PROCESS ENGINEERING SERVICES

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Report No: 003

Tongaat Wastewater Treatment Plant

Tongaat WWTW Phase I Upgrade: Concept Design Report

Conducted by Process Engineering Services Branch

Sanitation Operations Department

eThekwini Water and Sanitation

Compiled By: K. Dharmalingum, N. Buthelezi

Contributors: M. Dlamini, L. Mabodi, B. Maharaj, S. Mbamali, A. Pillay

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General Enquiries:

Process Engineering Services Branch

First Floor

24 Jeffels Road

Isipingo

4113

Tel: 031 322 8615

Fax:031 311 8747

Email: nqobile.dlamini@durban.gov.za

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1. Introduction

Tongaat Central Wastewater Treatment Works(WWTW) treats wastewater comprising predominately domestic sewage with certain fraction of industrial effluent entering the treatment works. The plant currently has a design treatment capacity of 10ML/day. However, recent developments in the area and future development plans for the area have necessitated the urgent need to upgrade the plant from 10Ml/day to 22.5 ML/day.

Tongaat WWTW has A/O (Anoxic and Oxic) process configuration meaning that the plant is designed to remove nitrogen and organic matter. However, it is envisaged that future water use authorization for Tongaat WWTW will require both nitrogen and phosphate removal in order to protect the receiving environment. In addition to the capacity upgrade, the special requirement on the discharge limits warrants that the current process be upgraded to Biological Nutrient Removal(BNR) process configuration which is capable of removing both nitrogen and phosphates.

Another significant aspect that the upgrade seeks to address is sludge dewatering at Tongaat Central WWTW. The current dewatering system (Screw Presses) at Tongaat WWTW is running intermittently. This is due to various mechanical and electrical related challenges coupled with aging infrastructure.

The Process Engineering Services (PES) branch has been tasked to undertake a design for Tongaat Central WWTW upgrade using in-house resources. This is the first stage of the design which discusses various options or concepts that have been considered by PES and the rationale behind the selection of certain options over the others.

2. Head of Works Concept Design

2.1. Flow Equalisation Basin

This option is included in the concept scope as there is an existing pond that requires refurbishment. The objective of the equalisation basin will dictate the relevant configuration required for the design.
The current objectives for the inclusion of an equalisation basin are:

- It will assist to handle excess flows due to storm water conditions. Excess flows can affect the plants hydraulic capacity and may result in process upset of the biological process.
- Assist to dampen the daily variation in flowrate, if the plant is set to receive only flows lower than the average dry weather flow
- Assist to dampen the variation in load such as COD, suspended solids due to excess flows.
- It will improve the performance of the existing plant.
- Figure 1 below shows the typical equalisation basin which should have a mixing/aeration component to prevent anaerobic conditions and settling of solids.
- The dam should be constructed in concrete (lining and sides)

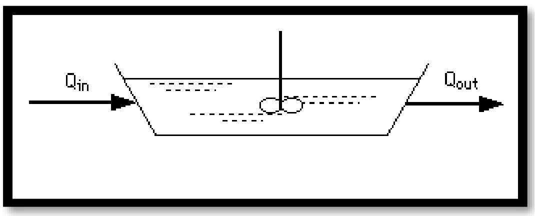

Figure 1: Equalisation basin

There are two configurations of the equalisation basin that are relevant, the in-line configuration and the side-line configuration.

Based on the objectives of the design, the side line configuration is selected due to the following reasons:

- The side line configuration will allow for a more cost effective option as it will reduce the volume of tank required. This is because not all the flow will be required to enter the tank. The tank will only be required if the flow exceeds the average daily flow or appropriate set point.
- The side line configuration can still offer the advantages of flow and load equalisation and associated improvement in plant performance.

2.2. Odour Control Design

Currently there is no odour control system at the head of works. PES recommends that an odour control system be installed and the design should ensure the following odour control features:

- Enclosed structure for effective odour control.
- All inlet channels to be enclosed.
- All screening equipment to be enclosed in a building (mechanical screens, screen washer/compactor, screen skips for screening collection).
- Odorous gas extraction system installed within the building.
- Gas extraction and piped to odour treatment system outside the head of works building.

