BEFORE THE Canterbury Regional Council

IN THE MATTER OF the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010

AND

IN THE MATTER OF Submission and Further Submission on the Proposed Canterbury Air Regional Plan

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STATEMENT OF EVIDENCE OF JOHN MILTON CRAWFORD ON BEHALF OF THE COMBINED CANTERBURY PROVINCES, FEDERATED FARMERS OF NEW ZEALAND

Dated 18 September 2015

John M Crawford, Technical Principal – Wastewater, Opus International Consultants Ltd, Private Bag 3057, Hamilton 3240. Ph 0274 831 046.

1. INTRODUCTION

Qualifications and experience

1.1 My full name is John Milton Crawford. I hold the degree of BE (Hons) in Agriculture from the University of Canterbury (1986). I am a Chartered Professional Engineer and a UK Chartered Engineer.

1.2 I am a member of the Institution of Professional Engineers, NZ. I am a member of the New Zealand Water and Waste Association, the Chartered Institution of Water and Environmental Management, the Institution of Civil Engineers

1.3 I am a Principal Environmental Engineer of Opus International Consultants Limited (Opus), based in Hamilton. I am the Technical Principal for Wastewater at Opus. My technical speciality is in wastewater treatment systems.

1.4 I have 25 years research and practical experience in the investigation, design and implementation of water and environmental engineering facilities including treatment and disposal systems for municipal, industrial and agricultural wastewater. I have been involved in investigations for, resource consenting, implementation or trouble shooting of wastewater treatment and disposal schemes at some 50 wastewater treatment plants in New Zealand, Singapore, Malaysia, Fiji and England.

1.5 As a result of this experience, I am familiar with a wide range of wastewater treatment processes and am qualified to comment on issues relevant to the Proposed Rule 7.68 relating to collection, storage, treatment and application of animal slurries.

1.6 I have lived on the boundary of an active, intensively farmed, dairy farm, in the Waikato, for the past 11 years and am fully familiar with the noises and odours associated with intensive farming activities.

1.7 I am familiar with RMA processes and have completed (2006) the certification course ‘Making Good Decisions’ for RMA Decision makers and have completed the 2008 and 2014 recertification modules.

Purpose and Scope of Evidence

1.8 My evidence is with reference to proposed Rule 7.68 of the proposed Canterbury Regional Air Plan and with reference to the submission of Dr Lionel Hume of Federated Farmers, dated 1 May 2015. The purpose of my evidence is to comment on the proposed rule 7.68, in particular subsection (5). My evidence will cover the following topics:

(a) Dissolved Oxygen (D.O) dynamics in wastewater treatment systems

(b) Farm wastewater storage.

Expert Witness Code of Conduct

1.9 I have been provided with a copy of the Code of Conduct for Expert Witnesses. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express. The opinions expressed are my own.

2. WASTEWATER TREATMENT

2.1 Wastewater (and animal wastewater is no exception) can be and is treated by a very wide variety of processes. Unlike water treatment, wastewater treatment is largely undertaken biologically, because of the very high proportion the waste products that are organic in nature. That is, the wastes are predominantly broken down and stabilized by microbial action rather than chemical or physical actions, although these may also be employed, to some extent, to assist.

2.2 Biological treatment systems may be configured to operate anaerobically or aerobically with different groups of microbes relying on different 'oxic' states.

2.3 Anaerobic treatment ponds, undertake their treatment process in conditions devoid of any free oxygen or readily available oxygen from molecules such as nitrates and sulphates.

2.4 Aerobic processes operate in the presence of free oxygen.

Anoxic conditions are an oxic state intermediate between anaerobic and aerobic states. In this state, there is zero free oxygen, but a small amount of available oxygen is present, bound to molecules such as nitrate, phosphate and sulphate, which can be scavenged by the heterotrophic, aerobic organisms which undertake most aerobic treatment.

Aerobic Systems

2.5 The aerobic treatment systems can be divided between algae based waste stabilization ponds, in which the activity of algae provides oxygen for bacteria and other microbes to destroy the waste materials, and bacteria based 'Activated Sludge' style processes, in which active bacteria do the same thing, but via different biochemical mechanisms.

