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## THE 2006 EDITION

This is the Revised and Updated Edition of this manual.

The original manual was written by Philip Heatley in 1996 with extensive input from dairy farmers, dairy company personnel, councils and rural professionals under the umbrella of the Dairying and the Environment Committee.

Revisions were undertaken by Helen Ritchie and coordinated by Fonterra under a project funded by New Zealand dairy farmers through Dairy InSight.

A new chapter has been added on effluent from feed pads and stand-off areas, and new sections added to existing chapters to discuss low-rate irrigation systems, advanced pond systems and solids separation.

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## PURPOSE

The purpose of this manual is to assist dairy farmers and farm management specialists with the practical, effective, safe and legal management of farm dairy effluent.

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## ACKNOWLEDGEMENTS

Staff of the following organisations reviewed and provided resources for this edition:

- Northland Regional Council
- Auckland Regional Council
- Environment Waikato
- Environment Bay Of Plenty
- Gisborne District Council
- Hawke's Bay Regional Council
- Taranaki Regional Council
- Horizons Regional Council (Manawatu-Wanganui)
- AgResearch
- Dexcel
- Effluent & Irrigation Services
- Fonterra Co-operative Group Ltd
- Massey University
- Greater Wellington Regional Council
- Nelson City Council
- Marlborough District Council
- Tasman District Council
- Environment Canterbury
- West Coast Regional Council
- Otago Regional Council
- Environment Southland
- NIWA
- Spitfire Irrigators Ltd
- Federated Farmers of New Zealand
- Westland Milk Products New Zealand

Apart from above organisations, important contributors to the original manual included:

- Livestock Improvement Advisory
- Mike O'Connor – AgResearch
- Andrew Dakers and Keith Cameron – Lincoln University
- Jim Barnett and John Russell – NZ Dairy Research Institute
- Chris Tanner – NIWA
- Frank Muldowny

Contributors to the revised and updated version included Chris Tanner and Rupert Craggs of NIWA, John Scandrett (consultant) and Ian Howatson (engineer).

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## HOW TO USE THIS MANUAL

A '**Glossary of Terms**' follows this introduction to the manual, as does the '**Table of Contents - An Overview**'. A separate, comprehensive '**Table of Contents**' can be found at the front of each chapter.

Chapter One '**Managing Farm Dairy Effluent**' gives an overview of the issues relating to effluent management. Practical guidelines on effluent management in the farm dairy are given, including practices that minimise the amount of effluent produced, ideas on how effluent is best collected and stored, an overview of various effluent treatment systems, and suggestions on how to successfully select and plan such systems.

Effluent treatment system processes and components are grouped under the relevant chapter, with cross-referencing to topics discussed elsewhere. Effluent treatment systems are broadly defined by the following chapters:

- Chapter Two '**Land Application**' (which includes information on solids separation and methane digestion).
- Chapter Three '**Pond Systems**' (which includes information on barrier ditches and constructed wetlands).

Effluent collected from sites other than the farm dairy is discussed in Chapter Four '**Effluent from Feed Pads, Stand-off Areas and Other Sources**'. This includes managing effluent from silage pits, races, crossings and underpasses.

Regional Council issues are addressed in Chapter Five '**Regional Council Perspectives**'. This chapter outlines the function of Regional Councils under the Resource Management Act (1991) and the process of applying for resource consents for effluent management.

All information has been compiled using current research data and following lengthy consultation with farmers, contractors, consultants, researchers, Regional Councils and Dairy Industry groups. Data presented in these sections are typical values for typical situations.

All effluent treatment systems and recommendations are addressed in regional or general terms, so there is a need for local interpretation. That is, the application of these guidelines may be varied depending on '**on-site conditions, practicability, economy, and regional regulatory controls**'.

The recommendations within this manual should be used in conjunction with local knowledge sourced from the Dairy Industry, Regional and District Councils and consultants.

## GLOSSARY OF TERMS

### **Activated sludge treatment**

Aerobic biological treatment system where a high concentration of active aerobic bacteria are maintained.

### **Advanced pond system**

Systems where the second pond of a two-pond system is replaced with a further three ponds, each performing a different function, developed to enhance the removal of BOD, nutrients and micro-organisms, even in cooler climates.

### **Aeration**

Mixing air and effluent together in order to raise the concentration of dissolved oxygen within the effluent.

### **Aerobic bacteria**

Bacteria that require free oxygen for growth. They are involved in effluent treatment within the aerobic pond.

### **Aerobic conditions**

Conditions where oxygen is freely available either in air or as dissolved oxygen within the effluent.

### **Aerobic pond**

The second pond in an effluent pond treatment system. Effluent entering the aerobic pond from the anaerobic pond is converted into carbon dioxide, water, and new bacterial and algae cells in the presence of oxygen - 'aerobically'.