The concept design specification for the odour treatment system must take the following into account:

- Isolation of the head of works channels and specified areas with full enclosure and/or GRP covers
- A system of ducts will link the covered areas with the odour treatment unit. This system will be sized and balanced to ensure that the specified air extraction rates are maintained while minimising pressure losses.
- The odour treatment technology for hydrogen sulphide will be the Trickling Biofilter. Trickling Biofilter offers the following advantages over other technologies:-
  - Media lasts longer (cost affective)
  - Can use both chemical and biological means to remove odour, i.e. flexible technology
  - Less intervention from the process controllers
  - Technology is well established and readily available locally
- The gases onsite will be measured for design purposes. In the absence of data, the following design criteria will apply:

  Average H2S = 40 – 50 ppm

  Peak H2S = 100 – 150 ppm

  Quantity of air = 60 000 to 70 000 m3/h (12 air changes per hour)
- Process Air handling system – exhaust fans
- Dedicated Water supply with a reservoir and pump on a concrete slab
- Installation of associated electrical panels and provision of a SCADA system.

2.3. Screening System design

Two inlet channels, one duty and one standby channel is provided. Efficient screening system to allow for the following:

- Retractable trash rack system per channel with bar spacing of 50mm to 100mm.
- Fine course screen downstream per channel with bar spacing of 6mm to 8mm.

- Retractable manual hand raked screens per channel downstream of the mechanical screens for emergency operation in the case of mechanical failure.
- Gantry’s provided for the servicing and maintenance of all screens.

Details of the screening system design will be as follows:

First Phase screening:
- Retractable trash rack system per channel with bar spacing of 50mm to 100mm.
- Fully automated lifting of screen to prevent intensive manual labour.

Second Phase screening:
- Mechanical bar screens – front raked screens with tapered bars to prevent tripping. We do not recommend the step screens, as a front line screen due to operational challenges identified by the treatment works branch.
- Bar spacing 6mm to 8mm
- 2 inlet channels comprising of:
    - 1 duty channel with mechanical front raked screen
    - 1 standby channel with mechanical front raked screen
- The Screenings will be washed and compacted utilising the two washer compactors with associated screw conveyors or hydro-conveyors. There must be redundancy in the design for the screening conveyor and washer/compactors. This will prevent manual intervention due to unnecessary downtime of the screens.
- Provision should be made for skip bins for the collection of screenings.

Third phase: Emergency screening system:

- Provision should be made for manual hand raked screens downstream of the second phase screens.
- These screens should have bar spacing of 10mm and should be installed as retractable screens. The default position of these screens will be lifted out of channel and will only be lowered in the case of mechanical breakdown of both mechanical screens.

In summary, the head of works screening system should cater for the following:

- 2X Front raked course fine screens (8mm -10mm)
- 1X 10 metre hydro conveyor with 10000 litre water supply tank and pump or 2X 10m spiral conveyor
- 2X Washer compactors
- 8X Sluice gates
- 2X Waste bin and dolly system
- 4X Gantry for maintenance
- Electrical panel(s) with differential level Control

2.4. Grit Removal System Design

Efficient grit removal system to allow for the following:

- High efficiency removal of grit with varying particle sizes less, including particle sizes smaller than 250microns at a specific gravity of 2.65.
- Grit separator system with associated grit washing and grit dewatering stages

The alternatives assessed were the following:

Table 1: Grit removal alternatives

Technology Option	**Design details**	**Comments**
Constant velocity grit channels	not considered feasible, existing system at the works	Intensive manual labour, lower grit removal efficiency
Gravity Vortex Grit Chambers	concrete tanks, 3 tanks of 6m diameter, associated grit washer and grit dewatering with airlift system or top mounted grit pumps.	large footprint and more costly than induced vortex systems, higher than constant velocity channels but lower than induced vortex systems
Induced Vortex Grit Chambers	concrete or steel tanks, patented designs, guaranteed performance, 2 tanks of 3m diameter, associated grit washing and grit dewatering units with airlift system or top mounted grit pumps.	small footprint, compact, modular and cost effective. Improved grit removal efficiency (removes smaller grit particles). Reduced civil work is a possibility based on options provided by supplier.

Inclusion of an induced vortex degritter is recommended to reduce footprint and increase efficiency of the grit removal. Details of the selected grit removal system design is as follows:

- Induced vortex grit removal system
- Stainless steel or concrete structures
- With the induced vortex degritter, a diameter of approximately 3m will be required compared to approximately 15m required for conventional vortex degritters* (*based on removal efficiency below)
- Associated grit washer and grit dewatering equipment per grit separator
- Grit pump removal system with associated redundancy built in to the design.

