate/nitrite rich water from the ponds to flow through the reedbed where anoxic conditions exist. In addition, the reeds will also take up a percentage of the nitrates/nitrites as nutrition for plant growth. The reedbed will need to be lined with an HDPE membrane to contain the growth of the plants.
8. Construct a Storage Pond with capacity to store at least 7 days of flow. Typical dimensions will be 40m x 20m x 1.50m deep.

9. The water from the last pond can then be utilized for irrigation of parks and sports fields. At Klaarstroom, this will be possible to do using a gravity system as the wastewater treatment plant is located at a higher elevation than the village. It is proposed to construct a 160mm dia uPVC pipeline of 300m in length which would terminate in a 6m dia x 1.8m high lined galvanized dam at the sports fields.

10. A small pump station will be provided at the dam to provide a flow of 4.5 l/s at a head of 3.5 bar feeding a Rotrix crawling irrigator which will be used to irrigate the sports field. The pump station required may be solar powered should mains electricity not be available.

11. A chip doser for the dosing of a calcium hypochlorite solution into the circular dam will be provided to disinfect the final effluent prior to irrigation to avoid any pathogens from remaining in the irrigation water. This is a precaution to prevent infection during sports injuries.

The above proposed configuration will have a total retention period of approximately 45 days at Peak Dry Weather Flow which is the accepted norm for oxidation pond systems. If retention periods are shorter than this, the natural bacterial die-off will be insufficient and very high bacterial counts will occur such as the case is currently.

3.2. Process Description of Oxidation Pond systems

A pond system processes wastewater in shallow earth basins, referred to as stabilization or oxidation ponds. Pond systems are very popular in small communities due to low construction and operating costs. In rural areas, where large areas of relatively cheap land are available and towns and villages are quite small, this is often the preferred system. Oxidation Ponds are a natural treatment system which means that the wastewater is treated under naturally occurring conditions and that the process cannot be manipulated by external means.

3.2.1. Classification of ponds

Ponds are classified according to the nature of the biological process taking place:

- Aerobic – stabilization in the presence of oxygen
- Anaerobic – stabilization without the presence of oxygen
- Aerobic-**anaerobic**, or facultative ponds

Ponds can be used singly or in various combinations to treat wastewater. Experience has shown that a combination of various types of ponds in series is best for the treatment of domestic wastewater.

Anaerobic ponds are especially effective in bringing about rapid stabilization of waste that is high in organic content, while aerobic ponds are more suited to stabilising the soluble organic component. Anaerobic ponds are usually used in series with the other types, enabling almost complete stabilization of the effluent.

3.2.2. Limitations of Oxidation Pond Systems

Compared to conventional treatment plants, ponds produce **a stable effluent** that does <u>**not always comply with the General Limit Values**</u> as required by law, due to the excessive amount of suspended solids in the final effluent. These suspended solids are primarily due to the nature of oxidation ponds which utilize algae to provide the oxygen required in the process.

3.2.3. What does the Algae do?

Algae are essentially plants that utilize carbon dioxide, nutrients in the waste water and sunlight to produce sugars and oxygen through photosynthesis. The problem with algae is that they have a neutral density. This means that both live and dead algae do not settle to the floor of the pond, nor does it float to the surface, it basically remains in suspension in a uniform concentration through the water profile in the ponds.

3.2.4. Problem with Total Suspended Solids in Oxidation Pond effluent

Although the algae is essential for the production of dissolved oxygen to nitrify ammonia and break down the organic fraction, they do however create a problem with suspended solids in the final effluent. The General Limit Value for Total Suspended Solids in Final Treated Effluent is 25mg/l. Typically **oxidation pond effluent will not comply to this requirement**. Hence the requirement for further treatment by passing the effluent through a horizontal reedbed process unit to ensure compliance.

3.2.5. Temperature dependence of bacterial and algal metabolism

Oxidation Ponds typically have a retention period varying between 40 to 50 days in order to provide sufficient time for natural bacteria to oxidise and stabilize the pollutants in the water. Typically, the metabolism of the active bacteria and algae are temperature dependent. Subsequently, the lowest average ambient temperature dictates the size of ponds and by implication, the retention time needed to fully treat the wastewater. Oxidation Ponds are therefore less active during periods of low temperature, and more active during periods of warm temperature.

3.3. Reed Bed Treatment Unit

3.3.1. Process Description of a Reedbed Treatment Unit

The combination of oxidation ponds and reed beds in series has been used very successfully by the South African National Parks in the Kruger National Park where the use of natural systems is encouraged. Due to the nature of these two systems, they serve to compliment each other, with the reedbeds correcting the inadequacies of the oxidation pond systems.

Reed beds or constructed wetlands are large areas of land inundated with water typically not deeper than 600 mm, that support the growth of emergent plants such as cattail, bulrush, reeds and sedges. The most popular of these plants being the common reed or ***phragmites australis*** hence the name “reed bed treatment system”. The plants, or more specifically their roots, in combination with the growth media they are planted in, act as natural biological filters. The aerobic zones around their roots are the habitat for a multitude of microorganisms that utilize the nutrients found in wastewater as food.

Typically reed beds are shallow basins filled with a growth medium such as soil, sand or gravel which has an impervious layer that retains the water and prevents contamination of the natural ground below. The media is then planted with distinct plant communities such as reeds, sedges, bulrushes, etc.

