Land & Water Australia Project No. SOU3

Changing irrigation systems and management in the Harvey Irrigation Area

Stage 1: Report
Stage 2: Project and communication plan

Principal Investigator: Ken Moore

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PART 1: REPORT ON STAGE 1

1. Project Summary

The project is examining issues of water use efficiency (WUE) in the South West Irrigation Area (hereafter called the Harvey Irrigation Area). A significant WUE issue is whether water savings, improved pasture yields and farm productivity can be achieved through sprinkler (centre pivot) irrigation of dairy pasture in comparison with traditional surface bay irrigation (often called flood irrigation).

This project is a case study conducted on a commercial dairy farm and is generating information that is relevant to the planning and operational context of the farm. Irrigators have been seeking such information derived locally and within a commercial and practical context. Furthermore, they are seeking the information within the immediate future in order to have it available for imminent decisions on whether or not to invest in sprinkler irrigation.

Planning for this project commenced in 2001 and in the 2002/03 irrigation season, there was substantial pre-trial testing to bring the centre pivot up to farm operational and case study standards. The project itself is designed to continue over two irrigation seasons to provide comparison of results over more than one season and for adjustments in the management of the systems. In 2003/04, we are comparing centre pivot irrigation with what we are assuming is best practice surface bay irrigation for dairy farmers in the area. In the 2004/05 irrigation season, we will be seeking to improve on year 1 practices, particularly for surface bay irrigation. We will consider the applicability of SIRMOD or AIM models to improve the surface bay irrigation in Year 2.

The case study is comparing systems by measuring two water use efficiency indexes:
Irrigation water use index = yield/irrigation water applied = kg dry matter/ML
Pasture water use index = yield/evapotranspiration = kg/mm.
It is also simulating pivots of various sizes in order to determine the optimum size on Harvey's clay based soils. The case study is linking with the DairyCatch project for monitoring water and nutrient run-off and infiltration under both systems.

A key aspect of the project is the development of a whole farm-planning framework that will enhance decision making for investment in changes to irrigation systems. A decision support framework (DSF) that is being applied in the Shepparton Irrigation Area by the Victorian Department of Primary Industries is being used in the case study. This is working through a four-step evaluation process:

1. Articulation and review of the farmer's profitability, development and lifestyle goals;
2. An assessment of farm biophysical, economic and institutional conditions – soils, water availability, topography, farm layout and regulations on land use and management;
3. Detailed consideration of system design and operation, its economics and feasibility; and
4. Making the investment decision.

In comparing irrigation systems, the project is using research knowledge available elsewhere in Australia (eg, project DAV11163, DPI Tatura & Kyabram) and practical industry experience (eg, NCEA Toowoomba) to the extent it is applicable in the Harvey Irrigation Area. We are exchanging information with DPI Victoria and are confident this will assist their work in changing irrigation systems.

The case study approach employed in this project enables all aspects of a major investment decision to be examined in a commercial and practical context prior to the actual decision having to be made. It is providing information on irrigation system performance that can be considered by farmers in the Harvey Irrigation Area and in other areas of Australia with similar soil types and climate. The results will be made widely available through the Harvey

Water website and appropriate publications. For Harvey Water irrigators, we are demonstrating results through field days and field walks.

The project will also demonstrate the energy efficiencies and overall energy balance of a pressurized gravity-fed piped system of irrigation water delivery. The on-farm research will generate information that can be used by Harvey Water in system-wide planning for future water supply if there is multiple or widespread adoption of centre pivot technology. The project will provide data on the water requirements for a dairy farmer to successfully operate a centre pivot system. Baseline information will be provided on system capacity in mm per day, ML per hectare per year and the pivot size limitations that might apply to the Harvey Irrigation Area on clay soils.

Based on this information, Harvey Water will model and plan for a conveyancing and supply system that can cater for the requirements of a multiple and growing number of outlets for varying pivot sizes, multiple sites per farm and on-demand water supply. This is likely to be a significant engineering and economic exercise and the project Steering Committee will provide advice on how this aspect of the case study could be approached by Harvey Water.

2. Rationale for this Project

The project was initiated by Rob Kuzich & Co., a south-west irrigation technology supplier, who foresaw both a productivity and water use efficiency issue with surface bay irrigation of dairy pasture. He also saw the need of farmers and their service providers for practically tested integrated research and demonstration that enables sound investment decisions to be made when considering changes to irrigation systems.

In 2001, Rob Kuzich & Co. approached a leading local farmer, Dale Hanks, to undertake a case study comparing surface bay and sprinkler (centre-pivot) irrigation. He supplied a used centre pivot at his cost and during the 2002/03 irrigation season, the centre pivot was trialled and brought up to operational and research standard performance. In 2003, Dale's property was selected as the DairyCatch monitor farm for the South West Irrigation Area. The main purpose of this work is to monitoring sewerage management, nutrient run-off and water infiltration and run-off. Dale's selection as a Dairy Catch monitor farm provided the opportunity to integrate the two projects in relation to his property.

The project is commencing at an opportune time, as Harvey dairy farmers must improve their productivity due to record low milk prices and low returns on assets. All options for improving productivity need to be explored by farmers wishing to remain in the industry and achieve growth. With pressures on margins, farmers must improve returns on inputs, including water use efficiency. In this climate, farmers need robust decision support systems to introduce change, particularly when considering sizable investments in sprinkler irrigation.

Hence, the importance of the project is to ensure that investment in centre pivots is based on the best available knowledge from national and local sources and that this is applied and demonstrated on-farm. The case study information that will be generated relates to clay-loam soil types in the Harvey area. Some of the technical information can be used in other areas with similar soil and/or climatic conditions.

Research results will be directly communicated to Harvey Water irrigators. Through NPSI, the results will be made available nationally, but we are not claiming that this project is a comparison of the relative efficiency of sprinkler and surface bay irrigation in all situations.

The Harvey Irrigation Area is a suitable location in Australia to undertake a nationally funded case study because Harvey Water delivers piped water under pressure, which gives substantial efficiency for operating centre pivot systems and also for total water supply efficiency. Implementation of a State Water Strategy and policy on water conservation plans is also requiring Harvey Water to achieve improved WUE from irrigation at a system wide level. The case study will provide information and observations which may help other irrigation areas of Australia in this respect.

3. Research Design

NPSI requested that the project partners undertake the project in two stages to ensure adequate consideration of the issues and planning for the case study, along with integration with other related research work.

As a result, **Stage 1** has involved:

- working with the project partners, including NPSI to develop the project plan;
- locating the centre pivot on a trial site on the Hanks' property and bringing it up to case study and farm operational standards;
- selecting a comparable surface bay irrigation site;
- establishing working relationships between the partners;
- establishing links with the DairyCatch project;
- examining research and experiences elsewhere in Australia on changing irrigation systems and the relative merits of surface bay versus centre pivot irrigation;
- surveying irrigators as to their level of knowledge and interest in changing irrigation systems; and
- considering the aspects of farm planning and decision support necessary for farmers to make informed decisions.

The output of Stage 1 is this report which documents the issues and work involved in progressing to a plan for Stage 2. This includes a survey of irrigators' perceptions on changing irrigation systems.

Stage 2 of the project will involve a case study that compares centre pivot and surface bay irrigation over 2 irrigation seasons on a commercial dairy farm. Two sites have been selected on the farm which are comparable in size, topography, soil type and pasture species, and are initially subject to the same grazing and nutrient regime. The case study will aim to:

- demonstrate the design requirements of centre pivot irrigation necessary to optimise its performance;
- measure water use efficiency for centre pivot and surface irrigation;
- measure pasture yields and make observations on quality and resulting milk production under both systems;
- monitor nutrient and water run-off and infiltration; and
- establish a whole farm planning approach supported by a decision support framework that allows farmers to systematically work through investment decisions for changing irrigation systems.

Stage 2 will also highlight modelling and planning issues for Harvey Water in meeting the needs of irrigators if there was widespread adoption of sprinkler (centre pivot systems). The outputs of Stage 2 will be the reports of results which will be communicated through field days, field walks, project updates, milestone reports and articles.

4. Research Agreement

The National Program for Sustainable Irrigation has approved funding of up to $25,000 for Stage 1 and subject to the agreement of the NPSI Program Management Committee $106,000 for Stage 2. Funding by financial year is $115,800 for 2003-04 and $115,800 for 2004-05.

