OPTIMISING THE TREATMENT PERFORMANCE OF THE OTOROHANGA OXIDATION POND SYSTEM

A Paper by Cliff Boyt – For Water NZ Conference September 2019

Abstract

A normal procedure when improving performance of a wastewater treatment plant would see an engineer lead the design and over-view the construction, later handing the plant back to the operators and not having any further involvement. In the case of the oxidation pond-based treatment plant that serves Otorohanga the author has been privileged to have continued the over-view for at least 9 years and to implement further improvements based on sound monitoring and analysis of performance. All of the improvements have been based on a “simple is best” philosophy.

When the author was engaged late in 2010 the treatment plant was in a sorry state and had a high level of non-compliance with the (then current) Resource Consent. In addition there was less than a year before an application for new Resource Consent(s) had to be submitted. By the time the hearing for a new resource consent was held the plant had been desludged, upgraded and was operating at an acceptable level at a modest upgrading cost. A very practical consent with a 25-year life was secured. The upgrade included installing curtains, increasing the water depth and modifying the wetlands.

Through his involvement in the ensuing years the author has been able to gain a high level of understanding of the key drivers of success with oxidation pond treatment systems and has been instrumental in introducing some further improvements to fine-tune the operation. In particular the installation of a bottom-deployed diffused aeration system and further desludging of the oxidation pond have improved the consistency of compliance with the resource consent conditions. A trial has been introduced to deal with the daily mass-load of phosphorous in the discharge.

Through this paper the author gives his personal viewpoint on the importance of managing solids in the oxidation pond in ensuring reliable treatment with minimal operating costs and shares the knowledge that he has gained. The paper also gives information on the initial results from the trial to reduce phosphorous levels in the discharge. The intention is to improve the overall understanding of the key drivers of successful improvements to old oxidation ponds which can still provide effective treatment of domestic wastes well into the future.

KEYWORDS :

oxidation pond; treatment optimisation; solids management; bottom-deployed diffused aeration; total phosphorous reduction

Presenter Profile

Following a 36-year career in local government engineering, Cliff Boyt “retired” in 2004 with the aim of setting up as a sole-practicing consultant operating in the disciplines of water supply and wastewater management and project management. He has had an ongoing relationship with the Otorohanga wastewater treatment plant for the last 9 years.

1 INTRODUCTION

I became involved with the oxidation pond and wetland-based wastewater treatment plant for Otorohanga in 2010. At the time the system was in a poor state, was not compliant with the conditions of the resource consent and had just an 11-month lead-time before an application for a replacement resource consent needed to be submitted to Waikato Regional Council.

I managed and worked with Global Environmental Engineering (G2E) to review the treatment system and to design upgrade works for the plant and with MWH Global to prepare the application and AEE for the resource consent. These projects were both successful and within 2 years we had completed the stage 1 upgrade works and had secured a set of resource consents with a 25-year "life".

I have had the privilege of continuing involvement with this treatment plant at an oversight level right through until the current year (2019) and I have had the opportunity to drive some further refinements to the treatment process.

This paper records the changes that have been made to the treatment system and the successes achieved. I record a number of observations that I consider provide a key to the success and that may be useful to others involved with oxidation pond/wetland based plants around New Zealand.

2 DISCUSSION

2.1 A BRIEF HISTORY OF THE WWTP

The oxidation pond was constructed around 1974, which was a time when there was a huge drive throughout New Zealand to improve the way that wastewater from communities of all sizes was dealt with. It seems that the pond was constructed over a relatively flat, North-sloping field simply by forming embankments around the perimeter. It does not appear that the pond was lined. The pond is roughly rectangular 200 metres by 180 metres with an original water depth varying between 1.4 and 1.7 metres. Wastewater flowed into the pond at the South West corner and out at the North West corner. The treated wastewater is conveyed about 2.2 km parallel to the main trunk railway line and discharged into the Mangaorongo Stream, which is a tributary to the Waipa River.

Wetlands, comprising two in-parallel surface-flow cells followed by two in-parallel subsurface-flow gravel bed cells, were added in 2000. The addition of the wetlands necessitated that a discharge pump station had to be installed to compensate for the loss of hydraulic head. A step-screen was also installed at the inlet to the oxidation pond at the same time as the wetlands' construction.

Through much of the 2000s the plant was operated by contractors, but operations were brought back in-house in 2010 due to poor contractor outcomes.

The stage 1 upgrade works that I drove were carried out in 2011/12 and a second stage was carried out in 2013/14. These are described in the paper.

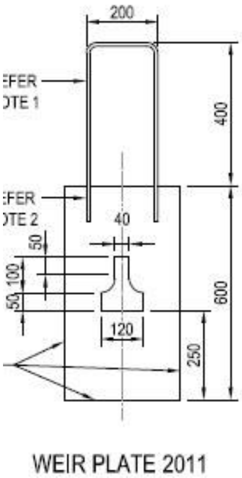
2.2 The 2011/12 Upgrade and Resource Consent Application Process

The short lead-time from when I became involved (November 2010) to the date by which the application for new resource consent had to be submitted (October 2011) meant that we were locked into the treatment processes as they existed at that time – i.e. inlet screen, oxidation pond and wetlands. We had to make the best of these processes with the funding available.

