

Land Treatment – Operating in an Era of Tightening Regulations

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ABSTRACT

Land treatment in New Zealand is coming under intense pressure from regulatory authorities, as there is recognition of the degrading water quality of the natural waterways and groundwater in agricultural land catchments subjected to increased intensive farming.

There has been a myriad of evolving rules and tightening limits with respect to the allowable movement of nutrients from land based activities. When land treatment is coupled to farming activities, an increased level of complexity arises and the cautious to reactive approaches of regulatory authorities are resulting in increased pressure for land treatment system operators. This leads land treatment system operators to continually re-examine the viability of land treatment systems on highly valued pastoral farmland.

This paper examines combined land treatment and farming operations to expose the continued constraints to making land treatment a viable option for the management of wastewater treatment and disposal. Overseer[®] modelling is utilised to determine the nutrient leaching sensitivity to changing operational parameters, in order to highlight the constraints with the management of land treatment systems in conjunction with farming operations.

Keywords: nitrogen, management, regulation, Overseer

INTRODUCTION

Land treatment of wastewater via irrigation is widely practiced throughout New Zealand for both municipal and agro-industrial wastewaters. The use of land for the management of the disposal of wastewater has also been actively promoted by regional authorities throughout New Zealand, not only to provide a disposal route to minimise direct discharges to surface water but also for water reuse and as a nutrient resource for agricultural and forestry land-use activities.

Over the past 20 to 30 years there has been a progressive push by regulatory authorities for treated wastewater to be irrigated to land rather than discharged directly to surface water. This has resulted in large investment in land purchase and irrigation systems for conversion to land treatment systems, which are often incorporated with complimentary farming activities.

In recent years there has been a drive from regional authorities for sustained net reductions in consequential nutrient leaching to groundwater from farming activities. One of the main mechanisms for the management of this control is the widely accepted use of the farm nutrient management model Overseer[®] developed by Overseer Limited.

Due to the common use of farm land for land treatment systems, Overseer[®] is also being enforced by regulators as a de-facto tool to be utilised for identifying nutrient loss from land treatment systems. While Overseer[®] may be an effective tool to identify nutrient loss

management measures at farm level, these measures do not effectively accommodate land treatment systems because of the need to irrigate wastewater outside of normal agronomic requirements.

One of the major challenges currently faced by land treatment system operators is how to maintain a land treatment system and achieve a reduction in nutrient leaching rates, as required by increased restrictions set by regulators, without substantially altering farm practices and limiting economic sustainability (Newman & Howard, 2013). This is especially challenging when the land treatment system is operated on land owned by third parties, as their priority will be to operate the farm with maximum economic returns without the burden of managing a land treatment system with substantial regulatory controls.

Evidently, the responsibility of improving water quality status does not solely lie with land owners and land treatment system operators. It is important for policy makers to be aware and understand the complexities of nutrient transfer from soil to water and not simply to use legislation to introduce and/or reinforce compliance measures, such as tightening of nitrogen leaching fraction (Stark & Richards, 2008). If nutrient reduction measures are found to be ineffective as a result of system effects, such as the response time of receiving waters and long hydrological pathways, it would be unjustified to burden land treatment system operators with more regulations and related cost increases.

This paper explores the paradox of whether a land treatment system will continue to be a viable proposition under increasing regulatory restrictions. In order to address this, operation and management of land treatment systems have been examined with Overseer[®].

RELEVANT REGULATIONS RESTRICTING LAND TREATMENT

The National Policy Statement – Freshwater (NPS Freshwater) (MFE, 2014) outlines specific freshwater quality goals for different ‘attribute states’ which communities (represented by regional/unitary councils) within New Zealand are required to enact and implement. For example, in order for a surface water body to achieve “*Attribute State A*”, it must meet certain water quality standards for various nutrient based water quality parameters, including ammoniacal nitrogen, nitrate nitrogen and phosphorus.

Diffuse discharges from land can be considered under the NPS Freshwater in a number of ways, as outlined in the guidance document for regional councils (MFE, 2016). One of the aspects is having the catchments identified using land management units (LMU). Diffuse discharges from farming and land treatment systems can be captured, along with direct surface water discharges, within a surface water catchment LMU, where connections between shallow groundwater underlying the land treatment area and the surface water body have been assumed or demonstrated. Alternatively the receiving groundwater itself can be a designated land management unit (MFE, 2016).

Given the relatively high phosphate retention of New Zealand soils, the key concern of diffuse discharge is invariably nitrogen discharge via loss to groundwater. Although surface water degradation can be caused by sediment and wastewater runoff, this can be mitigated through appropriately designed irrigation systems and riparian zones. Following best farming practice and designing suitable irrigation systems should limit sediment and phosphorus runoff, and this has not been considered further. Therefore, the key nutrient issue examined is nitrogen because of its mobility into groundwater.

The way in which land and water regional plans have approached managing and allocating nitrogen discharges and diffuse discharges from land with respect to the NPS Freshwater has varied between regional councils, which is reflective of the varied issues and challenges facing freshwater quality in different regions of New Zealand. However, it is generally understood that the majority are capping nitrogen discharge allowances (NDAs) within catchments or seeking to actively reduce NDAs within catchments where they consider that nitrogen has been over allocated (Baker-Galloway, 2013).