Harvey Water will be the Research Organisation under the terms of the Research Agreement and it will contract the services of Ken Moore of Boorara Management as the Principal Investigator and other partners as members of the Project Team.

Research Organization and third party contributions (cash and in-kind) are $248,300 in 2003-04 and $162,300 for 2004-05. This brings the total project investment of all parties to $642,200.

Some legal and indemnity issues have arisen which have prevented the Research Agreement being signed by Harvey Water to date. While we expect to resolve these issues, it has highlighted questions that need to be considered further in research that involves commercial partners and team members who are not employed by the research organization. This is important because Australian Government funding of R&D is increasingly emphasising commercially focussed research that contributes to Australian industrial, commercial and economic growth. In addition, the Government is requiring the involvement of the private sector, particularly small and medium enterprises, in R&D so that it is directed to meeting market needs. Consequently, contracting and partnership agreements need to facilitate rather then constrain or even prevent meeting the Government's R&D objectives and intentions.

5. The Project Partnership

The partners for this research project include: the National Program for Sustainable Irrigation as a funder; Harvey Water as the Research Organisation, and partners Rob Kuzich & Co., Horizon Farming, Dale and Leanne Hanks (dairy farm partnership), Department of Agriculture, Chemistry Centre of Western Australia, Dairy Australia and Boorara Research+Management.

Formation of the partnership has taken place over an 18-month period commencing with Rob Kuzich & Co. and Dale Hanks agreeing on the need for the research at property level and pre-trialling the centre pivot during the 2002/03 irrigation season. Harvey Water saw the implications for potential water use efficiency and gave support for the project. Dario Nandapi of Horizon Farming was engaged to undertake the agronomy aspects of the project. In view of the wider implications on the project at an irrigation area, regional and national scale, Ken Moore of Boorara Management was engaged as the Principal Investigator to develop an application to the National Program for Sustainable Irrigation. With progression of the application, plans for this project and of DairyCatch in relation to the Hanks' property were linked and as a result the Department of Agriculture, Chemistry Centre and Dairy Australia became partners. During the application, the Program Coordinator for NPSI and other members of the Sustainable Irrigation Management Committee made very significant contributions to the project design and with funding approved for Stage 1, NPSI became a key partner.

Iterative planning with inputs by the Steering Committee and NPSI, team formation and development, and establishing funding arrangements have been essential features of this project to date and improved the quality of project planning.

The partners have held many meetings and spent considerable time and effort in the development of the project application and in implementing the project. Their in-kind contribution of time in the development of the partnership, preparing the application and documenting the planning has far exceeded that originally expected. However, the team members regard this project as a learning experience for themselves in all aspects. While all are highly experienced and successful in their field, being involved in the planning issues, establishing a working team and implementing the actual case study is providing major learning outcomes. It has provided opportunities for bringing in outside perspectives, varied experiences and new networks.

Formation of a partnership that brings together the key commercial players supported by public sector knowledge generators has been strongly praised by a major bank with agribusiness interests. Discussions have been held with the bank on the potential for innovative financial packages backed by on-farm research and technical support to be provided should the case study be successful.

Project team
The project team and their contributions to this project includes:

Ken Moore (Principal Investigator) – expertise in socio-economic, commercial, regulatory and governmental analysis. Role – project management with specific responsibility for coordinating and synthesizing all the dimensions of the project in a commercial and public good context to produce the required outcomes from the project for funding under the NPSI. Mr Moore will ensure integration of all research, maintenance of acceptable research standards and achievement of reporting milestones.

Robin Kuzich – expertise in irrigation technology. Role – to analyse irrigation data on the performance of the centre pivot and surface bay systems and undertake simulations on pivot sizes for soil type and infiltration rates. The aim of this research will be to establish optimum centre pivot size and operation and demonstrate best irrigation practice under both systems relating to water use efficiency. Mr Kuzich will also participate in communication and adoption activities, reporting and whole farm planning.

Dale Hanks – expertise in dairy farming and farm management. Role – to operate the centre pivot and surface bay irrigation sites; make decisions on irrigation scheduling in association with Rob Kuzich & Co.; and collect pasture samples and make decisions on grazing and nutrition management in association with Horizon Farming. The aim of this activity will be to improve productivity and water use efficiency by comparing both systems and to integrate the centre pivot into farm planning and management. Dale Hanks in association with the rest of the team and with contracted professional planning assistance as required will work on a whole farm planning framework that will accommodate changes to irrigation systems into farm operations and budgets. Mr Hanks will also participate in communication and adoption activities and reporting.

David Chester – expertise in water supply and Irrigation Area management. Role - research water supply issues on-farm and in the Irrigation Area. Harvey Water will bring the perspectives and expertise of the irrigation water provider and their interest in water availability, water quality and water use efficiency issues over the SWIA and support the adoption of best practice amongst its cooperative membership. They will report on the overall energy balance of a pressurized gravity-fed piped system of water delivery and the operation/ordering procedures for managing such a system if there was widespread adoption of sprinkler technology.

Mark Rivers – expertise in the development of sustainable farming systems and in integrated catchment management. Role – research the performance of trailed irrigation systems in terms of regional sustainability. The Department of Agriculture and the Chemistry Centre of WA will bring experience of research in sustainable irrigation and its application on working properties. The Department will also provide a direct link to DairyCatch and NPIRD best management practice work, and support the extension of the results in the broader industry and irrigation area.

Dr Dario Nandapi (Horizon Farming) - expertise in agronomy. Role - compare pasture yields and make observations on pasture quality and milk production under both systems and also to compare the performance of perennial and annual pastures under centre-pivot irrigation. Dario will also participate in communication and adoption activities, reporting and whole farm planning.

6. Project Steering Committee

A Project Steering Committee has been formed to oversee the project and provide advice on research rigour and achievement of required outputs and outcomes. Its membership and terms of reference are outlined below. The Committee met for the first time on 9 December 2003.

Membership involves a working number of key participants who can provide independent advice and oversight of the project. The members of the Steering Committee are:

- Andrew McCrea (Chair), Department of Environment and member of NPSI Program Management Committee
- Dan Norton, Chairman, Harvey Water
- Murray Chapman, Coordinator, National Program for Sustainable Irrigation
- Joe Foley, National Centre for Engineering in Agriculture and CRC for Irrigation Futures
- Mathew Bethune, Institute for Sustainable Irrigated Agriculture, DPI, Victoria.

An additional irrigator will be added to the Steering Committee during February and a further approach made to the Irrigation Association of Australia to nominate a representative.

Functions

- Provide external perspectives and expert guidance on all aspects of the project.
- Provide quality control and endorsement of key project documentation for approval of the NPSI Program Management Committee.
- Provide leadership within personal and organizational networks to promote the project and its outputs, facilitate contacts and assist in negotiations where this is necessary.

Meetings

- Meetings will generally be held in the Harvey Water office, unless otherwise decided, and be held in adequate time prior to key project milestone dates.
- A total of 5 members will constitute a quorum.
- Meetings will be conducted according to an agenda and meeting papers which indicate the outcomes required from the meeting.
- Minutes and actions arising from the meeting will be maintained.

Meeting expenses

Costs of individual members to attend meeting will be made from the project when this is required. Unless special circumstances apply, members will not be paid sitting or service fees.

7. Features of the South West Irrigation Area

This section and sections 8 and 9 below relate to output (b) of Stage 1 as identified in the application.

The SWIA is located to the west of the Darling Scarp on the Swan Coastal Plain, around 100kms south of Perth. It covers an area of 112,000 hectares (around 75kms long and 15kms wide) in three Irrigation Zones: Harvey, Waroona and Collie.

Over 90% of the land has been cleared for agriculture, mainly for dairy farming and beef cattle raising, with expanding horticultural and viticultural activities. The gross value of agricultural production in the SWIA is estimated at over $120m per annum (ABS, 2000) and 45% of this comes from dairy production.

There are approximately 112,000 hectares of productive agricultural land in the SWIA of which some 34,000 ha are irrigable (ie, have access to the present irrigation system). Only about 10,000 ha has been under permanent irrigation because of limitations on water supply from the dams which can only provide sufficient water to surface irrigate pasture on about one-third of each property based on current WUE practices.

Historically, more than 65% of irrigation water has been used on dairy pastures, with 30% on beef pastures and the balance on fruit and vegetable horticulture.

