A Summary of Sustainable Irrigation Papers

Technical Paper 00/01

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Foreword

This is one of a series of 10 technical bulletins, which report the detail of projects commissioned by MAF Policy on sustainable irrigation.

This work arises as part of MAF's contribution towards Government's "Sustainable Land Management Strategy."

The projects in this series broadly divide into two groups, technical irrigation design factors and management factors. A key issue identified by farmers at the onset of this work was that to ensure irrigation could operate in sustainable ways physically and for the environment, it also had to be profitable irrigation.

The emphasis on water use efficiency and cost effectiveness of plant and management, which has arisen from this, has been developed throughout the research. It is clear that win/win situations are possible. Improvements for both environmental and farm profitability objectives can be achieved.

More efficient ways of monitoring and managing water use on farms are described in the series.

There is a large amount of base data and technical information in these papers which is likely to be helpful background for designers, consultants and local and regional authorities.

Much of this information is also being incorporated into a simpler National Irrigation Handbook. This is being designed as a ready reference for farmers and commercial firms, and will be available in 2001.

An overall summary of the technical reports in this series and copies of the reports themselves can be obtained from: Information Bureau, Ministry of Agriculture & Forestry, P O Box 2526,
Wellington.

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Director
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The other technical bulletins in this series are:

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1 Summary of Reports

The ten reports in this series have been commissioned by MAF Policy since 1997. They are as follows:

1.1 TECHNICAL PAPER 00/02

1.1.1 A survey of Farmers approaches to and perceptions about irrigation management

A joint project between Lincoln Environment and Agriculture NZ Ltd, which surveyed irrigators throughout New Zealand. A postal survey covered ten sub regions of NZ. The survey was successful in identifying what was actually done in the way of irrigation management but was less successful in determining how managers thought they should be making decisions. The postal survey provides an estimate of the total area of land irrigated in New Zealand.

Key findings from the postal survey regarding farmers' irrigation management were:

- Most farmers do not have a problem in deciding when to irrigate, how much to apply or which crops to not irrigate when water was in short supply.
- Many farmers were concerned about the adequacy of their water supply, whether from a scheme, a stream or a well, in that they are often unable to supply the amount of water they believe is necessary for crop production.
- Windy conditions frequently provide a problem in managing irrigation effectively and efficiently.
- Farmers were most concerned about the longer-term issue of ongoing access to their water resource and the effect the Resource Management Act will have on this.
- Lack of profit was often cited as a reason for limiting farmers' ability to improve their irrigation management.
- About 50 percent of farmers report monitoring of soil moisture for management of irrigation timing and irrigation amount although it is thought that between 10 percent and 12 percent regularly measure soil moisture using a neutron probe or equivalent service. For the remaining 38 percent to 40 percent, monitoring of soil moisture may be more qualitative than quantitative.
- In about one-third of irrigators, and about 50 percent of those in large irrigation schemes, a fixed amount of water is applied each irrigation because of the system's size or the supply roster and irrigation is pretty much applied when it is available.
- In many cases, it is more cost-efficient for a farmer to irrigate when it may not be needed or to apply more water than is needed than to risk the crop being stressed either then or at a later stage.
- Overall, farmers' focus is more on the effectiveness of the irrigation than on its efficiency and the cost of delivering some water which is wasted may be relatively small compared with the potential yield losses of excessive crop stress.

The second part of this project was to hold a series of focus group meetings throughout the ten sub regions. Each of the focus groups followed a similar format for discussion so that perceptions, constraints and requirements could be documented.

1.2 TECHNICAL PAPER 00/03

1.2.1 Indicators of Sustainable Irrigated Agriculture

A range of indicators had been developed from previous workshops where irrigators were asked for indicators that farm businesses and communities could use to develop benchmarks.

The important overall goal which farmers identified for Sustainable Irrigation was to maximise net profit over the long term.

Other key goals were categorised as economic, environmental or social goals. This report undertaken by Lincoln Environment had developed a set of indicators that could be used by farmers to record the performance and impact of irrigation.