Common methodologies for managing NDAs (Crofoot, 2016) for diffuse discharges include:

- Limiting nitrogen losses of existing land use operations based their current nitrogen leaching rates (commonly referred to as grand-parenting).
- Setting an average land nitrogen loss (leaching) rate limit, potentially to allow nitrogen credit trading (polluter pays).

The implication of grand-parenting for controlling diffuse nitrogen discharges is that dischargers will be limited to the existing or reductions on the existing discharge, which does not acknowledge previous efforts to reduce nitrogen losses from the land treatment system. It means that current operators are restricted economically and by technology from increasing wastewater production and therefore commercial production above current levels. This restriction is acutely realised where previous “best practice” investments in reducing the effects of their operations have been made by land treatment operators. Essentially, if historical efforts have been put in place to reduce the effects of land treatment operations through improved wastewater treatment or farming operations, there becomes less opportunity for further required reductions. On the contrary, operators that have not reduced effects are better placed to achieve the same reductions. On the face of it, this method seemingly punishes those who have showed initiative prior to implementation of grand-parenting provisions.

Where an average nitrogen loss rate is utilised, diffuse discharges are required to decrease nitrogen losses, or suffer additional economic costs where nitrogen credits are allowed, to continue existing discharge or potentially to increase discharge. This method ignores the fact that land treatment system operators have invested significantly in infrastructure to avoid direct discharge to surface water, or even move from an existing direct surface water discharge system, and in the process reducing direct nutrient discharges to surface water bodies. Furthermore, where nitrogen credit trading is not considered by regional councils, land treatment systems tend to be more restricted than normal farming operations.

Utilising the common methods for managing nutrient leaching described, grand-parenting or average leaching rate, there is a tendency to further curtail activities where the operators have demonstrated good environmental practice of existing land treatment systems. When managing nitrogen loss through average diffuse nitrogen leaching rates, regional plans place land treatment in a farming context, not necessarily recognising land treatment in a wastewater discharge context, which includes consequential discharge to surface water. In doing so, additional burden is placed on land treatment systems while failing to be cognizant of other benefits that land treatment system contributes, in relation to pathogen and phosphorus removal, when compared with direct surface water discharge.

When considering land treatment systems in a context of nutrient losses from regional farming operations (beyond the farm footprint), there appears to be a disconnect. However, if we consider the land treatment systems in a context of net total discharge within a catchment, where the discharge of wastewater to land provides nutrients such as nitrogen and phosphorus

for removal as a sustainable resource, it could result in a better environmental footprint fit alongside other forms of wastewater discharge such as direct surface water discharge.

LAND TREATMENT SYSTEM ASSESSMENT - OVERSEER[®]

The Overseer[®] nutrient budget model is a New Zealand industry standard for assessing nutrient uptake and/or leaching from agricultural activities such as sheep, beef and dairy farms, including systems where fertiliser application and irrigation occur.

Due to the common use of farm land for land treatment systems, Overseer[®] is also now utilised to assess nutrient loss from land treatment systems. While Overseer[®] may be a tool to assess nutrient loss management at farm level, the extension of its use is fraught with difficulties.

Furthermore, Overseer[®] has a number of limitations including an output results uncertainty range of $\pm 30\%$ for models that sit within an agreed validation range. The level of output data uncertainty increases for more un-validated models such as bespoke land treatment systems modelling.

Despite its limitations, Overseer[®] is an appropriate management tool currently available for assessing nitrogen losses below rooting depth, including when land treatment activity is incorporated into the farming operations. However, as a regulatory tool where confidence in results is required, the limitations are questionable with respect to reliability and validity of repeatable output. The uncertainties are likely to exacerbate when comparing Overseer[®] modelling results for land treatment systems with farming systems.

When groundwater and surface water relationships are tested, then sufficient surface water monitoring can indicate with some certainty the actual land treatment discharge effects to surface water bodies, and the outcomes of these water quality monitoring programmes must be acknowledged to tighten the uncertainties presented from Overseer[®] model outputs. For example, the potential for nitrogen removal beyond the rooting depth, where denitrifying and/or reducing conditions exist, should be taken into account to allow for higher nitrogen leaching rates for land treatment systems.

Although direct field testing of leachable fraction through lysimeter monitoring can provide an indication of actual potential for leaching and for Overseer[®] model validation, the amount of variability in such field programmes generally preclude extensive use of comprehensive field lysimeter monitoring and its reliability for assessing leaching. To this end, the regulators generally rely on Overseer[®] model to assess and monitor compliance with consents.

TIGHTENING CONSTRAINTS PUT ON LAND TREATMENT SYSTEMS

In order to assist in an assessment of the viability and sustainability of land treatment systems under regulation in the context of regional farming further examination utilising Overseer[®] modelling is undertaken. The outcomes suggest that land treatment systems are constrained in terms of reducing nitrogen discharges when compared with other forms of diffuse discharge such as dairy farming operations. As land treatment systems vary throughout New Zealand, the outcomes discussed should be interpreted as indicative of likely trends.

