DAIRY GREEN:
ALTERNATE DAIRY EFFLUENT APPLICATION METHODS

A MAF SUSTAINABLE FARMING FUND PROJECT

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Abstract

A large increase in dairy farms and dairy cow numbers in Southland over the last 25 years has had a significant impact on the local environment. Traditional methods of dealing with dairy shed effluent needed to be updated to prevent pollution of surface and ground water. The use of rotating boom travelling irrigators in the mid 1990s up to present have contributed to environmental damage in the region. Effluent runoff, ponding and contamination of water ways by effluent that entered tile and mole drains has been observed. This occurs mainly because of the application rate and soil conditions at the time of application.

A project funded from MAF's Sustainable Farming Fund allowed studies to be carried out on dairy effluent irrigation. One key finding was travelling irrigators were often not the correct tool for the job when considering soil conditions, application rate, distribution pattern and nutrient loading. The milking season in Southland runs from August to May. Soil moisture conditions can be at field capacity during August and September and April and May and for periods up to three weeks at any other time. Grazing animals during these periods damages soil structure and as a result reduces effluent infiltration rate. Monitoring of soil infiltration rates showed low values especially in spring, some as low as 0mm after 20 minutes. The rate of application with a travelling irrigator can be very high, up to 40mm depth in 30 minutes which causes ponding, runoff and preferential flow to subsurface drains. Nutrient loading was also a potential issue with nitrogen applications ranging from 24 kg/ha up to 90 kg/ha, assuming 15 mm depth was applied.

The studies highlighted some key points. Effluent needs to be applied at a rate that matches infiltration rate. Application should only be when a suitable soil moisture deficit exists and effluent nutrient analysis is important for nutrient budgets.

K-line was trialled as a low rate application method; 4.0mm nozzles gave the best result. The significance of effluent application via K-line to moist or very dry soils was highlighted. K-line has proven benefits for the farmer and environment with reduced nutrient loss and water contamination, more palatable pasture, electricity savings and ease of use.

Regional councils evaluated and accepted low rate application using K-line. This was important as the councils set the conditions in regards to effluent discharge and storage.

Key Words: Dairy shed effluent, low rate application, travelling irrigator, K-line.

Background

Southland is the southernmost province in New Zealand and covers 31,600 square kilometres. 23 percent of the land area is farmed. The population is 90,000 people.

STOCK NUMBERS - Trends

1981	9 million sheep
	20,000 dairy cows
2009	4.5 million sheep
	418,000 dairy cows
	785 dairy farms

Note the increase in dairy cows!

Dairy Shed Effluent Treatment

In the 1970's two pond, anaerobic aerobic treatment systems were used with discharges to waterways. With an expanding industry there was concern the discharges from an increasing number of dairy farms would impact on water quality. By the mid 1990s a change had been made to land irrigation for effluent primarily using rotating boom travelling irrigators.

Regional council monitoring and farmer experience was that the application of dairy shed effluent to land sometimes caused pollution to waterways.

It was subsequently found the irrigators being used had an application rate up to five times higher than soils could cope with.

Excess effluent from irrigation would sometimes run off the paddock or go into mole and tile drains and into waterways. The recommendation was to set irrigators to the fastest speed and apply only small amounts of effluent – 10 mm depth. This was not always practical and some system designs would not achieve this.

The Dairy Green Project

An application was made to the Sustainable Farming Fund administered by MAF for a project to study the issues related to dairy effluent irrigation and to find better, alternate application methods. The project was divided into three parts with a proposed timeline as follows:

1. 2002 – Starting in spring a study of 10 farms looked at how dairy shed effluent is managed and what issues farmers face in their day to day management
2. 2003 – Develop and trial alternate effluent irrigation methods.
3. 2004 – Make public the research findings.