The stage 1 upgrade works included:

- Raising and strengthening the embankments of the oxidation pond to allow a slightly increased water depth and to provide for flow buffering by water level variations;
- Modifying the inlet arrangement;
- Modifying the oxidation pond outlet chamber by the addition of a "keyhole" weir to utilise the flow buffering capacity of the pond (see illustration below);
- Removing a significant volume of sludge from the floor of the oxidation pond by dredging;

- Installing 3 impervious curtains to introduce a "serpentine" flow channel (about 620 m long) with 4 legs;
- Installing "keyhole" weirs in the outlet chambers from the surface-flow wetland cells to utilise the flow buffering capacity of these cells;
- Modifying the gravel-bed wetland cells by forming a series of shallow "vee" channels through the clogged gravel and installing new inlet diffusers and outlet collection channels;
- New monitoring and control systems;
- Some measures to address infiltration and ingress in the sewerage system were also carried out at the same time.



Gravel-bed Outlet Channel

Our investigations and calculations showed that the average daily flow from the community of about 2,900 people was around 800 m^3 / day (276 L/p/d). With the increased water depth the oxidation pond provided about 65 days retention at this average daily flow rate. In sunny summer conditions with high evaporation from the pond surface the retention increased to at least 95 days, whereas in wet weather conditions and taking advantage of the higher water level that provides flow and volume buffering, the retention time could reduce to 37 days. Regular monitoring of the adjacent open drains suggests that any losses through the unlined pond floor are no more than minimal.

Working with the team from MWH Global we assembled a sound AEE and documents to support the application for a replacement resource consent. By the time that the WRC hearing was held we had completed the first stage upgrade works which showed the positive commitment of the Otorohanga District Council. Recognising that the performance of the upgraded treatment plant had not been proven at the time of application we proposed a 2-stage introduction of conditions applying to the quality of the discharge – an initial set of conditions and a second, more stringent, set of conditions that came into force 5-years after the consent-issue date – i.e. 1 December 2017. The consent was issued with a 25-year term which was a very satisfying outcome.

2.3 The Impact of the Stage 1 Upgrade Works and the Need for Stage 2 Additions

For the first few months following the stage 1 works completion and a settling down period the treatment performance showed significant improvement. The discharge came close to compliance with what were the proposed resource consent conditions. However, during 2013 the Ammoniacal-N results deteriorated and it was discovered that the number of septage tanker-loads that were then being discharged into the system had increased significantly. The cause of this increase was discovered to be related to a change in policy for reception of septage by a neighbouring local authority.

Following some research, working again with G2E, it was decided that we needed to introduce more aeration to the pond. After some deliberation it was decided to use a bottom-deployed aeration system and to install it at the mid-way area through the pond (see photograph 1). The system incorporates nine PDP aeration lines, each 60 metres long with air supplied from an 11kw blower. The air to the PDP lines is supplied from both ends.

2.4 Effect of the Additional Aeration

The new aeration system was commissioned about February 2014. For about 4 months following the commissioning of the aeration there was a significant increase in the Total Suspended Solids, BOD_5, Ammoniacal-N and Total-N concentrations at the discharge. In hindsight we can attribute this to the bubbles re-suspending sludge from the floor of the pond in that area, with this material then being carried through to the pond outlet and thence to the discharge point. By the end of October 2014 these short-term increases had passed through and the performance showed significant improvement for all parameters with the exception of Total Phosphorous. For the next 12-month period the discharge was consistently in compliance, with the exception of TP, which was marginal (see section 2.6).

2.5 Wetlands Performance and Renovation

When I became involved in 2010 we found that the surface-flow wetland cells were fairly clogged with sludge and weeds and that the sub-surface flow gravel-beds were completely clogged with roots and sludge. Council could not afford to deal with the surface-flow cells as part of the 2011 upgrade, but we developed a low-cost way to improve the gravel-bed cells. Apart from installing "key-hole" weir plates in the outlet from the surface-flow cells to utilise the flow buffering capacity available all renovation of those cells was deferred.

In September 2015 the Eastern surface-flow wetland was taken off-line for a complete renovation and replanting to be carried out. While this cell was off-line all flow was passed through the Western surface-flow wetland cell. Both surface-flow wetland cells were by then heavily overgrown and "sludged-up" so the doubled-up flow through the western cell resulted in sludge being disturbed and carried through to the discharge.

The Eastern cell was replanted in February 2016 and, following a period to allow the new plants to become well-established the cell was brought back on-line in October 2016.

The Western surface-flow cell was subsequently taken off-line for renovation in August 2017 so the Eastern cell carried doubled-up flow from then until late-2018.

It had been noticeable that the discharge quality has been inconsistent since late 2015 and this was attributed mainly to the renovation of the wetland cells.

