Managing irrigation and fertiliser in dairy farming

Second Interim Report

September 2001

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School of Marketing and Management
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Executive Summary

In the first stage of this study we identified the factors that influence the adoption of laser graded flood irrigation, spray irrigation systems, reuse systems and whole farm planning. The type of irrigation system chosen by farmers depends on the soils and topography of their property, financial constraints, and farm layout. Time and labour constraints were also identified as key factors in the choice of an irrigation system.

In this second stage of the study we conducted a mail survey of farmers. Approximately 30 per cent of farmers in the Macalister completed the survey. We found that most respondents use flood irrigation. Approximately 50 per cent of farmers who responded to the survey used laser graded flood irrigation that they had installed to save time irrigating and to save water. Another 25 per cent of respondents use land planed flood irrigation. Most of these farmers had laser graded a portion of their properties, primarily to save time irrigating. Approximately 17 per cent of respondents irrigated using a mix of flood and spray irrigation systems. The remaining 7 per cent relied on spray irrigation alone.

Approximately 50 per cent of respondents indicated they had installed a reuse system. Most used their system to capture rainfall and irrigation run-off.

Approximately 35 per cent of farmers indicated they had a whole farm plan drawn up by a consultant. The survey responses were consistent with these view that most farmers view whole farm plans as a method for planning the staged redevelopment of the farm when implementing a laser-grading program. Consequently, whole farm plans are seen to be largely irrelevant to the installation of spray irrigation systems.

Most respondents indicated did not 'wash in' fertiliser, preferring to apply fertiliser after they have irrigated. Most farmers indicated they seek advice about fertiliser management from consultants and fertiliser company representatives.

Finally, we classified farmers into four groups based on their social values. The results indicate that farmers in all of these groups are likely to respond positively to actions that will benefit the environment if these actions are associated with the expression of conservative values. We found no relationship between social values and the type of irrigation system used on farms, whole farm plans or installation of reuse systems.

Our findings suggest that:

- Widespread adoption of spray irrigation by dairy farmers in the Macalister Irrigation District is unlikely. For the majority of farmers, laser grading has been, and will continue to be, the most effective means of reducing water and labour use per hectare. <u>As a result, we believe consideration should be given to offering incentives for laser grading in order to promote more efficient use of water.</u>

- Lack of access to water on demand (groundwater, pressurised pipe or on-farm storage) may be a factor preventing the adoption of spray irrigation for some farmers. The adoption of spray irrigation may be prevented in some instances by

poor reliability in terms of water delivery and variability in channel flow. Poor reliability in terms of water delivery and variability in channel flow may also be a factor limiting the effectiveness of flood irrigation on some farms. We believe consideration should be given to improving irrigation infrastructure in the district and reviewing groundwater policies.

- Given the decline in water reliability in the district, and the continuing investment in laser grading, we believe recycling systems will be installed on farms throughout the District. However, farmers on more permeable soils may wish to use recycling systems both to conserve run-off and to store irrigation water for spray irrigation. We believe consideration should be given to extending the incentive offered for reuse systems to include systems that are also designed to store water, as this would facilitate the installation of spray irrigation.

- Most farmers regard whole farm planning as an instrument for planning farm layout for flood irrigation. Few farmers are aware of the benefits of whole farm planning for spray irrigation. We suggest that the full potential of whole farm planning for both flood and spray irrigation be promoted to farmers.

- Virtually all farmers are aware that fertiliser should not be 'watered in'. We believe most farmers, and their fertiliser advisers, would be interested in receiving detailed information about fertiliser management.

Acknowledgments

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We are indebted to the dairy farmers who participated in the study by being kind enough to grant us interviews.

All errors and omissions remain the responsibility of the authors.

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Managing Irrigation and fertiliser in dairy farming

Introduction

The efficiency of water and fertiliser use on irrigated farms has become an issue for dairy, beef and other farmers and the community in the Macalister Irrigation District in Gippsland, Victoria for a number of reasons. For example, the demand for irrigation water in the district has been increasing as the area under irrigation in the district has been expanding over time. This has resulted in a long-term decline in water allocations, which has been exacerbated by a series of unusually dry seasons. In addition, water and nutrient losses from both dryland and irrigated farms in the Lake Wellington catchment are believed to be contributing to algal blooms in the Gippsland Lakes and to the salinisation of agricultural land in the district.

A suite of best management practices is being identified to improve the efficiency of water and fertiliser use on dairy farms in the Macalister Irrigation District (see for example, Slee and Ewert 1998 and DNRE 2000). These practices are to be promoted through initiatives such as the Lake Wellington Salinity Management Plan and the Macalister Irrigation District Nutrient Reduction Plan. The nutrient reduction plan contains a number of financial incentives to promote the adoption of Whole Farm Plans, water recycling or reuse systems and the installation of spray irrigation systems. The salinity management plan has an irrigation extension component aimed at improving irrigation management on dairy farms.

Our objective in this study is to understand the adoption of Whole Farm Plans, water reuse systems and spray irrigation systems on dairy farms, and to identify and understand the factors that influence fertiliser management. This knowledge will be used to develop extension strategies to promote more widespread adoption of these systems and practices.

The study involves three stages. In the first stage we identified the technologies, practices and resources at the farm level that influence the benefits and costs of adopting different types of irrigation systems and fertiliser management practices. This stage involved interviews with farmers, extension staff and other relevant experts or specialists.

In the second stage, we use data collected through a mail survey to classify dairy farmers into adoption segments based on key differences in their endowment of relevant irrigation technologies, and fertiliser practices.

In the third stage extension and research strategies and priorities are determined. This involves detailed analysis and interpretation of the study results by the project team in collaboration with research and extension personnel. For a more detailed description and justification of the methods used in the study see Kaine and Niall (1999), Kaine and Bewsell (2000), and Kaine and Niall (2001).

In this report we describe the findings from the second stage of this study. The results reported here are based on a mail survey sent to all irrigated dairy farmers in the Macalister Irrigation District. The survey consisted of a 20-page booklet in which we sought information from farmers on:

- Farm characteristics such as size, soils and location.
- Types of irrigation systems installed on the farm.
- Reasons for installing each type of irrigation system.
- Installation and use of reuse systems
- Use of fertiliser and fertiliser management.

The survey was promoted through local radio and print media. A reminder postcard was mailed four weeks after the survey was posted. The response rate was 30 per cent with 147 farmers completing and returning the survey. This response was more than sufficient to obtain reliable estimates of the characteristics of the 500 or so dairy farmers in the Macalister (Scheaffer, Mendenhall and Ott 1979).

Factors influencing irrigation on dairy farms in the Macalister

Discussions with dairy farmers in the first stage of the study revealed that a range of irrigation systems are used in the Macalister Irrigation District and that number of factors determine the type of irrigation system adopted by farmers. The types of systems used in the District include:

- Wild flood irrigation. This is basically uncontrolled flooding of ungraded land.
- Graded flood irrigation. This is controlled flooding of land that has been graded into short, narrow bays that follow the contours of the land by tractor or some other means without the assistance of laser levelling. Some of this land may have been graded more than three decades ago.
- Laser graded flood irrigation. This is controlled flooding of land that has been graded into long, wide bays by earthmoving equipment with the assistance of laser levelling.
- Spray irrigation. The most common types of spray irrigation are lateral move sprays (ie hand or bike shift, van den Bosch). Linear move and centre pivot spray systems are less demanding of labour but are more expensive to install. Fixed sprinkler spray irrigation requires perhaps the least labour and is the most flexible in terms of paddock layout but is probably the most expensive spray irrigation system to install.

Generally speaking, the original motivation for farmers to laser grade was to save time irrigating. The earlier methods of land planing produced many small, narrow bays that were irrigated using relatively low flow rates. This meant that a considerable amount of time needed to be devoted to irrigation. Over time, as herd sizes increased and holdings were amalgamated this type of irrigation layout became increasingly impractical to irrigate. Consequently, laser grading was used to consolidate many small bays into a few long, wide bays that were irrigated using relatively high flow rates, thereby reducing the time that needed to be spent irrigating.

More recently, farmers have been motivated to adopt laser grading in an effort to save irrigation water. By using high flow rates to rapidly irrigate long, wide bays the

infiltration of water into the soil can be considerably reduced. In addition, surface run-off can be collected in a reuse system for subsequent use in later irrigations. Consequently, to reduce water use per hectare per irrigation some farmers have adopted laser grading and installed a reuse system.

Although an attractive option for some, laser grading can be impractical for a number of reasons. For example, laser grading is more suited to heavier soils and a relatively flat topography. Much of the Macalister consists of highly permeable soils and hilly or broken topography. Also, there must be sufficient capacity in the irrigation delivery system to permit laser-graded bays to be irrigated at high flow rates if savings in water use are to be achieved.