Land Treatment Compared with Farming Only Systems

The operation of a land treatment system in combination with a pastoral farming operation is particularly common for industrial agricultural activities such as dairy and meat processing, where large facilities are located within productive farm land generally utilised for dairy farming.

Nitrogen losses to groundwater will generally be higher for dairy farm land utilised as part of land treatment than for other surrounding dairy farms receiving the same nitrogen loading on the same or similar soil types. To demonstrate this, a number of scenarios were modelled using Overseer[®]. All scenarios were modelled as an intensive dairy farm in the Waikato region with a stocking rate of 3.3 cows/ha, situated on a well-drained soil and receiving a nitrogen loading of approximately 200 kg-N/ha/yr. However, the following variation in the form of the nitrogen and irrigation between scenarios were made:

- i. Fertiliser application of 200 kg/ha/yr, applied in four applications (August, September, November, January). No Irrigation.
- ii. Fertiliser application of 200 kg/ha/yr, applied in four applications (August, September, November, January). Freshwater irrigation of 200 mm/yr, applied at 25 mm/month from October to May inclusive.
- iii. Wastewater irrigation of 200 mm/yr applied at 25 mm/month from October to May inclusive, containing a nitrogen concentration of 100 mg/L resulting in a nitrogen load of 200 kg-N/ha/yr.

Figure 1 below outlines the estimated leaching rates for the modelled scenarios. To demonstrate this variation across a number of nitrogen loading rates, the three scenarios described above were also modelled at a different nitrogen loading rates with the estimated nitrogen losses as shown in Figure 2 below. The results in Figure 2 are the estimated from simplified modelling to demonstrate this variation, as in practice, reduced nitrogen loading would generally lead to reduced productivity, resulting in lower stocking rates and consequential reduction in nitrogen losses.

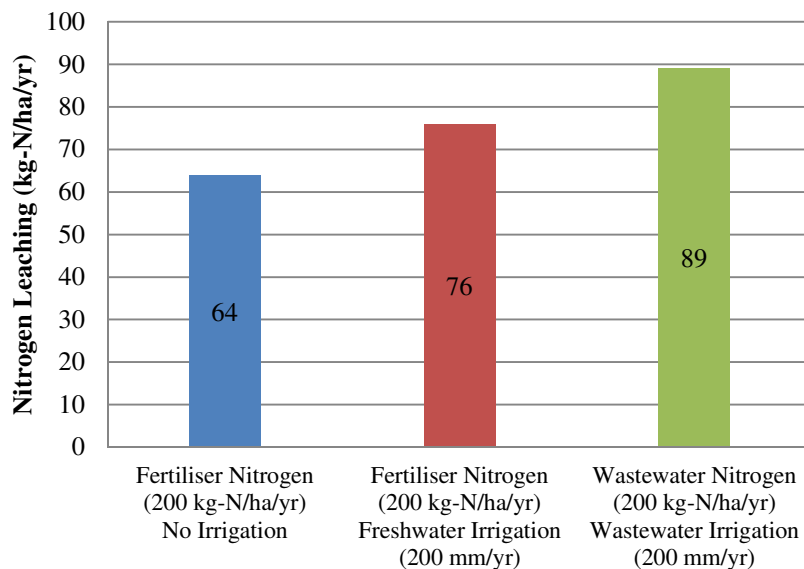


Fig. 1. Modelled Effect of Freshwater Irrigation and Wastewater Irrigation on Nitrogen Leaching Rates from Dairy Pasture at a Nitrogen Loading Rate of 200 kg-N/ha/yr

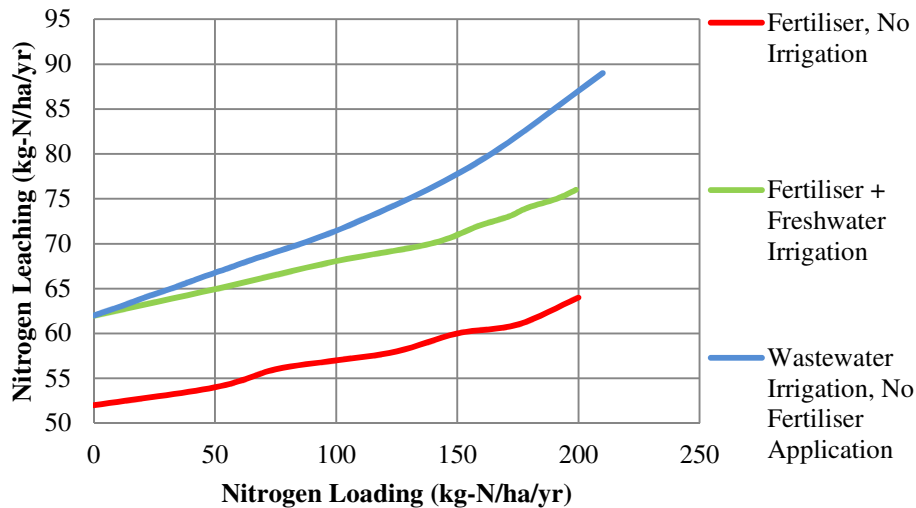


Fig 2. Modelled Effects of Irrigation and Wastewater Irrigation on Nitrogen Leaching Rates from Dairy Farm Pasture at Various Nitrogen Loading Rates

