MANAGEMENT PRACTICES AND TECHNOLOGIES FOR REDUCING NITROGEN AND PHOSPHORUS LOSSES FROM SOILS RECEIVING FARM DAIRY EFFLUENT

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This thesis is dedicated to my wife Jolanda,

and my children Nicholas and Jasmine.

Thank you for your encouragement,

inspiration and love!

ABSTRACT

The loss of nutrients to the aquatic environment caused by the irrigation of farm dairy effluent (FDE) is a prominent and contentious feature of dairy farming in New Zealand. This thesis investigates management practices and technologies with potential to reduce nitrogen (N) and phosphorus (P) losses in drainage water from mole and pipe drained dairy pasture soils irrigated with FDE.

Farm dairy effluent management was both monitored, using remote sensing technologies, and modelled on a case study farm. During the winter and spring of 2008, an estimated 7,890 m^3 of FDE was applied in excess of the soil water deficit (SWD). System constraints were the cause of about two-thirds (5,070 m^3) of this over-applied FDE volume. It was estimated that as much as 502 kg TN and 83 kg TP could have been lost to surface waters due to inadequate infrastructure. The two main system constraints were the farm's insufficient FDE storage capacity (2,000 m^3) and the inability of the farm's irrigator to apply small application depths (<8 mm). Furthermore, this study highlighted the significant loss of nutrients that can occur under FDE irrigation and reinforced the need for tools to assist farmers with FDE management.

A number of tools were developed to help farmers manage FDE irrigation. The use of a soil water balance, incorporating actual farm daily rainfall, is an effective method for informing the scheduling of FDE irrigations. Also, the risk of over-application of FDE to soils caused by travelling irrigator breakdowns or stoppages was substantially reduced by the use of a breakdown alert and automatic shut-off system developed and evaluated in this study.

Given the elevated risk of P losses from soils treated with FDE, a method of capturing P from drainage waters was investigated. A field experiment was conducted to quantify the ability of Papakai tephra, installed into mole and pipe drainage systems, to remove P from drainage waters. This drainage system reduced TP losses in drainage by about 50% (c. 0.14 kg P/ha) over a drainage season, which equated to a 2.8 kg P reduction for a 20-hectare effluent block.

As farmers frequently crop effluent block soils, the effect of summer forage cropping on nutrient losses was quantified. The practice of spring cultivating long-term dairy pasture, summer forage cropping and autumn regrassing increased the quantity of TN measured in drainage water, over three drainage seasons (2006 to 2008), by 84% (21 kg N/ha), compared to long-term pasture. If this study had commenced in spring with a more typical pattern of rainfall and drainage, this increase is estimated to have only been about 23.7% (5.9 kg N/ha). Based on these results, summer forage cropping is estimated to increase whole-farm drainage water N losses by about 5%, when 10% of a farm's area is cultivated each year.

Of the management practices and technologies studied, the greatest opportunity to reduce the losses of N and P to surface water from the case study farm's effluent block, is through investment in FDE system infrastructure, particularly adequate storage capacity, and the use of decision support and fail-safe tools to assist the implementation of *deficit irrigation* of FDE.

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