Consequently, many farmers in the Macalister use spray irrigations systems. In the past spray systems have been installed to irrigate land that is unsuited to flood irrigation. More recently, farmers have been motivated to install spray irrigation in an effort to save irrigation water. Although a variety of spray systems are available most farmers that use spray irrigation have installed a lateral move spray system. This is the least expensive system to install but is labour intensive as sprays must be shifted individually using a tractor or bike every few hours. In the interviews with farmers it became clear the type of spray irrigation system adopted by a farmer depends on a number of factors. These include:

- The time and labour constraints the farmer faces. For example, lateral moves will be unattractive to farmers with a restricted amount of time to devote to irrigation.
- Financial constraints. Labour saving systems such as linear moves and centre pivots are considerably more expensive to install than a lateral move system.
- The layout of the farm. Centre pivots and linear moves are not suited to paddocks of an irregular shape. Also, the installation of centre pivots and linear moves may require changing location of channels and fences, installing bridges and the clearing of obstacles such as trees and hedges. Fixed sprinklers can be installed in oddly shaped paddocks but are relatively expensive.
- Whether the property has been laser graded. Farmers may have laser graded at considerable expense in order to reduce the amount of time they need to spend

irrigating. Farmers in this situation are reluctant to install a lateral move system, as this would increase the time they spend irrigating. On the other hand, the cost of installing centre pivots or linear moves could be prohibitive, especially if changes are required to the farm layout.

Note, however, that the entire property may not have to be converted from flood to spray irrigation. Placing a proportion of the property under spray irrigation may be sufficient to give the water savings that are needed.

The reliability of water delivery can be a factor influencing the installation of spray irrigation. Most of the farmers we interviewed with spray irrigation either ran their sprays from groundwater or are in a district with a pressurised pipe delivery system. Some farmers, with bores producing relatively low flows, stored groundwater in a reuse system (often a natural depression). The risk of pasture and production losses may be a barrier to the adoption of spray systems in areas where water delivery through the district channel system is unreliable. Ordering water in advance and storing it on farm ready for use could reduce this risk.

Survey of dairy farming in the Macalister

In table 1 the farm size and irrigation characteristics of the farmers that responded to the survey are presented. Almost 70 per cent of respondents were owner operators and a further 21 per cent were landowners with a sharefarmer managing the farm. Virtually all farmers that responded (94 per cent) had some form of flood irrigation. Approximately 40 per cent of farmers had spray irrigation, almost entirely in the form of lateral move systems. The average stocking rate was approximately 3 cows per irrigated hectare.

Approximately 34 per cent of farmers had a whole farm plan drawn up by a consultant. Nearly 50 per cent of farmers had a reuse system or farm storage and approximately 45 per cent have groundwater pumps that they use for irrigation.

Almost 40 per cent of farmers indicated they regularly experienced disruptive delays

Table 1 Characteristics of responding farms

Item	Average	Minimum	Maximum
Total farm area (ha)	165.02	13	1180
Milking area (ha)	87	10	610
Irrigated area (ha)	90	13	470
Flood irrigation:	81	0	470
Wild (ha)	5	0	114
Graded (ha)	30	0	140
Lasered (ha)	45	0	470
Spray irrigation (ha)	9	0	110
Herd size (cows)	231	43	1400

Proportion of respondents with:	
Whole farm plan produced by a consultant	34%
Recycling system	48%
Groundwater pumps	45%
Insufficient water right	53%
Disruptive delays in starting irrigations	39%
Problems with inconsistent water levels	54%
Problems due to high water tables or salinity	18%

in starting irrigations due to late delivery and queuing problems. Over 50 per cent of farmers reported that they experienced inconsistent water levels in their irrigation supply channel during irrigations and 30 per cent indicated that their irrigation supply channel was unable to consistently deliver high flow rates during an irrigation.

Over 50 per cent of farmers indicated that they did not have enough water right. Approximately 18 per cent of farmers indicated they have a problem with high watertables or saline groundwater.

Almost 90 per cent of the farmers that responded to the survey indicated that they would like to receive a summary of the results. Approximately 30 per cent indicated they would be willing to participate in an interview.

Irrigation segments in dairy farming in the Macalister

Broadly speaking, farmers face two alternatives when it comes to increasing the efficiency with which they use irrigation water. One alternative is to use less water per irrigation either by laser grading or by installing spray irrigation. The other alternative is to use the same amount of water but increase milk production per hectare, perhaps by using feed supplements to increase stocking rates. The information obtained in the first stage of this study suggests that the choice between these alternatives will depend on a number of factors.

The first factor is the relative importance of flood and spray irrigation on the farm. Where a large proportion of the farm is spray irrigated there is probably little opportunity to reduce water use per hectare. Where a large proportion of the farm is flood irrigated there may be an opportunity to reduce water use per hectare through laser grading, installing reuse systems or installing spray irrigation.

The second factor is the proportion of the dairy farm that can be laser graded. Where a large proportion of the farm can be laser graded then there may be potential to significantly increase water use efficiency by laser grading. On the other hand where

only a small proportion of the farm can be laser graded then there may be potential to significantly increase water use efficiency by installing spray irrigation. Which option is the more attractive depends largely on soil permeability and labour availability.

The third factor affecting the choice between laser grading and spray irrigation is the extent to which the dairy farm has already been laser graded. Where a large proportion of the farm has been laser graded to save water then the potential to increase efficiency further by reducing water use per hectare is probably limited in most cases. While completing the program will reduce water use to some extent the major gains in saving water will have already been achieved given the laser grading has been effective.

Where a large proportion of the farm has been laser graded primarily to save time there may be some potential to increase efficiency by installing spray irrigation. Farmers in this situation would be highly unlikely to adopt lateral move sprays on any scale because of the heavy labour demands involved in operating this type of system. Consequently, farmers in this situation would be most attracted to centre pivot or linear move spray systems. The gains in efficiency of water use would need to be quite substantial to justify investing in these systems. Hence, the area of the farm that has been laser graded is a third factor influencing farmers options in terms of increasing water use efficiency.

These three factors were used to classify dairy farmers into irrigation segments.[1] The variables used in the classification analysis that corresponded to these three factors were:

- The proportion of the irrigated area on the farm that is flood irrigated (*flood*). This provides an indication of the relative importance of flood irrigation and spray irrigation in the farm enterprise.
- The proportion of the irrigated area that it is practical to laser grade (*practical*). This provides an indication of the extent to which water use might be reduced through laser grading.

[1] Classification analysis was undertaken using Wards Method available in SPSS (SPSS 1988).

- The proportion of the area that it is practical to laser grade that has been laser graded (*laser*). Where the entire area that it is practical to laser grade has been lasered the opportunity to reduce water use is likely to be limited.

We classified dairy farms in the Macalister into four segments. The profiles of these segments in terms of the classification variables are presented in figure 1. The profiles of the segments in terms of different types of irrigation systems are presented in figure 2.

The farmers in the first segment, the 'lasered layout' segment, rely mostly on flood irrigation and have undertaken an extensive program of laser grading on their properties (see figures 1 and 2). This segment represents 50 per cent of respondents. Most of these farmers have either completed or are near to completing their program. Laser grading on these farms was motivated by a need to save time irrigating because there were too many bays, to improve layout, to consolidate bays and to save water by maximising flow rates down bays (see figure 3). The majority of farms in this segment are in the districts around Sale and Heyfield.

The following examples are typical of the farms in this segment:

> *Wally and his wife Jenny run 160 cows on a property of 56 hectares in Tinamba. They began a development program for the farm in the early 80's. They began lasering to save time irrigating, and water as well. Wally estimates he has decreased the amount of water he uses by as much as 50 per cent by lasering the farm. He also spends a lot less time irrigating. It used to take him five days to irrigate the property, now it only takes two.*

> *David milks 200 cows on two blocks making up 90 hectares. The entire property is under flood irrigation and there is 10 per cent of the farm left to laser grade. He lasered his farm to save water and to cover the property more effectively. The farm is in a high water use area and they need to get water across the bays quickly. David has a reuse dam on one block, and the other block drains to a Southern Rural Water drain. Although he's still got some water problems he believes the biggest gains to be had are to improve the channels, install larger bay outlets, put in automatic irrigation and catch run-off in a sump.*

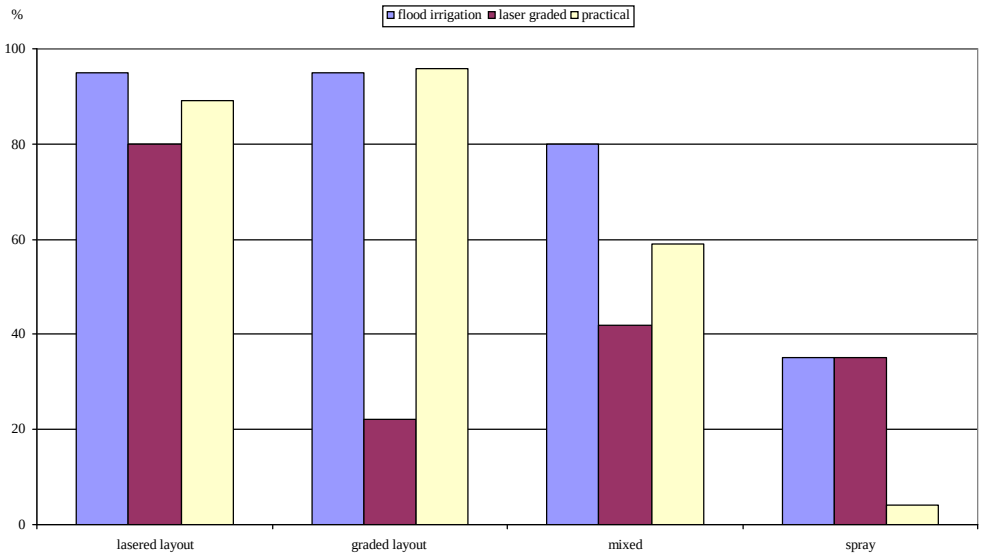

Figure 1 Irrigation structure by segment

Flood irrigation– proportion of irrigated area that is flood irrigated. Laser graded – proportion of area that it is practical to laser grade that has been laser graded. Practical – proportion of irrigated area that it is practical to laser grade.