The climate of the SWIA is Mediterranean with hot dry summers and cool wet winters. The average annual rainfall for the area is 1000mm with evaporation rates ranging from 1200mm in the south to 1600mm in the north.

The landform of the area is flat to gently undulating with alluvial soils laid down by streams descending from the Darling Scarp.

The hydrology of the SWIA is influenced by the relatively high rainfall and flat topography and discharge from the underlying Perth Basin sediments. During winter much of the area is waterlogged or inundated due to groundwater staying perched on the sandy and loamy duplex soils.

The SWIA has been identified as having state, regional and local agricultural significance. It is representative of many irrigation areas of Australia in terms of the increasing pressures on the water resources from agricultural production, growing urban populations and the need to return adequate quality water to the environment.

The Area is experiencing some soil salinity and saline water problems mainly in the southern portions of the SWIA, and produces drainage water that runs to environmentally sensitive estuarine bodies. A related project, DairyCatch, being funded by Dairy Australia and the Department of Agriculture WA is supporting dairy farmers with effluent management plans and will be monitoring nutrient and water run-off on monitor farms, including the Hanks' property in the SWIA.

Much of the work to set strategies and define the economic, biophysical and social characteristics of the SWIA has been completed through previous work including the Harvey Water strategic plan, the INTERACT partnership of key agencies for land use planning and the *Invest for Success* strategies.

8. Irrigation Water Provision

The key parties in irrigation water provision are:

- the Department of Environment (formerly the Water and Rivers Commission) which controls the allocation of water from 7 dams that supply the SWIA;
- a state government owned corporation, the Water Corporation, which controls the dam structures and water release points;
- South West Irrigation Asset Cooperative Limited which manages the water supply assets (channels and pipelines); and
- South West Irrigation Management Cooperative Limited (Harvey Water), which manages the delivery of water to irrigators.

Harvey Water has a licence to draw an annual amount of 153,460 MLs from the dams and it pays the Water Corporation a head-works service charge for the operation of the dams on the basis of water delivered. Harvey Water delivers water to irrigators via a system of channels (concrete and earth) and pipes. The steep gradients between the dams and irrigated areas allows water to be delivered by gravity.

Harvey Water services about 550 irrigators who are invoiced for the amount of water they consume along with an asset charge to pay for the cost of maintaining the delivery system. The approximate cost is $40 per ML.

The water is held by irrigators as Transferable Water Entitlements (TWEs) and these are historically based on 9.2 MLs of water per rated hectare. Irrigators hold shares in the Asset and Management Cooperative and one share gives an entitlement to one ML of water. Irrigator TWEs can be traded on a lease or permanent basis within the irrigation system, but Board approval is required outside.

9. Centre Pivot Irrigation of Dairy Pasture in the SWIA

As mentioned above, more than 65% of irrigation water has been used on dairy pastures predominantly using surface bay systems. Prima facia, there are considerable opportunities for both more efficient and effective use of irrigation water and given development of sustainable irrigation practices potential for expansion of agricultural production.

Harvey Water has noted that if it is to 'retain its licensed allocation and protect the livelihoods of those who use it, it must demonstrate to the licensors that its use of water is defensible in the face of competition for water' (Dan Norton, Chairperson, June 2002). Mr Norton believes the Harvey Irrigation Area has a window of opportunity now in which to demonstrate optimal use of water. Implementation of water conservation plans, including water use efficiency strategies and best management practices are a requirement for licensing.

There are only two known centre pivots (including the trial site) in the Area. In order to assess, irrigator knowledge and views on alternative irrigation systems a questionnaire was administered to Harvey Water irrigators in December 2003. Results of the survey are provided below.

10. Harvey Water Irrigators' Survey

This section relates to output (d) of Stage 1 as identified in our application.

Forty-four irrigators were selected from the Harvey and Waroona irrigation areas of the SWIA. The selection was based on irrigators that presently irrigate more than 30 ha of land within these areas. Of this selection, twenty eight responded to the phone survey undertaken during office business hours. Those that did not respond were phoned again on another day and if contact was made were included in the survey.

Responses and number that responded are shown below. The answers are the actual responses, but these may not be the 'right' answers. For example, the respondents clearly indicated water use per irrigation event rather than per irrigation season. Where irrigators responded on tonnes of dry matter produced, these may be guesses as they appear low compared to production figures of 18 tonnes per hectare with surface irrigation. The responses indicate that much more learning is required for WUE issues.

1. What is your present irrigation water allocation (TWE) mainly used for?
   a. Pasture 18
   b. Pasture and fodder crops 7
   c. Pasture and horticulture
   d. Horticulture 3
   e. Other -

2. What irrigation system are you presently using?
   a. Surface bay/surface 25
   b. Sprinkler
   c. Centre pivot
   d. Canon sprinkler

e. Other - 3 horticultural drip tape

3. If you irrigate for pasture, how many Megalitres of water per irrigated hectare do you use each irrigation season under your present irrigation system?
   19 responses ranging from 0.8 Meg/ha to 1.6 Meg/ha
   6 did not know
4. If you irrigate for pasture, how many tonnes of dry matter per hectare do you grow under your present irrigation system?
   6 responses with a range from 5 tonne through to 10 tonne / ha
   19 did not know
5. If you were able to save water from your present allocation by improving the efficiency of your irrigation system, would you:
   a. Increase the area you irrigate 17
   b. Trade the water you save to other irrigators or buyers 16
   c. Look at other options for using the water on farm? 2

6. Do you have information available to allow you to investigate the possibilities of improving or changing your current irrigation system?
   a. Yes 9
   b. No 19

7. What kind of information do you require to make better decisions on improving or changing your current irrigation system?
   a. Economic benefits and costs 23
   b. Technology available 23
   c. Pasture varieties and responses 9
   d. Production gains 26
   e. Water management 22
   f. Other -

8. How soon would you like to have access to new information?
   a. Next 6 months 22
   b. Next 12 months 9
   c. Next 2 years

9. Do you believe local industry based research is necessary for obtaining the information you need for improving or changing your irrigation system?
   a. Yes 28
   b. No
   c. Other comment -

10. How would you prefer to obtain/receive information on irrigation systems relevant to your industry and area?
   a. Harvey Water website
   b. Email newsletters
   c. Hardcopy newsletters 15
   d. Research reports 12
   e. Field days 27
   f. Workshops/seminars
   g. Other -

Summary of results

The survey shows that the majority of irrigators surveyed are irrigating pasture and that they feel very strongly that research into irrigation should be undertaken at a local level. The majority also felt that the best way to receive this information is via field days, newsletters and research reports in that order. Furthermore, they would like to have information within the next six to twelve months as they felt that they had very little knowledge of centre pivot systems. They majority are interested in production gains followed by the economic benefits and costs involved in changing their irrigation systems.

South-west irrigators, typically, have diversified and many rely on off-farm incomes. In such circumstances, adoption of change, particularly where major investments are involved, is a difficult issue. The survey indicates that information needs to be carefully targeted and written in appropriate language.

We will also keep in mind during the project that potential investors in underutilized parcels of land may be interested in the results.

Since the formal launch of the project in December with a field day, many irrigators have expressed interest in the results of the project and several are seriously considering sprinkler irrigation. For this reason, establishment of a decision support framework backed by substantive information is important to assist them in making the right decisions on their future investment in their irrigation systems.

The pre-trial establishment and operation of the centre pivot during the 2002/03 and bringing the pivot to farm operating and research standards demonstrate that sprinkler irrigation is feasible in the Harvey Irrigation Area on clay-based soils. This case study will demonstrate the economic viability of the pivot and best management practices for both sprinkler and surface bay irrigation.

11. Australian Research and Experience on Alternative Irrigation Systems

This section relates to output (a) of Stage 1 as identified in our application. It considers other Australian research on alternative irrigation systems that will inform the Harvey Irrigation Systems Project.

Our team does not have the resources to undertake an extensive literature review of all related research, as would be the case with most academic studies. We note that Project DAV11163, which is an extension of DAV422, undertook an extensive literature review and has documented a lengthy reference list.