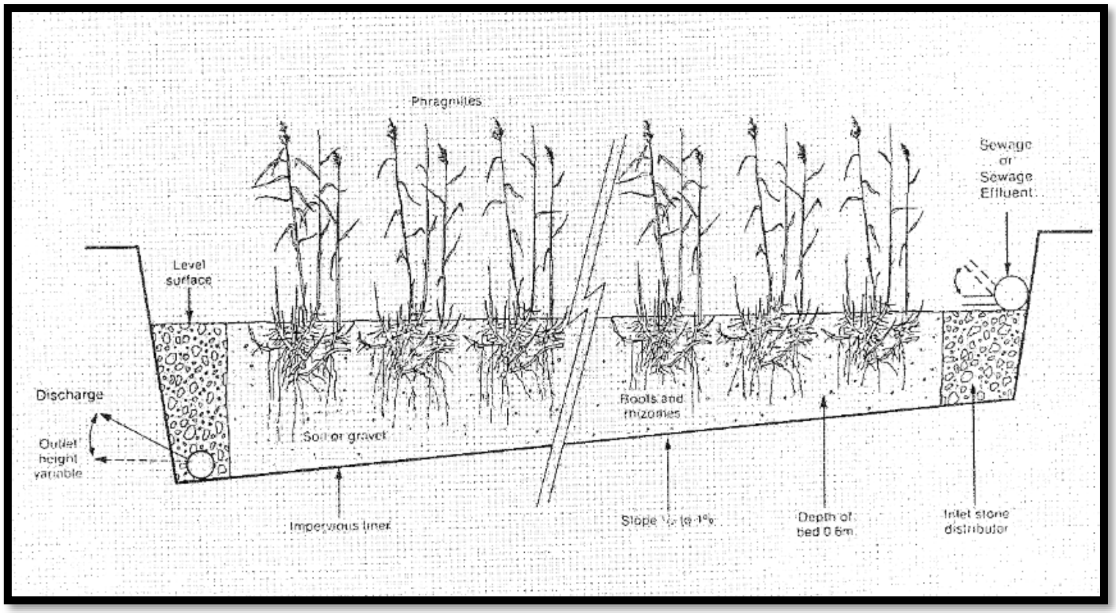


Figure 7: Typical Cross Section of a Horizontal Flow Reedbed

3.4. Combination of Oxidation Ponds and Reed Bed Treatment Systems

Constructed wetlands have distinct advantages over other means of treating wastewater in that they are not dependent on external energy or chemical inputs and require very little maintenance. Their lifespan can reach anything up to 80 years and in addition they are scenically attractive and provide a habitat for a wide variety of plants, birds, reptiles and invertebrates.

Reed beds generally provide an effluent much better than an oxidation pond system, and better or similar to that of a conventional treatment system and are especially suited to fluctuating flows. Reed beds can be constructed with unskilled labor and are devoid of high tech equipment and therefore can be considered a low maintenance option.

The water purification function of reed beds is dependent on four principle components:

a) the vegetation,
b) the water column,
c) substrate; and the
d) associated microbial populations.

The only function of the vegetation is to provide additional environment/habitat for the microbial populations. The stems of the plants and the falling leaves in the water column obstruct flow and facilitate sedimentation of suspended solids and increase surface area. The choice of vegetation is critical as most terrestrial plants cannot survive in waterlogged soils due to the depletion of oxygen which is normally associated with flooding conditions.

Aquatic plants have specialized stems, which enable them to conduct atmospheric gases such as oxygen down into their roots. The oxygen is exuded out of their root hairs forming an aerobic rhizosphere around every root hair while the rest of the surface volume remains anaerobic. Within the rhizosphere large populations of common aerobic and anaerobic bacteria thrive and aid the biological breakdown of the organic compounds found in wastewater.

The vegetation only take up a fraction of the available nutrients found in the wastewater, their primary role being to increase the amount of aerobic environment for the microbial populations found in the water column and below the water/substrate interface.

Suspended solids in the wastewater are aerobically composted in the above substrate layer of straw and plant debris formed by the dead leaves and stems. By this means, constructed wetlands are able to remove organic compounds (measured as Chemical Oxygen Demand), suspended solids and nitrogen.

In Horizontal Flow Reed Beds the wastewater flows horizontally through the substrate below the surface. The fact that there is no visible water ensures that vectors such as mosquitoes cannot breed. The horizontal flow reed beds are utilized as a secondary treatment or polishing stage to remove the suspended solids which the oxidation ponds inherently cannot do.

The combination of oxidation ponds and reedbeds was pioneered by the South African National Parks in the early 1980's with great success. They have several such systems which have ben operating successfully for many years. They are considered a "green system" as they fully utilize renewable resources such as plants and sand. In addition, if sized correctly, they produce a beautiful effluent which fully complies with the General Limit Values as dictated by the Department of Water & Sanitation.

3.5. Technical Complexity of the proposed system

Oxidation ponds and Reed Beds are not technically complex to operate. No special human intervention is required to operate the process except for the occasional removal of floating debris off the surface of the ponds and normal maintenance in terms of the inlet works where rags and grit are removed.

The advantage of "natural systems" are that they continue to function even if they are severely neglected in terms of normal maintenance, as they are only dependant on naturally occurring processes.

The proposed plant and related unit processes could be operated by two persons with minimum qualification and schooling who both work a single dayshift.

3.6. Land requirement

The calculated treatment capacity required by Klaarstroom entails that the following units will be required for the effluent to comply with the General Limit Values set by Department of Water & Sanitation:

- Inlet works : 25m²
- 2 x Anaerobic Ponds 60m²
- 1 x Facultative pond: 1 740m²
- 2 x Aerobic ponds: 1 140m²
- 1 x Horizontal flow reed bed: 1 200m²
- 1 x 7 day Storage Pond: 800m²

Total area required: 4 965m²

Figure 8: Example of an Oxidation Pond and Reedbed in the Kruger National Park

Figure 9: Proposed Layout of Refurbishment and Improvement works for Klaarstroom WWTP

3.7. Maintenance Input Required

Both Oxidation ponds and reedbeds require fairly little maintenance. The primary tasks being the following:

- Removal of grit and screenings from the inlet works
- Removal drifting debris from pond surfaces
- Desludging of septic tanks once every 3 to 5 years
- Removal of weeds and growth from pond verges to prevent vector nuisance
- Repairs to embankment walls and lining when required
- Maintenance of the irrigation system on a 3-monthly basis
- Harvesting of reeds from reedbeds once a year, preferably in September which is when the growth season commences.