2.6 Treatment Performance from November 2014 to October 2015

As described above the period from the installation of the aeration lines and the re-suspension of sludge had settled down until just after the Eastern wetland cell had been taken off-line (i.e. November 2014 to October 2015) is the most representative period of the performance that can be expected from the current arrangement under stable operation. Monitoring results of the discharge for this 12-month period are presented below:

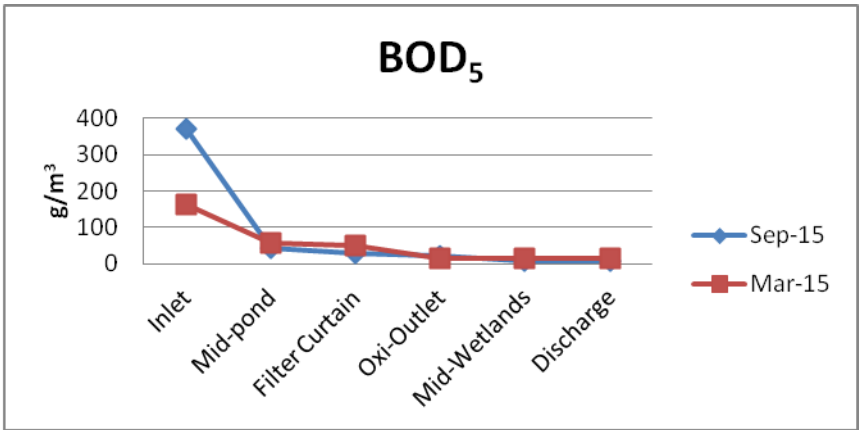
PARAMETER	MEASURE	CONSENTED MEDIAN/AVERAGE PRE/POST DEC 2018	MEDIAN/ AVERAGE	90%ILE

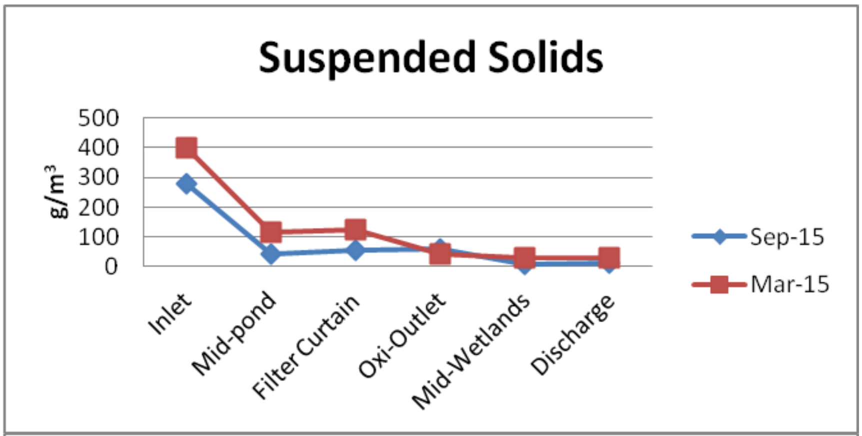
cBOD5	**g/m³**	**25/25**	**13**	**14**
Total Suspended Solids	**g/m³**	**30/30**	**26**	**30**
Ammoniacal-N	**g/m³**	**15/12**	**5**	**20**
Ave Total Nitrogen Summer	**kg/d**	**20/16**	**10**	
Ave Total Nitrogen Winter	**kg/d**	**30/30**	**20**	
Ave Total Phosphorous Summer	**kg/d**	**4/3**	**5**	
Ave Total Phosphorous Winter	**kg/d**	**5/5**	**6.5**	
E. Coli Summer	**cfu/100ml**	**500/500**	**209**	**2092**
E. Coli Winter	**cfu/100ml**	**2500/2500**	**196**	**365**

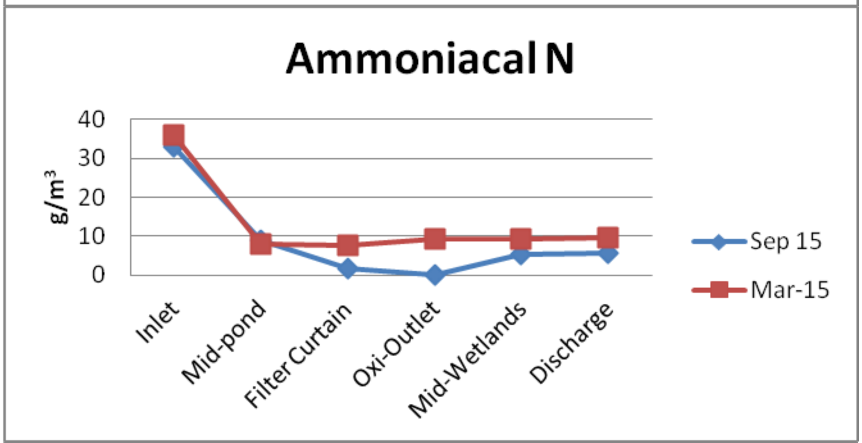
It is worth noting here that these results are from a 12-month period that started 2 ½ years after the pond had been partly de-sludged – refer to section 2.8 on sludge in the oxidation pond.

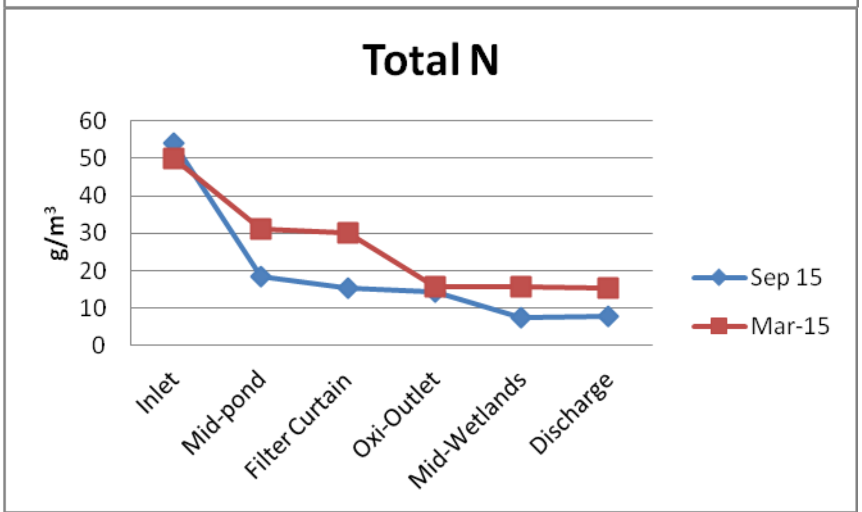
The progressive treatment of the wastewater as it passes through the oxidation pond and wetland cells was tested in March and September of each year using longitudinal sampling. The following graphs show the two results for the parameters as recorded in 2015. Sampling locations are:

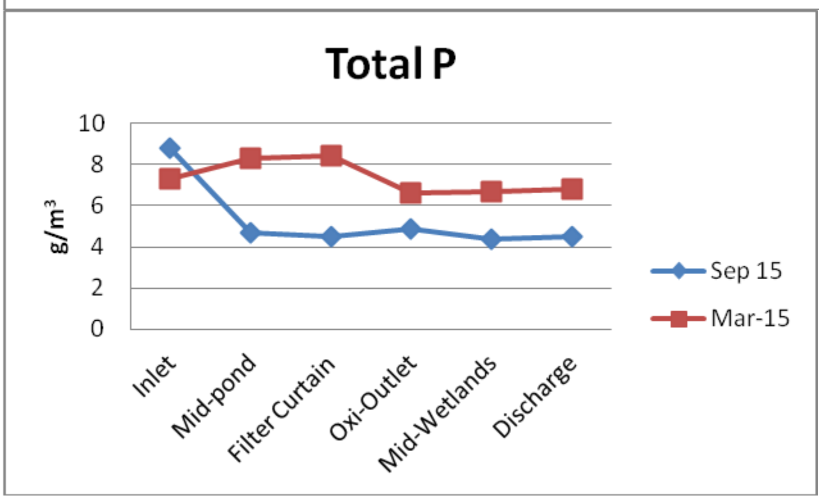
i. The inlet to the oxidation pond;
ii. The mid-point of the pond; where the aeration is applied;
iii. The upstream face of the filter curtain prior to the oxidation pond outlet;
iv. The oxi-pond outlet;
v. Midway through the wetlands, before the gravel-bed cells; and
vi. The discharge pump station.

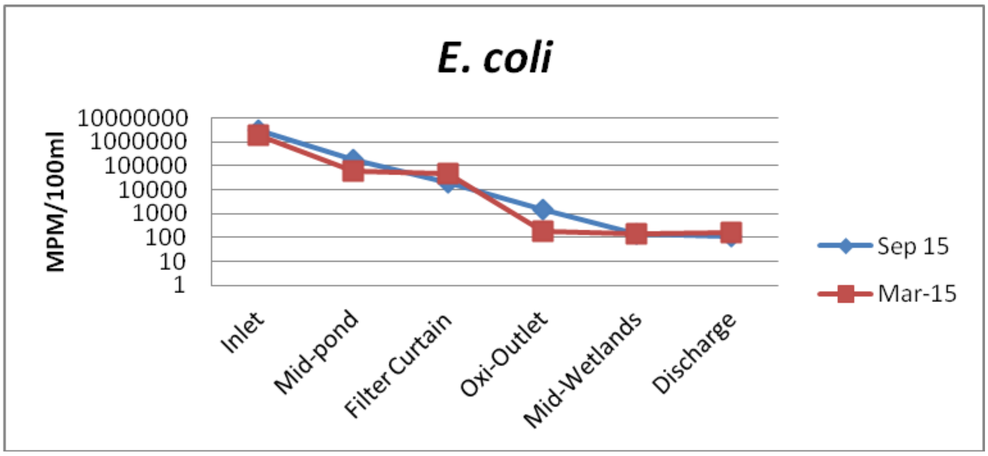



Suspended Solids
g/m³
500
400
300
200
100
0
Inlet
Mid-pond
Filter Curtain
Oxi-Outlet
Mid-Wetlands
Discharge
Sep-15
Mar-15


Ammoniacal N
g/m³
40
30
20
10
0
Inlet
Mid-pond
Filter Curtain
Oxi-Outlet
Mid-Wetlands
Discharge
Sep 15
Mar-15


Total N
g/m³
60
50
40
30
20
10
0
Inlet
Mid-pond
Filter Curtain
Oxi-Outlet
Mid-Wetlands
Discharge
Sep 15
Mar-15


Total P
g/m³
10
8
6
4
2
0
Inlet
Mid-pond
Filter Curtain
Oxi-Outlet
Mid-Wetlands
Discharge
Sep 15
Mar-15



It appears that BOD_5 and Total suspended solids are largely reduced in the first half of the pond. This removal of BOD_5 ensures sufficient residual aeration for nitrifying bacteria to convert Ammoniacal-N to Nitrites and Nitrates (nitrification). De-nitrification (breaking down of Nitrites and Nitrates to yield Nitrogen gas and Nitrous Oxides) then takes place through the second half of the pond. In this latter zone, where active aeration and mixing is absent, anoxic conditions (necessary for denitrification) develop, probably at the water / sediment interface and deeper water sections. The E.coli reduction increases as the wastewater progresses through the pond and wetlands as the water becomes clearer, thereby allowing penetration by sunlight. However the Total Phosphorous concentration shows little reduction through the entire process.