While the focus of these projects has been on sustainable irrigation, MAF and its researchers have been acutely aware that irrigation is one part of a farm or horticultural production system and that best irrigation management practices must fit into the overall context of the best management for the whole farm system.

It is anticipated that the use of the indicators and other measures developed through this research will create a win/win situation by enabling farmers achieve more effective and/or efficient irrigation and through this result in reduced costs and/or improved production and at the same time improve the utilisation of one of our most valuable natural resources—water.

Table 1: Suggested List of Indicators

Economic	Profit per unit of water used Requires net profit after tax and/or gross margin per hectare	$/m^3
Production	Production per unit of water Requires quantity of produce per hectare for each crop or product Quality of produce	t or kg/m^3 t or kg/ha % in each grade
Energy	Energy used per unit of water Requires annual energy usage	kWh/m^3 kWh
Labour	Labour units per irrigated hectare for year Possibly peak labour demand	Hours/ha Hours/week
Water	Daily volumes of water flowing on to farm for each crop % of water stored in the root zone Ratio of water depth applied (D) to rainfall corrected water demand ET* Depth applied/evapotranspiration Number of days crop stress as shown by neutron probe monitoring suggested by J Greer Maximum water abstraction rate each season Daily visual assessment of ponding or run-off	m^3/day Requires soil monitoring mm/mm Rainfall Doesn't detect short-term under- or over-irrigation m^3/day
Environmental	Resource consents obtained and complied with Record of abatement notices	
Soils	Aggregate stability Water-holding capacity	 Required for planning irrigation

This report suggests that in assessing the sustainability of an irrigation system, it is important to recognise that performance on some indicators will be more strongly influenced by general farm management practices than by the operation of the irrigation system per se. For instance, application of additional nitrogen may improve crop yield or milk production and thus improve output per unit of water far more substantially than attempts to improve the efficiency of irrigation.

It is also important to recognise that the irrigation system and its operation on a particular farm is the outcome of many variables and, once established, there may be little flexibility in altering the performance of the system.

1.3 TECHNICAL PAPER 00/04

1.3.1 Field testing Indicators of Sustainable Irrigated Agriculture

A project undertaken by Agriculture NZ to field trial the indicators of Sustainable Irrigation as developed in 00/03. The report comments on the particulars of collecting the data and the meaning of the information from the farmer's viewpoint.

Six farms were selected to field-test the indicators of sustainable irrigation. These were selected as three pairs of farms with two borderdyke dairy farms, two spray irrigation dairy farms, and two-spray irrigation cropping farms. Within each pair of farms, there was a traditional established irrigation system paired with a more recently installed system. The selection of properties was intended to provide a range of performance on the indicators.

The purpose of the field-testing was to establish practical methods of gathering the information needed to assess whether it was feasible to obtain all the information needed on the indicators and to assess the farmer response to the information how meaningful it was to them.

It had been intended to measure the water flow on each property with appropriate metering devices. However, this was not possible on most properties because of complications in the turnout design on the borderdyke properties or because of insufficient straight pipe near the headworks of the spray irrigation properties. Accurate water metering devices were installed on one spray irrigation property and one borderdyke property as part of the best management guidelines project, and good information was obtained on water flow. For the remainder of properties, total water flow had to be estimated from the number of irrigations, the average depth of application per irrigation and the irrigation area.

The daily percentage of water stored in the root zone was considered to be a very good indicator of the efficiency of irrigation in that it captures precisely the amount of rainfall and irrigation that is lost to ground water. Measurement of this requires daily monitoring of soil moisture and irrigation flows. Where this was installed as part of the best management guidelines project, graphs indicating accurately the percentage of water stored in the root zone provide very good information to assist in enhancing management of the irrigation scheme.

Where this was not available, the ratio of seasonal water application to seasonal water demand was calculated using the total depth of water applied as irrigation, the potential evapotranspiration demand and the rainfall. This ratio detects significant under- or over-irrigation on a seasonal basis but does not show periods of over- or under-irrigation on a day-to-day basis.