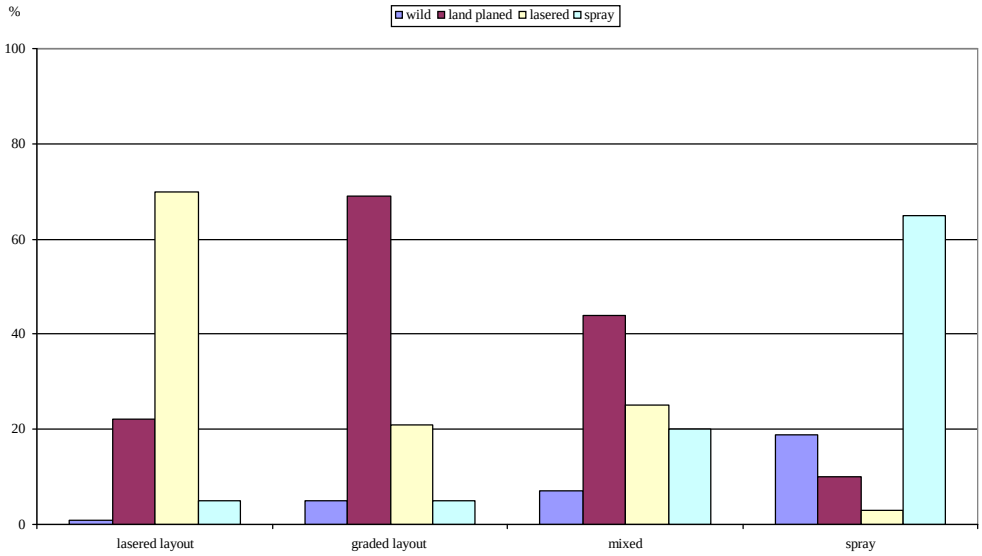

Figure 2 Proportion of area irrigated under each system by segment

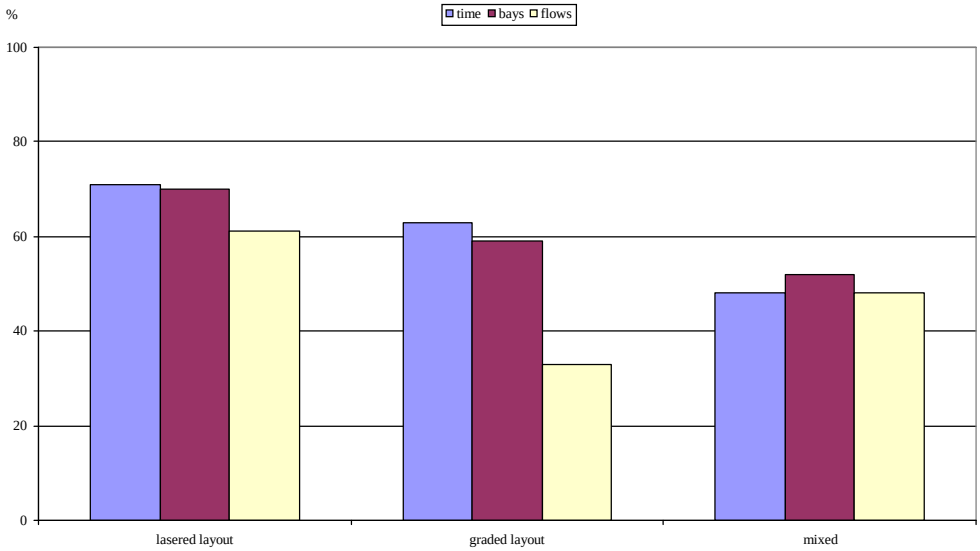

Figure 3 Reasons for laser grading by segment

With the property lasered David is able to do all the irrigating himself. He uses a water baby but with flows split several ways you get to know how long the watering will take and visit the bay appropriately. He is on the top of a main channel so water flows generally don't vary much.

The farms in this segment are relatively large with average stocking rates and are located on moderate to heavier soils (see figures 4 and 5).

Spray irrigation may offer some savings in water use to farmers in this segment, however most farmers in this segment are unlikely to find spray irrigation attractive on a large scale. Lateral move irrigation will be too labour intensive on a large scale while centre pivot or linear move systems are likely to be too expensive. However, it may be sufficient for some farmers to install lateral moves on those areas of the property that use the most water. For example,

Steven works in a partnership with his brother in Tinamba. They irrigate 140 hectares and all but 8 hectares of this has been graded over the last 20 years. Steven has a groundwater pump and irrigates 30 hectares solely from this. Another 40 hectares can be watered with groundwater if needed. Prior to putting down the pump Steven regularly used 200 per cent of his water right. He had thought about installing lateral move spray irrigation but, apart from problems with wind, they are very time consuming to shift. They are better for more porous soil. Steven weighed this up and came to the conclusion that as long as you can get a fair flow of water and can get it down the bay quickly, flood is preferable.

Some of the farms in this segment can expand the area they have under irrigation by converting dryland. Given the limited availability of water right, most farmers in this situation are relying on groundwater to irrigate the extra land. Usually, farmers install centre pivot spray irrigation as the shape of paddocks is not an issue and there is a need to minimise the extra demand labour needed to irrigate the additional area. Although centre pivots are expensive to install, the cost is more than justified by the additional stock that can be carried.

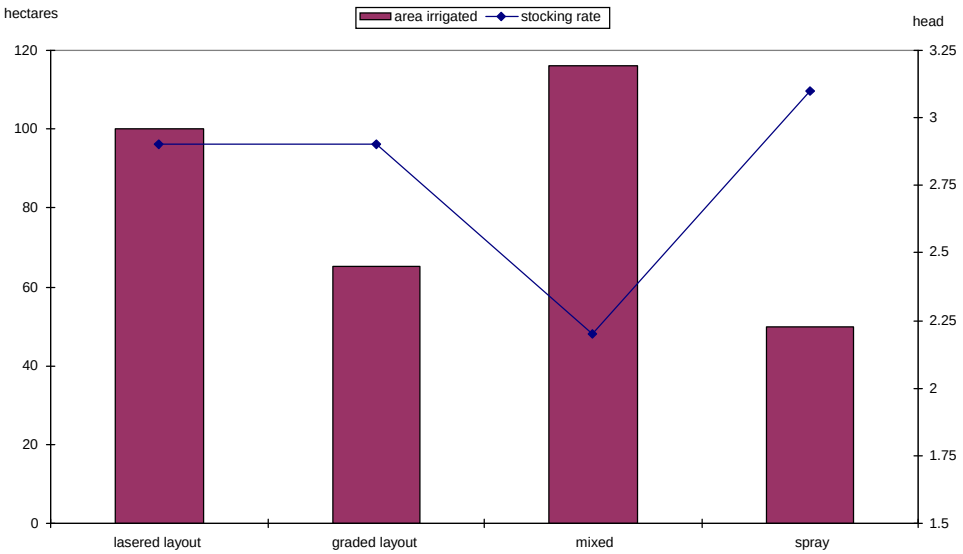

Figure 4 Total area irrigated and stocking rates by segment

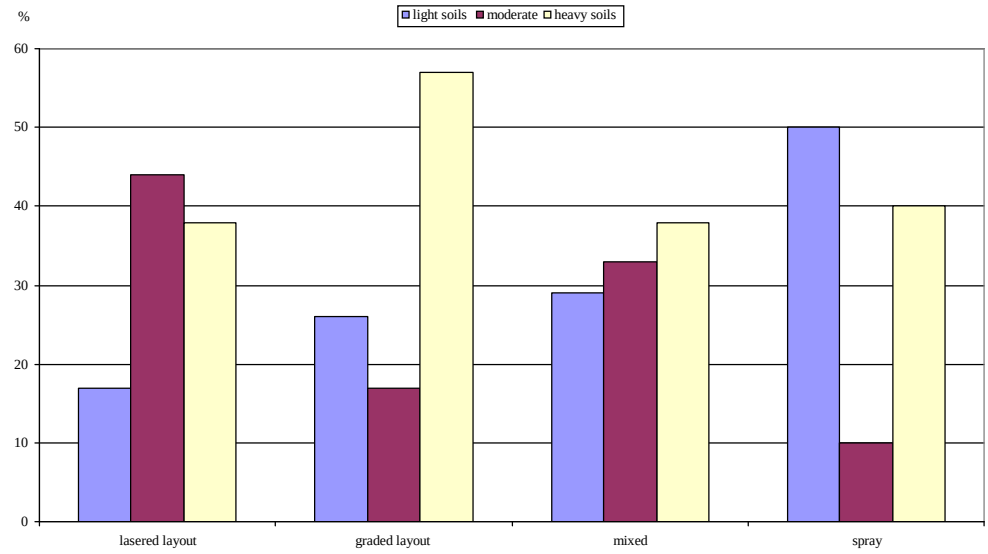

Figure 5 Soil type by segment

Anthony runs a 450-cow dairy farm and has just bought a new property on the river. This new land has no water right so he now has more land than water. As he wants to milk 100 extra cows with no extra labour, he is going to install a centre pivot irrigation system. He can pump directly out of the river for the pivot, which is an advantage compared to having to use channel water. Channel flows can be variable, particularly at the end of a system, and this will affect the performance of the pivot. Anthony says you can run a pivot off the channel, but it would depend where you were on the channel. He prefers to work on night rate power, it's cheaper and it reduces evaporation.

