AN INNOVATIVE APPROACH FOR THE OPERATION AND MAINTENANCE OF ZEERUST WASTEWATER TREATMENT WORKS

By Casper Coetzer and Hendrik Honey

ABSTRACT

The successful and efficient treatment of municipal wastewater to ensure continuous compliance with legislative requirements at the lowest possible life cycle cost depends both on the suitability and durability of capital infrastructure for the specific type and quantity of wastewater, as well as the long term operation and maintenance of the processes and infrastructure.

Professional Engineering Service Providers have traditionally mainly been involved with the design and construction stages of wastewater infrastructure. At Zeerust Wastewater Treatment Works (ZWWTW) the Consultant was appointed by the Ngaka Modiri Molema District Municipality (NMMDM) to undertake the professional services for refurbishment and upgrade, as well as the Operation and Maintenance of the works for a period of 6 months. The first phase focused on the repairing and replacement of infrastructure to obtain the outcomes indicated above. Various contractors were appointed to carry out this phase, while Water Solutions Southern Africa(WSSA) had been appointed to carry out the operation and maintenance (O&M) requirement and to train operational staff.

At the end of the six month period the effluent quality complied with all effluent quality standards stipulated by the Department of Water Affairs and the works was handed to the NMMDM in a very good condition with all process units functioning efficiently and comprehensively. Due to various site specific reasons, the six month period was insufficient to provide comprehensive accredited training and was therefore restricted to site specific matters.

1. INTRODUCTION

The ZWWTW is located in the town of Zeerust in the North West Province. The ZWWTW falls under the NMMDM's jurisdiction; the NMMDM is the Water Service Provider (WSP). The ZWWTW serves the town of Zeerust, Ikageleng Township as well as an abattoir and a few other light industries in the area.

The works was built and commissioned during the 1960's and the current documented design capacity is 2.6 Mℓ/day. The works was not operating according to design, mainly due to mechanical failure of some of the equipment and due to incorrect process configurations. Also, the high organic loading sometimes experienced at the works due to flow from the local abattoir impacted on the operation of the works, resulting in a poor effluent quality.

The ZWWTW discharges its treated effluent into the Kareespruit River. At the time, the effluent discharged underwent partial treatment, and did not comply with the general limits as set by the Department of Water Affairs (DWA). Further, the Green Drop Report (2011) highlighted the ZWWTW as a critical risk and it received a risk rating of 100% in the North West Province. The Green Drop Report (2011) also indicated that the ZWWTW should remain a top priority and should receive regulatory attention from the WSP. In light of the above, the NMMDM decided to upgrade the Works in the short term to ensure compliance with effluent quality.

2. STATUS QUO AT HANDOVER

During inception it was discovered that the works was in a poor physical state with the majority of the mechanical equipment non-functional. The aeration system was in a very poor physical state and inadequate for the hydraulic and organic load that was received by the works.

The works has been upgraded several times since construction in the mid 1960's. The latest upgrading took place in the 2010/11 and 2011/12 financial years and consisted of the following:

1. The replacement of the horizontal brush aerators and mixers with:
   - Four 3.7 kW Aire-O2 mixers installed on four galvanised steel bridges
   - Eighteen 11kW Aire-O2 Aspirator Aerators installed in batches of three on six galvanised steel bridges
2. Replacement of the return sludge pumps (RAS) with two Gormann Rupp T4 pumps
3. Replacement of the waste sludge pumps (WAS) with two Gormann Rupp T3 pumps
4. Installation of flow meters at the inlet and outlet of the works
5. New mechanical step screen
6. Upgrading of the bulk electricity supply system

The upgrading and replacement of the aerators and other mechanical equipment was completed on 20 March 2012 and was funded by the ACIP programme. Since then the plant has been operated by the local municipality.

3. SCOPE OF PROJECT

A consortium of consultants and contractors, comprising The Consultant and Water Solutions Southern Africa (WSSA) took over the daily operation, maintenance and management of the works for a six month period with the objective to:

1. Build capacity within the NMMDM to take over the operations and management of the works after six months
2. Repair all the damaged and faulty mechanical and electrical equipment
3. General renovations to offices, rest rooms and security fence
4. Stabilize the works to achieve effluent standard as per original intended design
5. Prove the efficiency of the refurbished aerator system
6. Procurement of laboratory equipment
7. Develop and establish procedures and systems for the operation and management of the works
8. Employment, management and training of workers
9. Investigation and implementation of by-laws relating to sanitation.

The remainder of this report specifically focuses on items 1, 4, 7 and 8 above.