Project Findings – Year One

Dairy farmers face a range of problems in managing effluent systems. There is no standard system design. Inappropriate design of system components creates management problems, for example, sand traps that cannot be easily cleaned, pumps that are hard to service and prone to wear, pumps that were undersized for the range of irrigator duties required, irrigators that were unreliable or performed poorly.

Design can happen by "default" – those who have products to sell create a design to use their product rather than considering the outcomes required and designing accordingly.

A key finding was that the travelling irrigators commonly used to apply effluent were not always the right tool for the job when considering soil conditions. The distribution pattern was usually very uneven and the application rate very high.

In Southland the milking season typically runs from August to May. Soil moisture levels can be at field capacity or close to it during August and September and April and May and often for periods up

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to three weeks at any other time during the season. Soils at field capacity are prone to soil structure damage during grazing and a loss of infiltration rate.

Measurements were taken on 10 farms to record the soil infiltration rates of paddocks that were being used to receive effluent.

Soil Infiltration Results

Infiltration measurements were taken in spring, summer and autumn on 10 farms.

Table (1): 20 minute Cumulative Infiltration depth for clean water-Spring, 2002

Infiltration Depth (mm)	No. of Farms
0-10 mm	4
10-20 mm	2
20-50 mm	2
50 mm +	2

Ideally travelling irrigators should be set to apply a depth of 10mm effluent. Typically this means they would need to travel at a speed where they apply this in 20 minutes. By measuring the soils infiltration ability for a 20 minute period, an indication can be gained as to whether there will be ponding on the soil surface.

In reality, the average application depth was much greater than 10mm and irrigators were taking longer than 20 minutes to pass any one point. Ponding was a significant problem on 6 farms. Two farms had infiltration rates of 0mm after 20 minutes indicating serious surface soil structure problems.

Infiltration rates improved during summer and deteriorated in autumn again to approach the results measured in spring.

Irrigator Performance

When the irrigator is stationary and distributing effluent the wetted pattern is a "donut" shape. When the irrigator moves forward this pattern is maintained. Consequently the depth of application is quite variable. The application depth is much greater at the outside of the wetted width and less in the centre.

The depth of application can vary from 12-40 mm across the wetted pattern. The rate of application is also very high. Up to 40 mm depth could be applied in 0.5 hours or less. For many farms this leads to ponding followed by overland flow and in some situations preferential, rapid flow down the soil profile to subsurface drains.

Nutrient Loadings

During the season samples of the effluent were randomly collected from what was being irrigated onto pasture. Assuming 15 mm depth of application (i.e. 150 m^3 volume applied per hectare) the following table shows total nitrogen and phosphate loadings for a single irrigation event for 8 farms. Often effluent was being applied several times during a season and at greater than 15mm depth.

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Nutrient Loadings

Table (2): Nutrient Loadings per ha per 15 mm effluent application depth

Nitrogen (N) and Phosphate (P)

Farm	Total N, kg	Total P, kg
1	50	8
2	69	6
3	90	27
4	57	7
5	24	4
6	60	9
7	54	7
8	51	8

Key Implications from Monitoring Information

Soils receiving effluent need to be managed:

- to maintain soil structure
- to balance nutrients, from effluent and fertiliser

Effluent needs to be applied at a rate that matches soil infiltration rates.
Effluent should be applied when there is a suitable soil moisture deficit.
Effluent should be analysed for nutrient content so that a nutrient budget can be completed.

It was clear that the travelling irrigators being used to apply effluent had too high an application rate for much of the milking season.

A means of applying effluent at a lower rate was required. Speeding up the irrigators would reduce the depth of application, but not the rate that the soil received effluent. To reduce the application rate, the option of using smaller nozzles was looked at.

Trial Work – Year Two

K Line for Effluent Application

To achieve a low application rate (mm/hr) much smaller nozzles are required than those currently used on travelling irrigators, which typically range from 12mm to 15mm.

We trialled a range of nozzle types and sizes from 2.5mm up to 7mm diameter.
4.0 mm nozzles were found to be a good compromise giving a reasonable volume irrigated and reduced chance of blockage while still maintaining a low application rate.