We believe that in commencing this project we have adequately reviewed key literature and experience so that we have a strong up-to-date knowledge base in conducting this project. The key references that have contributed to our understanding of the issues are:

- *The Al Khadra NE Core Development, Large farm irrigation equipment study*, Libyan Government, December 1989. This study, while undertaken 15 years ago in 1989, provides detailed and advanced information on pivot size, pivot operations and economics on clay based soils similar to Harvey.
- Adam, A.C., Norton, S.W., and Sparrow, D.K. *Site and engineering guidelines for centre pivots* (NIRF Project 91-S15), Irrigators Cooperative Management Services, 1993. This reference provides base information regarding the important site characteristics and pivot design/performance parameter that must be considered to ensure the efficient operation of the system.
- Foley, JP and Raine SR, *Centre pivot and lateral move machines in the Australian cotton industry*, NCEA, University of Southern Queensland, December 2001
- Bethune, M., Wood, M., Finger, L., and Wang, Q.J. *Sprinkler, sub-surface, drip and surge irrigation experiment* (Final report of Project DAV11163 – an extension of DAV422), Department of Primary Industries, Tatura and Kyabram, June 2003.

The DAV11163 Final Report is the most directly relevant to our case study and includes and extensive bibliography of relevant research literature. As issues arise during the course of this project, we will consult DPI Tatura and Kyabram on references that are relevant to understanding and dealing with those issues.

Project SOU3 can be seen as a logical extension of Project DAV11163 undertaken in Western Australia. We note that the DPI researchers will also be extending their work through a field trial of sprinkler irrigation on-farm, and we will exchange information, thus building up a substantial body of knowledge and experience.

The DPI Tatura research, which involved a field experiment comparing water use and pasture dry matter production under border check, sprinkler and other systems on a Lemnos Loam soil, indicated the potential of sprinkler irrigation for water use efficiency and pasture productivity gains. This was supported by a second stage of the project which investigated how the experimental results relate to farm conditions, and the economic and environmental conditions of adopting sprinkler irrigation systems in the Shepparton Irrigation Region. This work provides us with a knowledge base and confidence to undertake this case study in the Harvey Irrigation Area with a view to demonstrating similar or greater WUE and pasture productivity gains.

Project SOU3 is examining the operation and performance of centre pivot (sprinkler) irrigation in comparison with surface bay ('flood') irrigation on a commercial dairy farm. An eight-hectare pivot is being using rather than simulated sprinkler system as in the case of the initial DPI research and the trial sites (8 ha for the pivot and 6 ha for the surface bay) are of a practical size in terms of farm management. The project is also measuring pasture yield and making observations on pasture quality and impact on milk production which is the variable of most interest to dairy farmers.

Apart from the Department of Agriculture, all partners of this project are commercial players in the water and agricultural industries and, as such, the way in which the case study is conducted is being shaped by commercial drivers. However, we are aiming for an approach and objectivity which provides convincing information to irrigators to make key investment decisions for changing irrigation systems.

We note the results of Project DAV11163 that were presented at the 50th National Irrigation Conference in Shepparton in October 2003 and are highly interested in its main conclusions summarized in the box below.

"The dairy industry is a major user of irrigation water in Australia, particularly in the Murray-Darling Basin. The industry is under increasing pressure to improve water use efficiency in response to limited water availability and the rising cost of water.

Currently 90% of pasture is irrigated using border-check (surface bay) irrigation. The border-check system offers limited control over the depth of application and can be inefficient when used on inappropriate soils.

This paper describes a field experiment that investigated the potential for improving water use efficiency by using alternative irrigation methods. The experiment quantified water use, pasture production, pasture composition and irrigation water efficiency arising from the use of four irrigation methods.

The experiment was conducted between July 2000 and July 2002 at the Department of Primary Industries, Tatura, Victoria.

The 4.2 hectare experimental site contained 22 adjacent bays (8 x 240 m) graded to a slope of 1 in 750, on Lemnos loam soil. The bays were fertilised and sown to perennial pasture (perennial ryegrass and white clover) in March 2000.

The four irrigation systems investigated were border-check, surge,
subsurface drip and sprinkler. Measurements included applied water, tailwater runoff, soil water status, dry matter production and pasture composition.

In both years, the sprinkler and subsurface drip systems used 2 ML/ha/y (up to 20%) less water than border-check and surge irrigation, excluding the impact of runoff. There were minimal differences in pasture production in the first year. However, in the second year the sprinkler and subsurface drip treatments produced 1.9 t DM/ha/y (up to 10%) more pasture than the border-check and surge treatments. The sprinkler
and subsurface drip systems had significantly higher irrigation water efficiency than border-check irrigation for the two years of the experiment. Irrigation method had no consistent effect on pasture composition."

Source: Lucy Finger and Mark Wood of the Research and Development Division, Department of Primary Industries, Tatura, Victoria – presentation to 50th National Irrigation Conference, Shepparton, October 2003

We note the conclusion of the above study that conversion from border check to centre pivot irrigation can be economically viable for a dairy farm if water savings can be used to expand the area of irrigated pasture on the property. They also added that conversion from border check to centre pivot is not economic when there is no potential to expand the irrigated area. If water savings greater than 3 ML/ha are achievable, or the cost of water increases substantially, centre pivot irrigation may be economic on farms where there is no additional land for expansion. Conversion from border check to sprinkler irrigation becomes more favourable under conditions of reduced water availability.

We are more optimistic than these conclusions on the benefits of sprinkler irrigation on appropriate soils in the Harvey Irrigation Area. We are pursuing further the following conclusions of the Tatura study namely:

- "There is considerable scope to achieve water savings on many dairy farms by converting to more efficient irrigation systems. However, the key question is when do the potential savings and pasture production benefits pay for the cost of conversion to sprinkler irrigation.
- There is an urgent need for material that allows farmers to make informed decisions on the value of converting to sprinkler irrigation systems. Until better information is available, some of the risks associated with conversion need to be clearly understood and communicated to farmers.
- There is a need to identify the information requirement of farmers for making decisions regarding the best irrigation system within their business context.
- A simple decision support system may be required to assist farmers in selecting the best irrigation system within the context of their farm. The development of such a DSS needs to be done in close consultation with farmers and irrigation designers to ensure that the end product is useful.
- Farmers who have recently converted to sprinkler irrigation will need support to quickly maximize the benefit of conversion.
- Simple diagnostic tools that allow assessment of the level of achievable farm water savings through the use of alternative irrigation systems would be of use to irrigation designers, extension staff and other service providers."
  Source: Bethune, M, et al (June 2003) *Sprinkler, subsurface, drip and surge irrigation equipment*, DAV11163 final report, Department of Primary Industries, Tatura and Kyabram.

Our project is also cognizant of the findings of the work of Foley, JP and Raine SR mentioned above, particularly their conclusions on grower responses to centre pivot irrigation, namely that:

- "All growers reported an improvement in the crop water use efficiency using centre pivots and lateral move when compared with their own traditional surface irrigation systems.
- All growers applied less water per unit area with their machines than they applied using surface irrigation systems. Growers reported using on average 3.1 ML/ha less than fully irrigated surface systems.

- The performance of centre pivot and lateral move machines within the cotton industry is not limited by soil type or regional characteristics. Systems will work effectively on a wide range of soil types across the full spectrum of industry climatic conditions.
- The centre pivot and lateral move machines available for the cotton industry are generally appropriate and effective if designed and managed appropriately.
- The key drivers for the adoption of centre pivot and lateral move machines were the potential water savings , labour savings, yield improvements due to reduced water logging and better irrigation management, and improvements in germination.
- Barriers to the adoption of these machines within the industry include:
  - The perception of growers using furrow techniques that these machines are not capable of supplying the volumetric capacities required to irrigate cotton,
  - the lack of experience in the full-time cotton growing sector regarding both water and crop management under centre pivot and lateral move machines, and
  - the lack of dealer, supplier and extension support regarding the appropriate management of these machines for cotton production."

Project SOU3 is considering the following recommendations of that study in relation to the dairy industry in the Harvey Irrigation Area to the extent that they are applicable and is liaising with Joe Foley on ways in which our respective work can inform each other:

- There is a need for industry development and promotion of standards and guidelines on best management practices for the design and management of the centre pivot machines. In particular, better promotion of existing information on the following is required:
  - Calculating appropriate system capacity requirements.
  - Strategies to reduce wheel rutting and bogging.
  - Management of rank crop growth.
  - Fertilizer and chemical application strategies.