2.6 The dynamics of dissolved oxygen (DO) in ponds are governed by biological processes, such as photosynthesis and respiration, and by oxygen exchange with the atmosphere. In the photosynthesis process, phytoplankton use sunlight energy to synthesize oxygen and carbohydrates for growth. In this process ultraviolet light is absorbed by chlorophyll, the energy obtained splits water, and oxygen gas is produced. Dense growths of algae contribute large amounts of D.O. in ponds during the daylight period, resulting in super-saturation (Typically greater than10 milligrams per litre (mg/l)) of oxygen in the water body, but consume substantial quantities of oxygen at night causing anoxic conditions in pre-dawn hours (Schroeder, 1974; Boyd, 1982). Thus, even the healthiest oxidation pond can be discharging effluent at zero D.O simply by reason of the natural activity of the algae.

2.7 Oxygen levels in ponds are affected by water temperature. This is for several reasons; colder water is able to hold more dissolved oxygen before it is saturated, but warmer water temperatures will speed up the rate of decomposition of waste and promote the growth of organisms in the pond, including algae, which add oxygen by photosynthesis. Figure 14 (of the Oxidation Ponds Guidelines) below shows how oxygen levels and temperature relate for a specific (non-mechanically aerated) oxidation pond.

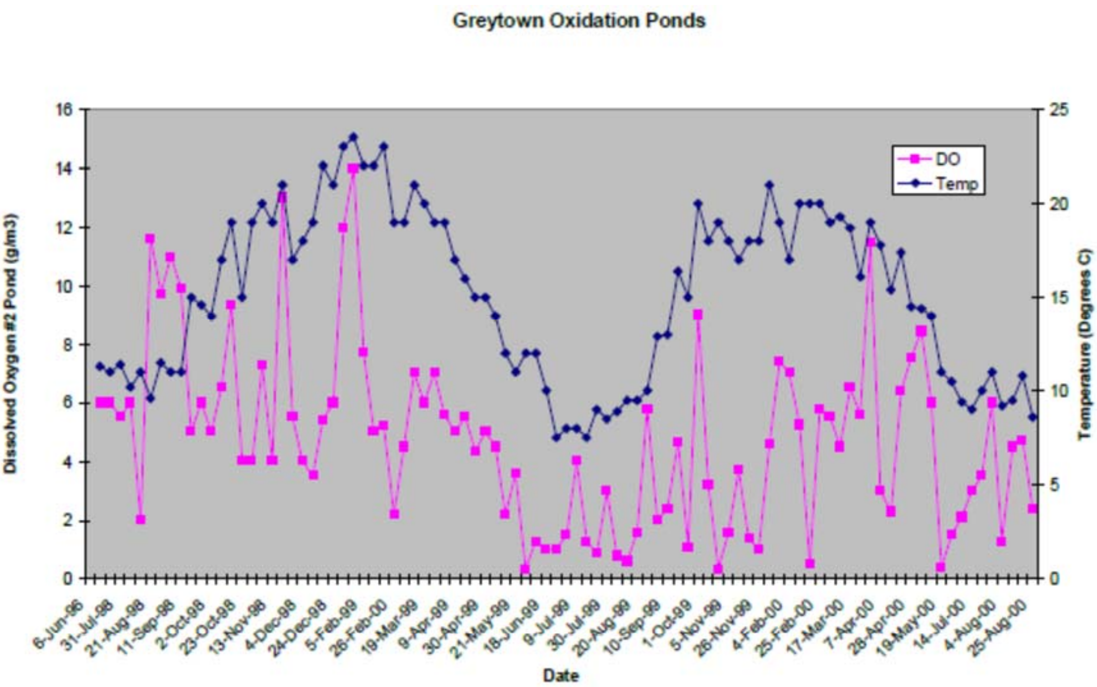


Fig 14: Seasonal dissolved oxygen and temperature variability

2.8 Pond systems will naturally exhibit a seasonal swing in dissolved oxygen levels. The example above illustrates a pond system in the Wairarapa where the daily D.O. level essentially reaches zero, without anything being ‘wrong’ with the treatment system, except that its ability to ‘treat’ is diminished in cooler weather. Superimposed on this are the diurnal swings in D.O. as a result of the photosynthetic activity of any algae present. During the day, the algae consume carbon dioxide (an acid) and split water to grow more biomass. Free oxygen is released during daylight hours, sometimes supersaturating the water column with oxygen. However, during the hours of darkness, this activity ceases and no further oxygen is released. That oxygen already released during daylight is either given off to the atmosphere or utilized by other organisms in the water column. Thus, quite naturally, there will be significant periods in the season of the pond system, when the effluent will be devoid of dissolved oxygen or even anaerobic.

2.9 Activated sludge type systems, that is the alternative form of aerobic treatment, are commonly used for municipal waste treatment but rarely on-farm. In this type of system, oxygen is introduced mechanically to satisfy the needs of an active biomass that cannot produce oxygen of its own. Aeration means are surface agitating machines or fine bubble diffusers on the reactor base.

2.10 These artificially aerated reactors are typically managed to operate at D.O. 1.5 to 2.0mg/l. However, when not properly controlled D.O. can reach 4 to 6mg/l. Any positive D.O is simply excess oxygen that the microorganisms do not require at a particular instant.