One likely cause for increased nitrogen losses is the nitrogen flushing effect of irrigation. As shown in Figures 1 and 2, the leaching loss from the scenarios receiving fertiliser application at the same loading rate was greater for the scenario also receiving freshwater irrigation. This is demonstrating the flushing effect of irrigation water on receiving soils, where the irrigation simulates a longer period when opportunities for flushing of nitrogen can occur. As land treatment systems need to operate outside of normal crop water requirements, the effect is likely to be more pronounced.

Another contributing cause of increased nitrogen losses from land treatment system is the concurrency of nitrogen applied to the land area. As shown in Figures 1 and 2, for the same nitrogen loading rate, the scenario receiving wastewater irrigation results in a greater nitrogen leaching rate than for the scenario receiving fertiliser and freshwater irrigation. Both these scenarios have received the same depth or volume, with 25 mm/month being applied October to May, at a depth of 200 mm annually. The cause of higher nitrogen leaching rates for the irrigated wastewater scenario is likely associated with the form of nitrogen that is present in the wastewater.

The irrigation function of the Overseer[®] model assumes that nitrogen in the irrigable water is in the form of highly mobile nitrate nitrogen (NO₃-N). The majority of municipal and industrial land treatment systems apply pre-treated wastewater to land. Aeration of wastewater during treatment processes results in the majority of nitrogen in effluent wastewater being in the form of nitrate nitrogen, therefore, the Overseer[®] assumptions around the form of nitrogen in irrigation systems are applicable for wastewater irrigation systems. The majority of nitrogen rich fertilisers utilised for pasture systems contain ammoniacal nitrogen (NH₄-N) and/or organic nitrogen, which requires time to mineralise and is generally matched to plant uptake, reducing the risk of leaching.

The implications of the higher nitrogen leaching from land treatment systems compared to dairy farms is that where an average leaching rate for a LMU is set by regulatory authorities, the level of nitrogen loading reduction required will be much greater for land treatment systems even for similar levels of nitrogen loading. Where nitrogen credit trading is allowed, the required amount will be much greater for land treatment systems.

For land treatment operators, this represents an added investment required either for increased pretreatment or nitrogen credits to discharge a waste product for beneficial reuse. This cost is in addition to the existing investment in land treatment system infrastructure and pretreatment. Similarly, dairy farm operators operating above this LMU limit will have reduced profits resulting from decreased nitrogen loading and productivity, or, as a result of nitrogen credit costs.

Despite the higher nitrogen leaching rates for the land treatment system compared to the farming operation, this only represents one aspect of the environmental cost for the two operations. Other environmental costs or benefits to consider could include:

- Cost of production transport and farm application of chemical fertilisers.
- Cost of using of freshwater resource for farm irrigation.
- Benefit of utilising treated wastewater as a resource rather than direct disposal into surface water bodies.

Impact on Dairy Production

To provide a comparison the reduction in productivity required to bring leaching for a land treatment system into line with a similar farming operation, stocking rates for a combined land treatment dairy farm system and an irrigated dairy farm receiving fertiliser were modelled at varied stocking rates. The estimated nitrogen leaching rates for these varied stocking rates are given in Figure 3. As this shows, the land treatment system would need to reduce its dairy stocking rate (measured as stocking units (su)) from 3.3 su/ha to 2.2 su/ha in order to achieve the same nitrogen losses. This represents a significant reduction in productivity for the land treatment dairy farm, where both systems receive the same nitrogen loading rate.

The average milk solids (MS) production reduction from around 1,228 kg MS/ha to 818 kg MS/ha, based on average milk solids per stocking unit and reduced stocking rate, could lower the revenue for the farming operation from around \$7,800 per hectare to \$5,200 per hectare, based on average gross milk solids revenue for the 2014/2015 year (DairyNZ, 2016). This could have socioeconomic consequences such as loss of jobs or decreased wages for industries which are often major employers in rural New Zealand, or alternatively if operating a land treatment system on land owned by a third party farm owner, this could cause a withdrawal of land from the system.