### **Algae**

Primitive plants, usually aquatic, and capable of photosynthesis.

### **Ammonia-N**

Nitrogen occurring in the form of ammonia (i.e.  $\text{NH}_3$ ).

### **Ammonium-N**

Nitrogen occurring in the form of ammonium (i.e.  $\text{NH}_4^+$ ).

### **Anaerobic bacteria**

Bacteria that do not require free oxygen for growth. They are involved in effluent treatment within the anaerobic pond.

### **Anaerobic conditions**

Conditions where oxygen is not freely available either in air or as dissolved oxygen within the effluent.

### **Anaerobic pond**

The first pond in an effluent pond treatment system. Effluent is initially piped to the anaerobic pond from the farm dairy sump. In the anaerobic pond, the effluent begins breaking down in the absence of oxygen - 'anaerobically'. Anaerobic bacteria are involved in these processes.

### **Applicator**

Irrigator specifically used to spray effluent onto pasture or crops.

### **Approved**

Approved by a competent body to a recognised Dairy Industry standard.

### **Aquifer**

A layer of rock or soil that is able to hold or transmit water.

### **Batter**

A slope immediately above or below a track, road, pond, ditch or other excavation.

### **Best practicable option**

The best effluent treatment method identified after due consideration of its adverse effects on the environment, the sensitivity of the environment to such effects, the financial implications as compared with other options, and the state of technical knowledge at the time.

### **Bioremediation**

Process using bacteria to degrade effluent solids to liquids.

### **BOD**

Biochemical Oxygen Demand gives an estimate of the amount of oxygen required by bacteria to break down the organic matter in effluent. This oxygen could otherwise sustain aquatic life in a waterway.

**BOD<sub>5</sub>**

Biochemical Oxygen Demand measured in a five-day bottle test at 20°C. It may express biochemical oxygen uptake in terms of quantity (i.e. BOD<sub>5</sub> g), concentration (i.e. BOD<sub>5</sub> g/m<sup>3</sup>) or loading rate (i.e. BOD<sub>5</sub> g/m<sup>3</sup>/day).

**Catchment**

Watershed area defined by the ridges of the terrain, where surface water runs towards a storage area or waterway.

**Cavitation**

Rapid formation and collapse of vapour pockets in a flowing liquid where there is very low or negative pressures. Frequently causes structural and mechanical damage to pumps.

**Clean**

Visibly free from dirt, manure, milk residues and other objectionable matter.

**Coliforms**

A group of bacteria used as an indicator of the total concentration of bacteria in an effluent sample.

**Conditions**

In terms of regional plans and resource consents includes terms, standards, restrictions and prohibitions.

**Constructed wetland**

An artificial wetland designed to further treat effluent.

**Consultation**

Involves putting forward a proposal that is not yet finally decided upon, listening to the reactions of other parties, considering their responses and then deciding what action should be taken.

**Controlled activity**

An activity that complies with conditions specified in the regional plan, is assessed according to matters the Regional Council has reserved control over, and is allowed only if a resource consent is obtained.

**Crusting**

The accumulated effluent solids that typically gather on, and completely cover, the surface of effluent ponds.

**Deferred irrigation**

Involves storing effluent in a pond and then applying it strategically when there is a suitable soil water deficit to reduce the risk of surface runoff or drainage.

**Delivery line**

The complete pipeline carrying the effluent from the storage facility to the applicator.

**Denitrification**

A biological process, carried out by specialist bacteria, where nitrate (i.e. NO<sub>3</sub><sup>-</sup>) is converted to nitric oxide (i.e. NO) or nitrous oxide (i.e. N<sub>2</sub>O) or nitrogen gas (i.e. N<sub>2</sub>). Anaerobic conditions, with a supply of free carbon, are required for denitrification.

**Deoxygenation**

Removal of dissolved oxygen from water.

**Digestion**

Anaerobic breakdown of organic matter within the effluent.

**Discharging**

Includes 'emitting', 'depositing', or 'allowing to escape' any contaminant into the environment.

**Discretionary activity**

An activity that complies with conditions that may be specified in the regional plan, is permitted at the discretion of the Regional Council, and is allowed only if a resource consent is obtained.

**Dissolved oxygen**

The concentration of free oxygen dissolved in water, and usually expressed as g/m<sup>3</sup> or mg/l.

**E. coli**

Escherichia coli is the main coliform found in the gut of warm blooded animals.

**Ecosystem**

The interaction of collective plant, animal and micro-organism communities and their non-living environment.

**Effluent**

Effluent may contain stormwater, spilled milk, soil and feed residue, detergents and other chemicals, in addition to the faeces, urine and washdown water. Effluent referred to in this manual is material containing between 5% and 20% solids. Effluent less than 10% solids can be conveyed through piping systems by gravity or pumps, or by using vehicle spreaders. Effluent between 10 and 20% total solids is referred to as slurry. Effluent exceeding 20% total solids is referred to as sludge.