Anthony does not have ready access to groundwater. There may be some deep groundwater but it is uneconomic as it would cost him between $300 and $800 a megalitre to develop.

Farmers in the second segment, the 'graded layout' segment rely mostly on flood irrigation. This segment represents 26 per cent of respondents. Unlike the farmers in the first segment, the farmers in the second segment have only laser graded a small proportion of their land (see figures 1 and 2). The laser grading that has been undertaken on these farms was motivated by a need to save time irrigating, to improve layout, to consolidate bays and to grade land that had not been properly graded before. Increasing flow rates down bays to save water was not a major motivation for many farmers in this segment to laser grade (see figure 3). The majority of farms in this segment are in the districts around Sale and Heyfield.

That only a small proportion of the area on the farms in this has been laser graded suggests that the farmers in this segment have not experienced major problems in the past either with the time they spend irrigating or getting the water they need. This suggests that these farms probably have relatively good layouts, are likely to be relatively small and situated on heavier soils. An examination of figures 4 and 5 reveals this is the case. The following example is representative of this segment.

John runs a 60-hectare dairy farm with 200 cows just south of Maffra. With the exception of a small paddock at the front that he irrigates using lateral moves, the property is under flood irrigation. Originally the farm was graded but now about half of the farm has been lasered. John didn't think the rest needed to be lasered as the layout is good and the water flow is satisfactory. John has had little trouble over the years irrigating the property. He does not see any need to laser more ground especially as lasering disturbs the soil structure and it takes a long time for the paddock to come back – often 10 to 12 years. He has a reuse system but finds that it doesn't catch enough water from the property to even irrigate one bay.

There would seem to be an opportunity to save water on these farms by promoting a program of laser grading. On average less than a quarter of the irrigated area on these farms has been laser graded. While spray irrigation may have the potential to save water on these farms, most farmers in this segment are unlikely to find spray irrigation attractive on a large scale. Given that saving time was a key motivation for the farmers in this segment to commence laser grading they are likely to find lateral move irrigation too labour intensive. Centre pivot or linear move systems are likely to be too expensive relative to laser grading. However, it may be sufficient for some farmers in this segment to install lateral moves on small areas of the property that use large amounts of water.

Farmers in the third segment, the 'mixed systems' segment, have properties with a mix of highly permeable soils or undulating country that is unsuitable for laser grading as well as flatter, heavier country that is suited to laser grading (see figure 5). This segment represents 17 per cent of respondents. These farms are predominantly flood irrigated and more than half the irrigated area has been laser graded (see figures 1 and 2). Laser grading on these farms was motivated by a need to save time irrigating, to improve layout, to consolidate bays and to increase flow rates down bays to save water (see figure 3).

These farms are relatively large with low stocking rates and are located on a mix of soils (see figures 4 and 5). The farms in this segment have access to both surface water right and groundwater (see figure 6). The majority of farms in this segment are in the districts around Cowarr and Briagolong.

There is opportunity to improve irrigation on these farms either by laser grading or by installing sprays depending on soils and topography. The following example is representative of this segment.

> *Roger has owns 170 hectares of land in Clydebank. He has had a sharefarmer running the property for two years. Roger says this has worked out well. At present he has 20 hectares under lateral sprays, and 70 hectares laser graded. Roger plans to develop another 50 hectares in the future. This area is not suitable for lasering however and to give him some extra water he will be installing more laterals.*

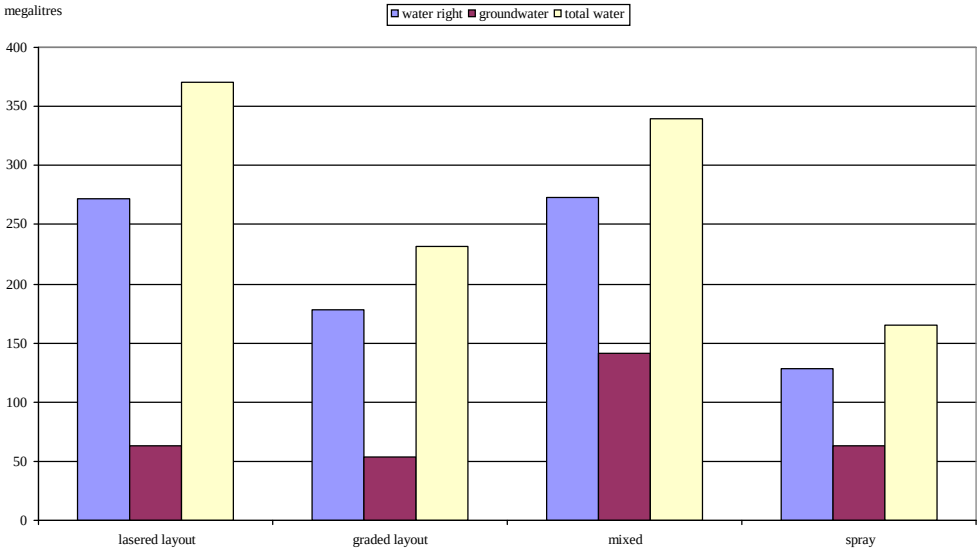

Figure 6 Irrigation water supply by segment

Total water = Surface water right + groundwater right + drainage diversion + river diversion

All the lasered ground drains into a billabong. The quality of this water is generally OK, although it can have high levels of fertiliser sometimes. Roger will pump out of this to run the new sprays as it gives him a high and constant flow rate. He weighed up the alternatives – a centre pivot or linear move is impractical because of the shape of the block. Lateral sprays would cover the entire area, and although labour was a bit of a concern, the figures worked out OK.

Farmers in the fourth segment, the 'spray irrigator' segment, have properties with light, highly permeable soils or undulating country that is unsuitable for laser grading (see figure 5). This segment represents 7 per cent of respondents. These farms are relatively small with average stocking rates (see figure 4). These irrigators have installed spray irrigation primarily to save water. The type of system they chose will depend on the characteristics of their properties and the district delivery system. These farmers have access to surface water right, usually through a piped delivery system, and groundwater (see figure 6). The farms in this segment are in the Briagolong district.

The following examples are typical of the farmers in this segment.

Mark runs 450 cows on a farm near Boisdale. He tried laser grading the property 15 years ago. He did not go to longer bays because of the light soils – with longer bays the water soaks in halfway down the bay. He found that the changes meant he was saving time but not saving water. Recently, Mark has been running out of water and so has installed spray irrigation on 75 per cent of the property. Mark found the spray irrigation generally successful, with some limitations. The lateral move sprays are quite time consuming.

Ray and Cathy run 500 cows on 130 hectares at Bushy Park. They have a mix of spray irrigation systems. They began with lateral move spray irrigation, and have since put in travelling irrigators and rain guns. They've found laterals and travelling irrigators are a "labour nightmare". Employees don't like moving laterals particularly. Now they have two centre pivots. They are finding they grow more feed, have a much more even water distribution and much less time is involved.

Reuse systems

About 48 per cent of farmers have recycling systems. A relatively high proportion of farmers in the laser-graded and mixed system segments have installed recycling systems (see figure 7). Note that, sometimes, a natural depression may be used quite effectively as a reuse system. In interviews with farmers we found reuse systems were being installed for a variety of reasons and managed in a variety of ways as a consequence. For example, farmers may install dams to:

- Store groundwater. Farmers with bores that yield relatively low flow rates may pump groundwater into a reuse system prior to spray irrigating.
- Conserve irrigation water and run-off. Farmers that have laser graded may use a reuse system to catch irrigation run-off and as a means of avoiding the risk of severe water losses from lasered bays that run too long.
- Manage effluent. This depends on the layout and topography of the farm.

The reasons for installing dams are shown in figure 8 as a proportion of those who have installed dams. The main reasons for installing dams are to capture irrigation and rainfall run-off, to irrigate on demand, as a backup to prevent losses when bays run too long, and to assist in effluent disposal. Note that a relatively high proportion of farmers in the mixed segment, approximately 40 per cent, indicated they installed a dam to assist them to spray irrigate (7 per cent and 25 per cent in the lasered layout and graded layout segments respectively).

In discussions with farmers a number of factors were identified that might prevent the installation of a reuse system. These were:

- The topography and soils of the property. Often, on very undulating properties, the property is broken up into a number of sub-catchments. This means reuse systems are too expensive to install as a number will be needed to catch all the run-off from the property.
- The use of spray irrigation. Most farmers regard reuse systems as unnecessary with spray irrigation as there is little or no run-off with this type of irrigation.