3.1 Training and Capacity Building

Initially it was intended to provide a 30-credit skills programme to provide in the need for trained and qualified operators. This was in preference to a full learnership which can take up to 2 years for a National Certificate at NQF level 2 to be completed. The 30 credits would have taken the operators to the next classification level and was realistically achievable in 3 to 4 months. Upon completion of the course the trainees would have been eligible for registrationas Class 1 operators.

Unfortunately the six-month contract proved to be too short for an accredited qualification to be obtained. This was due to unforeseen eventualities such as labour unrestand unexpected complexities in stabilising the plant which took precedence to all else. It was therefore decided that the focus of the training be on plant-specific practical training as well as occupational health and safety (OH&S) training.

The training of the temporary staff was done by the WSSA site staff while WSSA trainers visited the site for two days per month to train the WSSA site staff and the temporary staff on more advanced topics including:

1. Chlorine handling (accredited)
2. Sampling (accredited)
3. Quality monitoring (non-accredited)
4. Operation of activated sludge treatment (accredited).

A comprehensive training programme was drawn up once the qualifications and experience of the temporary staff had been established and verified by assessment on site. This programme was tailored to enable the NMMDM staff to operate the plant at the end of the 6 months, but due to the limited duration of the contract, it was not possible for the NMMDM staff to comply with the requirements of Regulation 2834. The options for the NMMDM will now be informedby the results of a Section 78 process but one of the following options could also have been selected in the short- to medium-term:

1. The contract could have been extended beyond the six month term;
2. The O&M of the plant could be outsourced via a tender process; or
3. The NMMDM could take over the O&M after the six months with a plan in place to comply with Regulation 2834 within a reasonable time.

The latter option was opted for and it is therefore assumed that the NMMDM has been in contact with the DWA to discuss how compliance will be achieved within a reasonable time.

3.2 Daily Operations

The scope of operations included the entire WWTW situated within the boundaries of the plant but excluded the networks, pump stations and all other infrastructure both upstream and downstream of the works. The following items were operated:

1. The Inlet works
2. The Biological Reactors
3. The Clarifiers
4. The RAS and WAS pump station
5. The disinfection installation
6. The sludge lagoons

The Consultant as the service provider was responsible for the following activities:

1. Provide staff, in accordance with Regulation 2834 for a Class CWWTW, to operate the works on a 24 hours per day and seven days per week basis;
2. Carry out routine inspection and maintenance limited to cleaning, greasing, oiling and inspecting of the plant and equipment;
3. Report timeously to the Client any non-emergency break-downs or potential breakdowns requiring repairs;
4. Arrange for, manage and report on repairs done under emergency breakdowns;
5. Take samples of the influent, process water and final effluent at the WWTW;
6. Take samples of the abattoir effluent weekly and ad hoc when a non-compliant discharge is suspected;
7. Take samples of the discharges of other industries and businesses when a non-compliant discharge is suspected;
8. Provide instruments and consumables to do the on-site analyses specified in the Project Specifications;
9. Do the daily control testing;
10. Handle, prepare and transport the compliance and industrial samples to a SANASaccredited or z-score compliant laboratory for analysis;
11. Keep the shift, daily and weekly records as required and provide daily and weekly reports;
12. Carry out a weekly inspection of the WWTW by a Class V Operator.

The plant was continuously operated using a four team by three shift basis in order to comply with labour legislation. The operational duties of the operator's staff included:

1. Daily cleaning of the screens
2. Daily cleaning of the detritus channels
3. Disposal of the screenings and grit by placing in trenches on site, sprinkling with lime and covering with a thin layer of soil
4. Daily cleaning of clarifier final effluent over flow channels
5. Daily monitoring of the chlorine dosing system and changing of chlorine containers when necessary
6. Ordering and management of chemicals and other consumables required for the operation of the plant
7. Visual monitoring of the influent and noting of any unusual colour, odour or contents which indicates an upstream discharge which may affect the process
8. Recording of the flow meter readings at the start and end of each shift
9. Operating and maintaining the aerators as per the training and operations manuals
10. Monitor and control sludge age in the reactors, by accurate and appropriate sludge wastage procedures, in accordance with the operating manuals
11. Resetting of electrical trips strictly in accordance with the procedures to be providedby the Engineer;
12. Emergency repairs and maintenance of equipment
13. Daily process monitoring
14. On-the-job training of the Client's staff deployed to the site
15. Record-keeping and reporting.

A condition assessment of all the mechanical equipment and infrastructure was done at the start of the project in order to draw up a comprehensive asset register to satisfy the requirements of the MFMA and the Green Drop programme.