The results from the progressive sampling confirmed that locating the bottom-deployed aeration around the mid-point of the oxidation pond was about right. It allowed for the majority of the BOD_5 demand to be satisfied before the forced-aeration promoted Nitrification. The second half of the pond, having no forced-aeration, provides adequate anoxic volume for de-nitrification to occur before discharge to the wetlands.

While only from two samplings the progressive (longitudinal) monitoring in 2015 has confirmed that removal within the wetlands was variable and often poor. It was thought that this is possibly because the surface-flow wetland cells were so overgrown and sludged-up. The September sampling run showed some reduction of TN and *E. coli* but no similar reduction is shown in the March sampling. The modified gravel-bed cells do offer some degree of cultural purification by way of seepage through the gravel and slow flow through the channels so that the condition of the final discharge can be clearly visible.

It is important to note that the sampling is of different "parcels" of water – the wastewater that entered the plant in March would probably not reach the discharge point until mid-June.

2.7 Treatment Process in the Oxidation Pond

Our environmental objectives in treating wastewater are to reduce the concentrations of the following parameters to levels that will have minimal effect on the environment:

Suspended solids;
Biochemical Oxidation Demand (Five day);
Ammoniacal Nitrogen;
Total Nitrogen;
Total Phosphorous; and
Pathogens (as indicated by *E. Coli*).

I was taught that there are distinct zones in an oxidation pond – mainly facultative followed by maturation zones. However I now question that premise as the picture is continually changing as the flow increases and decreases and water depth rises and falls.

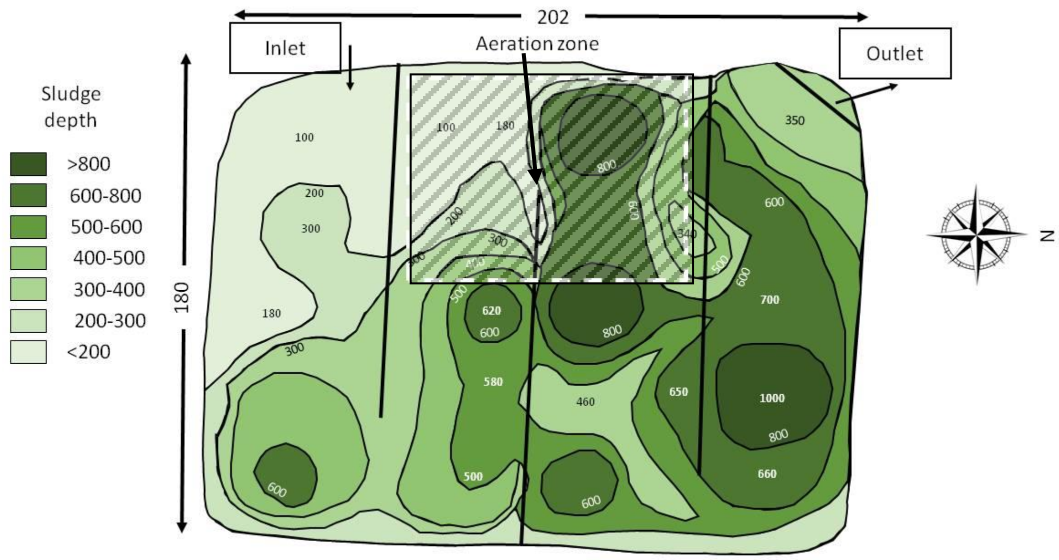
The treatment of the various parameters is progressive and the "zones" overlap as well as extending and contracting. I take a "Keep It Simple Stupid" (KISS) approach to the process - the following is a simple summary of the way that I see the treatment operating.

- Suspended solids in the inflow settle out in the first reach of the treatment channel in the pond. However later treatment "processes" generate further suspended solids (micro-organisms) that die and settle out further through the pond. Also there is a healthy growth of algae in the pond during the summer period – all factors that complicate the suspended solids monitoring.
- The 5-day BOD (a measure of "oxygen demand") needs to be largely satisfied before other biological treatment processes can commence. Our progressive sampling shows that the BOD_5 demand is largely satisfied in the first half of the treatment channel.
- Once the BOD_5 concentration has been lowered sufficiently then aeration can start to create an environment where nitrifying bacteria can flourish and work to convert Ammoniacal-N to Nitrites and Nitrates. By installing the bottom-deployed aeration system in the mid-pond area (see photograph 1) we effectively achieve satisfactory nitrification in just a few days whereas it would take at least 20 days if we rely on natural aeration from the atmosphere.
- In order to reduce the Total Nitrogen concentration, we need to create conditions where de-nitrifying bacteria can work to convert nitrites and nitrates to nitrogen gas and nitrous-oxides. This requires anoxic conditions – which are provided downstream from the aeration area. While the top 200 mm of water will have some natural aeration from the water / air interface the water below this down to the surface of the sludge will be anoxic. It is in this zone where de-nitrification takes place. Our experience has shown that at least 20 days retention time is preferable to ensure adequate de-nitrification.
- Most wastewater treatment plants incorporate UV radiation to reduce pathogenic bacteria. In order to be effective, the treated wastewater needs to have a high level of "transmissivity". Normally the target is to reduce the concentration of *E. coli* to less than 100 organisms / 100 ml. In the Otorohanga plant we utilise natural UV from sunlight to penetrate into the water to achieve similar results. At every stage in the progressive treatment monitoring the *E. coli* concentration reduces, with the shallow channels in the gravel-bed cells providing "final polishing".
- Unfortunately the oxidation pond and wetland cells have been shown to have virtually no effect on reducing Total Phosphorous, except for some "capture" by association with settling solids – this is locked in with the sludge that accumulates on the pond floor and is subsequently removed by dredging.