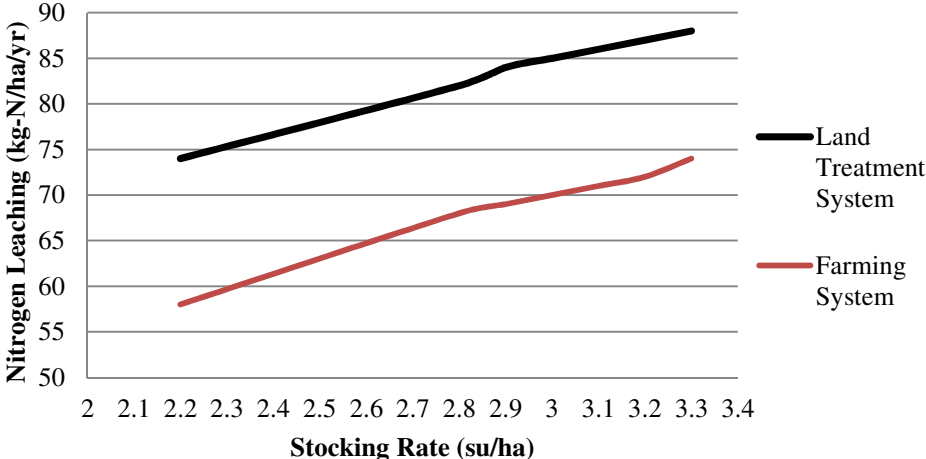


Fig 3. Nitrogen Leaching Rates from Dairy Farm Pasture at Various Stocking Rates for a Land Treatment System and for a solely Farming Operation

Limitations of Wastewater Pre-treatment

A typical response to increasing regulation and restrictions on diffuse discharge from land treatment system is to increase the level of pretreatment to reduce nitrogen concentrations in the discharged treated wastewater. Using Overseer[®] modelling the limitations of this management response is discussed.

Figure 4 below shows the estimated nitrogen losses for the modelling scenarios discussed in Figure 2, however, in addition to the scenarios discussed the results of an additional scenario are included (Wastewater Irrigation + Fertiliser Application). For this scenario, both wastewater and fertiliser nitrogen application was utilised to maintain an assumed crop requirement of 200 kg-N/ha/yr. Where wastewater nitrogen content is reduced, fertiliser nitrogen loading is increased so the total nitrogen loading of 200 kg-N/ha/yr is maintained.

The reason this additional scenario was modelled was that in practice, in order to operate a productive dairy farm operation, nitrogen application is utilised to promote pasture growth and sustain milking herds, and if the nitrogen content of the applied wastewater is reduced, additional nitrogen fertiliser will be required or the productivity of the dairy farm will be impaired.

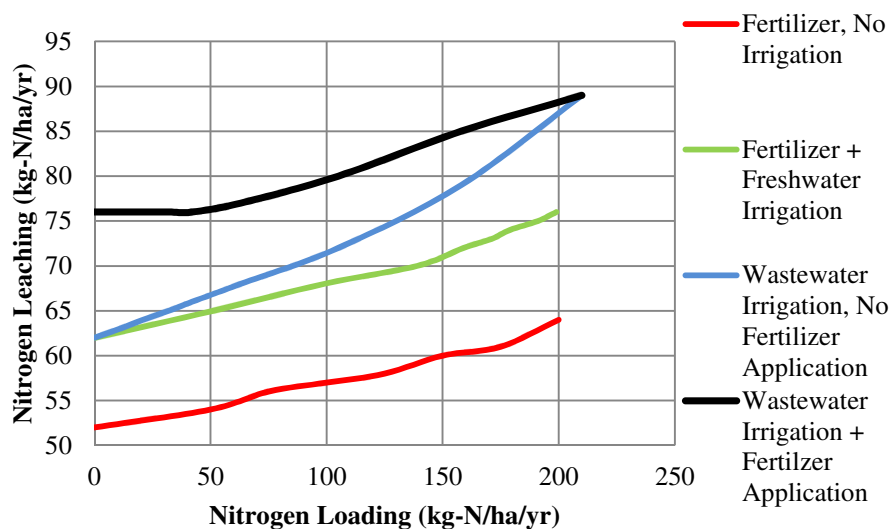


Fig 4. Effects of Irrigation and Wastewater Irrigation on Nitrogen Leaching Rates from Dairy Farm Pasture at Various Nitrogen Loading Rates

Figure 4 indicates that reductions in wastewater nitrogen loading through wastewater treatment will reduce nitrogen leaching rates for systems with high wastewater nitrogen loadings, however, for systems with low nitrogen loading, the benefits of reducing nitrogen loading further are minor.

For wastewater nitrogen loading of 200 kg-N/ha/yr (100 mg/L TN), the estimated nitrogen leaching is approximately 89 kg N/ha/yr. Through improved wastewater treatment to achieve a wastewater nitrogen loading of 40 kg N/ha/yr (20 mg/L TN), this leaching rate can be decreased to 76 kg-N/ha/yr. However, further treatment to reduce wastewater nitrogen loading will not result in decreased nitrogen leaching rates, or changes are so minor that they are not observable in Overseer[®] outputs. This is because as nitrogen levels within wastewater are reduced, the land treatment approaches the leaching rate of 76 kg-N/ha/yr for the modeled system receiving fertiliser and freshwater irrigation water, as presented in Figure 1. This

indicates that leaching rates cannot be reduced below this level through wastewater treatment alone without reducing fertiliser loading rates, which may have a negative impact on farming operations. For each farming and land treatment operation, the limit to what nitrogen leaching mitigation can be achieved with wastewater treatment will vary, depending on the pasture and fertiliser requirements and a number of other factors.