The following design specification for grit removal will apply for the Tongaat Wastewater Treatment Works:

- 95 % removal of grit particles greater than 50 mesh (and smaller than 70 mesh) (greater than 300 microns)
- 85 % removal of grit particles greater than 70 mesh (and smaller than 100 mesh)
- 65 % removal of grit particles greater than 100 mesh
- The efficiency level relates to grit having a S.G. of 2.65 and to the difference in grit content in the influent channel, as compared to that in the effluent channel.
- It is proposed that an induced vortex type degritter such as an **induced vortex grit chamber** be utilized to achieve this efficiency.

The features of an efficient induced vortex grit removal system are as follows:

- Efficient operation on a wide range of flow rates.
- Constant velocity assisted by paddles.
- Low head loss.
- Compact size resulting in low excavation and civil works costs.

• Able to retrofit into existing plants.
• Simple mechanics
• Reliable robust design. No moving parts subject to wear or blockage located under water.
• Low maintenance cost.
• Transition and rotating motion designed to eliminate accumulation of grit in the separation chamber under all conditions.
• Induce vortex paddle mixer design to provide optimum grit removal conditions, while limiting organics accumulation in the grit well.
• Full accessibility to grit collecting well.

Typical grit installation schemes are as follows:

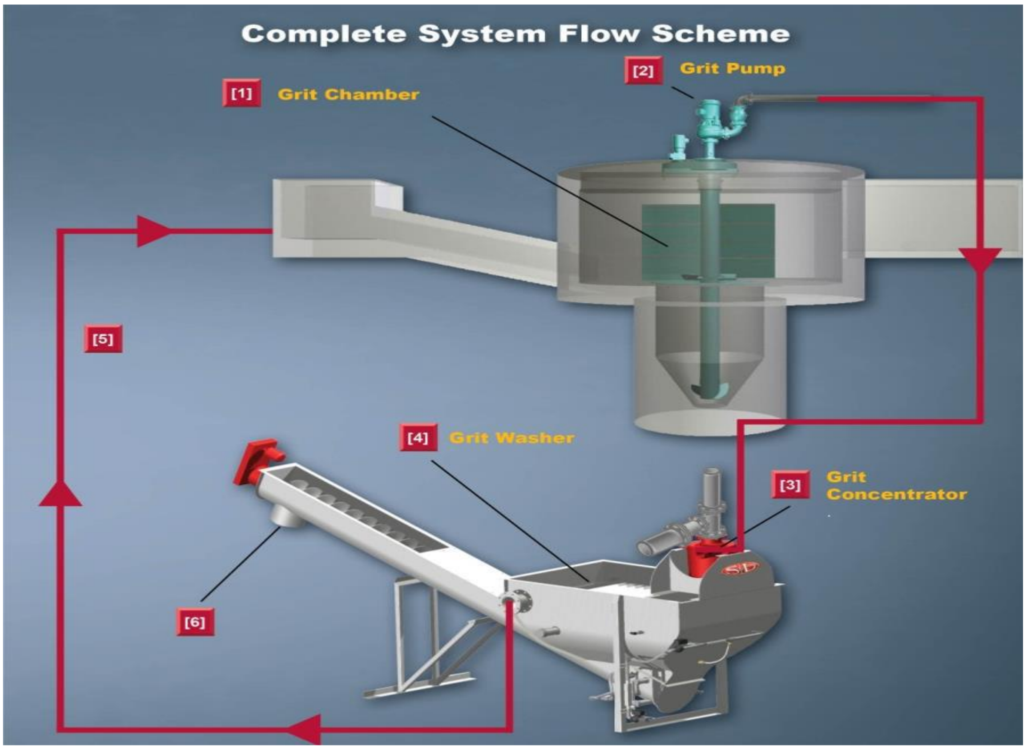

Figure 2: Typical induced vortex installation scheme

In summary, the head of works grit removal system upgrade should cater for the following:

- 1X Induced Vortex Grit separator (additional)
- 2X Grit Washer/Dewatering Equipment (for both vortex systems)
- 4X Sluice gates (to cater for both grit vortex systems)
- 2X Waste bin and dolly system
- 2X Electrical panel with differential Level Control (for both grit vortex systems)

3. Activated Sludge Process Concept Design

Tongaat WWTW has A/O (Anoxic and Oxic) or Ludzack-Ettinger(LE) process configuration meaning that the plant is designed to remove Nitrogen and organic matter. However, it is envisaged that future water use authorization for Tongaat WWTW will require both Nitrogen and Phosphorus removal in order to protect the receiving environment. For an example, researchers have found that 0.005 mg/L of soluble orthophosphate will limit algae growth(WEF,2001) while more than 0.2 mg/L of un-ionized ammonia can induce acute toxicity to certain species of fish. In addition to the capacity upgrade, the special requirement on the discharge limits warrants that the current process be upgraded to remove both Nitrogen and Phosphates.