2.8 Sludge in the Oxidation Pond

It had originally been recommended that the operators should carry out a sludge depth survey every 2 years so as to keep track of the rate of accumulation of sludge across the floor of the oxidation pond. However the pressure of other work meant that they did not actually carry out the first such survey until March 2017 – 5 years after the part de-sludging of 2012. The results surprised all, with the depth of sludge ranging from as low as 200mm to over 1 metre. The results from that survey did provide some answers to the deterioration of treatment performance.

The results from the survey were analysed, the total volume of sludge was calculated as was the volume that had accumulated since 2012 and a contour plan of the sludge depths across the pond was prepared. The analysis showed that there was an average depth of about 500 mm of sludge across the floor of the pond, but that the most significant accumulation of sludge was in the final leg of the pond – towards the outlet end. A rough contour plan of the sludge depths is shown below.



The total volume of sludge was calculated as 19,000 cu m of wet sludge with an estimated average consistency of about 3.5 % dry solids. The volume of sludge as surveyed following the 2012 de-sludging was calculated as 8,000 cu m of wet sludge with a similar consistency. Therefore about 11,000 cu m of wet sludge had accumulated in the 5 years. The rapid build-up of sludge volume is likely partly attributed to additional sludge generation through the aeration zone.

The survey showed that the sludge is being gradually moved through the serpentine channels towards the outlet end of the pond. It also showed that the aeration area causes sludge to be re-suspended, but also that there is a "dead zone" in the Northwest corner of the aeration zone where it appears that the current "cuts the corner".

The sludge survey gave the suggestion that sludge had been getting past the filter curtain, carried over into the wetlands and has elevated the Total Suspended Solids concentration in the discharge.

A further partial de-sludging exercise was carried out during the winter of 2018 and the subsequent accumulation of sludge will be monitored more closely. Council has now provided in the LTP for de-sludging to be carried out every 3 years and it is expected that this will focus mainly in the second half of the pond.

2.9 The Effects of the Sludge Build-up in the Second Half of the Pond

The treatment of Ammoniacal-N relies on "nitrification" occurring in the mid-pond aerobic zone and then "de-nitrification" occurring in the "anoxic" zone between mid-pond and the outlet. The longer the retention time (treatment volume) that is provided in this "anoxic" zone, the better de-nitrification that can be achieved. The 2017 sludge survey showed that the retention time downstream from the aerobic zone at average daily flow had been reduced from about 31 days in 2012 to about 21 days in 2017 – a reduction of 31%. Significantly the water column depth between the "aerated" top 200 mm and the top of the accumulated sludge (the anoxic layer) had been reduced by over 50%.

The loss of retention time in the "anoxic" zone has resulted in a lowering of efficiency of de-nitrification so that the Total Nitrogen concentration in the discharge has gradually increased over time. This is a clear signal as to the importance of regular de-sludging of the second half of the pond.

2.10 Trial to Reduce Total Phosphorous

We have recently installed a trial process whereby the effluent from the oxidation pond is dosed with coagulants and then passed through a settlement basin. The target is to consistently reduce the TP concentration to less than $3g/m^3$ – that will ensure that both the winter and summer average daily mass loads of TP in the discharge will be below the respective limits set out in the resource consent.

For the trial the western surface-flow wetland cell is being used as the settlement basin. The discharge is then passed through the gravel-bed cells before discharge to the Mangaorongo Stream.

In order to be able to convert the Western surface-flow wetland to a settlement basin we needed to gain Iwi approval to decommission the wetlands. They were satisfied that our proposal would provide more treatment than the surface-flow wetland cell, but wanted to have the gravel-bed cells retained so they could "see" the final treated wastewater before it is discharged to the Mangaorongo Stream.

Early results show TP concentrations in the discharge of around $2.6g/m^3$ can be achieved. The test will be whether using the wetland cell as a settlement basin is sustainable through all seasons. If the trial is successful then the proposal is to use the two surface-flow wetland cells alternately and to dewater, dry and remove the sludge from the cell that is being rested. If the settlement basin trial is not successful then we propose to install a low-cost clarifier and sludge drying facility – time will tell.

An important measure is that the sludge developed through the coagulation process is not returned to the oxidation pond.

2.11 Septage Management and Reception

I am a strong advocate that local authorities have a similar responsibility to their rural citizens as to their urban citizens in regard to management of wastewater. A household septic tank needs to be cleaned out at least every 5 years or after a shorter period where there are a number of residents in the house – excess solids in the tank can lead to solids carry-over into the soakage field with serious environmental consequences. The local authority should at least have a record of all tanks and a record of the servicing history and send out a reminder to the householder when the tank needs to be cleaned.

Having ensured that the tank has been cleaned then the local authority has a responsibility to see that the septage is treated properly, preferably by passing it through their wastewater treatment plant.