As a rule of thumb, the Operations and Maintenance costs of these type of systems over their lifecycle are determined as follows:

3.7.1. Maintenance Costs:

Civil Works: 1% of capital costs per annum: R19 512-76

Mechanical Works: 5% of capital costs per annum: R35 500-00

Total Maintenance Cost per annum: R55 012-76

3.7.2. Operational Costs:

Personnel: 2 x Class I Process Controllers at R 98 000 per annum each

Chemicals: 50kg of Chlorine per month @ R1 530 per month = R18 360/annum

Harvesting of Reeds: 10 Casuals @ R200/day x 5 days = R10 000-00 / annum

Total Operational Costs per annum: R126 360-00

Notes to the above costs:

- Typically, the maintenance costs will increase by 6% per annum after year 2.
- The Operational costs will increase as salary levels go up, anything between 5 – 9%.

3.8. Disposal Options

Typically, oxidation ponds are licensed under a General Authorization which prohibits effluent from such systems to be discharged directly to a watercourse. However, up to 1000m^3 per day of oxidation pond effluent may be irrigated legally. It would therefore be pertinent to beneficially use this water for irrigation.

The current oxidation ponds at Klaarstroom dispose of the final effluent simply by irrigating it onto the veld north of the ponds. Eventually, this water finds its way into a water course which leads to the Grootrivier.

3.8.1. Proposed irrigation system for sports fields

A more suitable option would be to re-use the Treated Effluent to irrigate the sports fields to the south of the N12 national road. This is possible by utilizing a gravity main from the Storage Pond to the sports fields which is only 300m away. It is therefore proposed that a 160mm dia uPVC gravity main be constructed to deliver the treated effluent into a 6m dia x 1.8m high galvanized and lined dam.
Calcium hypochlorite can the be dosed into the water utilizing a chip doser to disinfect the water from all possible pathogens.

A small pump station will be required to pressurize the water to a crawling irrigator. Typically, a flow of 4.5l/s at a minimum pressure of 3.5bar is required.

The reason for this is that the crawling irrigator utilizes the energy from the water to drive a small Pelton wheel turbine which in turn drives a reduction gearbox allowing the crawling irrigator to propel itself across the length of the sports field. This is the simplest possible system to irrigate medium to large areas and ideally suited for sports fields.

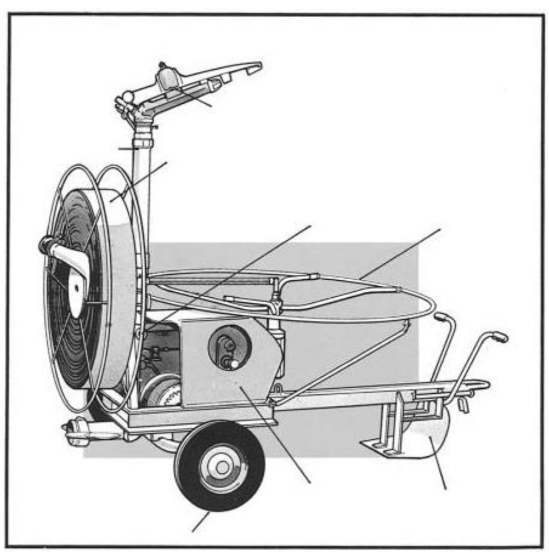


Figure 10: Illustration of a typical crawling irrigator

3.9. Sludge Management

Anaerobic Ponds accumulate sludge. At normal rates, it would be required that these ponds be desludged once in 5 to 7 years. Typically this is done by taking one pond out of operation and physically removing the sludge by hand and disposing of it in a landfill site or burying the sludge in pre-excavated trenches.

3.10. Expected Effluent Quality

Oxidation pond systems are quite capable of treating sewage to the General Limit Values as legally required by the Department of Water & Sanitation. Typically, it is not difficult to comply with these requirements with the exception of the suspended solids requirement. This is due to the nature of oxidation ponds utilizing algae as oxygen producer and remaining in suspension in the final effluent.

4. Geotechnical Conditions on Site

A basic geotechnical investigation was conducted by means of the excavation of test pits. Five number pits were excavated by means of a digger loader. Each pit was excavated until failure, or until the excavator reached its maximum depth.

Figure 11: Position of test pits for geotechnical investigation

The test pits yielded the following results:

TP1: Excavator reached a depth of 1.70m before hitting hard rock
TP2: Excavator reached a depth of 3.0m before hitting hard rock
TP3: Excavator reached a depth of 0.8m before hitting hard rock
TP4: Excavator reached a depth of 2.50m before hitting hard rock
TP5: Excavator reached a depth of 2,0m before hitting hard rock

The soils on site could be described as a Dark Brown Shaley Rock mixed with a Light Brown to Grey clayey shale. Weathered shales break down quite easily when compacted and we therefore do not foresee any problems with regards to utilizing the in-situ materials at the site.

Given that the proposed Anaerobic Ponds will be excavated to a depth of 3.50m, an allowance was made for 20% hard rock excavation in this area. The remainder of the earthworks structures are all less than 1.50m deep and as such, we expect limited problems with hard excavations over the majority of the site.

Although the site is located on the slope of one of the foothills of the Swartberg Mountains, it appears as if the upper layers are heavily weathered and only the deeper (>2.0m) layers become harder. The site has a natural slope from north to south which is conducive to this type of construction where every effort is made to balance the volume of excavated material with that required for fill. In this case, we were able to balance the cut to fill within 95%.

Figure 12: Photograph of site from south looking north

Figure 13: Photograph of site from north looking south

Three number soil samples were taken for the following tests:

- Sieve Grading analysis
- Determination of Maximum Dry Density and Optimum Moisture Content
- Atterberg Limits to determine percentage of clay available to curb permeability.