3.3 Emergency repairs

Emergency maintenance comprised the repairs required in order for the plant to be able to operate effectively. This is work which needed to be carried out by artisans qualified in the relevant trades such as fitters, electricians and millwrights.

The bulk of the mechanical equipment at the plant had been supplied and installed by Circuit Water Engineering Equipment. To ensure that the warranty on the aerators and mixers staysintact, Circuit had to attend to any breakdowns on this equipment.

The bulk electricity supply to the WWTW is erratic and power outages occur regularly. Depending on the extent of the fault, the protection on the mechanicalequipment trips inside the electrical panels. Only a qualified electrician is allowedto open the panels and re-set the protection equipment.

To reduce the response time and to minimise the effect of power outages on the effectiveness of the plant, it was decided to enter into an agreement with a local electrical contractor to attend the major power outages.

Since Electric Town was the local agent for Circuit, it was decided to appoint them for all the emergency repair work required for the plant to be able to operate effectively.

3.4 Process and Compliance Monitoring

The consultant was responsible for the process and compliance monitoring and reporting. The monitoring consisted of the following activities:

3.4.1 Equipment performance and availability

One of the objectives for the Consultant and Circuit Water Engineering was to prove the suitability of the aeration system that was installed. The condition and availability of all mechanical equipment was daily monitored and reported. During the duration of the contract sufficient proof was established that the aeration

system is suitable for the application. For further details please refer the graphical analysis results over the six month period, at the end of the section.

3.4.2 Operation compliance monitoring

Operation systems and programmes were developed by the Consultant and WSSA for the works. This was used for daily monitoring of operations by the senior operator on the plant. A representative from the consultant performed a regular inspection and audit.

3.4.3 Process monitoring

The daily process testing was done on site by WSSA. The portable DO meter already purchased for the works was made available for the operator's use. Daily process monitoring analyses was done on the raw sewage as well as the final effluent for the following parameters: pH, conductivity, dissolved oxygen, ammonia and free chlorine.

These results were analysed by both the consultant and WSSA process experts and usedto control and adjust the process.

3.4.4 Compliance monitoring by an independent accredited laboratory

Sampling and testing of the final effluent was done by Integral Laboratories in Rustenburg. The Rustenburg facility is a satellite laboratory of Integral Laboratory which is SANAS accredited for chemistry and micro-biology. The laboratory hasrecently relocated to Rustenburg and participates in inter-laboratory proficiency testing while re-instating its SANAS accreditation.

Initially the compliance monitoring was done on grab samples. In order to improve the accuracy of the monitoring results, permission was obtained from the NMMDM to procure composite sampling equipment. The following compliance monitoring analyses was done on the untreated sewage and final effluent: pH, conductivity, ammonia, nitrate, ortho-phosphate, chemical oxygen demand (COD), mixed liquid suspended solids (MLSS), Total Kjeldahl Nitrogen (TKN), free chlorine, faecal coliforms and *E.Coli*.

Results of the most important effluent parameters are indicated in Figures 1 to 5 below. These graphs clearly show the steady improvement in effluent quality, up to the point where all parameters complied with the required standards when the works was handed back to the NMMDM in March 2013.