**Euphotic depth**

The depth immediately below the water surface at which photosynthetically active radiation (i.e. PAR) is reduced to 1% of its value.

**Evaporation**

The loss of water, from a surface (e.g. soil) to the air, in the form of vapour. Usually expressed in mm in a given time period (e.g. mm/day).

**Evapotranspiration**

The combination of evaporation and transpiration (i.e. the combined loss of water from the soil and from plant surfaces to the air, in the form of vapour). Usually expressed in mm in a given time period (e.g. mm/day).

**Facultative bacteria**

Bacteria that can grow both in the presence and in the absence of free oxygen.

**Facultative pond**

The correct term for what are commonly referred to as aerobic ponds. A facultative pond has both an aerobic upper layer and an anaerobic lower layer. Therefore, both aerobic and anaerobic processes are carried out in a facultative pond.

**Faecal coliforms**

A group of bacteria associated with the faecal wastes of warm-blooded animals. They are used as an indicator of the extent of faecal contamination in a liquid sample (e.g. water or effluent).

**Farm dairy**

Includes any milking area, milk receiving area, milk storage area, and yards used in connection with milking.

**Freeboard**

The vertical distance between the top of the embankment and the maximum effluent level of the storage facility.

**Groundwater**

Subsurface water contributing to the water table, an aquifer or a confined aquifer.

**Hapu**

Subtribe, usually associated with one or more marae of a local area.

**Herbicide**

Any substance used to destroy or control any form of plant life.

**Holding pond**

A pond storage facility usually used for the storage of effluent prior to land application.

**Hydraulic loading**

Volume of water applied to an area of land (mm).

**Hydrological design**

Irrigation design process which determines the volume of water to be applied and the interval between successive applications.

**Hydrometer**

Instrument for determining the density of liquids.

**Infiltration**

The process of effluent entering the soil surface.

**Instantaneous application rate**

The actual rate at which water or effluent is applied to a site (amount of liquid applied over a defined time period). Unlike average application rates that mask uneven distribution patterns, instantaneous application rates give the quantity of water or effluent being applied to any one spot at that time, a more accurate description of loading to the soil.

**Iwi**

Tribal grouping with an association to a particular district.

**K**

Potassium.

**Lactation days**

The average number of milking days in an average year.

**Leaching**

The removal of soluble constituents (e.g. salts, fertiliser nutrients) from the soil by water moving downward through the soil profile.

**Local Authority**

A Regional Council or Territorial Authority (i.e. District Council or City Council or Unitary Authority).

**Mainline**

The initial section of the delivery pipeline carrying the effluent from the storage facility to the sprayline.

**Marae**

Traditional meeting centre of the hapu or iwi.

**Maximum application**

The maximum amount of effluent that should be applied to pasture at one time (mm).

**Maximum application rate**

The maximum speed at which effluent should be applied to pasture (mm/h).

**Mechanical aeration**

Mechanically mixing air and effluent together, using air pumps, agitators or liquid sprayers, in order to raise the concentration of dissolved oxygen within the effluent.

**Micro-organisms**

Microscopic organisms, such as bacteria, viruses, algae and fungi, that can live in water, soil, air, animals and plants.

**Mineralisation**

Conversion of organic matter into a mineral substance.

**Minimum application interval**

The minimum interval between successive effluent applications to pasture (days).

**Multiple sprinkler system**

Involves either a portable sprayline carrying several sprinklers or a series of fixed spraylines carrying a single or several sprinklers. Where the sprayline is portable, sprinklers require individual stands, a base, or a pod for support.

**N**

Nitrogen.

**Nitrification**

A biological process carried out by specialist bacteria where ammonium-N (i.e.  $\text{NH}_4^+$ ) is converted to nitrate (i.e.  $\text{NO}_3^-$ ). Aerobic conditions are required for nitrification, although the process can continue at low oxygen concentrations.

**Non-complying activity**

An activity that contravenes a rule in the regional plan or is not included in any other category. Applications for a resource consent can be made and will be assessed on their individual merit.

**Notification**

Public notification of a resource consent, or any policy statement or plan, or changes to them.

**Nutrient budget**

A system of calculating and comparing nutrient inputs and outputs from all or part of the farm system to help select fertiliser rates and management techniques for efficient nutrient use and reduced environmental impact.

**Organic matter**

Substances of animal or plant origin.

**P**

Phosphorus.

**PAR**

Photosynthetically active radiation which is radiation (light) useful to plants and algae for growth.

**Pathogenic micro-organisms**

Micro-organisms (e.g. bacteria, viruses, cysts, eggs and larvae of parasites) considered harmful to animals, plants and humans.

**Permeability**

The property of a soil describing the ability to allow significant movement of water through it.

