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Dear Bill

Sludge Survey Report - Martinborough and Featherston WWTP's

1 Introduction

Wairarapa District Council has commissioned Opus International Consultants to investigate the following for both the Martinborough and Featherson WWTP ponds:

- Provide an opinion on the sludge survey results supplied by Conhur with respect to validity of methodology and results;
- Determine what effect the sludge in the ponds is having on the pond effluent quality;
- Estimate when pond desludging might be required.

The assessment we have provided below is based on the information provided in the Conhur reports (reference 1&2), flow and load summaries, and our knowledge of pond systems.

2 Design Limits For Facultative and Maturation Ponds

The following design limits and conditions are sourced from Shilton (reference 3).

2.1 Minimum Hydraulic Retention Time (HRT)

The ability of a facultative or oxidation pond to remove contaminants decreases as the HRT decreases unless there is some other intervention to replace the capacity lost. Below a certain HRT, the pond will fail to operate. This point is called the "minimum HRT".

2.1.1 Facultative Pond

For facultative ponds, the minimum HRT for pond temperatures below 20°C is approximately 5 days and above 20°C, 4 days.

2.1.2 Maturation Pond

For maturation ponds the minimum HRT for pond temperatures below 10°C is approximately 5 days and above 10°C, 3 days.

The HRT in the first maturation pond must not exceed the HRT in the facultative pond.

2.2 Maximum/Design Surface BOD_5 Load

There is also a theoretical maximum BOD_5 loading to a given pond for a given treatment objective to be met. If the BOD_5 load entering the pond exceeds the maximum permissible surface BOD_5 load, the effluent quality is likely to start to deteriorate and as the load increases further the pond may fail and discontinue acting as a facultative/maturation pond. The pond may become anaerobic and cease to operate as a facultative/maturation pond. The maximum/design surface BOD_5 load is temperature dependant.

2.2.1 Facultative Pond

The theoretical maximum/design surface loading that can be applied to a facultative pond can be calculated using the equation:

$$\lambda_s = 350(1.107 - 0.002T)^{(T - 25)}$$

For example, at a temperature of 8°C the max surface BOD_5 load for a facultative pond is 80kg/ha/d whereas at 24°C the max permissible surface load is 331kg/ha/d.

2.2.2 Maturation Pond

The surface BOD_5 loading applied to the first maturation pond must not be greater than 75% of the surface load applied to the preceding facultative pond, that is:

$\lambda_{s\,(m1)} < 0.75.\lambda_{s(f)}$

3 Martinborough Pond

3.1 Discussion - Conhur Sludge Survey Methodology and Results

As discussed in the “Introduction” section above we have reviewed the Martinborough and Featherston Conhur reports with respect to the sludge survey methodology they used and the results provided.

The dry solids (DS) percentage of the primary pond sludge samples collected by Conhur varied between from 3.72% and 6.39%.. This range is lower than what we would expect from a primary oxidation pond. We would have anticipated more like 7-10% depending upon where in the pond the samples are taken (eg grit raises percentage at inlet end).

Conhur stated in their report that, “The retrieval of intact, undisturbed insitu sludge samples from ponds is a difficult process and does not provide 100% accurate results. This is a true statement, and for the Martinborough samples we believe that some form of error has affected the accuracy of the result, that is, the results are lower than expected.

It is possible that the bottom sludge was not represented accurately. The bottom sludge will have the highest DS content, therefore if the sample does not include the bottom sludge the DS result for each sub-sample will be less than it should be.

The sludge survey at Martinborough was carried out on a windy day (refer to p3 of the Conhur report). The wind may have affected the accuracy of the results. Perhaps the sludge/water interface was difficult to define under those conditions and too much of the water fraction was included in the sample?

It is common for sludge surveys to underestimate the amount of sludge that is actually contained in the pond.

3.2 Sludge Effect on Effluent Quality

The following calculations have been undertaken to check that the pond is not operating outside the design limits.

3.2.1 HRT Input Data, Calculations and Results

The following data is sourced from an extract from reference 4:

- Average plant influent flow for Martinborough is approximately: 490m^3/d.
- Peak flow is approximately: 2300m^3/d.

- Total pond volume: 23,000m^3
- Hydraulic retention time (HRT) for average flow conditions (zero sludge depth): 47days.
- Hydraulic retention time (HRT) for peak flow conditions (zero sludge depth): 10days.

Based on the "Conhur – Martinborough Oxidation Pond Sludge Survey" report:

- Average sludge depth in the pond is: 0.19m
- Total sludge volume in the pond is: 2580m^3

Therefore, when the sludge volume is taken into account, under average plant influent flow conditions (490m^3/d) the hydraulic retention time (HRT) of the primary oxidation pond will be a maximum **41.8days** and under peak flow conditions (2300m^3/d) the HRT will be **8.9days**. (Assumes no short circuiting and plant performance suggests this is a reasonable assumption).