In comparison where fertiliser loading is not increased to maintain productivity (i.e. just wastewater application to land), increased wastewater treatment results in a better response in nitrogen leaching, however, impairment of farm production will be experienced at lower nitrogen loading rates.

When considering the implication of this limitation to what reductions in nitrogen loads can be made, the constraint is common to farming operations (excluding the elevated nitrogen losses for similar loading rates discussed earlier). However, if you compare this limitation to surface water discharges, a disparity becomes apparent.

Consider a region where the regulator is trying to reduce rather than cap existing nitrogen discharges. Within an LMU with a targeted nitrogen discharge reduction of 10%, any direct discharge to surface water will need to be improved through further wastewater treatment processes to achieve a 10% decrease in nitrogen loads discharged, with no downstream impact on productivity in a farming system. However, a combined land treatment dairy system in the same LMU will have to achieve much higher levels of treatment, as the relationship between applied nitrogen loads, and leached nitrogen loads is not linear. Figure 4 indicates that for a system where wastewater irrigation and fertiliser is utilised, in order to reduce nitrogen leaching losses from 89 kg N/ha/yr to 80 kg N/ha/yr (approximately 10% reduction), wastewater nitrogen loads discharged from pretreatment to land will need to be reduced by 50%. For a wastewater irrigated dairy farm receiving no additional fertiliser, the required reduction in nitrogen loads discharged is lower, at 25%. However, this will result in reduced productivity for the farm and is still well above the 10% required for surface water discharge.

If the land treatment system in question already has a high pretreated effluent quality, there is a restriction in what can be achieved without reducing fertiliser application and reducing farm production levels. This indicates how assessing land treatment systems as a diffuse discharge source in a regional farming context could be more restrictive than for point source discharges. Furthermore this does not acknowledge the additional treatment achieved by land treatment following pretreatment such as pathogen and phosphorus removal.

Zero Grazed Land Treatment Systems

The conversion of a land treatment system from a grazed pastoral system to a cut and carry system is generally considered to be an effective method for reducing the nitrogen leachable fraction.

In order to fully assess the effects of a conversion from grazed pasture to cut and carry, the effect of providing supplementary feed to stock on other farms needs to be considered. The supply of supplementary feed on other farms can allow increased stocking rates and lead to increased nitrogen losses. Modelling the increase in stocking rate and nitrogen losses at an adjacent dairy farm as a result of cut and carry supplied supplement feed (to the extent that the amount of dry matter production is similar to that of a grazed farm) can provide an indication of the true nitrogen loss reduction.

Utilising overseer the following scenarios were modelled:

- i. **Land Treatment Grazed (2.2 su/ha):** Wastewater irrigation of 200 mm/yr applied at 25 mm/month from October to May inclusive, containing a nitrogen concentration of 100 mg/L resulting in a nitrogen load of 200 kg-N/ha/yr. No supplement feed. Pasture growth estimated by Overseer[®], as a function of herd requirements, to be approximately 14,200 kgDM/ha/yr.
- ii. **Dairy Farm Grazed (2.2 su/ha):** Fertiliser application of 200 kg/ha/yr applied in four applications (August, September, November, January). Freshwater irrigation of 200 mm/yr, applied at 25 mm/month from October to May inclusive. No supplement feed. Pasture growth estimated by Overseer[®], as a function of herd requirements, to be approximately 14,200 kgDM/ha/yr.
- iii. **Land Treatment Cut and Carry:** Wastewater irrigation of 200 mm/yr applied at 25 mm/month from October to May inclusive, containing a nitrogen concentration of 100 mg/L resulting in a nitrogen load of 200 kg-N/ha/yr. Supplement made assumed to be 12,000 kgDM/ha/yr (approximately 85% harvest efficiency for growth of 14,200 kgDM/ha/yr)
- iv. **Dairy Farm Grazed (4.4 su/ha):** Fertiliser application of 200 kg/ha/yr applied in four applications (August, September, November, January). Freshwater irrigation of 200 mm/yr, applied at 25 mm/month from October to May inclusive. Supplement feed of 12,000 kgDM/ha/yr hay. Pasture growth estimated by Overseer, as a function of herd requirements, maintained at approximately 14,200 kgDM/ha/yr.