- An effort is required to develop appropriate training and certification processes for users of centre pivot machines.
- There is also a need to continue and/or expand research and development in the following areas:
  - Refine existing guidelines for managing the soil, crop and machine interactions under regional conditions.

11. Development of a Whole Farm Plan and Decision Support Framework

This section relates to output (c) of Stage 1 as outlined in our application. This project is largely about developing a whole farm plan for changing irrigation systems and management in the Harvey Irrigation Area and a decision support framework for farmers that will support this process.

Dale Hanks is working to develop a whole farm plan for his property with support from a private farm consultant Glenys Hough and from members of the project team. This plan and the associated decision support framework is being documented and when complete will provide a useful guide for other producers. Several aspects of Dale's plan are in place, but considerable further work is required over the next two years and the developing plan will be subjected to ongoing review and updating.

A key issue for Dale is whether to invest in centre pivot irrigation as a result of the outcomes of this project and what decision support framework will assist in making the right decision for optimising irrigation performance.

As a result of discussions with Mathew Bethune of DPI Tatura/Kyabram, who is a member of the project Steering Committee, we have decided to utilise a decision support framework that they intend to use in further work on irrigation systems in the Shepparton Irrigation Area.

We have made minor adjustments to how Tatura have presented the framework and are working with Dale through the following steps:

1. Articulation and review of the farmer's profitability, development and lifestyle goals;
2. An assessment of the farm's biophysical, economic and institutional conditions – soils, water availability, topography, farm layout and regulations on land use and management;
3. Detailed consideration of system design and operation, its economics and feasibility; and
4. Making the investment decision.

A. Goals

Dale and Leanne Hanks are operating as a newly formed business entity developed from involvement in a family dairy farm. Key initial goals for the partners were to establish profitability and time-saving targets in operations where possible for personal and family reasons. A major factor in changing irrigation systems will be labour and time savings.

Current pressures on the dairy industry, has meant that the initial focus is to increase productivity. Their variable costs (herd, shed and feed costs) have increased largely due to an increase in feed costs. The increase in feed costs ($ per kg milk solids) has been due to an increase in costs per se and a fall in milk components.

Controlling feed costs and increasing milk components are presently key issues for the business and as a result grain feeding practices and pasture management and productivity have been reviewed and reassessed.

Farm operating surplus is impacted by several factors including a fall in the average price received for milk (formerly 80% quota), increasing feed costs as mentioned and historically high fixed costs.

To improve business profitability in the medium to long term, Dale and Leanne Hanks are working on increasing milk production and reducing costs of production from land presently irrigated and if water savings are achieved to increase the area of irrigated land.

While the concentration of the case study is on the irrigation season (approximately October to May) and the irrigated trial site, the Hanks are seeking to optimise annual performance across the whole farm. This includes the importance of irrigation scheduling and water application for establishing a pasture base for spring and winter growth.

Opportunities which they have identified for the business include:

- increasing productivity from existing resources and infrastructure;
- investing in new infrastructure, particularly for irrigation (eg centre pivot); and
- leasing additional land.

B. Assessment of local conditions

The bio-physical characteristics of the Hanks' property are typical of clay-based soils in the Harvey Irrigation Area. The complete set of biophysical, economic and institutional factors that are being assessed include soils and their distribution (on-farm and area wide), water availability, available land for expansion, water table and sub-surface drainage, farm paddock layout and fencing, native vegetation remnants, land use and management regulations and environmental management requirements.

Soils and distribution

Soils on the property are loams over clay. There has been little previous objective testing and analysis of soil properties. As part of this and the DairyCatch projects, a detailed soil assessment (including the pivot and surface bay trial sites) is presently underway and scheduled for completion in February. We are sampling at 30 GPS points around the farm:

20 points are being sampled from the top 10cm, the other 10 are being sampled at 0-5cm, 5-10, 10-20 and 20-40cm. All samples are being analysed for sand/silt/clay, phosphorous, nitrogen, potassium, sulphur, organic carbon, pH, EC and Phosphorus Retention Index. The data will then be developed into property maps of all parameters as well as down-profile analyses to determine irrigation scheduling and water application under both systems, crop-nutrient requirements and expected nutrient breakthrough points (if any). The nutrient data will also be used to provide comprehensive fertiliser advice.

Water availability
Harvey Water supplies gravity fed piped water past the Hanks' property and Dale is the first farmer on this particular line. Pressures are adequate to operate the case study pivot without a booster pump. It is also anticipated that a larger pivot of the size being considered by Dale would also be able to be operated without a booster pump, but this will be confirmed by the case study. The Hanks' property has a water allocation which is sufficient for surface bay irrigation requirements on present irrigated land.

Watertable and subsurface drainage
A farm drainage plan, both surface and sub-surface is being prepared. This will be an important outcome of the DairyCatch work in monitoring water and nutrient run-off and infiltration from both the pivot and surface bay sites. In addition, as part of DairyCatch, an effluent management plan is being prepared by a private consultant which will be developed into a full nutrient management plan. The watertable on the sites, as with most of this low lying and flat land, is above the surface in winter and falls to 1-1.5 metres below in summer. Water logging is a considerable problem in winter and careful irrigation management is required to ensure waterlogging does not occur in the irrigation season. The economic viability of drainage will be established during the course of this project and DairyCatch including use of recycled groundwater and tail water. Management of pugging will also be assessed as an issue and reported on in Stage 2 of the project (see Part 2 below).

Native vegetation remnants
Present land is fully cleared with some remnant and planted trees down fence lines and stock and vehicle pathways. There are no significant impediments for expansion of the area of centre pivot irrigation apart from the removal of a limited number of trees on existing laneways and fence lines. There are no regulatory restrictions on the removal of these trees.

Land use and environmental regulations
Land is zoned for agricultural use and there are no land use or environmental regulations which prevent changes to irrigation systems.

C. System design, economics and feasibility

The decision faced by the Hanks' partnership is whether to invest in a centre pivot system and of what size.

Pre-selection work as defined in the DPI decision support framework has been proceeding over the past 18 months with the offer from Rob Kuzich and Co to provide a centre pivot on the Hanks' property to evaluate size, design, operations, maintenance and results in water use and pasture yields. During the 2002-03 irrigation season, the pivot was installed and trialled for Dale to become familiar with its operation and to bring it up to farm operation standard. The realisation of both Rob Kuzich & Co and Dale Hanks that inadequate information and demonstration results existed for farmers to make decisions on investing in new irrigation systems led to the establishment of this project.

Dale has the opportunity of this case study involving his property to generate information that will help him make a decision to invest in a centre pivot. Similarly, we expect the results of the project to assist other farmers in assessing their irrigation systems and their future investment in improved systems and management.

In relation to new infrastructure, namely use of a centre pivot system, the partners are going through a process of:

- Clarifying business goals and objectives including personal goals in relation to family and personal time.
- Determining and understanding the operational requirements of a centre pivot, including labour, time and maintenance requirements to keep the pivot operating to meet the irrigation scheduling plan. The initial assessment of Dale Hanks and Rob Kuzich is that it takes at least a year of operation for farmers to become competent in managing a centre pivot and up to two years to become fully proficient.
- Making adjustments to irrigation scheduling, nutrition management and grazing rotations of both the centre pivot and surface bay sites based on continuing review of results in order to optimise the performance of both systems. [We note that this a key characteristic of the case study approach on a commercial farm as distinct from a scientific experiment on a research station. In the former, the farmer cannot afford to hold non-irrigation variables constant in both sites, but must move to optimise performance in both sites and then make a comparison on relative performance. In a scientific experiment, non-irrigation variables would be kept constant and results used to design an optimum system to adopt on-farm.]
- Determining and understanding the costs of centre pivot operation and their impact on business performance (includes labour, time, energy and maintenance costs).
- Identify production potential of the centre pivot vis a vis the existing system. For this phase the partners will undertake the following:

  - *Pasture production and productivity from the surface bay versus centre pivot sites. Pasture samples to be collected by Dale for analysis and assessment by Dario Nandapi.*
  - *Water use efficiency. Water monitoring using Enviroscan units is in place on both surface bay and centre pivot sites. Calculations, assessment and reporting to be completed by Rob Kuzich.*

- Determine profitability of the centre pivot, available options and their constraints. This will include return on capital (discounted cash flow, internal rate of return and pay-back period) and year-in-year out budgets.
- On chosen option, determine monthly cashflow budgets until year-in-year out scenario is achieved.
- Develop targets and appropriate monitoring strategies to assess progress.