2.11 From the aerated reactor, the effluent travels to an unaerated clarifier structure where the active biomass is removed. The effluent typically rises through the clarifier over a period of 3 to 4 hours.

2.12 Any free dissolved oxygen leaving the aeration reactor will be consumed in in a very few minutes, if not seconds, of leaving the aerated space and the final effluent will leave the clarifier in an anoxic state except, perhaps for that induced in a small fall from the clarifier weir (typically 300mm) to the launder channel conveying the effluent from the weir to the discharge pipe.

2.13 Very occasionally it is possible to construct a cascade at the discharge that induces some air (and with it dissolved oxygen) entrainment before the final effluent reaches the receiving receptor, whether that be a storage basin or a receiving water.

2.14 In summary, it is impractical to expect all aerobic effluent treatment systems to operate and or discharge with a positive dissolved oxygen level at all times. The D.O. level of the effluent has little impact on whether it is odorous or not. Most of the best treated effluent will have zero D.O. on exiting the treatment plant.

Anaerobic Treatment Systems

2.15 This common process is used as an effective method of biologically degrading high strength wastes.

2.16 Most effective, non-covered, anaerobic ponds will tend to form a dense matt of low density solid material that floats on the surface. This matt prevents wind action from aerating the surface of the pond and creating an aerobic surface. However, this matt also tends to filter out most of the odorous compounds released as a result of the anaerobic decomposition/digestion process occurring at depth.

2.17 Generally, an anaerobic pond will subsequently discharge to one of the aerobic processes described above, prior to final discharge or disposal.

2.18 Thus, it will not be possible for animal effluent, held or treated in an anaerobic pond to be maintained at a D.O of 1mg/l or more.

3. WASTEWATER STORAGE SYSTEMS

3.1 In the current era, the most common method of dealing with dairy effluent is irrigation back to the dairy pasture as soon as is practicable after generation of the waste. This is normally dictated by weather and or ground conditions. Treatment and subsequent disposal is now comparatively uncommon.

3.2 Farm wastewater storage systems generally consist of either day tanks or storage ponds.

3.3 Day tanks receive daily wash-down water which is subsequently irrigated directly to pasture (if ground conditions allow) or transferred to much larger storage ponds.

3.4 The water level in day tanks is continually changing and frequently, they are empty and it is not practical to install aerators in these small vessels. Each aeration system has a minimum depth requirement before it can be used so there will always be a certain amount of the liquid that is not aerated. As discussed in section 2 above, any such oxygen transmitted to the liquid would quickly disappear and, if introduced immediately prior to irrigation pumping would result in pump cavitation problems and air entrainment in the irrigation lines. Therefore, in my opinion, it is impractical and unnecessary to impose an aeration requirement on day tanks.