(For example, where an irrigation system could apply 60 mm/day on a 12-day return cycle, then a constant 5 mm/day demand for moisture would be perfectly satisfied by the irrigation system. However, if soil water-holding capacity was only 50 mm, then 10 mm of each irrigation would be lost below the root zone at the time of application and the crop would be under water stress for the last two days of each cycle.)

For some of the farms, design audits were carried out on the irrigation system to identify how well the systems were performing compared with the best management guidelines on design and to identify the degree to which the performance of the irrigation systems might be increased. It was also anticipated that this audit would gather information that might explain some of the variation in indicator values.

1.4 TECHNICAL PAPER 00/05

1.4.1 Best Management Guidelines for Sustainable Irrigated Agriculture

Undertaken by Lincoln Environmental. This project has focused on selecting practical methods that farmers can use to obtain benefits form having a well designed irrigation system that is managed to its optimum capability. The report recommends suitable indicators and suggests methods to monitor them on a daily and seasonal basis.
The project was carried out to provide farmers with practical information to assist their decisions relating to the design and operation of their irrigation systems. The project suggests guidelines for the following areas of decision-making on irrigation:

- New system design;
- Pre-season checks;
- Planning the irrigation strategy for the season;
- Operating and managing the irrigation system during the season;
- Reviewing the performance at the end of the season.

The guidelines set out in detail the factors to be considered and each step of this process. Particularly important areas the guidelines covered are set out below:

- Estimation of soil moisture status and actual water use.
- Accurate measurement of both these factors provides very good information for farmer decision-making on the use of irrigation.
- Knowledge of soil moisture status and amount of water pumped enables a farmer to minimise water use while ensuring that crop yield suffers minimal restrictions from soil moisture deficits.

Considerable emphasis is placed on the factors to consider in the design of new irrigation systems. The design of the system sets clear limits to what can be achieved with the irrigation and no amount of careful day-to-day irrigation management can compensate for system design problems. In particular, it is vital that the long-term cost of some design decisions are carefully evaluated including the match between pump, motor and irrigator and the selection of site for extraction of the water. Decisions which minimise capital costs at time of installation of the irrigation can incur substantial annual operating costs which far outweigh the capital savings in the long term.

The guidelines set out the appropriate pre-season checks and planning to be carried out. In planning the irrigation season, a key choice in the irrigation strategy is selection of the trigger level of moisture deficit that the farmer will start irrigation at, how to manage irrigation when rainfall occurs during the season, and the decision on when to apply the last irrigation for the season.

The guidelines set out the data that should be gathered on both a seasonal and daily basis to enable adequate calculation of the indicators of sustainable irrigation.

1.5 TECHNICAL PAPER 00/06

1.5.1 Testing of Irrigation Best Management Guidelines 1998

Two Canterbury Dairy farms were selected by Lincoln Environmental to carry out design audits and have the farmers follow the Best Management guidelines recommended in the technical paper 00/05. Water usage was measured using pressure gauges and calibrating this to water flow. Soil moisture levels were monitored following the installation of neutron probe and Aquaflex monitoring equipment. Design audits were completed for each of the farm's irrigation system. Although problems were encountered in obtaining accurate water usuage and the audit process identified deficiencies in the system design it was considered that the project was successful. None of the problems were insurmountable and it was possible to provide recommendations to improve the overall efficiency of water use without comprising production.

1.6 TECHNICAL PAPER 00/07

1.6.1 Testing of Irrigation Best Management Guidelines 1999

A further season of testing the guidelines as described in Technical Paper 00/05. Three Canterbury Properties were included in the testing. This included the two dairy farms from the previous year and an additional cropping farm. The programme of the previous year was repeated with the aim of eliminating many of the problems encountered in the first year of the testing.

Sufficient data was obtained for the three farms to make good irrigation management decisions.

Total seasonal water use was calculated for each farm and the percentages of water stored in the crop root zone provided an indication of the efficiency of water use. An important outcome of the project was that the concept of measuring field data and calculating indicators to make short-term and long-term irrigation decisions was identified as being workable.