The soil analysis returned the following positive results:

Sieve Grading Analysis:

All samples had in excess of 30% pass through the 0.0425mm screen, this indicates a reasonable percentage of clay which bodes well for the impermeability of the soil once compacted.

Atterberg Limits:

The liquid limits of the samples varied between 21% and 24%, while the Plasticity Index varied between 10 and 14%. This again is a sure indicator of a reasonable clay content present in the samples analysed.

Maximum Dry density and Optimum Moisture Content:

Maximum Dry Density varied between 2229kg/m3 and 2248kg/m3 at an Optimum Moisture Content of 6%. This indicates that the soils are sufficiently compactable for the construction of stable soil embankments.

5. Capital Cost Required

For Klaarstroom, the estimate for the modifications and additional ponds amounts to **R 4 023 758.82.** This figure may vary depending on the specific site, availability of materials and rates offered by the construction industry at any point in time. This figure includes preliminary and general costs, professional fees and disbursements, an allowance of 6% for escalation as well as 15% Value Added Tax.

DESCRIPTION	ESTIMATED COST
PRELIMINARY AND GENERAL COSTS	**R262 241.00**
INLET WORKS	**R135 350.00**
ANAEROBIC PONDS	**R89 765.00**
FACULTATIVE POND	**R223 500.00**
AEROBIC PONDS	**R212 700.00**
HORIZONTAL FLOW REEDBED	**R579 400.00**
STORAGE POND	**R189 420.00**
IRRIGATION SYSTEM	**R710 000.00**
CONNECTOR PIPEWORK	**R115 000.00**
SITE WORKS	**R143 900.00**
SUBTOTAL:	**R2 661 276.00**
10% CONTINGENCIES:	R266 127.60
SUBTOTAL:	**R2 927 403.60**
PROFESSIONAL FEES & DISBURSEMENTS	R373 465.00
SUBTOTAL:	**R3 300 868.60**
ALOWANCE FOR ESCALATION (6%)	R198 052.12
SUBTOTAL:	**R3 498 920.72**
VAT @15%	R524 838.11
ESTIMATED PROJECT COST:	**R4 023 758.82**

Figure 14: Summary of Estimated Project Cost

See attached annexure for breakdown of the costs for this proposal.

6. Proposed Cashflow Projection for the Project

It is proposed that construction does not commence earlier than May 2019. The reason for this is that only R1 250 000-00 has been provided for in the 2018/19 Financial Year.

Our experience with these projects has shown that the expenditure is more or less in the ratio as shown in the cashflow projection below. **If the municipality was to commence in April 2019, the cash provided will be problematic.**

CASHFLOW PROJECTION: KLAARSTROOM WASTEWATER TREATMENT PLANT

Month:	Estimated Costs:	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Totals
Contractor:	R2 927 403.60	R292 740.36	R644 028.79	R1 112 413.37	R526 932.65	R351 288.43	R2 927 403.60
Consultant:	R373 465.00	R168 059.25	R51 351.44	R51 351.44	R51 351.44	R51 351.44	R373 465.00
Tot. for Month (ex VAT)		**R460 799.61**	**R695 380.23**	**R1 163 764.81**	**R578 284.09**	**R402 639.87**	**R3 300 868.60**
Escalation: 6%		R27 647.98	R41 722.81	R69 825.89	R34 697.05	R24 158.39	R198 052.12
Subtotal:		**R488 447.59**	**R737 103.04**	**R1 233 590.69**	**R612 981.13**	**R426 798.26**	**R3 498 920.72**
VAT @15%		R73 267.14	R110 565.46	R185 038.60	R91 947.17	R64 019.74	R524 838.11
Total Cash Reqd for Month:		**R561 714.72**	**R847 668.50**	**R1 418 629.30**	**R704 928.30**	**R490 818.00**	**R4 023 758.82**

If the proposed cashflow above, is matched to the proposed municipal MTEF as provided to BVi by the Prince Albert Municipality, it appears as if the cashflow is feasible. This includes for an escalation of 6% as well as the fact that the 15% VAT can be reclaimed from the Receiver of Revenue as Wastewater is considered to be a Trade Service and VAT is reclaimable.

AVAILABLE BUDGET FOR KLAARSTROOM WASTEWATER TREATMENT PLANT

Financial Year	2018/19	2019/20	TOTALS
Available Budget (ex VAT)	R1 250 561.00	R2 249 439.00	R3 500 000.00
Proposed Spending from Cashflow (ex VAT):	R1 225 550.63	R2 273 370.09	R3 498 920.72

7. Proposed Project Implementation Schedule

The following timeframes are proposed for the project:

Business Plan Submitted:	4th October 2018
Business Plan Adjudication by COGHSTA/DWS:	18 October 2018
Business Plan Approved:	22 October 2018
Final Design Completed:	31 October 2018
Tender Documentation Completed:	15 November 2018
Tender Advertisement:	16 November to 7th December 2018
Tender Period Closed:	7th December 2018
Annual Builders Holiday:	**15th December 2018 to 7th January 2019**
Tender Evaluation:	7th January 2019 – 28 February 2019
Tender Award to Contractor:	15th March 2019
Site Establishment:	15th April 2019
Construction Period:	1 May 2019 to 30 September 2019
Completion:	30 September 2019
Retention Period:	1 October 2019 to 2 October 2020

8. Motivation for the additional expenses above the norm

Although Klaarstroom is a small village with limited resources, the people residing there have the same rights to drinking water and good levels of sanitation as any other citizens in South Africa.

The use of "natural systems" such as oxidation ponds and reedbed treatment systems are heavily promoted due to their simplicity of operation and low maintenance requirements. Unfortunately, oxidation ponds alone do have their limitations in terms of Final Effluent quality due to the nature of how they work. This proposal for a combination of oxidation ponds and a reedbed tries to address the shortcomings of an oxidation pond by supplementing treatment with a horizontal flow reedbed.

