WORCESTER WASTEWATER TREATMENT WORKS: *STATUS QUO ASSESSMENT 2005*

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11.1 BACKGROUND

The treatment capacity and effluent quality of the Worcester Wastewater Treatment Works (WwTW) has been of particular concern since 1984. Various proposals to provide for upgradings of the works have been submitted in the past by officials to the Local Council. As a result, a previous upgrading was done in 1996.

Currently the quality of the effluent from the Worcester WwTW is not according to the Standards as stipulated by the Department of Water Affairs and Forestry (DWAF). In addition, the operation of certain units of the works is critical, e.g. the treatment of instantaneous mass inflows from Rainbow Chickens and the breakdown of certain mechanical equipment. The resulting overload can not be handled by the works in the short term with resulting problems such as odours, operational difficulty and effluent quality not complying with the Standards.

A further problem is that the abstraction point of the Worcester East Irrigation Board (IB) from the Breede River is located downstream and very close to the outlet of the Worcester WwTW to the Breede River. Since the water abstracted by the Worcester East IB is also used for drinking water purposes the effluent quality is of serious concern BKS (Pty) Ltd Engineering and Management (BKS) was subsequently appointed by the Breede Valley Municipality in July 2005 for an evaluation of the hydraulic and organic capacity of the WwTW. The scope of work was aimed to include:

- Flow projections.
- Hydraulic evaluation.
- Process evaluation.
- Condition survey.
- Rehabilitation and upgrade recommendations.
- Cost estimate for upgrading and refurbishment.

The Worcester WwTW was constructed in 1955 and originally consisted of a biological filtration system with a capacity of 8 M_/d, which was extended to 16.4 M_/d and again to 20 M_/d. This system was supported by primary settling tanks and a clarifier. Sludge handling was accommodated by anaerobic digesters and sludge drying beds.

Two planning reports were previously completed in 1978 and 1990, respectively, to address wastewater treatment in Worcester. The subsequent 1996 upgrading allowed for an average design capacity capable of handling an Average Dry Weather Peak (ADWP) of 28.2 M_/d as determined for the year 2010. This upgrading included the construction of a new inlet works, an activated sludge plant, two new clarifiers and three sludge dams.

Currently the system is a combination of biological filtration and activated sludge with sludge handling facilities for both systems. After a process of maturation and chlorination treated sewage is released to drain towards the Breede River.

11.1.1 FLOW PROJECTIONS

The present Peak Dry Weather Flow (PDWF) for Worcester is approximately 21 271 k_/d, or roughly 61.7% of the Average Annual Daily Demand (AADD). Approximately 89% of this is a direct contribution from connections to the sewerage system and the other 11% is contributed to groundwater infiltration.

Potential areas for future developments were identified in consultation with the Breede Valley Municipality's town planning consultants during a previous compilation of a Sewer Master Plan. Typical unit water demands were assumed for the future development areas, based on the statistics obtained from an analysis of the present water demands in Worcester and in consultation with the Breede Valley Municipality, to determine potential water demand.

According to the Sewer Master Plan the future AADD (2013) of Worcester is approximately 45 243 k_/d, which is approximately 63 of the future AADD. The Sewer Master Plan's future planning to the year 2013 (10 year period) indicates an increase in flow to 28.8 M_/d.

Assuming an annual average daily flow of 21.6 M_/d for 2005 and a flow rate increase of 3.45% per year, Table E.1 summarises the estimated future flows up to 2025.

Table E.1: Estimated future annual average daily flows at the Worcester WwTW

Year	*2005 Current*	*2010 + 5 years*	*2015 + 10 years*	*2020 +15 years*	*2025 +20 years*
Flow rate (Mℓ/d)	*21.6*	*25.6*	*30.3*	*35.9*	*42.6*

Hydraulic and process evaluation

Based on an analysis of flows within the treatment works it follows that the unfiltered Chemical Oxygen Demand (COD) of the raw sewage is higher than for normal domestic sewage, while the filtered COD is more in line indicating that the suspended solids is a main contributor to the higher values. The concentrations of the COD, suspended solids and nitrogen constituents of the raw sewage are higher than used in the previous designs with the result that the loadings to the plant are higher at the same flows compared to that of the previous designs.

The current applicable Effluent Standard for the Worcester WwTW is the Gazetted 1984 General Standard, while the General Limit given in the General Authorisation of 1999 will apply for any upgrading and/or extensions. Table E.2 summarises a comparison of the average latest (August to July 2005) treated effluent quality obtained from the Worcester WwTW with the General Standard and General Limit in terms of the most important constituents.