The report concludes that if farmers follow the best management guidelines and adopt changes that are identified through the system audits and the monitoring of irrigation performance it is possible to improve profit and minimise the environmental effects of irrigation.

1.7 TECHNICAL PAPER 00/08

1.7.1 Benchmark Data on Sustainable Irrigation Indicators

This project carried out by Agriculture NZ collected benchmark information from 30 farms covering a range of farm type and a range of irrigation systems. The purpose was to develop data that covers the most likely range of each indicator that had been identified in earlier reports. Other irrigating farmers that are prepared to monitor these indicators will have a range of benchmarks that will allow a wide range of farm types

on different soils and achieving different levels of production to be able to compare with the range of measures recorded.

The benchmarks for dairy farms include such measures as:

- Water use per Kg of Milk solids produced.
- $ Gross Margin per cubic meter of water used.
- Energy used per Hectare.
- Energy used per unit of water used.
- Total cost of irrigation.
- An efficiency index that calculates the water applied compared to evapotranspiration minus rainfall.

A similar set of benchmarks is published for arable farms.

The benchmark data is set out in excel spreadsheets so that any farmer or their adviser can compare with a range of similar farms. The authors suggest that this information should be made available on an accessible website so that a larger database could be developed.

The report summarises the comments of 22 farmers describing their use of the indicators and the implications for their properties.

1.8 TECHNICAL PAPER 00/09

1.8.1 Designing Effective and Efficient Irrigation Systems

A report prepared by Lincoln Environment sets out the performance measures that need to be considered when designing an irrigation system. The report illustrates the effects that design decisions have on performance measures.

The report concludes that that irrigation system design is the principal reason for lower than expected levels of efficiency. Part of this is due to the fact that farmers place more emphasis on their irrigation system being effective in delivering water to ensure production rather than being efficient at utilising the scarce water resource.

Most irrigation systems fail to have the flexibility that is required to allow the manager to water in a way that is both effective and efficient.

The report looks at timing, application depth, uniformity and water supply characteristics as critical factors in describing irrigation system performance. It also assesses the feasibility of designing effective and efficient irrigation systems under New Zealand conditions. In some instances the technology is available and the expertise may be available but not in any one organisation in New Zealand.

A suggestion is made in the report that the paucity of information on the efficiency of irrigation systems in New Zealand and the lack of accepted performance criteria relating to the efficiency of water use puts New Zealand agriculture in a weak position for allocating scarce water resources. When new water permits are applied for or existing permits are being considered for renewal this weak position may be exposed.

Achievement of sustainable irrigated agriculture depends on better design of irrigation systems. This report suggests that the technology and expertise is available in New Zealand to increase the understanding and obtain the required information so that irrigation in New Zealand agriculture can move to a more sustainable level of performance.

1.9 TECHNICAL PAPER 00/10

1.9.1 Financial Benefits of Making Improvements to an Irrigation System: A Case Study

Lincoln Environment has completed a case study on the 163ha spray irrigation farm near Darfield on the Canterbury plains. The capital cost of upgrading has been considered against the forecast annual increase in financial returns.

The primary objective of the project was to demonstrate that improvements to the design of the irrigation system were financially beneficial to the farm business. Three options for improving the farms irrigation system are investigated.

For the chosen option a capital cost of $66500 + GST results in the improvement in consolidated Gross Margin for the property of between $17000 and $45000 + GST on an ongoing annual basis depending on the seasonal rainfall. Improvements to the system included replacing some of the equipment to allow increased water flow. This required

the owners to apply to the Regional Council for a permit to take an increased volume of water. Management changes were also suggested so that crop requirements better matched the new design of the system. The irrigation return interval was reduced and the total labour requirement was less as a result of the changes.

1.10 TECHNICAL PAPER 00/11

1.10.1 Developing an Effective Irrigation Water Use Meter

A prototype water use meter has been designed and built by Lincoln Environment for use on irrigation plants. This paper describes the objectives set for design and the technical specification for a unit that should be marketed for a price of approximately $1000.