3.1 Biological Reactor Configuration

Process Engineering Services (PES) has looked at various processes that can be used to achieve acceptable final effluent quality standards. The most practical options what were looked at by PES in the case of Tongaat WWTW include:

- Biological Nutrient Removal (BNR)configurations to biologically remove both Phosphorus and Nitrogen
- BNR combined with Chemical Phosphorus Removal to use when raw sewage characteristics are not in favour of BNR, e.g. low readily biodegradable organics and high toxicity
- Biological Nitrogen Removal, e.g. Modified Ludzack-Ettinger(MLE) combined with Chemical Phosphorus Removal
- Advanced biological wastewater treatment technologies such Nereda.

3.2 **Option 1**: Convectional Activated Sludge Process

3.2.1 Existing Bioreactor: 10ML/D

As indicated above, the existing 10ML/D Bioreactor was not designed to remove Phosphorus. Looking at the size of the existing bioreactor, modifying this plant to BNR through partitioning will not be practical and cost effective considering the amount of work that will be required. The most practical and cost effective option PES recommends is to keep the existing reactor as it is and incorporate chemical precipitation for Phosphorus Removal.

However, once the new bioreactor has been built, the existing bioreactor can be temporarily taken offline for minor modifications from LE to MLE configuration. This will increase the overall Nitrogen -removal efficiency of the existing bioreactor.

3.2.2 Proposed New Bioreactor: 12.5 ML/D

In a BNR process, enhanced biological Phosphorus removal works because *Acinetobacter* organisms also known as PAOs can absorb soluble COD under anaerobic conditions and store it until they are in an aerobic environment, where they then metabolize it. One of the critical requirements for a successful biological removal of Phosphorus is the availability of adequate readily biodegradable organics in the system. On the other hand, mathematical models have indicated that the size of a new BNR plant would be much bigger than the existing bioreactor.

Taking into account the susceptibility of biological phosphates removal systems to unfavourable characteristics of raw sewage (rCOD, toxicity, etc) and the land limitation at Tongaat WWTW, PES recommends the option of Biological Nitrogen Removal, e.g MLE combined with Chemical Phosphorus Removal.

Initial plans were to increase the plant's capacity from 10ML/d to 20ML/d. As a contingency, an additional capacity of 2.5ML/d will be built into the design thus providing a total capacity of 22.5ML/d after the upgrade.

3.2.3 Aeration system

The aeration system is the most important process in a wastewater plant. Aeration systems constitute about 75% of the energy used in a typical wastewater treatment plant. Therefore, the correct design of the aeration system is critical for a sustainable and efficient operation of a wastewater treatment plant. PES has investigated two options under this category, i.e. Diffused aeration system and Surface mechanical aeration system.

3.2.3.1 Existing Bioreactor: 10ML/D

The existing reactor uses surface mechanical aeration system. One of the major problems currently faced by Tongaat WWTW is the proliferation of thick foam on the surface of the reactor which significantly reduces interface oxygen transfer rate. Replacing surface mechanical aeration system with diffused aeration system would seemingly resolve this problem, however PES recommends that retrofitting of diffused aeration system be temporarily omitted from Phase I upgrade scope. This is primarily because there is an optimal depth of submergence range at which diffusers must be installed at for maximum performance and therefore more information is still required.

3.2.3.2 Proposed New Bioreactor: 12ML/D

Researchers have found that forcing air bubbles down is more difficult and incredibly inefficient. Bubbling from the bottom up ensures oxygen is delivered where it is needed most, i.e. sludge-water interface. PES recommends diffused aeration system for the new bioreactor based on the following benefits:

- Diffused aeration system provides uniform oxygenation and mixing
- Diffused aeration system requires 3 to 6 times less horsepower for the same amount of oxygen, i.e. more energy efficient than surface mechanical systems
- Diffused aeration system has excellent performance in deep water, i.e. requires lower footprint

3.2.4 Secondary Settling Tanks

Additional settling capacity for additional flow will need to be included in Phase I scope of work. The required additional settling capacity or area will be determined at preliminary design stage.