The effect of achieving a low application rate is very significant when soils are moist or very dry.

Trials were carried out applying effluent either by travelling irrigator or K line onto silt loam soils when at field capacity. The soils had subsurface drainage installed to collect effluent that dropped below the root zone.

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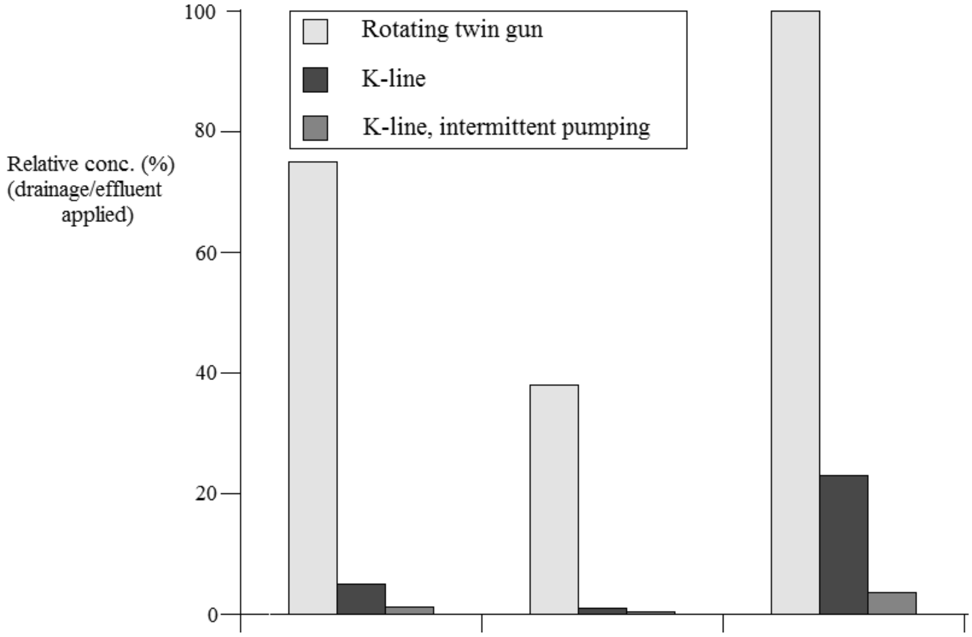
Filtration of effluent: K-Line vs. twin gun travelling irrigator



This graph shows the results of a trial on mole drained soils in West Otago. 10mm depth of effluent was applied either by irrigator or K line and the concentration of phosphate, ammonia nitrogen and E.coli bacteria were measure in the drainage water

To use 4.0 mm nozzles the solids need to be removed from the effluent. The use of clay lined primary pond(s), called sludge beds, is one option for this and these are fitted with a filter wall, locally called a weeping wall. Sludge beds are made 8 m wide, 1-2 m deep and up to 30 m long. A weeping wall is a slatted timber wall which retains solids but allows liquid to pass. The liquid then goes to a storage pond. The filter wall needs to be properly designed as it acts as a retaining wall. Concrete is recommended beneath the line of the weeping wall to prevent scour of any clay lining.

Since the solids are removed from the effluent more efficient pumps can be used and these can be located on the pond bank. A filter is used in the pond and connected to the suction line of the pump. The filter ensures there are minimal blockages of the sprinkler nozzles. The pump typically supplies 24 nozzles and the total flow rate is 18,000 litres per hour. This suits the 90mmMD mainline typically used on most farms.

The benefits of the smaller nozzles has been quite significant, reduced nutrient loss, more palatable pasture, electricity savings and no more time required to shift them than moving a travelling irrigator.

The concept has been evaluated and accepted by Regional Councils who set the operating rules for the discharge of dairy effluent.

Low rate irrigation has been installed on more than a quarter of the dairy farms in Southland now.

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