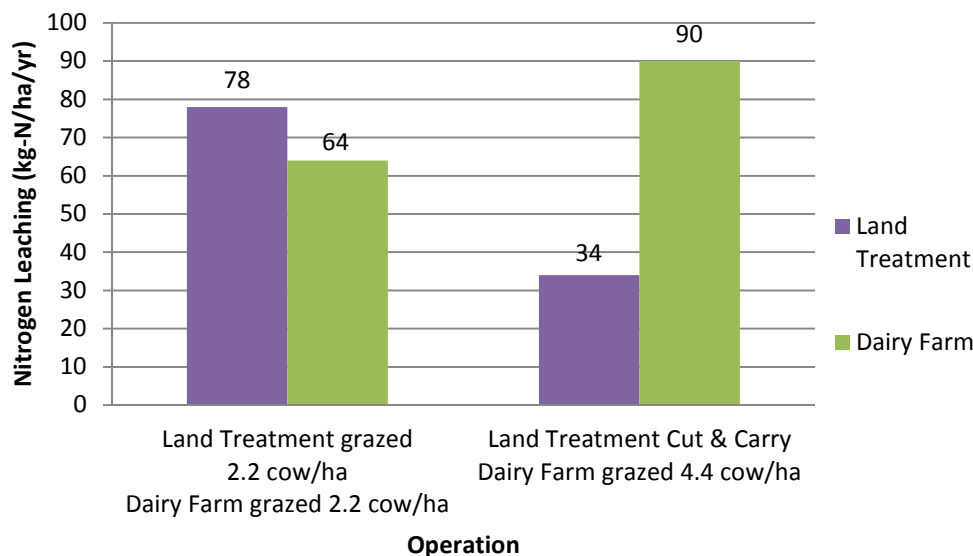


Fig 5. Effect of Land Treatment Change from Grazed to Cut & Carry System

As shown in Figure 5, the nitrogen leaching from the land treatment system reduced under the cut and carry system from 78 kg-N/ha/yr to 34 kg-N/ha/yr, a reduction in nitrogen losses of approximately 53%. However, the modelling assessment also shows a marked increase in nitrogen losses from the dairy farm from 64 kg-N/ha/yr to 90 kg-N/ha/yr, as a result of supplementary feed and increased stocking rates. The net nitrogen losses from a 100 ha land treatment system, before and after the change to cut and carry, and an adjacent 100 ha dairy farm, before and after receiving supplement feed, are given in Figure 6. The overall net nitrogen reduction from 14,200 kg-N/yr to 12,400 kg-N/yr is approximately 13%, much lower than the 53% achieved for the land treatment system alone. Although this is a modelled example, and supplement feed may in practice be spread across a number of farms, it indicates that the real reductions that can be achieved by a direct change to a cut and carry system are not as significant in a district/regional context as generally promoted.

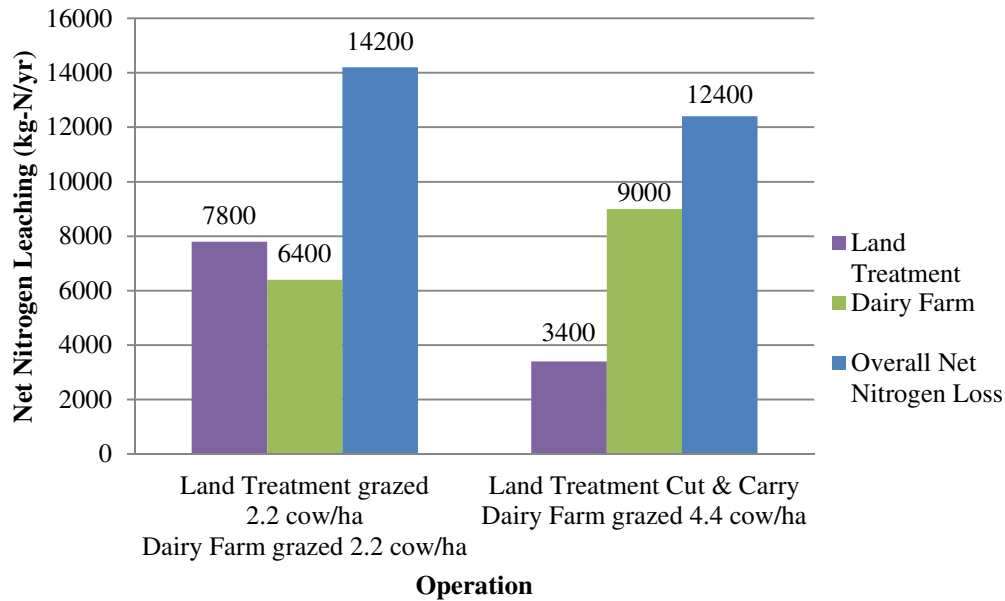


Fig 6. Net Effect of Land Treatment Change from Grazed to Cut & Carry System for 100 ha Land Treatment area and 100 ha Dairy Farm Receiving Supplement Cut & Carry Feed

Given that the difference in the nitrogen losses is marginal, an examination of the resultant negative economic return on the farmland also needs to be considered. The average total revenue for dairy farms in New Zealand was \$8,771 per hectare in 2013-2014 and \$6,986 per hectare in 2014-2015 (DairyNZ, 2016). When a land treatment system is entirely converted to a cut and carry operation, the likely revenue for hay is approximately \$4,000 - \$5,000 per hectare (Farm Feed, 2016) (FAR, 2010). This means that for a typical 300 ha land treatment dairy farm operation, the annual opportunity cost of moving from a grazed dairy farm to a cut and carry hay production land use could be in the order of \$600,000 to \$1,400,000 in revenue.

Stock Standoff Pad - Potential Mitigation Method

One potential solution for reducing nitrogen leaching from land treatment systems, including where good pretreatment is already being achieved, is the use of standoff pads. The placement of dairy cattle onto standoff pads allows the capture of excreted nitrogen that would otherwise be deposited on the pasture and soil. This means that preferential loss pathways from urine patches is eliminated, resulting in better distribution and utilisation of nitrogen in a combined land treatment/grazing system.