The physical and biological processes provided by a reedbed will augment the quality of the effluent from the oxidation ponds and instead of delivering a green final effluent with a high Total Suspended Solids concentration, a colourless and clear effluent with very low turbidity will be achieved.

The advantages and disadvantages of natural treatment systems are listed below:

Pro's:

- Oxidation Ponds and Reedbeds are well suited for the treatment of low to medium strength domestic wastewater
- Very effective at removing nitrogen, phosphates and heavy metals
- Civil works limited to earthworks and HDPE linings, no major structures required
- Totally natural system, no external energy input required
- Reed beds and oxidation ponds can be scaled infinitely to fit the desired treatment capacity requirement
- No electricity required for operation
- Limited chemicals required for operation – only disinfectant required
- Very low maintenance costs, no mechanical or electrical equipment required
- Very low operational costs, limited supervision and operator input required
- Will continue working even if severely neglected
- Provides a good quality effluent that complies with General Limit values if not overloaded.
- Reed beds have no odours as water is always subsurface
- Reeds exude tannins from their root zone, which are toxic to most bacteria such as E.coli and therefore assist in disinfecting the final effluent without the addition of chemicals.
- Scenically attractive and provides a good habitat for birds
- Long life expectancy, in excess of 30 years

Con's

- Large footprint, significantly more land required than for conventional type plants
- Sensitive to effective pre-treatment, requires good screening and primary settlement to avoid solids blocking the reed bed growth media or primary ponds filling up with solids.
- Earthworks at Klaarstroom may be problematic due to hard rock excavations
- Reeds need to be cut and harvested on an annual basis
- Requires expert design and construction
- Sensitive to toxins entering the plant with wastewater, plants and active bacteria may die
- Odours can be problematic due to anaerobic nature of some ponds, exude hydrogen sulphide
- Requires secure fencing as deep ponds pose a risk for drowning if open to the public

- Primary anaerobic ponds need to be desludged once every 5 to 7 years due to accumulation of non-biodegradable solids on pond floor over time.
- Initial capital costs higher than for conventional systems of same capacity due to large footprint.
- Due to nature of technology, oxidation pond effluent does not always comply with the General Limit values. Total Suspended Solids in final effluent can be problematic and full denitrification does not always take place in pond systems.
- Filtration will be required if effluent is to be re-used without passing through reedbeds, otherwise algae may block sprinkler nozzles.

Given the above comparison of options and positive and negative aspects of the proposed system, we strongly urge the use of the horizontal Reed Bed to augment the quality of the Treated Effluent. The advantages and improvement in water quality will over time far outweigh the negative impact of an inferior quality water disposed of in the environment.

9. CONCLUSION

BVi Consulting Engineers trust that you will find this proposal to your satisfaction and wish to ensure you of our best possible service and cooperation in this regard. We wish to confirm that a final design can be completed within a period of 4-6 weeks upon receipt of a firm order to do so from the Prince Albert Municipality. Such a design will provide the sizing of the ponds, a set of layout drawings, a set of specifications as well as a Bill of Quantities which can be given to a contractor for pricing and execution.

Should you require any additional information in this regard, please feel free to contact us at your convenience.