3.2.5 Control philosophy for the bioreactor

PES recommends Dissolved Oxygen/Ammonia cascade control for optimal energy efficiency. This will save 25-30% of energy required for aeration. In addition to energy savings, automated aeration control also improves effluent quality

3.3 Option 2: Advanced biological wastewater treatment technologies

From the existing literature on advanced biological wastewater treatment technologies, Nereda was deemed the most practical option for consideration under advanced biological wastewater treatment options. Nereda® is an innovative and advanced biological wastewater treatment technology that purifies water using the unique features of 'aerobic granular biomass'. Contrary to conventional processes, the purifying bacteria concentrate naturally in compact granules, with superb settling properties. As a result of the large variety of biological processes that simultaneously take place in the granular biomass, Nereda® is capable of producing excellent effluent quality. Even when not particularly targeted, extensive biological phosphorus and nitrogen reduction is an intrinsic attribute of this technology, resulting generally in chemical-free operation. These unique process features translate into the following advantages: -

- Compact technology
- High energy saving
- Easy to operate installations for both industrial and municipal wastewater treatment.
- The technology presents attractive new solutions for green field installations and retrofitting or extending conventional activated sludge plants.

Based on the proposal dated 13 July 2018 compiled by WEC Projects (Pty) Ltd for eThekwini Municipality, the following comparison was undertaken between Nereda and conventional (MLE) processes.

Table 2: Comparison between Nereda and MLE will chemical phosphorus removal

Parameter	MLE with Chemical P Removal	Nereda
Footprint requirements	X	Requires 35% less compared to X of MLE
Nutrient removal capability (N&P)	Only possible with chemical addition	Superior to MLE and requires no chemical addition
Energy efficiency	X	Consumes 30-40% less compared to X of MLE
Sludge quality	Relatively poor settling sludge. Coagulant must be added to improve sludge settling properties.	Higher settling sludge attributable to size and density of the granules