Table E.2: Comparison of effluent standards

Constituent	General Standard (current)	General Limit (future)	Treated Quality
COD (mg/ℓ)	75	75	80
SS (mg/ℓ)	25	25	24
NH_3 (mg/ℓ)	10	3	27
Nitrate/Nitrite (mg/ℓ)	-	15	9
Ortho-Phosphate (mg/ℓ)	-	10	13
Faecal Coliforms per 100 mℓ	0	1 000	-

The treated effluent complies with the suspended solids (SS) and mostly with the COD (not shown) Standards, but not with the Ammonia (NH_3) Standard. Ortho-Phosphate is unexpectedly lowered in the plant. Any extensions or upgrading of the plant will affect the new General Limit, implying that nitrogen and phosphorus will need to be lowered in the plant.

The Operation and Maintenance Manual states the hydraulic capacity as 28.2 M_/d, 55.8 M_/d and 69.8 M_/d respectively for the ADWF, PDWF and the Peak Wet Weather Flow (PWWF). The design loadings for the plant are stated as 22 478 kg COD/d and 1 863 kg N/d. Comparing these values with current flows and loads, it indicates that the plant is hydraulically still underloaded. For COD loading, it is, however, overloaded, while underloaded for nitrogen.

The design of the existing works was done on the basis of treating 40% of the incoming flow via the biofilters, after primary settling, whereafter treatment in the activated sludge (AS) system, together with the 60% of flow diverted directly to the AS.

The AS system is based on a Modified Ludzack-Ettinger (MLE) process to remove COD and nitrogen by nitrification and denitrification. The biofilter system would mainly remove COD, but could also nitrify, thereby lowering ammonia (design basis not known).

A detailed water quality analysis indicated that the plant sufficiently removes COD, but does not nitrify (remove ammonia). This observation was confirmed by the process evaluation calculations and modelling done. It may, however, be debated that it was stated above that the design COD load is exceeded, while the nitrogen load is still within the design range. The explanation is that nitrification is generally the limiting process step, but that COD is preferentially removed in a biological system and that this process needs to be completed before nitrification can take place. Should the COD removal process thus be stressed, then the nitrification process is affected. It is interesting that, although the MLE process does not particularly remove phosphorus, this plant is very effective in removing phosphorus. This is again a result of the overloaded COD removal process resulting in the designed anoxic zone acting as an anaerobic zone and with a shortened sludge age, the process operates as a biological phosphate removal plant.

The conclusion is therefore that the plant is currently operating in an overloaded mode and in need of urgent rectification.

Due to the abovementioned outcome that the plant is operated in an overloaded mode, the process capacity was evaluated for different possible operations. The different options evaluated were:

- Option 1: AS with raw sewage as feed.
- Option 2: AS with settled sewage as feed.

- Option 3: AS with biofilter effluent as feed.
- Option 4: AS with mixed feed to comply with General Limit.
- Option 5: AS changed to Phoredox process with mixed feed to comply with General Limit.

The conclusions from the evaluation are:

- Option 1 can treat 2.7 Ml/d with treated COD too high.
- Option 2 can treat 6.2 Ml/d with phosphate too high (within General Standard).
- Option 3 can treat 22 Ml/d with phosphate too high (within General Standard).
- Option 4 can treat 4.5 Ml/d with effluent quality complying with the General Limit.
- Option 5 can treat 5.2 Ml/d with effluent quality complying with the General Limit.
- The existing plant can treat the current inflow to the General Standard by diverting all the flow through the primary settlers and biofilters. The plant will be operating at full capacity and will need to be extended.
- The plant can treat approximately 5 Ml/d to comply with the General Limit and utilizing biological nutrient removal.
- The plant can treat approximately 21 Ml/d to comply with the General Limit by adding chemical phosphorus removal.

11.2 RECOMMENDATIONS

11.2.1 FUTURE EXTENSIONS

The design period for an extension to the Worcester WwTW should be in the order of 10 (not less) to 15 years. Any extension should enable the plant to treat between 30 and 40 Ml/d. Noting that an extension to the plant will affect the new General Limit Effluent Standard to all of the treated effluent at the wastewater treatment site, it implies that, should the existing plant be used or part of it, then changes will need to be made to ensure that the treated effluent complies with the new General Limit. A number of different extension solutions are, however, possible.

It is recommended that a biological nutrient removal AS extension of 15 Ml/d be done as soon as possible. This will enable the plant to treat 27.5 Ml/d (+7.5 years) with a minimum amount of chemical used to comply with the General Limit by treating 7.5 Ml/d via the biofilters. Should it be possible to get a small relaxation on the phosphorus Standard, then chemical addition will not be required due to the dilution from the biologically removed phosphorus stream. The plant will also be able to treat the full flow up to approximately 36 Ml/d (+15 years) to the General Limit, although by dosing chemical for 21 Ml/d of the total. Should another 15 Ml/d extension train be added in the future, then approximately 35 Ml/d (+14 years) effluent can be treated without chemical addition and 42.5 Ml/d (+20 years) with minimum chemical phosphorus removal.