3.2.2 BOD_5 Loading Rate Input Data, Calculations and Results

The following figures have been used to calculate the BOD loading rate on the Martinborough primary oxidation pond:

- Average raw influent flow: 490m^3/d
- Average raw influent BOD5 concentration at average flows: 220g BOD5/m^3 (Metcalf &Eddy 3rd Ed, reference 5)
- Featherston pond area: 16,300m^2 (approx.) = 1.63ha

The reference 4 document provided by SWDC states that there are no significant industrial trade waste contributors that discharge to the Martinborough WWTP therefore the raw wastewater strength should be similar to typical domestic wastewater.

Using the above figures the average loading rate on the primary oxidation pond is:

66kg BOD_5/ha.d.

If we assume that 9°C is the mean air temperature for Martinborough in the coldest month then the maximum/design loading rate will be **89kg BOD_5/ha.d** and the size of the primary oxidation pond is sufficient based on the equations given in Section 2. However if the coldest month's mean air temperature is less than 9°C then the pond will be slightly under-sized based on the design loading rate.

3.2.3 Discussion and Assessment of Sludge Effect on Effluent Quality

Given that, the BOD5 loading rate calculated above (66kg BOD5/ha.d.) is well within the design limit, the calculated HRT is within the design limit, and, the pond is "fully compliant" with all the resource consent conditions, it is not expected that the amount of sludge in the primary pond is having an adverse effect on the pond effluent quality.

The average sludge depth in the maturation ponds is 0.07m (Reference 1). That sludge depth will have a negligible effect on the maturation pond effluent quality.

The reference 4 document infers that the Martinborough oxidation pond depth is 1.41m ($23,000m^3/16,300m^2$) but the Conhur survey estimated that the average pond depth is 1.65m. If the Conhur survey is correct and the pond is slightly deeper than 1.41m that will be providing some additional safety factor. However the Conhur figure may be incorrect possibly due to a discrepancy in the reference level.

3.3 Planning for Pond Desludging

The Martinborough ponds have been in service for 25-30years (refer to email from Bill Sloan 19th February 2013). The average sludge depth accumulation over those years is only 0.19m in the primary pond and 0.07m in the maturation cells (reference 1). Unless the loads on the pond increase significantly we expect that the pond will not need to be desludged for another 15 years or more.

Conhur recommends that the sludge depth should be at least 0.3m before desludging should take place. Desludging at depths less than 0.3m is considered inefficient.

Given the sludge accumulation time (25-30 years) we have some suspicions about the accuracy of the sludge depth, given that the pond sludge depth is so little for the time the pond has been in operation. Other ponds of this age we have had experience with have had significantly more sludge and have needed to be desludged. Also, following on from the discussion in Section 3.1 with regard to concerns about the accuracy of the sludge DS %, a systematic error may be affecting the sludge depth as well.

4 Featherston Pond

4.1 Discussion - Conhur Sludge Survey Methodology and Results

As discussed in Section 3.1 it is difficult to achieve 100% accurate results. Great care needs to be taken to eliminate/reduce the various errors that can occur. The methodology used by Conhur and described in their report appears to be reasonably sound and should work satisfactorily if the methodology is followed carefully and the operator understands the potential error sources and they take every effort to reduce the impact of those errors.

The dry solids (DS) percentage of the primary pond sludge samples collected by Conhur varied between 4.51% and 9.24% which is generally greater than the results for Martinborough and more in line, but still a bit less, than our expectations of between 7% to 10%.

4.2 Sludge Effect on Effluent Quality

The following calculations have been undertaken to check that the pond is not operating outside the design limits.

4.2.1 HRT Input Data, Calculations and Results

The following data is sourced from reference 4:

- Average plant influent flow for Featherston is approximately: 1050m^3/d.
- Peak flow is approximately: 4740m^3/d.
- Primary oxidation pond volume: 31,600m^3
- The primary oxidation pond hydraulic retention time (HRT) for average flow conditions (zero sludge depth): 30days.
- The primary oxidation pond hydraulic retention time (HRT) for peak flow conditions (zero sludge depth): 6.7days.

Based on reference 2:

- Average sludge depth in the pond is: 0.26m
- Total sludge volume in the pond is: 5950m^3

Therefore, when the sludge volume is taken into account, under average plant influent flow conditions (1050m^3/d) the hydraulic retention time (HRT) of the primary oxidation pond will be a maximum of **24.4days** and under peak flow conditions (4740m^3/d) the HRT will be **5.4days**. (Assumes no short-circuiting).

4.2.2 BOD_5 Loading Rate Input Data, Calculations and Results

Oxidation ponds are generally sized based on the BOD_5 loading rate. The following figures have been used to calculate the BOD_5 loading rate on the Featherston primary oxidation pond:

- Average raw influent flow: 1050m^3/d
- Average raw influent BOD_5 concentration at average flows: 220g BOD_5/m^3 (Metcalf &Eddy 3rd Ed)
- Featherston pond area: 25,930m^2 (approx.) = 2.593ha

The reference 6 document provided by SWDC states that there are no significant industrial trade waste contributors that discharge to the Featherston WWTP therefore the raw wastewater strength should be similar to typical domestic wastewater.