The design and operational requirements of the centre pivot and surface bay sites are being managed by Dale Hanks and Rob Kuzich. Dale is recording labour and time requirements and early indications show significant time savings particularly due to less monitoring being required for a centre pivot. It is noted that the case study pivot is not automated and further time savings would result from a fully automated system which automatically switches on and off and can be monitored from a laptop or office computer.

The economic analysis of both systems as outlined above will be completed by Dale Hanks, his farm consultant, Glenys Hough and Ken Moore with independent economic support and advice being provided by a Department of Environment economist, Russell King.

D. Making the investment decision

Based on a complete whole farm planning exercise, Dale will make a final decision on whether or not to invest in centre pivot irrigation and of what size. To support this, he will have a very strong information base derived from the work of this project and DairyCatch.

In addition to making a decision to invest in centre pivot irrigation, the project will generate information, particularly in the second year, on improved management of surface bay irrigation as it's likely that farmers will be using a combination of systems for some years to come.

The Whole Farm Planning framework and associated Decision Support System, plus the information generated by the project, will be made available to all farmers, both within and outside the Harvey Irrigation Areas, who are considering changes to their systems.

The planning approach as it develops during the project will be posted on the Harvey Water website and appropriate hard copies made available during field days and provided to NPSI.

12. Project Communication Activities

This section relates to outputs (e) and (f) of Stage 1 as outlined in our application.

A key objective of the project is to bring innovation to irrigation systems and agronomy on-farm in the South West Irrigation Area by generating information through this case study demonstration. The aim is for farmers to use this information to increase water use efficiency and farm productivity, and reduce ecological impacts through factors such as water and nutrient seepage to the water table, downstream nutrient run-off and soil structural problems. The project's communication and adoption activities are being directed at achieving this aim.

Initial communication activities completed for December 2003 have generated strong interest amongst SWIA irrigators concerning centre pivot irrigation. A number of producers are actively considering purchasing centre pivot systems and it is vital that adequate local data and information is available to support such decisions. The Harvey Water irrigators survey clearly indicated that information is required in the next 6-12 months. The survey also found that irrigators have a strong preference for receiving information via field days and field walk, hard copy newsletters and hard copy project reports.

In addition to irrigators, the project findings could specifically contribute to the *Water Wise on the Farm* program, the Harvey Water strategic plan, the Western Dairy Regional Action Plan and the South West Catchment Council strategies for the Peel sub-region. It can also potentially inform water planning and management in other regions of Australia, the WA water initiatives, and nationally the NHT and the National Action Plan for Salinity and Water Quality.

We believe the findings of this project are also of relevance to irrigators, irrigation water providers and policy makers in other regions of Australia. The outputs will be communicated for consideration in industry, NRM and land use planning policies from local to national level.

Communication activities completed to December 2003

Activities implemented to date include:

- Promotion of the project at the Harvey Water Waroona Field Day in September 2003 with a stand and also promotion of the project in speeches.
- Article in the IAA (WA) journal 'Overflow", September quarter edition.
- Presentation on the project to the NPSI Investors Forum in Shepparton in October 2003.
- High profile project launch in association with DairyCatch on 9 December 2003.
- Article in the Farmers Weekly, 11 December 2003.

Following on from the above, a field walk of the centre pivot and surface bay sites is planned for early March. **The communication strategy and annual action plan for Stage 2 of the project is presented in Section 17 of this report.**

13. Summary of Progress against Milestones

Milestone	Achievement criteria/outputs	Status
Milestone 1: Signing of Research Agreement	Research Agreement signed by LWA and Harvey Water Partnership Agreement between Harvey Water and project team members signed. Steering Committee formed.	Legal advice and indemnity and insurance issues have delayed signing of the Agreement by Harvey Water. Resolution pending advice from LWA. Partnership formed, roles agreed and operating. Formal agreement pending Research Agreement. Committee formed and met on 10 December 2003. An additional irrigator member has agreed to join and IAA approached again on a representative.
Milestone 2: Progress report on Stage 1 (including independent specialist endorsement to sprinkler irrigation plan, report on Stage 2 plan, first meeting of Steering Committee).	Generic deliverables met. Steering Committee meet and agree to the operations. Summary report of latest centre pivot research and experience and changing irrigation systems. Summary report of SWIA. Report on Harvey irrigators' survey. Report on whole farm planning framework to be used. Communication strategy prepared.	The progress report was discussed at the 10 December meeting of the SC. Revisions were distributed in December and further comments received in January. Revised report redistributed in January and final revisions received in February incorporated in this report. Steering Committee members have endorsed the report. Generic deliverable to be provided on advice from LWA Communications.
Milestone 3: Independent specialist endorses sprinkler irrigation research. Signing of contract for Stage 2.	Independent specialist endorses sprinkler irrigation research. Stage 1 progress report and plan for Stage 2 accepted by NPSI. PI gives presentation to Investors Forum at ANCID Conference. Contract with LWA signed.	Joe Foley who is a member of the Steering Committee has endorsed this report including the centre pivot case study. Progress report now part of this final report and includes the Stage 2 plan. To be considered by NPSI Management Committee on 26 February. Completed. See above.

Milestone 4: Final report of Stage 1 to peer review standard with all technical reports used in the research projects carried as attachments.	Generic deliverables met. Final report approved by the Steering Committee, submitted to NPSI and accepted.	Final report of Stage 1 and the Stage 2 plan has been approved by the Steering Committee and submitted to NPSI Program Coordinator for consideration by Management Committee on 26 February.

Knowledge assets produced to date:

- Results of irrigators' survey indicating level of understanding of irrigation practices and management, and irrigator needs for information on the operation and performance of centre pivot systems.
- Understanding of issues involved in establishing public-private sector partnerships in planning and undertaking irrigation research.
- Understanding of issues involved in establishing a case study of alternative irrigation systems on a commercially operated farm. This includes the necessary pre-case study set up and familiarisation required for managing a centre pivot system.
- Knowledge gained from a review of selected Australian and international literature and experience with centre pivot irrigation (see References).

PART 2: PLAN FOR STAGE 2

14. Project objectives

This section relates to outputs (g) and (h) as outlined in our application. The objectives as stated at that time are:

1. Bring innovation to irrigation systems and agronomy on-farm in the South West Irrigation Area that will increase water use efficiency and farm productivity, and reduce ecological impacts through factors such as water and nutrient seepage to the water table, downstream nutrient run-off and soil structural problems.
2. Demonstrate and document a model of integrated R&D and knowledge management through a strategic alliance that is capable of achieving sustainable irrigation on-farm and extended across the broader farming community and irrigation area with lessons.
3. Develop a learning and information exchange strategy to provide opportunities for SWIA irrigators to learn from other Australian irrigation areas and industries.
4. Demonstrate the energy efficiencies and overall energy balance of a pressurized gravity-fed piped system of irrigation water delivery.
5. Understand the issues surrounding the operation/ordering procedures for the water authority (managing a pressurized irrigation supply system) and irrigator if there was wide spread adoption of centre pivot sprinkler technology.

On further reflection of these objectives and discussion by the Steering Committee, some clarification of them is required.

Objective 1 is appropriate and the core purpose of the project. Our approach to achieving this is a case study demonstration of the costs and benefits of centre pivot irrigation and existing surface bay irrigation. The case study will provide irrigators with base information and a decision support framework that will assist in making investment decisions regarding changing irrigation systems from surface bay to centre pivot or establishing a combination of both. We believe outputs relating to this objective will be measurable, achievable and likely to produce outcomes extending well beyond the life of the project.

Objective 2 lacks meaning and practical application and we have re-worded it to provide greater clarity. The outcome being sought is to leave in place an approach and experience with partnership research that involves the key decision makers in the research itself because they have most at stake and are likely to be totally committed through necessity with achieving results. In other words, it is not an academic exercise or being pursued for other ends. Consequently, the restated objective is to:
"Demonstrate a model of partnership research that engages the key decision makers in research design, conduct and evaluation, and leaves a legacy of understanding and learning that allows on-going research in the same or other areas."

Objective 3 needs to be restated in outcome terms:
"Demonstrate and leave in place, a communication and adoption, and learning strategy that ensures research results are effectively communicated to end users in a way which allows their application, and creates openness to learning from other areas."