Yours truly

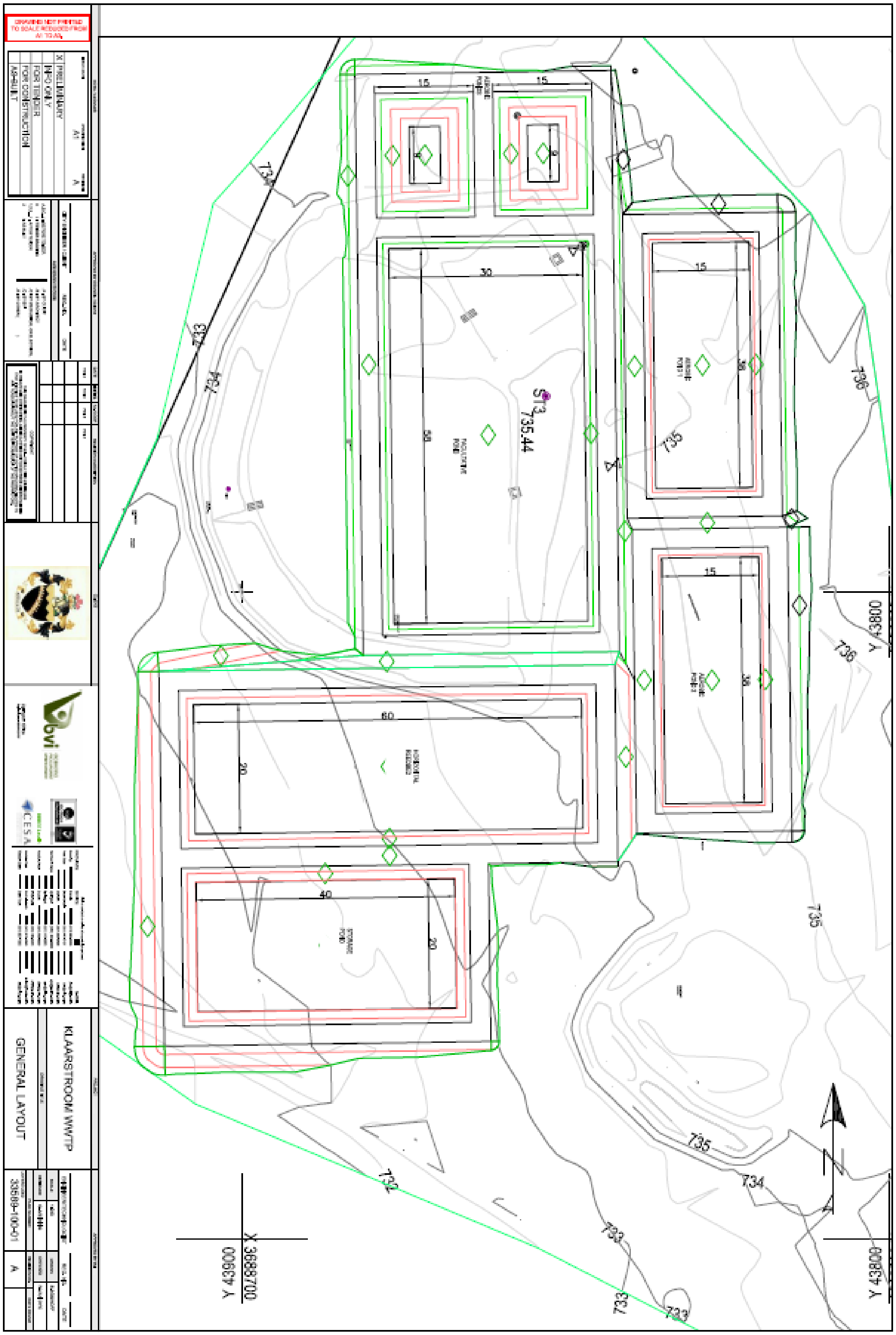
____

GH MEIRING Pr TECH ENG
BVi CONSULTING ENGINEERS

Annexure A – Detail Cost Estimate of Proposed WWTP

Item	Description	Unit	Qty	Rate	Amount
1	**Preliminary & General Costs (15%)**	Sum	1	R 262 241.00	R 262 241.00
2	**Inlet Works**				
2.1	Inlet channel	Sum	1	R 20 750.00	R 20 750.00
2.2	Degritting Channels	Sum	2	R 35 875.00	R 71 750.00
2.3	Flow measuring flume	Sum	1	R 12 850.00	R 12 850.00
2.4	Instrumentation	Sum	1	R 30 000.00	R 30 000.00
3	**Anaerobic Pond**				
3.1	Excavation in all materials to dimensions of 5.5m x 5.5m x 3.5m for Anaerobic Ponds x 2	m^3	220	R 65.00	R 14 300.00
3.2	Inlet and outlet structure inclusive of pipework	Sum	2	R 10 500.00	R 21 000.00
3.3	Pipe works from existing inlet to new ponds	Sum	1	R 37 525.00	R 37 525.00
3.4	Allowance for Hard Rock Excavations. (20% of volume)	m^3	44	R 385.00	R 16 940.00
4	**Facultative Pond**				
4.1	Excavate in all materials and shape to plan the existing facultative Pond with dimensions 58m x 30m x 1.2m	m^3	1500	R 65.00	R 97 500.00
4.2	Inlet and outlet structure inclusive of pipework	Sum	1	R 10 500.00	R 10 500.00
4.3	Allowance for Hard Rock Excavations. (20% of volume)	m^3	300	R 385.00	R 115 500.00
5	**Aerobic Secondary Ponds**				
5.1	Excavate in all materials and shape to plan 2 x Aerobic Ponds with dimensions 38m x 15m x 1m	m^3	1350	R 65.00	R 87 750.00
5.2	Inlet and outlet structure inclusive of pipework	Sum	2	R 10 500.00	R 21 000.00
5.3	Allowance for Hard Rock Excavations. (20% of volume)	m^3	270	R 385.00	R 103 950.00
6	**Horizontal Flow Reed Bed**				
6.1	Construction of Hor. Flow Reed Bed in all materials in cut to fill with dimensions of 60m x 20m x 1.0m deep	m^3	774	R 65.00	R 50 310.00
6.2	Supply & install of HDPE lining 1mm thc	m^2	1682	R 70.00	R 117 740.00
6.3	Supply and construction of stone-filled gabions inclusive of inlet and outlet pipes and manholes.	Sum	1	R 45 000.00	R 45 000.00
6.4	Growth media comprising course sand 1-3mm dia.	m^3	780	R 350.00	R 273 000.00
6.5	Supply, transport and establish of plant material at a density of 4 plants / m^2 (***phragmites australis***)	m^2	1347	R 25.00	R 33 675.00
6.6	Allowance for Hard Rock Excavations. (20% of volume)	m^3	155	R 385.00	R 59 675.00
7	**Storage Pond (7 days)**				
7.1	Construction of a Storage Pond in all materials in cut to fill with dimensions of 40m x 20m x 1.5m deep.	m^3	1260	R 65.00	R 81 900.00
7.2	Inlet and Outlet structures inclusive of valves	Sum	1	R 10 500.00	R 10 500.00
7.3	Allowance for Hard Rock Excavations. (20% of volume)	m^3	252	R 385.00	R 97 020.00
8	**Irrigation System**				
8.1	Gravity Main: 110mm dia uPVC Pipeline	m	350	R 1 200.00	R 420 000.00
8.2	Corrugated Metal Reservoir c/w roof and lining at sportsfield	ea.	1	R 120 000.00	R 120 000.00
8.3	Supply and installation of Chip Chlorinator at reservoir	ea.	1	R 25 000.00	R 25 000.00
8.4	Supply and install of Rotrix Crawler irrigator	ea.	1	R 70 000.00	R 70 000.00
8.5	Booster Pump Set at corrugated reservoir	ea.	1	R 75 000.00	R 75 000.00
9	**Connector Pipework**	Sum	1	R 115 000.00	R 115 000.00
10	**Site Works**				
10.1	Security Fencing	m	450	R 200.00	R 90 000.00
10.2	Removal and disposal of sludge in existing Anaerobic Pond	m3	350	R 55.00	R 19 250.00
10.3	Removal and disposal of sludge in existing Facultative Pond	m3	630	R 55.00	R 34 650.00
	Subtotal:				**R 2 661 276.00**
	Contingencies 10%				R 266 127.60
	Subtotal:				R 2 927 403.60
	Professional Fees & Reimbursable Expenses				R 373 465.00
	Subtotal				R 3 300 868.60
	Allowance for Escalation: 6%				R198 052.12
	Subtotal				**R3 498 920.72**
	VAT 15%				R 524 838.11
	Estimated Total Project Cost				**R 4 023 758.82**

Annexure B – Preliminary Earthworks model for layout of ponds



Annexure C – Soil Analysis Results from Test Pits

OUTENIQUA LAB (Pty) Ltd.