Disposal of septage into the urban wastewater system should be at some distance upstream from the treatment plant to ensure some blending of septage with domestic wastewater. The septage should be passed through a suitable septage screen before entering the normal wastewater stream. Under no circumstances should septage tankers be given access to the treatment plant to dispose of the septage.

2.12 Some Key Learnings

Through my ongoing involvement with the Otorohanga oxidation pond treatment system I have had the opportunity to learn a lot about oxidation pond-based treatment plants. The following is a summary of some key learnings:

- A suitably sized oxidation pond provides a very robust solution to the wastewater treatment requirements for a small community. Providing a "normal" retention time of over 60 days and ensuring good buffering for wet weather periods with proper pond outlet design and provision for the pond level to rise above "normal" ensures that in-pond and downstream facilities do not have to cater for extreme peak flows.
- The land that the pond is located on represents a significant investment by the community and optimising the performance of the pond will likely be a more economic option than outright replacement of the treatment system.

- In upgrading the pond system it is important to apply the KISS principle;
- Channelisation of the pond with impermeable curtains is essential to prevent short-circuiting and to provide a long channel situation rather than a large open body of water.
- Ongoing involvement of the upgrade designer at an appropriate level is a very good investment by the local authority.
- Good pond treatment performance depends on the retention time of wastewater in the pond. In the case of the Otorohanga pond we have found that the two key elements involved are provision of forced aeration in the mid-section of the pond and regular management of sludge in the second half of the pond by dredging about every three years.
    - A process for managing sludge accumulation that we have considered is the AMD process which stimulates digestion of the sludge by in-pond enzyme treatment. This process shows promise in ensuring that the available treatment volume is retained. However it cannot have any effect on inorganic silt and sand that enter the pond nor on removing phosphorous that is associated with sludge that has accumulated on the floor. Therefore a dredging operation will still be required, possibly every 15 to 20 years.
- Operating, maintaining and general housekeeping are all important. Any visitor to a wastewater treatment plant tends to "smell with their eyes" so a tidy plant is generally viewed in a better light. Under normal conditions operator visits to an oxidation pond plant may be not more often than once or twice a week.
- It is important that inputs and inflows to the plant are kept under control. Regular attention to rain and groundwater ingress into the collection system are important as is ensuring that septage contractors do not discharge any industrial wastes into the system.

2.13 Expected Results and Key Ongoing Actions

It is anticipated that the proposed coagulation/settlement treatment of the discharge from the oxidation pond will be able to bring the WWTP discharge into full compliance with all of the parameters limited by the resource consent.

The key actions that will be required to ensure that there is consistent compliance with the resource consent conditions are:

- Management of solids through the whole system;
    - It is important that the inlet screen is well maintained and serviced;
    - The sludge levels through the oxidation pond must be surveyed at least every 2 years and the results analysed;
    - The floor of the oxidation pond will need to be de-sludged regularly, probably every 3 years – particularly through the second half of the pond;
- The PDP aeration lines need to be cleaned by water-flushing at regular intervals – probably at least every 6 months;
- The coagulation dosing / settlement system to remove phosphorous from the discharge after the oxidation pond needs to be proven and either made permanent or changes made, depending on outcomes;
- Regularly checking the sewerage system to ensure that ingress and infiltration are managed within reasonable parameters.

2.14 Capacity for Growth

As discussed the level of treatment that can be provided by the oxidation pond based treatment system is largely determined by the retention time that can be provided. The retention time prior to the mid-pond aeration zone is important to address the BOD_5 demand so that nitrification can be successful in the aeration zone. Likewise the retention time in the anoxic zone after the mid-pond aeration zone is important so that denitrification can be successful. Effective sludge management is a key to this.

While the population of Otorohanga has been relatively stable and slightly reducing for many years there are some opportunities for extra population attractants. So long as the key actions are carried out there is probably adequate buffer capacity available for coping with any moderate extra load without compromising the conditions of the resource consent. The year by year monitoring results will need to be carefully reviewed and trends analysed so that any gradual deterioration in discharge quality is detected early.

The normal measure to deal with increased loading is to provide additional treatment volume - that is very difficult with an oxidation pond-based system as adjacent land is usually not available. Options within the current oxidation pond may include:

- Increasing the operating water depth – increasing the water depth by 100 mm would add about 7% available volume;
- Additional aeration can provide the equivalent of extra retention time. The aeration lines in the mid-pond zone have been generously spaced such that an extra line can be added between each pair of lines. That will increase the nitrification capacity in the pond. A larger air-blower would need to be installed.
    - An option would be to install 4 additional PDP aeration lines between the 5 lines to the South of curtain 2, but with the "slitted" section covering only the 60 metres from the upstream end of the current lines further upstream in "leg 2" (see photograph 1). This will increase the length of the aeration zone, but not the aeration intensity.
    - Aquamats could be installed between the aeration lines. Aquamats comprise sheets of non-woven "felt-like" material suspended into the pond from floating lines. The material provides "growth media" on which biological life will colonise. These organisms will consume organic material from the wastewater as well as providing an attachment surface for nitrifying bacteria. The micro-organisms form a biofilm layer which will eventually "slough off" and settle to the floor as sludge once the mass exceeds its ability to cling to the media. However the performance of Aquamats, particularly during colder months, needs to be explored to confirm that they are an acceptable solution.
- The coagulation / settling treatment can be intensified to remove a greater percentage of suspended material and TP in the oxidation pond discharge.