Objectives 4 and 5 have been endorsed by Harvey Water and remain as stated.

15. Project methodology

15.1 Methodology for Objective 1

Bring innovation to irrigation systems and agronomy on-farm in the South West Irrigation Area that will increase water use efficiency and farm productivity, and reduce ecological *impacts through factors such as water and nutrient seepage to the water table, downstream nutrient run-off and soil structural problems.*

1. Compare the water use efficiency (WUE) of surface bay irrigation and centre pivot irrigation on dairy pastures.

We are undertaking a case study on a commercial dairy farm owned by Dale and Leanne Hanks. Dale currently uses surface bay irrigation, but is considering investing in centre pivot irrigation depending on the results of the performance of the centre pivot provided for the case study by Rob Kuzich & Co.

The purpose of this aspect of the case study is to:

1. Compare the water use efficiency (WUE) of surface bay irrigation and pivot irrigation of dairy pasture on the Hanks' property.
2. Investigate the relationship between the increasing size of centre pivots and the effects on the loam over clay-based soils of the Harvey Irrigation Area.

In relation to WUE, we are adopting the terms and definitions as set out in the NPSI report, Water use efficiency; an information package, Irrigation Insights Number 5. In this sense, WUE is an umbrella concept covering a number of crop and irrigation water use indices.

In this project, we will calculate the Irrigation Water Use Index and Pasture Water Use Index (WUI) as:

Irrigation WUI = Yield /Irrigation water applied = kgs of dry matter/ML

Pasture WUI = Yield/Evapotranspiration = kgs of dry matter/mm.

Dale Hanks and Rob Kuzich are responsible for this part of the case study and the collection of data. An automatic water meter on the outlet of the Harvey Water pipe to Hanks' property is measuring water applied. It can also be calculated from the water being applied by the centre pivot which has been calibrated to apply 18 litres per second. The total water applied can be determined by multiplying this amount by the irrigation time. This is being recorded by Dale.

The calculations of irrigation and pasture WUI are to be made using this data and the pasture measurements supplied by Dario Nandapi from sampling undertaken by Dale.

All the centre pivot design calculations are being performed by Rob Kuzich with external and independent endorsement from Joe Foley of the National Centre for Engineering in Agriculture (University of Southern Queensland, Toowoomba).

Key Characteristics of Surface Bay and Centre Pivot Sites

Characteristics	Centre pivot site	Surface bay irrigation site
Area of site	8 ha	6 ha irrigated in 2 ha lots
Topography	Flat	Flat
Soil type	Loam on clay	Loam on clay
Drainage	Poor	Poor
Water table depth	Above surface winter; 1-1.5 m below in summer.	Above surface winter; 1-1.5 m below in summer.
Pasture type	Perennial rye grass and clover mix. A trial plot of annual Italian rye.	Perennial rye grass and clover mix.
Nutrient management	NKP blend applied approx. every 3 weeks with leaf analysis to determine quantity applied.	NKP blend applied approx. every 3 weeks with leaf analysis to determine quantity applied.

Grazing management	Graze when 2-2.5 leaves on rye grass plants	Graze when 2-2.5 leaves on rye grass plants

Surface Bay Irrigation Site and Practice

This surface bay is an existing 6-hectare site adjacent to the centre pivot site. The site is flat and has loam on clay soil. During winter, the water table is above the surface causing water-logging problems. In summer, it falls to 1-1.5 metres below the surface. Further assessment of the soil profile, groundwater flows, water table depth and drainage issues is taking place in the preparation of a farm drainage plan.

The site is pastured with perennial rye grass and clover mix. A NPK blend of nutrients is applied approximately every 3 weeks and the amount is determined according to leaf analysis performed by Horizon Farming. Cows are grazed on the site when leaf growth is 2-2.5 leaves per plant of rye grass.

Irrigation of the site is fed from an open channel. The current irrigation practice involves the assessment of soil moisture taking into account the water holding capacity of the soils, the daily ET figures available from the 'UDAC' weather station (located within 200 metres of Dale Hanks' property) and the growth stage of the crop.

The soil moisture content is also being continuously logged, measured and recorded using Sentek enviroscans. Sensors are placed at six depths: 100, 200, 300, 400, 500 and 800 millimetres respectively.

In applying current best management practice, the surface irrigation is operating typically on a eight or nine day cycle, and can be reduced to a seven day cycle during the peak period. Dale Hank's is recording his labour time in operating, monitoring and maintaining the surface bay site.

As the surface bay irrigation is fed from an open channel, it is necessary to order the water three to six days in advance from Harvey Water. The flow application is timed for four hours allowing the water to move to the most distant point within six hours. In order to improve the surface bay application, the trial site and other sites are being irrigated in two-hectare lots.

A Dethridge Wheel measures the amount of water applied and the amount is shown on the Harvey Water invoice received by Dale. Calculation of irrigation WUI and pasture WUI for the surface bay site will be undertaken as above.

Hydraulic optimisation of the surface bay irrigation system

There is little knowledge of SIRMOD in Western Australia and we are interested in exploring this methodology for optimising surface bay irrigation practice. As mentioned, for year 1 we will measure and analyse results based on current practice of a leading farmer. However, providing that we are able to obtain appropriate information and training, we will seek to apply the SIRMOD in year 2.

We understand that measurements that will need to be made to adequately simulate the surface bay irrigation with SIRMOD include 5 or more advance distance and time pairs, flowrate into the bay, width of the bay, length of the bay, field slopes and the top of bay water depth during the irrigation event.

Centre Pivot Irrigation Site and Practice

The centre pivot is on an 8-hectare flat site with loam on clay soils. It initially has the same grazing management and nutrient management practices to the surface bay site, but this may be varied as the case study progresses to achieve optimal results. The pasture species is also the same, although there is a trial plot of annual Italian rye grass under the pivot.

The centre pivot is an 8-hectare “Steriline” centre pivot fitted with Nelson yellow plate spinner sprinklers and 10 psi pressure regulators. It will normally be run with a nominal flowrate of 18.5 litres per second with a centre pressure of 18 psi. It is fed from a pressurized pipeline without the need of a booster pump.

It should be noted that due to lack of automation available, we have elected to run a 20mm precipitation package to keep the pivot operation within daylight hours. This will allow us to run the pivot for up to 10 -12 hours per day applying 9 -10 mm per pass. This allows Dale to operate the pivot within normal working hours to fit in with his normal farming program. With a fully commercial pivot design that is automated, we would run an 11-12 mm per 24-hour package to meet crop water requirements. Dale is recording his labour time in operating, monitoring and maintaining the centre pivot site.

The centre pivot that has been supplied by Rob Kuzich & Co. is a pre-used machine that has been brought up to trial standard through use on the dairy farm during the 2002-03 irrigation season. Modification of the sprinklers and spacing has now been undertaken and spare parts are on-hand to prevent major outages that could effect scheduling. The effectiveness of maintenance has been field tested. During operations this season, the pivot has worked smoothly and inevitable mechanical breakdowns have been corrected quickly without affecting the irrigation schedule.

Design of the centre pivot irrigation system is being developed from historical climatic data of the region, crop water use during each growth stage, and the soil type.

The following information is being collected:

- Epan data – Bureau of Meteorology plus UDAC weather station
- Precipitation - Bureau of Meteorology plus UDAC weather station
- Evapotranspiration data - UDAC weather station
- Crop factors-pasture – growth staged to link in with monthly climatic data
- Temperature – UDAC weather station
- Wind speed / direction – UDAC weather station

Effective rainfall is being taken into account in the irrigation scheduling and a Department of Agriculture sampler and flume will measure events. Typically, the Harvey Irrigation Area with a Mediterranean climate has very (infrequent) few effective rainfall events during summer. For the Harvey area, effective rainfall events are defined as those above 5mm - effective rainfall being that which infiltrates into the crop root zone after discounting for run-off, evaporation and deep drainage.

In calculating the water budget for the season, the target irrigation requirement will be calculated monthly. This calculation will make an adjustment for any differences between the calculations from Epan readings (ex Bureau of Meteorology) and the figure generated from the UDAC weather station.

The UDAC weather station is located 200 metres from the Dale Hanks property and has data back to July 2001. The information from the Bureau is for the last 15 years and is “regional” but not site specific to the Hanks property.