Registration No. 95/07742/07
Materials Testing Laboratory
6 Mirrorball Street, George : PO Box 3186, George Industria, 6536
Tel: 044 8743274 : Fax: 044 8745779 : e-mail: llewelyn@outeniqualab.co.za

R-CBR-1-7 Nov-16

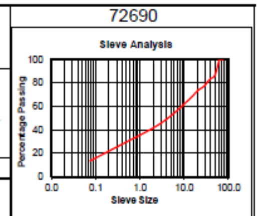
sanas Testing Laboratory T0347

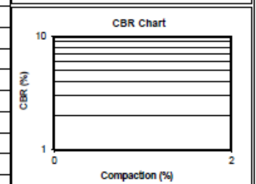
Customer :	Bvi Engineering Procurement Management 55 Bult Street Upington 8800	Project :	Klaarstroom WWTW
		Date Received :	12/09/18
		Date Reported :	02/10/18
		Req. Number :	4061/18
Attention :	Gert Meiring	No. of Pages :	1/2

TEST REPORT
CALIFORNIA BEARING RATIO

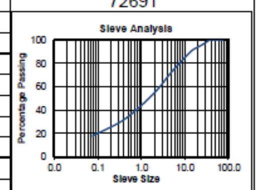
Sample Position (SV)		TP#5	COLTO:		TP#3	COLTO:	
Depth (mm)		N/A	Not		N/A	No Spec	
Sample No		**72690**	Classified		**72691**		
Materials Description	Source	Klaarstroom WWTW			Klaarstroom WWTW		
	Colour	Light Brownish Grey			Dark Brown		
	Soil Type	Clayey Shale			Shaley Rock mixed with Clay		
	Classification	Existing			Existing		
Material Indicators - (SANS 3001 Method AG1,GR20)							
Percentage Passing	75 mm	100		Opinion	100		
	63 mm	100			100		
	50 mm	87			100		
	37.5 mm	83			100		
	28 mm	77			97		
	20 mm	73			94		
	14 mm	67			90		
	5 mm	52			73		
	2 mm	42			55		
	0.425 mm	28			33		
	0.075 mm	13.5			17.9		
Material Indicators - (SANS 3001 Method PR5)							
Grading Modulus		2.17			1.95		
Coarse Sand Soil-Mortar (%)		32			41		
Atterberg Limits - (SANS 3001 Method GR10)							
Liquid Limit (%)		21			23		
Plasticity Index (%)		11			10		
Linear Shrinkage (%)		5.5			5.0		
Material Strength - (SANS 3001 Method GR30,GR40)							
MOD	Max Dry Density (kg/m^3)	2229			2236		
	Optimum Moisture Content (%)	6.3			6.1		
	Mould Moisture Content (%)						
	@100% Mod AASHTO						
	Swell (%)						
NRB	100% NRB						
	Swell (%)						
Proc	100% Proctor						
	Swell (%)						
CBR	@ 100% Mod AASHTO						
	@ 98% Mod AASHTO						
	@ 95% Mod AASHTO						
	@ 93% Mod AASHTO						
	@ 90% Mod AASHTO						
Material Condition - (SANS 3001 Method GR20)							
Insitu Moisture Content (%)							
Soil Classification Achieved By The Material							
COLTO:		Not Classified			Not Classified		
AASHTO System		A-2-6			A-2-4		
Unified System		GC			GC		

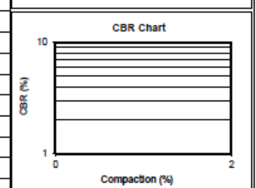
72690



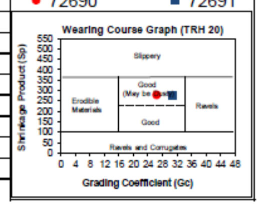


72691





● 72690 ■ 72691



- **Specimens delivered to Outeniqua Lab in good order.**

Llewelyn Heathcote
Technical Signatory
For Outeniqua Lab (Pty) Ltd.

1. The opinion column is an interpretation of the direct comparison between the quoted specification and the single test sample results obtained. The compliant (P), non compliant (Ì) and uncertain (Ù) opinion indicators are based on an approximate 95% level of confidence with reference to SAMM GUIDANCE 1, Issue 2 : 20 June 2007 Section 2.
2. The uncertain (Ù) indicates that the test result is either equal to or is above / below the specified limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliant (P) or non compliant (Ì) based on a 95% level of confidence with reference to SAMM GUIDANCE 1, Issue 2 : 20 June 2007 Section 2.
3. This report (with attachments) is the correct record of all measurements made, and may not be reproduced other than with full written approval from the Director of Outeniqua Lab (Pty) Ltd.
4. Measuring Equipment, traceable to National Standards is used where applicable. Results reported in this Test Report relate only to the items tested and are an indication only of the sample provided and/or taken.
5. While every care is taken to ensure the correctness of all tests and reports, neither Outeniqua Lab (Pty) Ltd nor its employees shall be liable in any way whatever for any error made in the execution or reporting of tests or any erroneous conclusions drawn therefrom or for any consequence thereof.

OUTENIQUA LAB (Pty) Ltd.