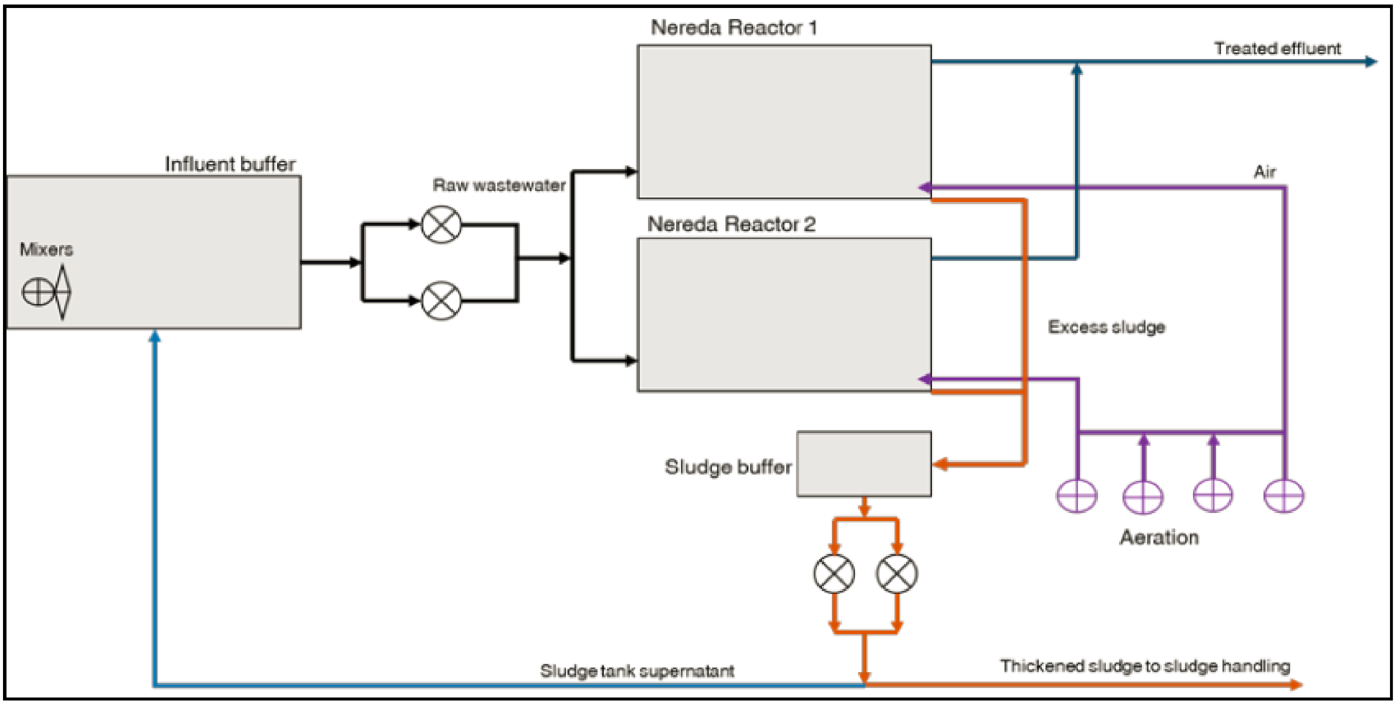

Figure 3: Nereda typical Process Flow Diagram

3.4 Financial implications and overall comparison

Based on the proposal dated 13 July 2018 compiled by WEC Projects (Pty) Ltd for eThekwini Municipality, the estimated cost for the installation of 12.5 MLD plant is **R 55 350 240.00.** PES estimated the cost of constructing a 12.5MLD MLE plant with P chemical removal to be **R 61 663 286.00.** Based on financial implications and comparison based on Table 2 above, Nereda appears to be a more favourable option for the 12.5MLD Tongaat WWTW upgrade. Despite Nereda seemingly a better option, PES still recommends MLE with P chemical removal based on the following challenges associated with Nereda option: -

- The procurement process will be challenging, take longer than normal procurement processes and anticipated to trigger Public-Private Partnership (PPP) model.
- PPP model is unlikely to be an economically viable option for a plant of this size, i.e. 12.5MLD
- Performance on challenging wastewaters is unknown.

4. Dewatering Plant Concept Design

The dewatering system is currently running intermittently. This is due to various mechanical and electrical related challenges coupled with the dewatering technology installed and aging infrastructure. Solids accumulation has been a result with effluent quality compliance deteriorating and increased electricity (aeration) and disinfection (chlorine gas) operating costs.

4.1 Dewatering Technology Selection

Table 1: Sludge Dewatering Technology Matrix

Dewatering Technology Matrix*				
		Option A	**Option B**	**Option C**
Key Factors	**Units**	**Solid Bowl Decanter Centrifuge**	**Belt Press**	**Screw Press**
Capex	%	100	100	120
Footprint	%	80	120	100
Dryness performance	%	100	90	100
Operation		continuous	continuous	continuous
Polyelectrolyte	kg/tDS	X	0.5X	X+2
Power	kWh	Y	Y/10	Y/10
Process Water	m3/h	0.25Z	Z	0.5Z
Recovery	%	95	90	90
Maintenance intervals	h	3000	6000	9000
Operator Input	%	2	65	5
Maintenance costs p.a.	%	100	100	75
*Sourced from a reputable supplier and augmented accordingly				

Centrifuge dewatering technology is the technology of choice. These are the capabilities and advantages:

- Yields higher solids cake – potential for reduced transportation costs than other technologies
- Cleaner and neater to operate
- No water requirement during dewatering which means continuous uninterrupted production. Washing is done at the end.
- Can be fed sludge directly without thickening
- Smaller footprint
- Lower installed cost
- Higher power consumption however modern designs have shown significant improvement with regards to power usage compared to older centrifuge technology designs.
- Best suited for the application – Waste activated sludge dewatering. Technology also proven to work well with sludge produced from the treatment of sewage that contains a portion of industrial influent.
- Full automation is possible
- Technology would be adaptable to the NDEBPR upgrade recommendation.

4.2 Poly dosing system

Powder poly shall be the choice of poly system for the following reasons:

- Higher active content than liquid poly
- Reduced logistics costs and onsite space requirements ultimately reducing the total operating cost of system whilst simultaneously considering the generally higher kg poly per dry ton solids treated ratio common to centrifuge dewatering technology.

- On condition that the dry poly and feeding system is in a moisture controlled environment – this will increase initial investments but will provide significant savings and problems in the future.