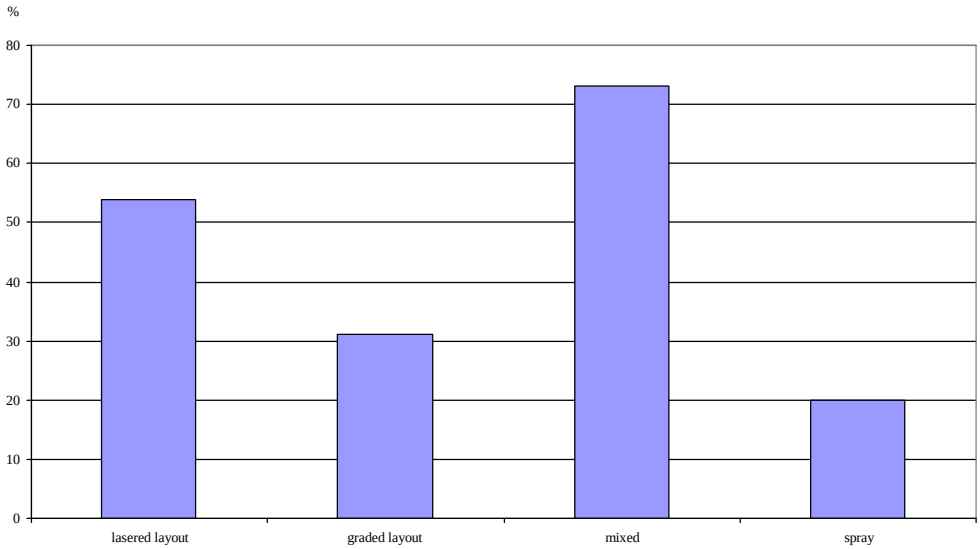

Figure 7 Reuse systems by segment

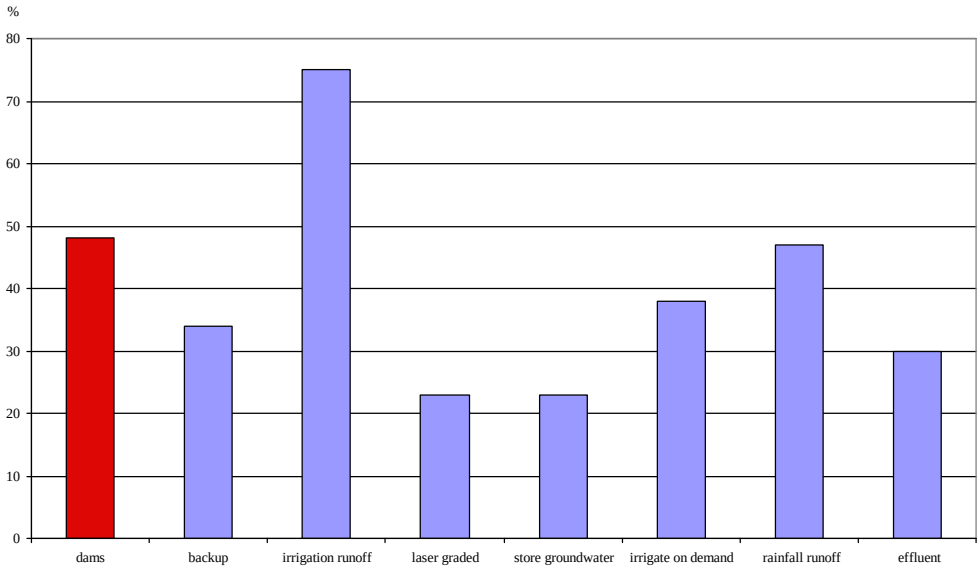

Figure 8 Reasons for installing reuse systems

The main reasons for not having a recycling system are because the property drains to a creek or drain, the topography is broken, or there are too many sub-catchments on the property (see figure 9).

Groundwater pumping

About 45 per cent of farmers have ground-water pumps (see figure 10). The main reasons for installing pumps are also shown in the figure (as a proportion of those who have installed pumps). The main reasons for installing pumps are to supplement irrigation supplies, to irrigate on demand and to install spray irrigation. A significantly higher proportion of farmers in the spray and mixed segments indicated they installed groundwater pumps in order to be able to spray irrigate.

Whole Farm Planning

We found during interviews with farmers that they see Whole Farm Plans mainly as a method for planning the staged redevelopment of the farm layout when laser grading. Consequently, whole farm plans are seen to be largely irrelevant to the installation of spray irrigation systems. As one farmer expressed the point:

> "You only need a whole farm plan if you need to move dirt."

Not surprisingly, many farmers expressed some concern about the need to obtain a whole farm plan from a consultant in order to qualify for the incentives offered under the Macalister Nutrient Reduction Program.

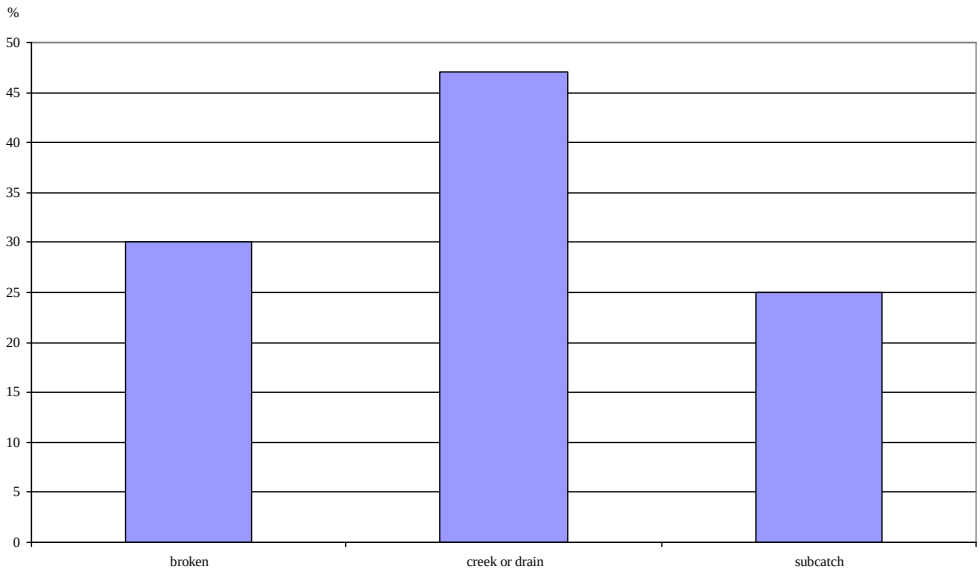

Figure 9 Reasons for not installing reuse systems

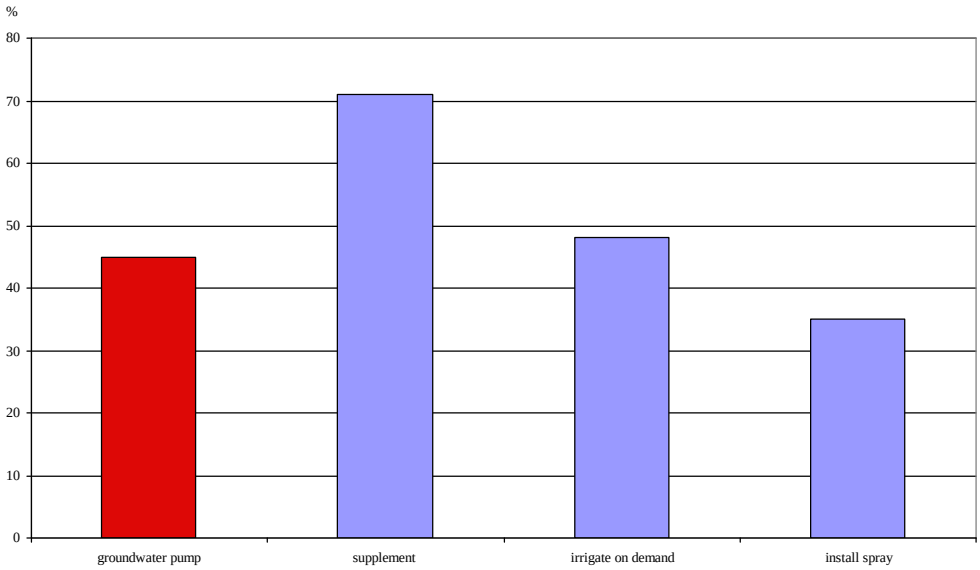

Figure 10 Reasons for installing groundwater pumps

This view was reflected in farmers' responses to the survey. About 34 per cent of farmers have whole farm plans drawn up by a contractor (see figure 11). In the figure the reasons for having a plan drawn up by a contractor are shown as a proportion of those who had plans. The main reasons for obtaining a plan are to improve irrigation layout and efficiency, because farmers were laser grading and redeveloping their farms, and as a map for contractors to use. Farmers in the lasered layout and graded layout segments were significantly more likely than farmers in other segments to have a whole farm plan because they were laser grading.