**Permitted activity**

An activity that is allowed by a regional plan without a resource consent if it complies in all respects with any conditions.

**Pesticide**

Chemical substance used to destroy, control or repel animal or plant pests.

**pH**

The pH is usually measured using a water extract and is a way of expressing how acidic or alkaline a solution is. A pH of 7.0 is neutral whereas lower values are said to be acidic and higher values are alkaline.

**Plate cooler**

A milk cooler consisting of a series of plates separated by gaskets. The cooling is effected by alternating milk and water flows through the plates.

**'Pod'-type sprinkler system**

A sprinkler system consisting of a series of sprinklers set on 'pods' along a water pipe, capable of delivering low depths or rates of application and suitable for mole or tile drained soil or soils with low infiltration rates.

**Polishing**

Where primary and secondary treated effluent undergoes a final treatment.

**Pond system**

A constructed ponding system designed for the holding and/or treatment of farm dairy effluent before discharge to a waterway or constructed wetland, or application to pastoral land. A treatment pond system is composed of an anaerobic pond and one or more aerobic ponds. A holding or storage pond does not treat effluent, but retains it prior to land application.

**Prohibited activity**

An activity that is not allowed under any circumstances.

**PTO**

Power take off. The tractor-driven rotating shaft.

**Region**

An area in relation to, and under the management of, the Regional Council.

**Regional plan**

A plan prepared by the Regional Council for managing the use and protection of natural and physical resources (i.e. geothermal, coastal, water, air and soil resources).

**Regional policy statement**

A statement that guides or directs the decision making in a region, so that the eventual course of action achieves the desired results.

**Retention time**

This is the average time, in days, that the effluent will remain in the storage facility. It is calculated by dividing the volume of the facility by the volume of effluent entering daily.

**Sediment**

Solid material (e.g. silt and sand) that is carried in water or effluent that will ultimately settle to the bottom of sumps, ponds, barrier ditches, constructed wetlands or waterways.

**Seepage**

Loss of effluent through the permeable floor and walls of a storage facility.

**Sludge**

Sludge referred to in this manual is effluent exceeding 20% total solids. Sludge accumulates at the bottom of sumps, barrier ditches or ponds. Sludge will not flow and requires mechanical spreading equipment such as scrapers and front-end loaders.

**Slurry**

Slurry referred to in this manual is effluent with between 10 and 20% total solids. Such material can be conveyed by using vehicle spreaders but cannot be conveyed by gravity or pumps through piping systems (refer Effluent).

**Sprayline**

The latter section of the delivery pipeline carrying the effluent from the mainline to the applicator.

**Stationary applicator**

Irrigates a specific area for a certain period, before being towed or hand-moved to a new area. This procedure is repeated at set time intervals until the complete application area is treated.

**Stone trap**

A screen or barrier facility placed before the farm dairy sump. Used to prevent solid materials within the flushed effluent (e.g. gloves, gravel, plastic containers, grass etc) from entering the sump and effluent treatment system.

**Stormwater**

Rainwater that has drained from the farm dairy and collected in guttering/pipes, or has run off from the surrounding land.

**Submission**

A written statement in support of, or in opposition to, a resource consent, policy statement or regional plan, or changes to them.

**Sump**

A small effluent storage facility located close to the farm dairy. Used to collect flushed effluent from the farm dairy and store it for short periods, prior to land application or pond treatment.

**Suspended solids**

Effluent solids that are in suspension within the liquid effluent but are removable through filtering.

**Sustainable dairying**

Farm practices that are economically viable, environmentally sound and socially acceptable.

**Taonga**

Treasured possession.

**Top bank**

The top of the pond embankment.

**Total solids**

The sum of dissolved solids and undissolved solids in effluent or water.

**Transpiration**

The loss of water from plant surfaces (e.g. leaves) to the air, in the form of vapour. Usually expressed in mm in a given time period (e.g. mm/day).

**Travelling applicator**

A mobile irrigator, powered by a small diesel motor or, more commonly, through water pressure, with a rotating boom and a nozzle at each end. Drags along by a winch and cable mechanism at a rate set by the operator.

**Unitary Authority**

These combine the functions of Regional and District / City Councils. The Unitary Authorities are Gisborne, Nelson, Marlborough and Tasman.

**Volatilisation**

Loss of ammonia gas (i.e.  $\text{NH}_3$ ) to the atmosphere following its conversion from ammonium-N (i.e.  $\text{NH}_4^+$ ). Volatilisation is pH and temperature dependent, increasing with increasing alkalinity and/or increasing temperature.

**Waahi tapu**

Sacred site or place.

**Waterway**

Fresh or geothermal surface water in a river, lake, stream, pond or natural wetland.

**Wetland**

Permanently or intermittently wet areas, shallow water and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

**Yards**

Those parts of the farm dairy used for holding livestock for milking, breeding or veterinary treatment.

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