To assess this scenario the following is modelled:

- 100 ha land treatment operating as a dairy farm with a stocking rate of 3.3 su/ha.
- Well drain Waikato region soil.
- Wastewater irrigation of 200 mm/yr applied at 25 mm/month from October to May inclusive, containing a nitrogen concentration of 30 mg/L resulting in a nitrogen load of 60 kg-N/ha/yr.
- Fertiliser application of 140 kg/ha/yr, applied in four applications (August, September, November, January).

In order to identify the potential benefit in reducing nitrogen losses to groundwater by utilising standoff pads, this scenario was then varied to utilise stock stand-off pads for July only, June-July, June-August, May-August, and May-September. Stock stand-off pads were utilised 16 hours a day for 100% of herd within the selected months indicated.

The capture of cow excreted nitrogen on standoff pads will create additional effluent to be exported offsite. In order to capture this increased effluent disposal within the standoff pad scenarios, each scenario was run with the export of effluent offsite, and again with the effluent spread across the dairy farm pasture

The results of standoff pad scenarios are shown in Figure 7. The results show that increased utilisation of standoff pads will reduce nitrogen leaching rates. The effects of discharging effluent collected within standoff pads back to the land treatment areas resulted in higher leaching rates than when the standoff pads were utilised for the same months but effluent was exported offsite. However, the utilisation of standoff pads still resulted in a net decrease in leaching rates to groundwater as shown in Figure 7. This is due to the redistribution of otherwise point source (urine patches) loading from stock evenly over the land treatment area.

This modelling indicates that standoff pads will reduce nitrogen leaching from land treatment systems. Standoff pads will also help prevent pugging for farms by reducing the time spent on pasture by stock during wet winter months.

Stand-off pads show promising results for nitrogen loss reductions, however, they require additional capital investment. A land treatment system required to meet average nitrogen limits within a LMU, where farming operations may not need to due to the nature of wastewater irrigation and its effect on elevating nitrogen losses, is another example of the constraints facing land treatment systems.

There is concern that the use of stand-off pads, which shows clear nitrogen leaching reduction for land treatment systems could raise animal welfare perception. New Zealand enjoys dairy's free range farming practices and wholesale shift in farm practices could negatively impact market share.

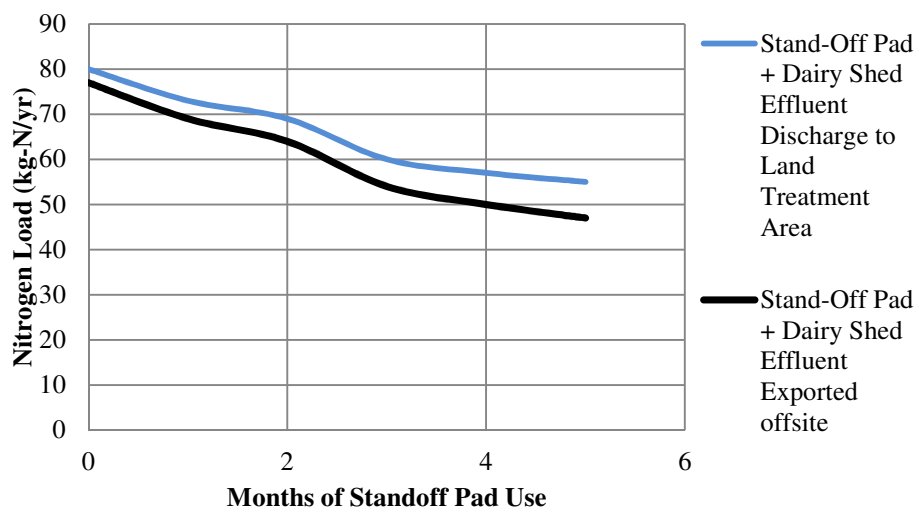


Fig 7. Effects of Standoff Pads on Nitrogen Leaching Rate

CONCLUSIONS

When considering land treatment in terms of total discharge to the receiving environment, land treatment appears to be a good fit, providing sustainable resource use of a wastewater which provides nutrient, pathogen and solids removal, as an alternative to direct discharge to surface water. However, when considering land treatment in the context of regional farming

operations and addressing diffuse discharges, land treatment appears to come under additional scrutiny, facing more constraints compared to farming operations and surface water discharges.

It is likely that as new policies evolve with tightening management of diffuse sources nutrient reduction under NPS Freshwater, the land treatment systems when combined with complementary farming operations will be under enormous pressure to the point where farming operations on such combined operations would become unsustainable. In addressing this constraint, the regulators need to address the effects based on wider regional scale, rather than strictly on a farm basis. It is also considered that land treatment systems need to be assessed individually on the basis of effects, and in the context of being an alternative to a direct surface water discharge, and recognising that it represents a sustainable use of resources.

When continued pressure is put on land treatment systems, it could potentially alienate some key environmental advantages of land treatment, especially when nutrient reductions are to the extent that they have a negative economic impact on complimentary farming operations.

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