The main reasons for not having a plan from a contractor are because farmers had drawn up their own plans or had a satisfactory farm layout (see figure 12). Farmers in the spray irrigation segment were significantly more likely to indicate that they did not have a whole farm plan because they 'did not need a whole farm plan to install spray irrigation' than were farmers in other segments.

Fertiliser management

The irrigated dairy farmers we interviewed employed contractors to spread fertiliser and perceived them to be quite cost effective. Farmers indicated they had not experienced any problems organising contractors when needed.

During the interviews farmers expressed some concern about the idea of not spreading fertiliser at the end of irrigation bays. They believed they would suffer significant pasture and production losses if they were to follow this recommendation. They also believed that even if they wished to follow the recommendation they would have to rely on the contractor to operate their machinery appropriately. Farmers believed that contractors did a reasonable job of avoiding unproductive areas on the farm such channels, drains, and streambeds when spreading.

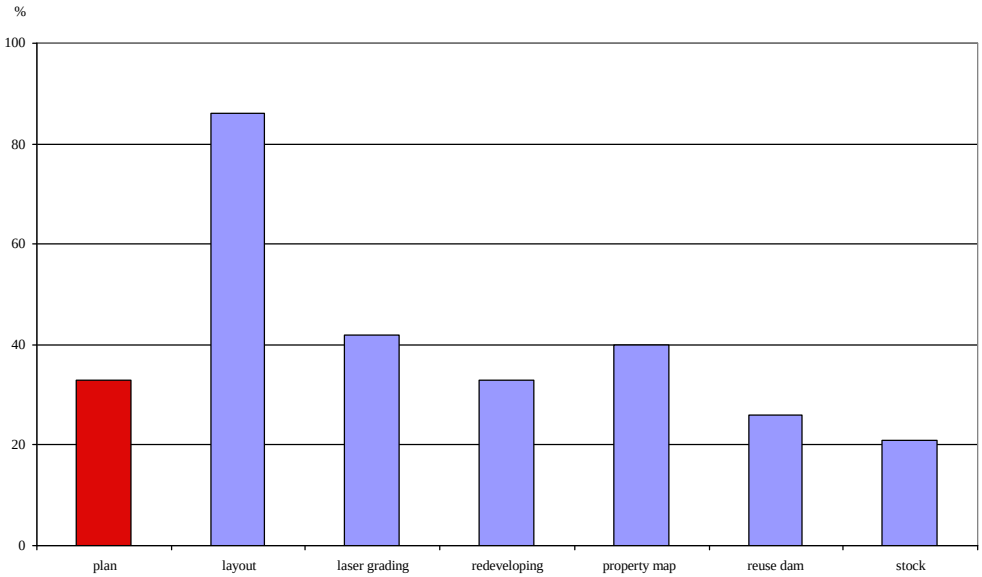

Figure 11 Reasons for having a whole farm plan drawn up by a contractor

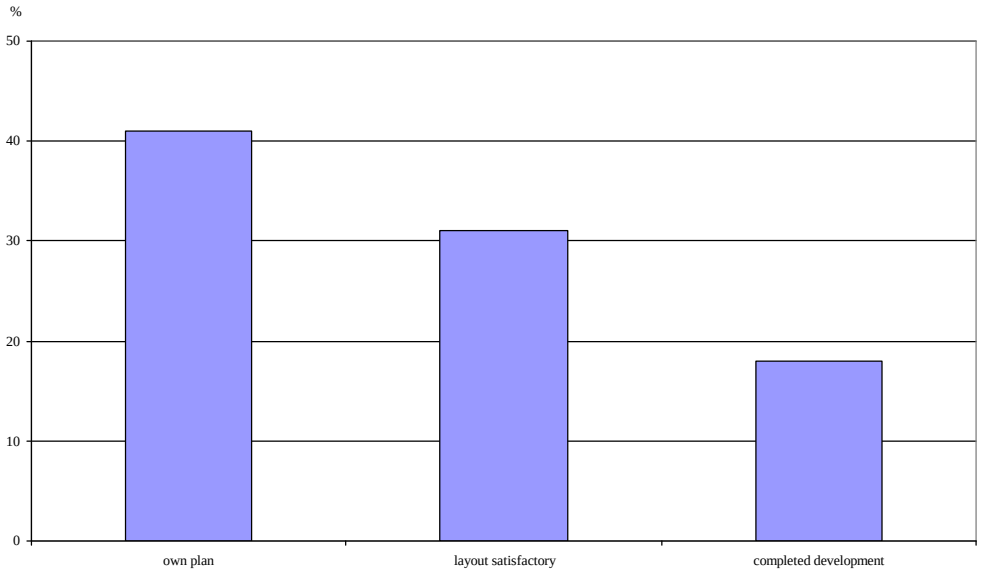

Figure 12 Reasons for not having a whole farm plan drawn up by a contractor

Note that the fertiliser budget represents a significant proportion of farm costs. Consequently, farmers were concerned to ensure that they received a satisfactory return on their fertiliser expenditure. This means most farmers wish to be as effective as possible in using fertiliser and to keep expenditure on fertiliser within reasonable limits. This means most farmers will be receptive to information that will assist them with fertiliser management. However, given the importance of fertiliser as an input to pasture growth and milk production, most farmers are unlikely to change fertiliser management until they are convinced the change will be beneficial.

Most farmers usually applied phosphorus between two and four times a year during spring, early summer and autumn (see figures 13 and 14). Nitrogen was commonly applied between one and four times a year. A substantial proportion of farmers did not apply nitrogen at all. Nitrogen was applied throughout the period between mid-summer and late winter. Virtually all farmers apply phosphorus and nitrogen as a soon as possible after an irrigation or within three or four days of an irrigation (see figure15).

Most farmers indicated that they soil test every second or third year and used an agronomist or company rep to assist them with their fertiliser program. Farmers were equally divided between those who tested the same paddocks each time and those that tested different paddocks each time (see figure16).

Value systems

Farmers were classified into four value groups based on their responses to a series of statements based on Schwartz (1994) and Stern, Deitz and Guagnano (1998). The statements covered values representing conservative (*self-discipline, showing, respect, family security*), altruistic (*care for the weak, a world of peace*), achievement (*wealth, being influential*) and openness to change orientations (*a varied life, curious*).