Additional notes on the powder poly system

- The dry poly feeding system must negate effects of humidity – modern system designs include a heated system. Another option is a venturi feed system in order to prevent caking of poly. Options with regards to manufacturers (what is out on the market) must be presented by PSP.
- Redundancy on the system (duty / standby)
- Continuous system is preferred but batch system should also be considered.

4.3 Dewatering System Sizing

4.3.1 Centrifuge Sizing

The dewatering system was sized according to existing and optimal operation of the extended activated sludge reactor. Wasting rate was calculated from the equation below based on the classic mass balance on the activated sludge process.

$$Q_W = \frac{V.X_{MLSS}}{SRT.X_{RMLSS}}$$

Where:
Q_W = Wasting rate, m^3/d
V = activated sludge reactor volume, m^3
X_{MLSS} = Mixed liquor suspended solids concentration in the activated sludge reactor, kg/m^3
X_{RMLSS} = Return Mixed liquor suspended solids concentration in the clarifier underflow, kg/m^3
SRT = sludge retention time / sludge age, d

Inputs:
V = 8000 m^3 (volume sourced from design report)
SRT = 20 d, lower bound of the range for extended activated sludge reactors (20 – 30 d) yields higher wasting rate.
X_{RMLSS}/X_{MLSS} = Ratio based on operation data i.e. 1.5 which yields a higher wasting rate requirement and better reflects sludge settling characteristics.
t = expected operational time of unit, 10h which accommodates the start-up and shut-down periods.

Outputs:
Q_W = 27m^3/h with a solids loading ranging between 162 and 243 kg/h for 6 and 9g/l X_{RMLSS} respectively.

4.3.2 Poly System Sizing

The poly system sizing was based on the following:

- Poly/dry ton solids ratio of 10 kg/dry ton solids
- A minimum and maximum poly make-up concentration of 0.15 and 0.2% TS respectively
- Mixing system retention time of 2.5h as recommended by literature for optimal "poly unwinding time"

Outputs:

- Minimum volume of poly mixing tank – 6000 l
- Maximum water requirement – 3m^3/h
- Active poly dosing requirement – 4.5 kg/h (45 kg/d)

The poly system must be in a separate room that is moisture controlled.

4.4 Ancillaries

- PD pumps to replace conveyors
- Silo with a 3 day capacity to be part of installation (silos similar to that installed at the KwaMashu WWTW)
- Full system automation is required

- Odour control system
- PSP shall provide input to the above items.

4.5 Scope of Work Summary: Dewatering Plant

Resolve the current dewatering and second class water system but with provision for a 12.5 ML/d upgrade.

- 3 new 55 m^3/h solid bowl decanter centrifuges in duty /duty /standby configuration to meet existing and future requirements.
- 2 poly dosing / mixing systems in duty /standby configuration
- PD and sludge feed pumps in duty/standby
- 2 sludge silos installation for easy removal of sludge via trucks
- Full automation with flow and mass flow devices on each process stream
- SCADA / PLC upgrade
- Water supply line review and upgrade
- Building revamp / upgrade with odour control
- Interim dewatering equipment whilst building is being revamped.

It is possible that there will be additions to the list above when the PSP is appointed and detailed designs are completed.

4.6 Proposed Dewatering Plant Layout

Figure 1: Proposed Layout

5. Second Class Water System

Part of the project will be to upgrade the second class water system for the following reasons:

- Washing of the centrifuge as per wash cycles (maintenance) – instead of using fresh water
- Cleaning of the dewatering facility
- Usage at other parts of the plant

6. General Instrumentation and Control Philosophy

Essential Requirements:

- Flow meters must be installed to measure incoming raw sewage and final treated effluent as required by authorization.
- Mass flow meters must be installed on all process lines associated with dewatering.
- All of the signals from the abovementioned instrumentation must be sent to a localised PLC with HMI and also be programmable from the Control room SCADA system.
- Full automation (especially Head of Works, Activated Sludge Process, Dewatering Plant and Second Class Water Plant)