The logical solution is to design for two 15 Ml/d biological nutrient removal trains, while constructing only one as a first phase and the second train as a second phase at a later stage. As a first step, however, it is recommended to confirm the appropriate extension size and combination by doing a cost comparison and taking operational costs into account. The influence of industrial effluents and the evaluation of on site treatment should form part of this first step investigation/preliminary design.

A preliminary cost estimate for a 15 Ml/d extension is in the order of R 45 million.

11.2.1.1 SLUDGE HANDLING

An extension to the works will result in additional sludge. The suggested treatment method thereof would be purpose designed open sludge dams to treat both the primary and activated sludges. This solution is very cost-effective, process successful and ideal due to the available land area next to the works. One of the existing sludge dams can be used and changed to a new design, which in area would be sufficient for a 30 Ml/d plant. Should this route be followed, then the digesters may be decommissioned with no need to be refurbished. This will result in only one sludge point of operation and avoid the relative complex operation of sludge digesters.

The sludge dam operation will be very similar to that of the existing dam system with supernatant decanted for recycling. Sludge will, however, be withdrawn from the dam to be dried on drying beds. The supernatant will need to be recycled back to the inlet, but may be treated first for phosphorus removal. This decision will form part of the design phase for an extension.

The drying beds are currently being extended and will need evaluation during the design phase of the extension of the treatment plant.

11.2.1.2 INTERIM SOLUTION

The proposed first phase extension is estimated to take two to three years to complete while plant operation is stressed.

The plant will, however, need to produce treated effluent to the General Standard up to the point when the new extension is operational. Phosphorus removal will thus not be required and the full flow can be diverted via the primary settlers to the biofilters and then to the AS system. This operational mode should produce treated effluent complying with the General Standard until commissioning of a new extension. All the primary sludge will, however, not be able to be treated in the digesters, even when refurbished.

It is recommended to construct the future sludge dams as an interim measure together with the planned refurbishment phase. A preliminary cost estimate for the construction of the dams is R 2.5 million.

11.2.1.3 EMERGENCY MEASURES

Primary sludge handling is currently an emergency due to the capacity and the partially operational status of the digesters. As an emergency solution, it is suggested that all the sludge be directed to the existing sludge dams. Two of the three existing dams should be used continuously after changes to the inlet pipe work have been done. A specific operational method will be required and instructed. This could be based on the following actions:

- Rainbow Chicken effluent
  - Fat needs to be removed at the abattoir and spillages can not be accepted.
- Primary sludge
  - Primary sludge from the primary settlers may be pumped to the anaerobic digesters at the highest possible concentration. This will give a total retention time of less than 10 days in the digesters. The digesters will only affect the first two steps in anaerobic digestion, hydrolysis and acidogenesis, because of nonheating.
  - From the digester the mixed, acid formed sludge should be pumped to the sludge dams for stabilisation together with the waste sludge from the activated sludge system.
  - Records of flows and loadings should be kept and analyses done on the feed and effluent from the digesters).
- Waste activated sludge

- The waste activated sludge should be wasted directly to the sludge dams together with the primary sludge from the anaerobic digesters.

- Sludge dams
  - The two existing used sludge dams need to be modified as an emergency measure to handle the partially anaerobic digested primary sludge together with the waste activated sludge. Only one dam may be used, but should then be carefully monitored to change the operation in time if required.
  - The sludge needs to be fed to the dams from the bottom at different points. Feeding points should be a maximum of 50 m apart, starting with 25 m from the dam wall. The existing dams are approximately 200 m long, giving four feed points spaced over the length of the dam.
  - Feeding should be sequential on a daily basis, starting at one end and skipping the next feed point, which is then used for the next round. If two dams are used, feeding should be done in series from the one dam to the second.
  - Any floating material should be hosed down to let it sink.
  - The sludge dams need to be monitored, taking samples opposite the feed points. Analyses to be done include pH, volatile acid and alkalinity

11.2.1.4 REFURBISHMENT OF EXISTING PLANT

Considering the condition assessment and taking the process evaluation into account as well as the recommendations for the interim and future solutions, the existing plant will be affected as follows :

- The old inlet works and the digesters with associated equipment will become obsolete.
- The new inlet works, primary settlers, biofilters, AS, secondary settlers, maturation ponds and chlorination, and the sludge dams, will all be used in the interim and probably be reused with a new extension.

These recommendations have a direct impact when considering the findings of the condition assessment of the existing plant and to a large extent determine critical priorities in terms of replacement and/refurbishment of such plant.