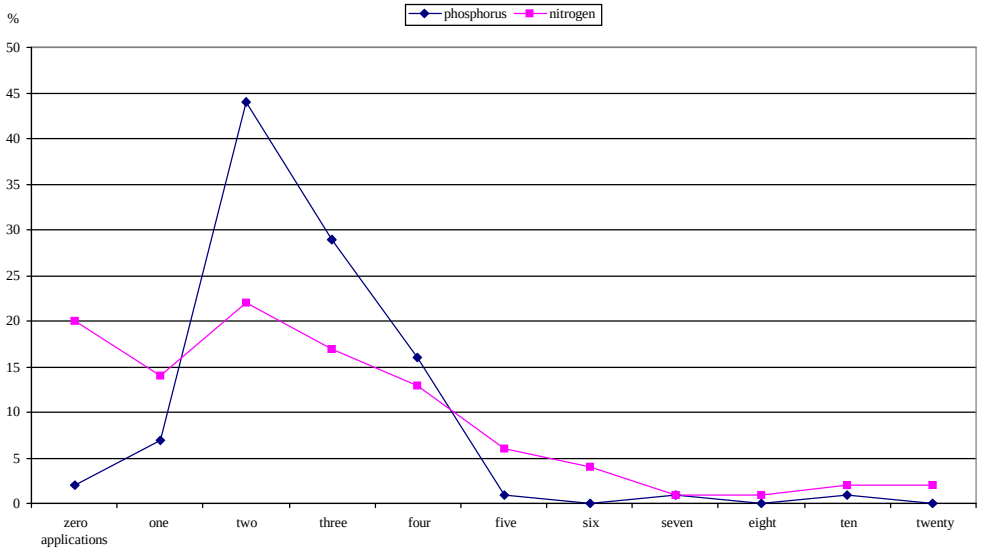

Figure 13 Frequency of application of phosphorus and nitrogen

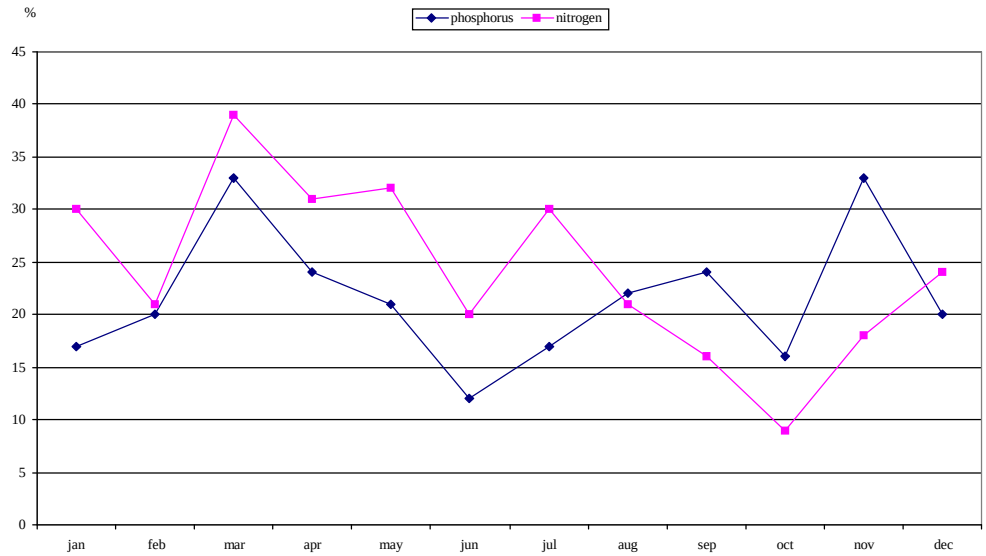

Figure 14 Timing of application for phosphorus and nitrogen

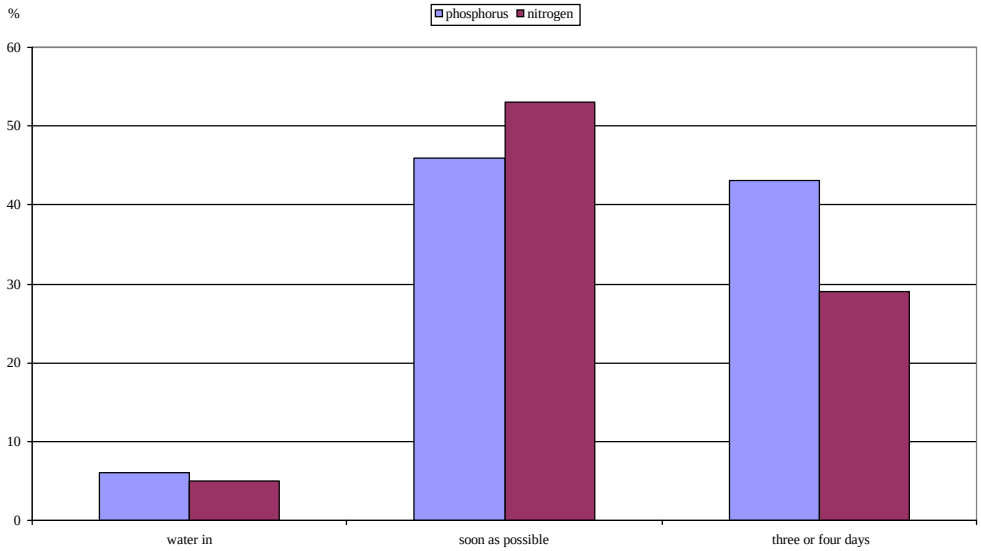

Figure 15 Irrigation and fertiliser application

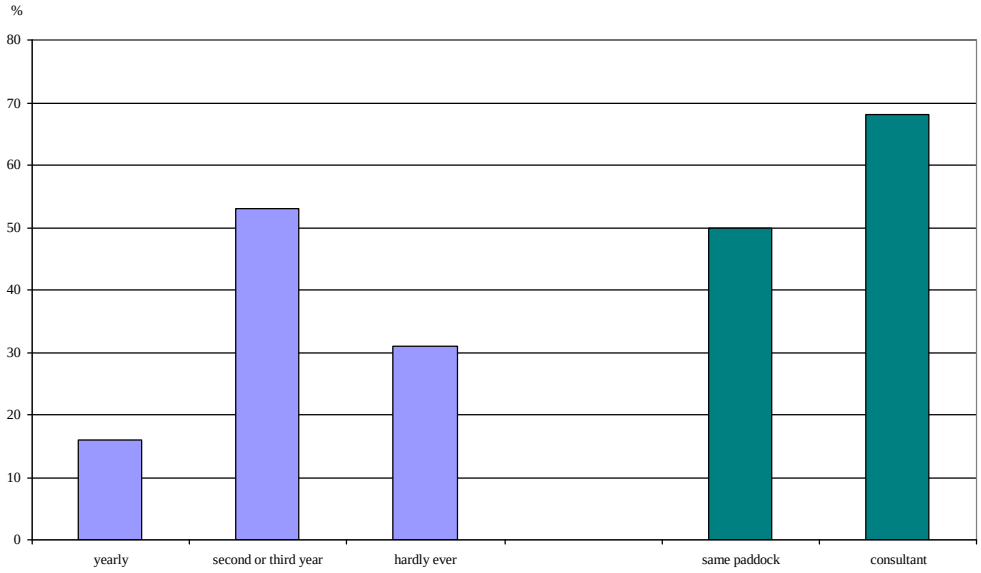

Figure 16 Soil testing

Farmers in the first group did not exhibit a strong orientation in terms of social values, although they placed least importance on achievement values (see figure 17). The behaviour of farmers in this group will be driven largely by contextual factors. They will decide each case on its' individual merit. These farmers may be motivated to undertake actions that will benefit the environment or others in the community in the right circumstances.

Farmers in the second group were strongly conservatively oriented but were also reasonably strongly oriented to altruism. In the right circumstances these farmers may be motivated to undertake actions that will benefit others in the community.

Farmers in the third group were most strongly oriented to altruism. They were also reasonably strongly oriented to conservatism and to change. These farmers placed least importance on achievement values. In the right circumstances these farmers may be motivated to undertake actions that will benefit others in the community.

Farmers in the fourth group were strongly oriented to conservatism and placed least importance on altruism.

Farmers were also asked to respond to statements indicating environmental values (*harmony with other species, preserving nature*). The line in figure 17 shows the relative importance of these values to the farmers in each group. Farmers in the first and third groups rated these values as important as their most strongly held social values. This suggests that the farmers in these groups may be motivated to undertake actions that will benefit the environment.

Because the farmers in the first group did not exhibit a particular value orientation, their propensity to undertake actions that will benefit the environment will depend on their individual circumstances.

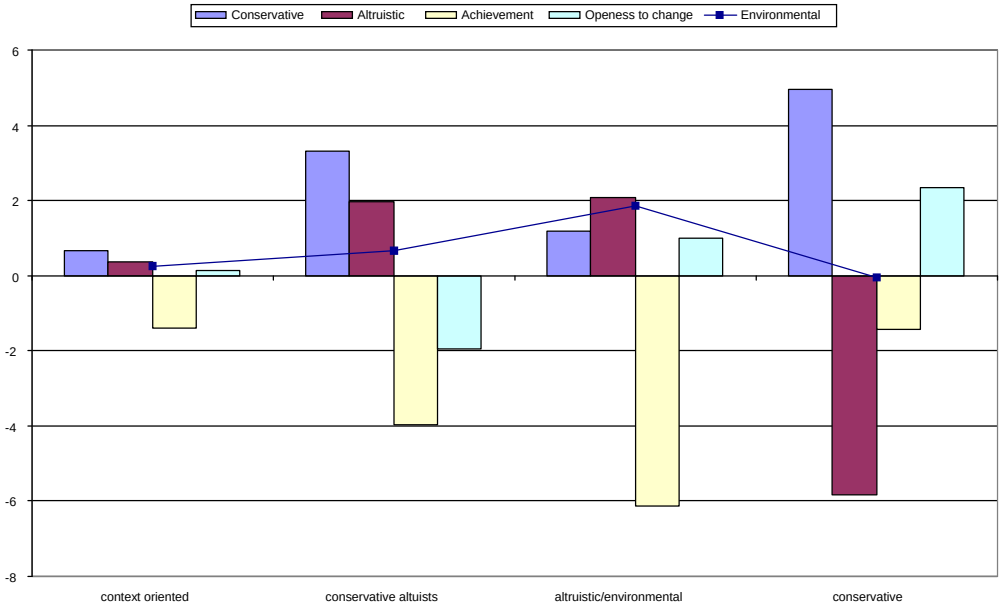

Figure 17 Value orientations of dairy farmers

Because the farmers in the third group rated altruistic values and environmental values as being equally important, these farmers are unlikely to undertake actions that will benefit the environment if those actions are perceived as imposing an unjust burden on some members of the community.

Note that farmers in the second group may be motivated to undertake actions that will benefit the environment if those actions are seen to benefit the community.

Farmers in all groups are likely to respond positively to actions that will benefit the environment if these actions are associated with the expression of conservative values.

Implications for incentive schemes

The incentives offered under the Macalister Nutrient Reduction Program are structured as follows. Farmers are eligible to receive 75 per cent of the cost per hectare of the survey component of a whole farm plan, up to a maximum of $37.50 per hectare. Farmers are also eligible to receive 75 per cent of the cost per hectare of the design component of a whole farm plan, up to a maximum of $37.50 per hectare. In the event that the survey or design applies to only part of the farm the rate is reduced to 50 per cent. Note that in some circumstances spray irrigation may not need as comprehensive a survey as flood irrigation. Also spray irrigation design is usually less expensive than flood irrigation design. A whole farm plan drawn up by a consultant is a prerequisite to eligibility for the incentives offered on spray irrigation and reuse systems. This prerequisite tends to offset the incentives on offer for spray and reuse systems for farmers contemplating installing either relatively small areas of spray irrigation or relatively small and inexpensive recycling systems (see appendix A).

With respect to spray irrigation farmers are eligible to receive 15 per cent of the cost per hectare of installation, up to a maximum of $370.00 per hectare. The ceiling represents 15 per cent of the typical cost of installing a lateral move system.