7. Preliminary Design Summary

Table 3: Preliminary Design datasheet

Preliminary Design Specifications				
Process	**Technologies / Parent component**	**Component**	**Sizing / Requirements**	**Units**
Head of Works (screening)	Mechanical front-raked screens	No. of screens (8mm-10mm fine screens)	2	-
	Washing and compacting	Hydro-conveyor - 10m	1	-
		Spiral conveyor - 10m	2	-
		No. washer compactors	2	-
		Waste bin and dolly system	2	-
		Sluice gates	8	-
		Gantries	4	-
	Instrumentation	No. of electrical panels with differential level control	2	-
Head of Works (Grit Removal)	Induced vortex grit removal	Grit separators	1	-
	Washing and dewatering	Grit washers with dewatering	2	-
		Sluice gates	4	-
		Waste - bin and dolly system	2	-
	Instrumentation	No. of electrical panels with differential level control	2	-
Activated sludge Reactor	MLE with chemical removal (Extended) - Nereda to be considered by the consultant at detailed design stage	Reactor volume	13 630	m^3
	Diffused aeration	Oxygen requirements	6 431	kg/d
Secondary settling	Circular tanks	No. of clarifiers	3	-
		Surface area per clarifier	350	m^2
		Side wall depth	5	m
		Minimum SST diameter	22	m
Sludge Dewatering	Solid bowl decanter	Machine size	55	m^3/h
		No. if units	3	-
		Mode of operation	Duty/duty/standby	-
	Poly makeup and dosing system	Poly to dry ton	10	kg poly/dry ton
		Poly type	Powder	-
		Active poly dosage	4.5	kg/h
		Max water requirement	3	m^3/h
		Minimum mixing tank volume	6000	L
		No. of mixing tanks	2	Duty/standby
	Sludge silos	No. of units	2	-
		Size	160	m^3
Second class water system	System that extracts, filters, distributes and stores secondary effluent	Overall WWTW treatment requirement (to be correctly sized when final designs are completed)	TBD	TBD

8. Total Expenditure

Total estimated expenditure for phase 1 is R98m, see breakdown below: -

Equipment costing		
Upgrade capacity	- 12.5	ML/d
Preliminary treatment	3.3025	MG/d
(Grit Removal and Flow Measurement) **Activated sludge reactor Costs**	63000	$
Activated sludge reactor Diffused aeration costs **Recycles**	14000 494405. 450000 25000	m3 ft3 $ $
Recycle pumping (A+S) Costing **Dewatering**	20 190000	MG/d $
Flowrate for 1 centrifuge Number of centrifuges Total cost of facility **Total construction cost** **Engineering costs** **Legal and admin costs** **Other costs** **Total CAPEX 1971**	55 14529 10 150000 3 450000 728000 100000 15000 210750 1053750	m3/h g/d gpm $ $ $ $ $ $ $
Indices 1971 2017 **Current CAPEX** **Dollar to Rand**	 15.1844 100 6939688. 14.08	 % % $ R/$
CAPEX ZA	**98**	**Rm**

9. Approval of Scope

Process	Sub-process	Options	PES's Recommendation	Client's Preferred Option
1. Head of Works	1.1 Flow Equalization Basin	1.1.1 In-line configuration		
		1.1.2 Side-line configuration	√	
		1.1.3 Other		
	1.2 Odour control	1.2.1 Trickling Biofilter	√	
		1.2.2 Granular Activated carbon		
		1.2.3 Other		
	1.3 Screening	1.3.1 Mechanical front-racked screens	√	
		1.3.2 Mechanical step screens		
		1.3.3 Other		
	1.4 Grit Removal System	1.4.1 Constant velocity grit channels		
		1.4.2 Gravity Vortex Grit chambers		
		1.4.3 Induced Vortex Grit Chambers	√	
		1.4.4 Other		
2. Activated Sludge Process	2.1 Biological Reactor	2.1.1. MLE with P Chemical Removal	√	
		2.1.2 BNR		
		2.1.3 Nereda		
		2.2.4 Other		
	2.2 Aeration system	2.2.1 Diffused aeration	√	
		2.2.2 Surface aeration		
		2.2.4 Other		
	2.3 Secondary settling	2.3.1 Circular tanks	√	
		2.3.2 Rectangular tanks		
		2.3.4 Other		
3. Sludge Handling Process	3.1 Dewatering	3.1.1 Solid bowl decanter	√	
		3.1.2 Belt Press		
		3.1.3 Screw Press		
		3.1.4 Other		
	3.2 Poly makeup and dosing system	3.2.1 Powder Poly	√	
		3.2.2 Liquid Poly		
		3.2.3 Other		

Client's Signature:……………………… Date:…………………….

Note: PES shall not be held liable should any of the following events occur: -

1. The client selects an option that was not recommend by PES.
2. A multidisciplinary team is not constituted to execute the project.
3. The project is not executed according to the original scope and specification.
4. The original PES's proposal is changed without a written consent from PES.