Seasonal Storage

3.5 In the current era short term effluent storage, followed by irrigation to pasture, predominates as the methodology for reuse and disposal of effluent produced at the farm dairy and associated infrastructure. This storage can extend to use on a monthly or seasonal basis as and when climatic or soil conditions dictate that application to ground is inappropriate.

3.6 Larger storage facilities should, and normally are fitted with surface based mixing systems that will induce some aeration at the surface which should deal with much of the odorous compounds released from deeper, anaerobic areas. However, the objective and or design, are not to induce any particular level of dissolved oxygen in the stored effluent as it is very unlikely that any form of stable and effective (with respect to treatment) biomass (algal or bacterial) will be established in a system with such level and volumetric dynamics.

3.7 As with effluent 'Day' tanks, there is also a minimum effective level at which mixers can be used in a larger storage facility and, because of the comparatively large volume, reasonably substantial volumes may have to remain unmixed. Fully mixing a typical pond in excess of 2 megalitres requires a lot of energy. This would be approximately 10kW for a deep, vertical sided tank but significantly more for an inefficiently shaped, shallow lagoon. This is not efficient use of resources when there is no specific benefit arising.

4. pH

4.1 As discussed in the Dairy NZ Technical Note on Odour Management, treatment and storage systems alike require some intervention, normally in terms of more aeration or pH correction if unreasonable odour conditions develop. However, I would emphasise the 'if'. The other implication of a regulated pH range is that the individual farmer would need to maintain a ready store of a substantial quantity of bagged lime, on site, to be able to adjust up the pH at short notice. There are a number of impracticalities around this, not least the issues around managing dampness and special equipment for effectively mixing the lime into the contents..

4.2 In my opinion, in a farming scenario, it is impractical for such interventions to be mandatory regardless of whether there is an odour problem or not. I fully accept that interventions are necessary when significant odour incidents are likely or have occurred and would strongly recommend promotion of good management practices, use of appropriately prepared guidance materials and provision of training in this regard.

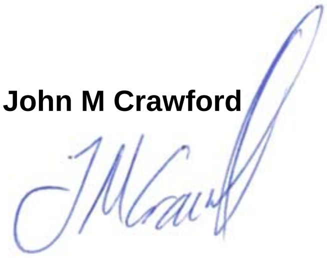
4.3 To have a permitted activity requirement to maintain effluent pH between any particular limits (and I include D.O monitoring here as well) would mean having the instruments to undertake regular monitoring. A combined, hand held instrument, of reasonable (but not high) quality, to measure both pH and dissolved oxygen is going to cost the individual farmer in the range of $2,000 to $5,000. On top of this, there is the cost for a regular calibration servicing as such instruments drift out of calibration.

5. **SUMMARY**

5.1 In summary, the pH range for effluent suggested in the proposed rule 7.68 (4) is reasonably pragmatic as a Guideline (not a target or limit). However, it would only be effective at managing certain odour compounds and, in my opinion should not become a limit unless there is a specific serious odour problem being addressed, and

5.2 the minimum effluent dissolved oxygen level of 1mg/l is not, in my opinion, a practical tool, is not going to be achieved, is not necessary and is not, in itself, going to prevent odour compounds being released.

John M Crawford



Principal Environmental Engineer
September 2015

APPENDIX 1: REFERENCES

Boyd, C.E., 1982. Water Quality Management for Pond Fish Culture. Elsevier, New York, NY,318 pp.

Dairy New Zealand, 2014. Technical Note on Odour management.

Mwegoha*, W. J. S., Kaseva, M. E. and Sabai, S. M. M. 2010. Mathematical modelling of dissolved oxygen in fish ponds. School of Environmental Science and Technology, Ardhi University (ARU), P. O. Box 35176, Dar es Salaam, Tanzania.

New Zealand Water and Waste Association, 2005. Oxidation Pond Guidelines.

Schroeder, G.L., 1974. Use of fluid cowshed manure in fish ponds. Bamidgeh, 26: 84-96.