With respect to reuse systems farmers are eligible to receive 50 per cent of the cost of installing a dam, up to a maximum of $15,000.00 per structure. No incentives are offered with respect to laser grading.

Our results suggest that farmers' response to the incentives offered under the Program is likely to be limited. In fact, only 12 per cent of respondents indicated they had decided to get a whole farm plan to qualify for the incentives offered under the Program. There are a number of reasons for this limited response. Consider, for example, the position of farmers in the laser-graded segment. Most farmers in this segment have laser graded much of their properties and over half have already installed reuse systems. Hence, the incentives will appeal mainly to those farmers in the segment who have not yet installed a reuse system and whose property does not discharge into a creek or drain. Consequently, the incentives to obtain whole farm plans and invest in reuse systems may have little appeal to many farmers in this segment.

Most farmers in the graded layout irrigation segment have only laser graded a relatively small area of their properties. Also, only a minority of farmers in this segment have already installed reuse systems. Hence, the incentives that are offered on whole farm plans and reuse systems have the potential to be attractive to these farmers. The number that consider adopting the incentive will depend on the proportion of farmers in the segment with properties that have suitable topography and that do not discharge into a creek or drain.

Farmers in the graded layout irrigation segment are unlikely to find the incentives offered for spray irrigation attractive. These farmers might to tend to find lateral move spray irrigation unappealing because of the time involved in managing this type of system. They are unlikely to be attracted to labour saving spray systems such as centre pivots and fixed sprays as these are much more expensive than laser grading.

Farmers in the mixed system irrigation segment may find the incentives offered for spray irrigation attractive. How attractive this incentive is will depend on the size of the area that farmers are considering converting to spray irrigation and the cost of a whole farm plan (see appendix A). The larger the area to be converted to spray

irrigation the more attractive the incentive will be relative the cost of obtaining a whole farm plan to qualify for the incentive. However the larger the area to be converted to spray irrigation the more likely the time involved in managing lateral moves will become a problem. While systems such as centre pivots and fixed sprays are suitable for larger areas, these systems are much more expensive to install than lateral sprays. This means the incentive represents a much smaller proportion of the cost of installation. Consequently, the incentive will not be a key factor influencing the decision to install these more expensive systems.

In short, the incentive will be most attractive to farmers in the mixed system segment who are planning to install relatively larger areas of lateral move spray irrigation. The attractiveness of the incentive will be diminished if farmers in this segment have already invested in whole farm plans. The incentive offered on reuse systems probably holds little appeal to farmers in this segment as most already have a reuse system and many are using their reuse systems as water storages to facilitate spray irrigation.

Farmers in the spray irrigation segment are unlikely to find the incentive on whole farm plans or spray irrigation attractive. Many will see whole farm plans as unnecessary and are not contemplating laser grading or installing reuse systems. Again, the value of the incentive to install reuse systems will be diminished to the extent that these farmers may wish to manage reuse systems as storage dams to facilitate spray irrigation.

Conclusion

In the first stage of this study we identified the factors that influence the adoption of laser graded flood irrigation, spray irrigation systems, reuse systems and whole farm planning. The type of irrigation system chosen by farmers depends on the soils and topography of their property, financial constraints, and farm layout. Time and labour constraints were also identified as key factors in the choice of an irrigation system.

In this second stage of the study we conducted a mail survey of farmers and used the responses to classify respondents into irrigation segments. We found that most respondents use flood irrigation. Approximately 50 per cent of farmers who responded to the survey used laser graded flood irrigation that they installed to save time irrigating and to save water. Another 25 per cent of respondents used land planed flood irrigation. Most of these farmers have laser graded a portion of their properties, primarily to save time irrigating. Approximately 17 per cent of respondents irrigated using a mix of flood and spray irrigation systems. The remaining 7 per cent relied on spray irrigation alone.

In the first stage we found the benefit of installing reuse systems depended heavily on the soil type, topography and type of irrigation system used on the farm. Management of groundwater and of effluent also influenced the need for, and management of, reuse systems. Approximately 50 per cent of farmers indicated they had installed a reuse system. Most used their system to capture rainfall and irrigation run-off.

In the first stage we found most farmers view whole farm plans as a method for planning the staged redevelopment of the farm when implementing a laser-grading program. Consequently, whole farm plans are seen to be largely irrelevant to the installation of spray irrigation systems. The survey responses were consistent with these views. Approximately 35 per cent of farmers indicated they had a whole farm plan drawn up by a consultant.

We also identified the factors that influence fertiliser management in the first stage of this study. Differences among farmers in fertiliser management were mainly

attributable to differences in soil types and pasture composition, beliefs about the value of nitrogen, and beliefs about the need to 'wash in' fertiliser after spreading. The results of the survey indicated that most farmers do not 'wash in' fertiliser, preferring to apply fertiliser after they have irrigated. Most farmers indicated they seek advice about fertiliser management from consultants and fertiliser company representatives.

Finally, we classified farmers into four groups based on their social values. The results indicated that farmers in all groups are likely to respond positively to actions that will benefit the environment if these actions are associated with the expression of conservative values. We found no relationship between social values and the type of irrigation system used on farms, whole farm plans or installation of reuse systems.

Our findings indicate that:

- Widespread adoption of spray irrigation by dairy farmers in the Macalister Irrigation District is unlikely. For the majority of farmers, laser grading has been, and will continue to be, the most effective means of reducing water and labour use per hectare. As a result, we believe consideration should be given to offering incentives for laser grading in order to promote more efficient use of water.

- Lack of access to water on demand (groundwater, pressurised pipe or on-farm storage) may be a factor preventing the adoption of spray irrigation for some farmers. The adoption of spray irrigation may be prevented in some instances by poor reliability in terms of water delivery and variability in channel flow. Poor reliability in terms of water delivery and variability in channel flow may also be a factor limiting the effectiveness of flood irrigation on some farms. We believe consideration should be given to improving irrigation infrastructure in the district and reviewing groundwater policies.

- Given the decline in water reliability in the district, and the continuing investment in laser grading, we believe recycling systems will be installed on farms throughout the District. However, farmers on more permeable soils may wish to use recycling systems both to conserve run-off and to store irrigation water for

spray irrigation. We believe consideration should be given to extending the incentive offered for reuse systems to include systems that are also designed to store water, as this would facilitate the installation of spray irrigation.

- Most farmers regarded whole farm planning as an instrument for planning farm layout for flood irrigation. Few farmers were aware of the benefits of whole farm planning for spray irrigation. We suggest that the full potential of whole farm planning for both flood and spray irrigation be promoted to farmers.

- Virtually all farmers were aware that fertiliser should not be 'watered in'. We believe most farmers, and their fertiliser advisers, would be interested in receiving detailed information about fertiliser management.

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Appendix A

Incentive Arrangements

For spray irrigation the incentive scheme offers 15 per cent of the cost of installation of spray up to a maximum of $370 per hectare. The maximum is representative of the cost of the cost per hectare of installing a lateral move spray system. Hence, the total incentive to the farmer of installing a lateral spray system would be about:

(1) SPRAY = $370 * AREA, where AREA is in hectares.

For reuse systems the incentive scheme offers 50 per cent of the cost of installation of a reuse structure up to a maximum of $15,000. Hence, the total incentive to the farmer of installing a reuse system would be:

(2) REUSE = 0.50 * COST, where COST is in dollars.

For whole farm plans the incentive scheme offers 75 per cent of the cost per hectare of a plan, up to a maximum of $75 per hectare (assuming the survey and design components of the plan apply to the same areas and the plan covers the entire farm). The cost of commissioning a consultant to prepare a whole farm plan is typically about per $100 per hectare. Hence, the total incentive to the farmer of a whole farm plan would be about:

(3) WFP = $75 * FARM AREA, where FARM AREA is in hectares.

Consequently, the total net cost to the farmer of a whole farm plan would be about:

(4) WFP = $25 * FARM AREA, where FARM AREA is in hectares.

A whole farm plan is required to qualify for incentives offered on spray or reuse systems. If the farmer requires a plan then the cost of the plan must be offset against the incentive for installing spray irrigation. In other words, equation (1) becomes:

(5) SPRAY = $370 SPRAY AREA - $25 * FARM AREA

Note that, at the maximum rebate per hectare for installing spray irrigation, the net cost of the whole farm plan will exceed the incentive offered for installing spray irrigation if the farm area is more than 15 times the area of spray to be installed. For example, the cost of the whole farm plan will exceed the incentive for spray irrigation if a farmer with a property of 90 hectares is planning to install less than 7 hectares of spray irrigation.

Similar reasoning shows that if the cost of a reuse system is less than 50 times the area of the farm then the cost of the whole farm plan will exceed the incentive offered for installing a reuse system. For example, the cost of the whole farm plan will exceed the incentive for a reuse system if a farmer with a property of 100 hectares is planning to install a structure that costs less than $5,000.

These calculations suggest that the incentive for reuse and spray systems will be most attractive to:

- Farmers that already have a whole farm plan drawn up by a consultant, or
- Farmers without a whole farm plan who are planning to install spray irrigation on seven per cent or more of their property (depending on the cost of installation), or
- Farmers without a whole farm plan who are planning to install a reuse system that is at least moderate in size.