3 CONCLUSIONS

The key findings from our observations of the performance of the Otorohanga oxidation pond based wastewater treatment plant over at least 9 years are:

- The impermeable curtains that were installed have been effective in preventing any short-circuiting and have created a long "serpentine" treatment channel.
- As the wastewater passes along the "serpentine" channel it undergoes 5 key treatment "processes":
    i. Reduction of suspended solids through gravity settling;
    ii. Satisfying BOD_5 demand;
    iii. Nitrification – conversion of Ammoniacal-N to Nitrites and Nitrates;

iv. De-nitrification – breaking down the Nitrites and Nitrates to Nitrogen and Nitrous oxides in anoxic conditions;
v. Reduction in pathogens as indicated by *E. Coli* concentration.

- Providing bottom-deployed aeration in the mid-pond zone has been effective in achieving nitrification;
- The “anoxic” zone downstream from the aeration zone is effective in providing de-nitrification.
- The sludge that accumulates on the floor of the oxidation pond is gradually moved along the channel by water flow so that there is more sludge accumulating in the second half of the pond while the first half pond is relatively “swept clean”. The accumulation in the second-half reduces the volume, and retention time, available for de-nitrification;
- Good management of solids is important to ensure consistent good treatment and compliance with consent conditions – this requires regular sludge depth surveys and pond de-sludging every 3 to 4 years, particularly in the second half of the pond;
- With attention to these factors there can be confidence that in-pond treatment can ensure compliance with all consent parameters except for average Total Phosphorous daily mass-loads which must be dealt with in a post-pond treatment system.
    i. Early results from the coagulation / settlement process indicate that TP can be successfully addressed, but the settlement arrangement needs to be proven.
- There are options for coping with moderate population growth – the means of addressing the growth will depend on the degree of increase and nature of the wastewater.

PHOTOGRAPH 1

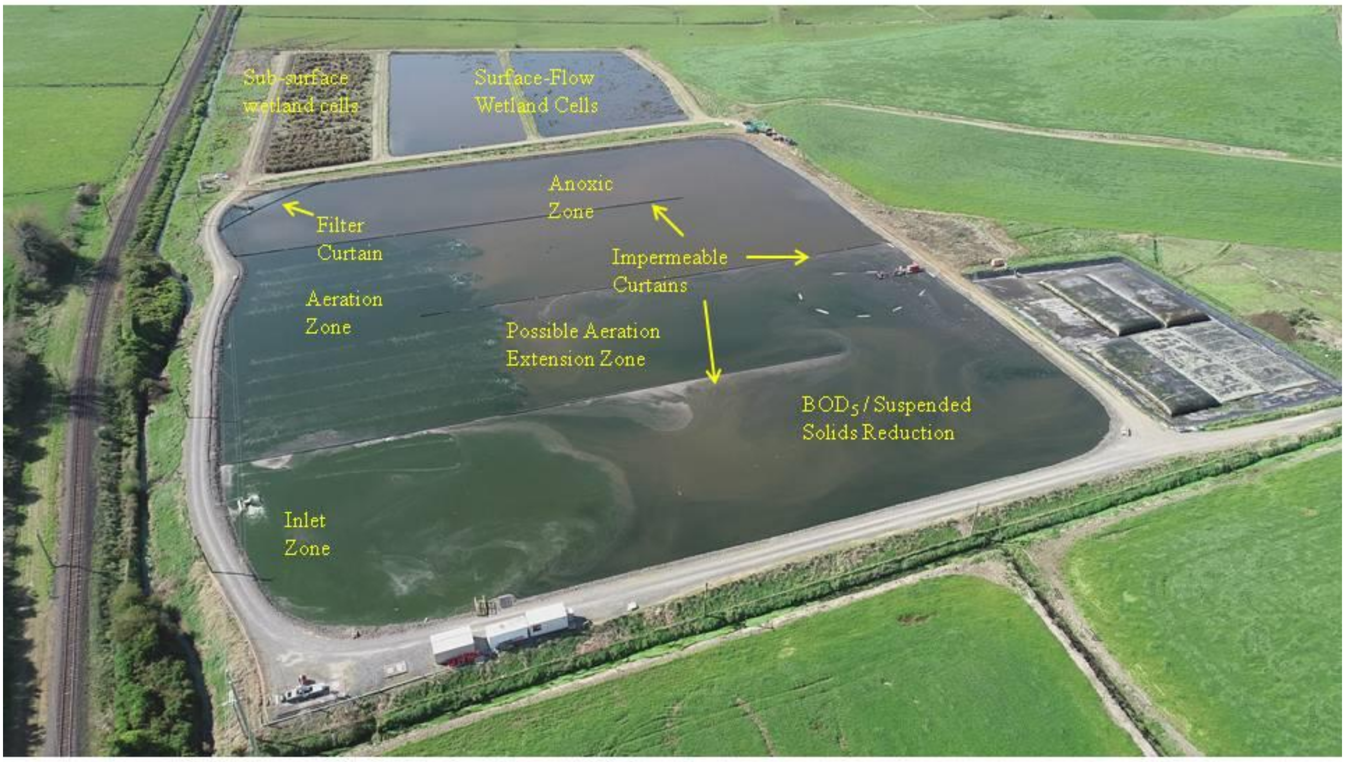


Photo of WWTP from Drone – September 2018, following desludging operation

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Cliff Boyt
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