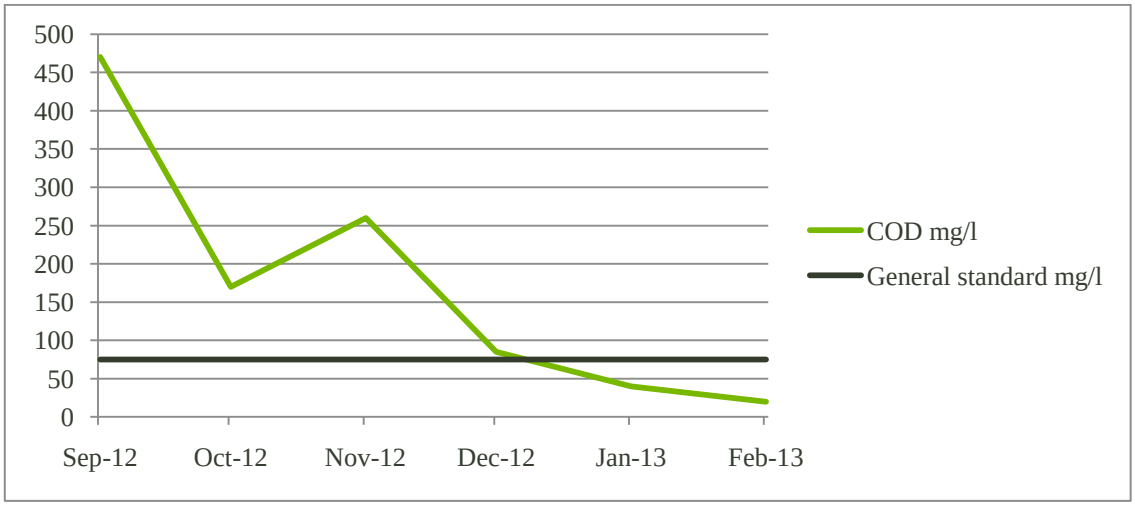

Figure 1: Effluent COD values

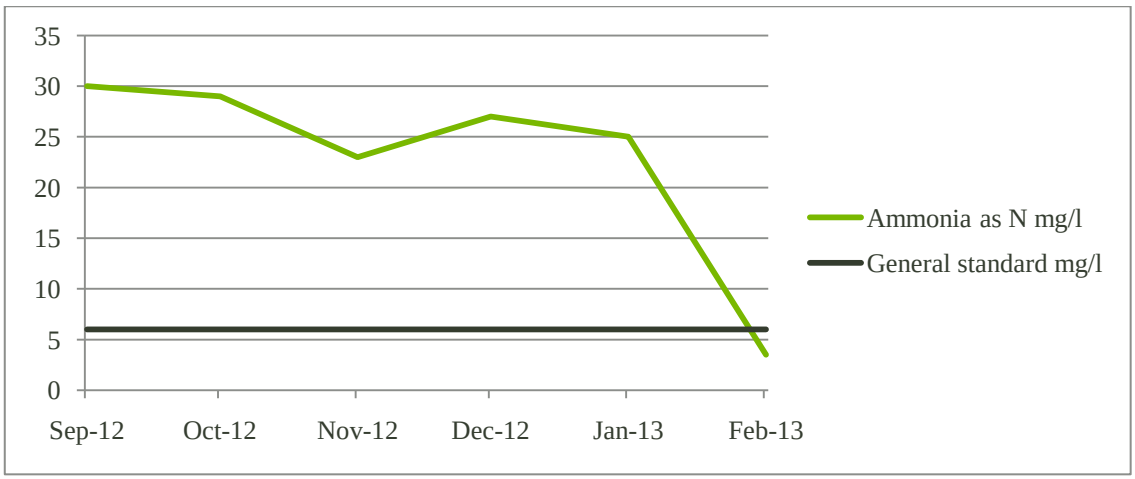

Figure 2: Effluent Ammonia values

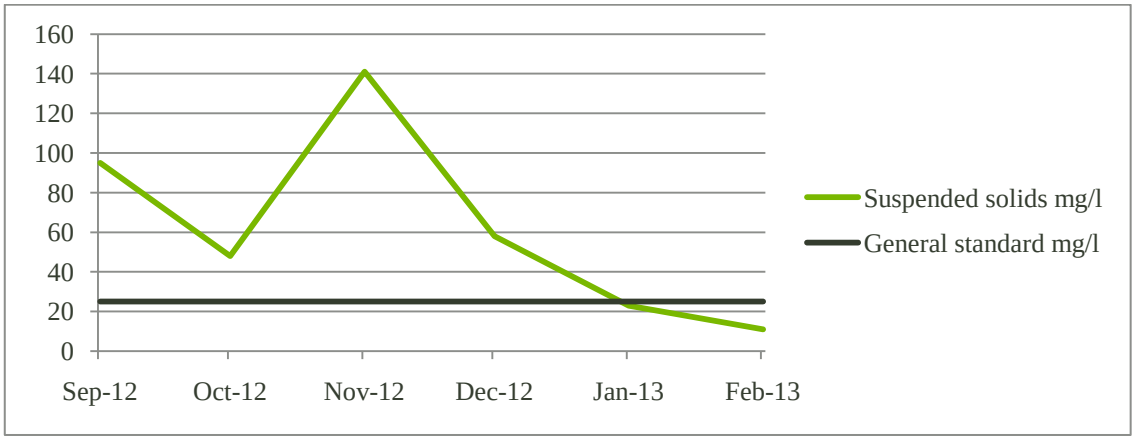

Figure 3: Effluent Suspended Solids values

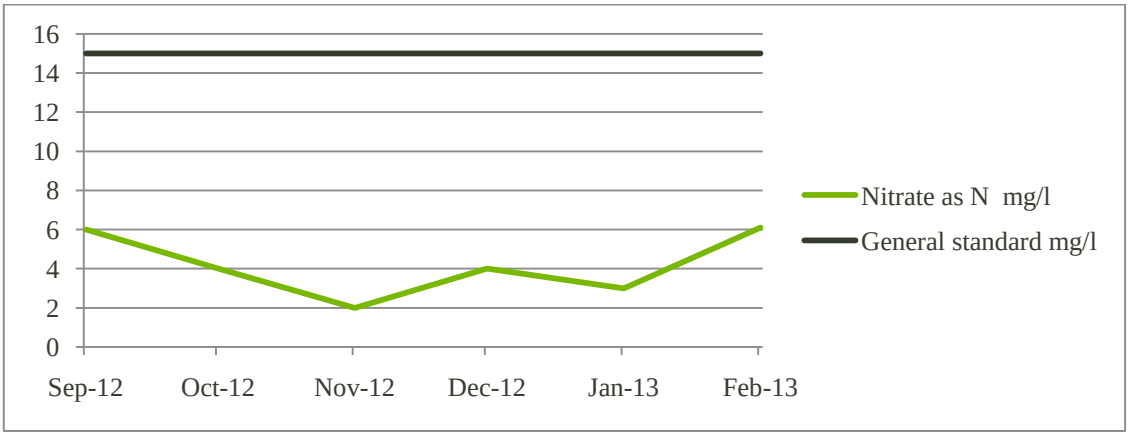

Figure 4: Effluent Nitrate values

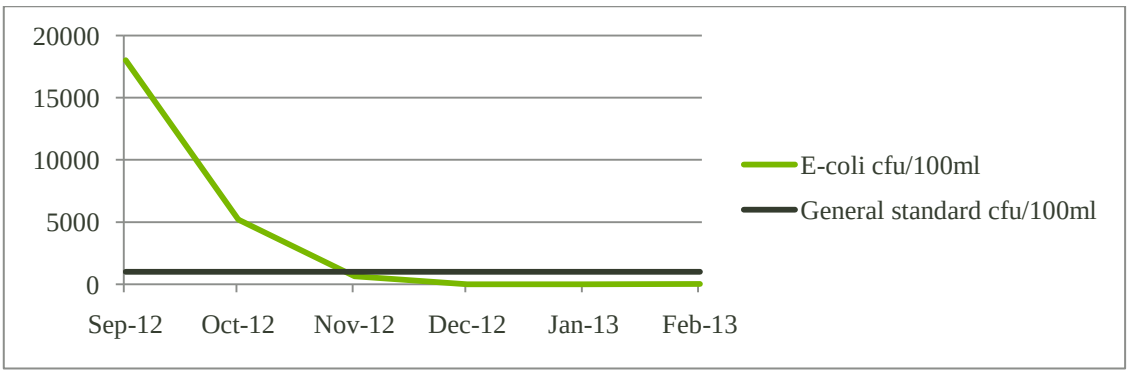

Figure 5: Effluent *E.-coli* values

Photos 1 to 4 show the visual improvement in effluent quality before and after the refurbishment and O&M periods.

Photos 1 and 2: Visual improvement in the effluent quality between October 2012 and April 2013 at the overflow of the secondary settling tanks

Photos 3 and 4: Visual improvement in the effluent quality between October 2012 and April 2013 at the overflow of the chlorine contact tank

4. CONCLUSION

The objectives of the appointment to operate and maintain the Zeerust WWTW for a period of six months were:

1. To re-commission all the equipment and stabilise the works
2. To proof the effectiveness of the aeration equipment
3. To put in place procedures and systems for the operation and maintenance of the works.

The re-commissioning of all the equipment and stabilization of the plant was achieved successfully, and the effectiveness of the aeration equipment is evident in the excellent effluent results obtained after a relatively short period. The effluent quality complied with all effluent quality standards stipulated by the DWA and the works was handed to the NMMDM in a very good condition with all process units functioning efficiently and comprehensively.

Unfortunately, due to the limited duration of the contract it was not possible to train NMMDM staff to comply with the requirements of Regulation 2834. One option available to the NMMDM would be to appoint a consultant for the O&M of the plant, and continue to train a core group of staff to eventually oversee not only the ZWWTW but also other Works within the NMMDM's jurisdiction. This process should take anything between 4 and 6 years to reach full compliancy in accordance with the Regulation 2834.

The initiative by NMMDM may therefore be regarded a prototype for other municipalities to follow. Increasing the 6 months O&M and training period to at least a 12 to 18 months period, however, requires consideration.

Finally, the consortium involved with this project are grateful to have been given the opportunity to undertake the project and acknowledge the input of many parties in making this undertaking a success, especially the input and support provided by the PMU department of the NMMDM under the leadership of Mr SB Sehole.

REFERENCES

Department of Water Affairs 2011.Wastewater Service Regulation.Green Drop Report.