Registration No. 95/07742/07

Materials Testing Laboratory

6 Mirrorball Street, George : PO Box 3186, George Industria, 6536

Tel: 044 8743274 : Fax: 044 8745779 : e-mail: llewelyn@outeniqualab.co.za

R-CBR-1-7 Nov-16

sanas Testing Laboratory

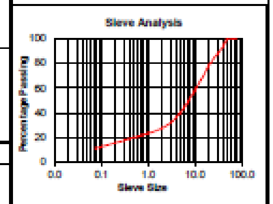
T0347

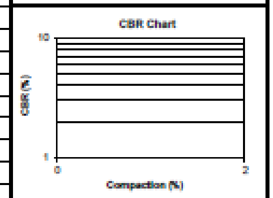
Customer :	Bvi Engineering Procurement Management	Project :	Klaarstroom WWTW
	55 Bult Street	Date Received :	12/09/18
	Upington	Date Reported :	02/10/18
	8800	Req. Number :	4061/18
Attention :	Gert Meiring	No. of Pages :	2/2

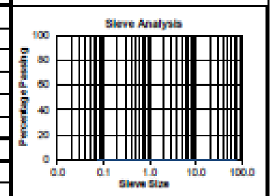
TEST REPORT
CALIFORNIA BEARING RATIO

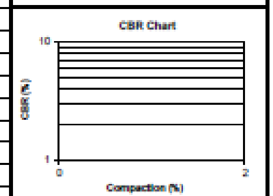
Sample Position (SV)		TP#2	COLTO:
Depth (mm)		N/A	Not
Sample No		72692	Classified
Materials Description	Source	Klaarstroom WWTW	
	Colour	Light Brown	
	Soil Type	Clay	
	Classification	Existing	
Material Indicators - (SANS 3001 Method AG1,GR20)			Opinion
Percentage Passing	75 mm	100	
	63 mm	100	
	50 mm	100	
	37.5 mm	92	
	28 mm	86	
	20 mm	78	
	14 mm	68	
	5 mm	41	
	2 mm	28	
	0.425 mm	19	
	0.075 mm	11.1	
Material Indicators - (SANS 3001 Method PR5)			
Grading Modulus		2.42	
Coarse Sand Soil-Mortar (%)		30	
Atterberg Limits - (SANS 3001 Method GR10)			
Liquid Limit (%)		24	
Plasticity Index (%)		14	
Linear Shrinkage (%)		7.0	
Material Strength - (SANS 3001 Method GR30,GR40)			
MOD	Max Dry Density (kg/m^3)	2248	
	Optimum Moisture Content (%)	6.0	
	Mould Moisture Content (%)		
	@100% Mod AASHTO		
	Swell (%)		
NRB	100% NRB		
	Swell (%)		
Proc	100% Proctor		
	Swell (%)		
CBR	@ 100% Mod AASHTO		
	@ 98% Mod AASHTO		
	@ 95% Mod AASHTO		
	@ 93% Mod AASHTO		
	@ 90% Mod AASHTO		
Material Condition - (SANS 3001 Method GR20)			
Insitu Moisture Content (%)			
Soil Classification Achieved By The Material			
COLTO:		Not Classified	
AASHTO System		A-2-6	
Unified System		GP-GC	

72692

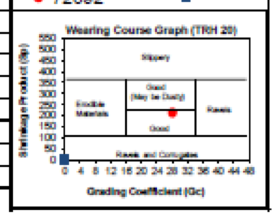








● 72692 ■



- **Specimens delivered to Outeniqua Lab in good order.**

Llewelyn Heathcote
Technical Signatory
For Outeniqua Lab (Pty) Ltd.

1. The opinion column is an interpretation of the direct comparison between the quoted specification and the single test sample results obtained. The compliant (P), non compliant (Ï) and uncertain (Û) opinion indicators are based on an approximate 95% level of confidence with reference to SAMM GUIDANCE 1, Issue 2 : 20 June 2007 Section 2.
2. The uncertain (Û) indicates that the test result is either equal to or is above / below the specified limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliant (P) or non compliant (Ï) based on a 95% level of confidence with reference to SAMM GUIDANCE 1, Issue 2 : 20 June 2007 Section 2.
3. This report (with attachments) is the correct record of all measurements made, and may not be reproduced other than with full written approval from the Director of Outeniqua Lab (Pty) Ltd.
4. Measuring Equipment, traceable to National Standards is used where applicable. Results reported in this Test Report relate only to the items tested and are an indication only of the sample provided and/or taken.
5. While every care is taken to ensure the correctness of all tests and reports, neither Outeniqua Lab (Pty) Ltd nor its employees shall be liable in any way whatever for any error made in the execution or reporting of tests or any erroneous

Annexure D – PROPOSED PROJECT EXECUTION SCHEDULE

PROPOSED PROJECT TIME SCHEDULE

Item No.	Activity	Responsible	OCTOBER 2018				NOVEMBER 2018				DECEMBER 2018				JANUARY 2019				FEBRUARY 2019				MARCH 2019	APRIL 2019	MAY 2019	JUNE 2019	JULY 2019	AUGUST 2019	SEPTEMBER 2019'
			WK1	WK2	WK3	WK4	WK1	WK2	WK3	WK4	WK1	WK2	WK3	WK4	WK1	WK2	WK3	WK4	WK1	WK2	WK3	WK4							
1	Business Plan Submitted	PAM / BVi	4/10																										
2	Business Plan Approved	COGHSTA/DWS	4/10		18/10																								
3	Final Design	BVi			22/10	31/10																							
4	Compile Tender Documentation	BVi				31/10		15/11																					
5	Tender Advertisement	PAM						15/11	20/11																				
6	Tender Period Closed	Contractors							20/11		05/12																		
	Annual Builders Holiday	All										15/12			07/01														
7	Tender Evaluation	PAM / BVi													07/01							28/02							
8	Tender Award to Contractor	PAM																					30/03						
9	Site Establishment	Contractors																						15/4					
10	Construction Period	BVi/Contractor																											
11	Project Completion	BVi/Contractor																											30-Sep

ANNEXURE E: PHOTOGRAPHS OF REED BEDS AND OXIDATION PONDS RECENTLY COMPLETED BY BVi

Typical Reedbed System: Nossob Rest Camp, Kgalagadi Transfronteir Park

Typical Primary Anaerobic Pond with full HDPE Lining, Brandvlei Northern Cape

Typical Facultative Pond with full HDPE Lining, Brandvlei, Northern Cape