Using the above figures the average loading rate on the primary oxidation pond is:

89kg BOD_5/ha.d.

If we assume that 9°C is the mean air temperature for Featherston in the coldest month then the **design** loading rate will be **89kg BOD_5/ha.d** .

4.2.3 Discussion and Assessment of Sludge Effect on Effluent Quality

As discussed in Section 2 above, the minimum HRT for primary oxidation ponds with temperatures below 20°C, is 5days. The minimum HRT is specified to minimise hydraulic short circuiting and to give the algae sufficient time to multiply (ie to prevent algal washout). The Featherston oxidation pond satisfies this minimum condition.

The BOD_5 loading rate calculated above (89kg BOD_5/ha.d.) is operating at the design limit for the coldest month/s, if the average temperature for the coldest month is 9°C. However, based on the design loading figure, the pond may be slightly undersized for the coldest period if the average monthly temperature drops below 9°C. There is some safety factor built into these limits and because the plant is "fully compliant" with all the resource consent conditions, it is not expected that the amount of sludge in the primary pond is having an adverse effect on the pond effluent quality.

It is important to note that the pond is sized so that it will perform satisfactorily under the worst case scenario which is usually through the coldest winter month. As the temperature rises the capacity of the pond increases, that is, the design BOD_5 loading rate increases quickly. For example, at 12°C the design loading rate is 124 kg BOD_5/ha.d.

The reference 4 document states that the Featherston oxidation pond depth is 1.2m but the Conhur survey estimated that the average pond depth is 1.4m. If the Conhur survey is correct and the pond is slightly deeper than 1.2m that could possibly improve the final effluent results. However the Conhur figure may be incorrect possibly due to a discrepancy in the reference level.

The average sludge depth in the secondary pond (0.15m) is less than the primary pond. Therefore, for similar reasons discussed above for the primary pond we do not believe that the secondary pond sludge is having a significant adverse effect on the pond effluent quality.

4.3 Planning for Pond Desludging

The average sludge depth in the Featherston primary oxidation pond is 0.26m. As previously discussed in Section 3.3 above, Conhur recommends that the sludge depth should be at least 0.3m before desludging should take place. While the average sludge depth is only 0.26m the maximum sludge depth in the pond is 0.95m therefore there will be significant areas within the pond that exceed the economically viable desludging depth of 0.3m.

The pond is performing satisfactorily and therefore from a pond effluent quality perspective it may not warrant desludging the pond at this point. However, there is another reason why some desludging is warranted.

When the sludge level rises to within 0.5m of the pond surface there is a risk that birdlife can become infected with botulism from the pond sludge.

The Conhur survey measured the maximum sludge depth in the primary pond at 0.95m and a water surface level 1.4m above the pond floor. Therefore, where the sludge is 0.95m deep there is only 0.45m water depth above the sludge.

There may not be a large area where the water depth between the sludge and the water surface is less than 0.5m so the risk to birdlife might be low at this stage but the risk will increase further with time.

Other risks that can be created due to isolated pockets of high sludge levels is the potential for poor mixing, short-circuiting and wave action suspending the sludge. However, while the pond is complying with the resource consent conditions it is not an issue that needs to be addressed.

Given that it has taken 25-30 years to accumulate this amount of sludge it seems reasonable to expect that the sludge accumulation is slow and immediate desludging may not be required but desludging the high spots within the next 5 years seems a reasonable approach.

The sludge depth in Pond 2, the secondary oxidation pond, is less than the sludge depth in Pond 1. The water depth above the maximum sludge depth is currently 0.61m. Therefore the time scale for desludging the high points in that pond will extend out further than the primary pond.

5 Conclusions

The sludge depth survey may contain some errors with regard to the measured sludge depth and DS percentage particularly with the Martinborough survey. However, we do not think that the ponds will require desludging in the near future. Both ponds are complying with their resource consent conditions which support the view that the ponds are performing satisfactorily with the amount of sludge contained in them.

6 References

Reference 1: Conhur, November 2012. Martinborough Oxidation Pond Sludge Survey Report.
Reference 2: Conhur, November 2012. Featherston Oxidation Pond Sludge Survey Report.
Reference 3: Shilton, A., 2005. Pond Treatment Technology.
Reference 4: Description and Assessment of Effects: SWDC – Martinborough/Featherston Community Wastewater Treatment Plant.
Reference 5: Metcalf and Eddy, 3rd Edition 1991. Wastewater Engineering. Treatment Disposal Reuse.
Reference 6: NZ Environmental Technologies, August 2012. Featherston Wastewater Treatment Plant Annual Report.

Regards

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