In calculating the pivot design flow rate [and/or the system capacity (mm/day), i.e. nozzle flowrate over irrigated area], the following information is being assessed:

- Peak daily water use calculations for consecutive high evaporation days. The calculation will ensure the system can handle this period including a 25% reserve.
- The crop factor for the peak evaporation period.
- The soil holding capacity (RAW) will be calculated.

- The rooting profile will be established and with the RAW value the maximum theoretical irrigation interval will be established from the plant available water (PAW)
- The water analysis will indicate if an allowance for a leaching fraction should be included. [Whilst it is acknowledged that the winter rainfall of this region may make this unnecessary, we will study soil chemistry information to see if there is any likelihood of a significant leaching fraction.]
- Allowance will be made for irrigation sprinkler efficiency. The Nelson yellow plate spinners fitted with 10 psi regulators will provide what we believe is the highest efficiency combination. It is difficult to measure sprinkler efficiency and we have nominally indicated 5 % to be applied in our calculations.

Irrigation scheduling for the pivot site is taking into account the following information:

- ET Data from the weather station daily
- Continuous logging of soil moisture from the Sentek enviroscan sensors
- Plant available water holding capacity of soil
- Growth stage of the crop
- Rainfall events and effective rainfall

In summary, for both the surface bay and pivot sites the following information is being recorded.

- Irrigation events and application
- Total water applied monthly
- Rainfall events
- Soil profile (RAW) and nutrient analysis
- Water analysis
- Every two months we will analyse the soils physical changes. We will examine clay content, phosphorous retention index, cation exchange capacity and percentages, and dispersive following completion of the detailed soil analyses in February.
- Detailed monitoring of surface water flows and water quality being undertaken by the Department of Agriculture through DairyCatch.

From the information collected above, we will calculate for each system:

Irrigation Water Use Index = yield/irrigation water applied = kg/hectare

Pasture Water Use Index = yield/evapotranspiration = kg/mm

With the sites being similar and with similar management practices, we believe that the results will objectively show the comparative performance of the two systems for the particular soil type.

2. Investigate the relationship between the increasing size of centre pivots and the effects on the clay-based soils.

As with all centre pivots, the end of the pivot has a high instantaneous application rate compared to elsewhere on the pivot. This becomes very noticeable as the pivot size increases.

The soils of the Harvey Irrigation Area are mostly clay-based soils (30% - 70% clay) and it is unknown at this stage at what size of pivot we are likely to encounter problems relating to the high instantaneous application rate.

Within the pivot site, we have set up an annular strip approximately 100 metres x 10 metres which includes an additional Sentek enviroscan probe. Within this test strip we will record all our data. Our method will be to simulate larger pivots by calculating the nozzle sizes and pivot rotation speed representing the outside of a large pivot. Only four nozzles will be altered and the rotation speed will be calculated for the middle two nozzles.

The simulations will be completed for pivots ranging from 20ha to 100ha. The testing will be undertaken during February and March.

Different sprinkler types will be trialled for each simulation. Where possible we will look at different application rates per pass.

The second stage of this test will look at repeating the simulation, but with varying modifications which will involve spreading the sprinklers apart to increase sprinkler wetted area. This is to be carried out in Year 2.

For each simulation the following data will be collected.

- Average instantaneous application rate (measured for each sprinkler type x height combination, from individual flowrate and divided by the area calculated from the sprinkler's wetted diameter)
- Average application per pass
- Sprinkler wetted throw diameter
- Centre pivot speed of rotation (of simulated size)
- Cumulative infiltration rate using a disc permeameter measuring saturated hydraulic conductivity.
- Continuous logging of soil moisture with Sentek sensors at 100, 200, 300, 400, 500 and 800mm
- Visual observation of ponding and surface water movement and recording digital imagery for later records and analysis.

The simulations will be a number of days apart to ensure the soil on the test strip returns to its pre-wetted condition. We will measure soil moisture exactly using the ES data to show that the antecedent soil moistures are the same or equivalent.

We will look very closely at the effects of ponding and water logging to establish if any "issues" may arise as a result.

These will include the following observations which will be recorded digitally for analysis and management action if necessary:

- Movement of surface water to preferred areas. We will observe movement to low-lying areas approximately 25 metres away.
- Potential for additional evaporation from water logged areas photographed immediately after the irrigation event and again at a later interval (eg, an hour later to show how much water is sitting around).
- Development of preferred pathway flow (non even wetting front) photographed immediately after the irrigation event.
- Slaking which will be the result of surface sealing caused by the higher impact energy from sprinkler heads.
- Increased "pugging" and potential for soil structure degradation. In WA, under pivot irrigation cattle graze at the same time as irrigation is applied. We will photograph before and after application any areas of pugging and at time intervals measure depth of water, ie, establish a general time of over saturation.

3. Details of pasture monitoring for the Harvey Irrigation Systems project to be conducted by Horizon Farming WA.

As mentioned above, the pasture species on both sites is the same, except that under the pivot there is a small trial plot of Italian annual rye grass.

The aim of this part of the case study is to determine the difference in yield and quality over the 2 years in the sites. From this information, we should be able to determine how much milk can be produced off each site so that more appropriate economic decisions can be used by dairy farmers to compare the productivity of each site.

The procedure is as follows

- Before each grazing
  - Dale Hanks is to measure and record pasture mass in kg DM/Ha using an electronic rising plate meter (supplied) and approximate leaf stage of ryegrass.
  - Dale is also to take a "grab" sample of pasture to be frozen and sent to a laboratory for analysis of metabolisable energy, digestible dry matter, neutral detergent fibre and crude protein.
- After each grazing
  - Dale is to measure and record the residual pasture mass in kg DM/ha using the electronic rising plate meter.
  - Dale is also to record the details of the rest of the ration fed to the milkers, the number of milkers, total amount of milk produced. (see appendix B)

- Milk components sent to the milk factory will be available monthly. These will be needed to accurately determine the amount of energy consumed by cows each day they are grazing trial paddocks so that, by reverse feed budgeting the amount of pasture consumed by cows can be determined.
- The electronic rising plate meter will be calibrated by taking pasture cuts at various times of the year.
- A fertiliser budget will be formulated for the pivot and surface bay sites and these may be adjusted to optimise growth on both sites so that fertiliser application will not be limiting production.

Production / Nutrient Removal Table

For: **Hanks**

Month	kg DM/ ha/day	kg/Ha N Applied	P Applied	K Applied	S Applied
July	30	30.0	0.0	0.0	0.0
August	60	40.0	0.0	0.0	0.0
September	80	30.0	12.0	20.0	12.0
October	80	30.0	8.0	12.0	6.0
November	90	30.0	8.0	12.0	6.0
December	100	45.0	8.0	12.0	6.0
January	100	45.0	6.0	12.0	6.0
February	100	45.0	6.0	12.0	6.0
March	100	40.0	6.0	12.0	6.0
April	100	30.0	6.0	12.0	6.0
May	80	30.0	6.0	10.0	4.0
June	50	30.0	6.0	8.0	4.0

Total	**425.0**	**72.0**	**122.0**	**62.0**

- Further to this, tissue tests of the pivot perennial site will be carried out each second month to monitor the fertiliser budget.
- Grazing management and ration formulation will be assessed monthly to ensure that grazing management is optimal for all sites and that the ration is set to optimise pasture use and milk production.

<u>Protocol of pasture quantity and quality</u>

1. *Protocol for measuring pasture mass.*

- The amount of pasture grown will be measured by measuring pre grazing and post grazing pasture heights with a rising plate meter. The rising plate meter measurement will then be converted to kg DM/Ha using equations that have been calibrated for the pasture species present and time of the year.
- From these measurements we can calculate the amount of pasture utilised/Ha/yr.

2. *Protocol for measuring pasture quality.*

- When pasture is measured pre grazing a “grab” sample of pasture will be collected. This “grab” sample will be a representative of pasture eaten by cows.
- These samples will be frozen and once a month will be pre dried in an oven at 60^{o}C and sent to Feedtest laboratory in Victoria for analysis. Feedtest will measure crude protein, neutral detergent fibre, digestibility and metabolisable energy.
- We can then see if there is any difference in feed quality between the treatments.

3. *Combination of the two measurements*

- Using the 2 measurements above we can then calculate how many megajoules of energy were produced/Ha/yr and tonnes of digestible dry matter/Ha/yr rather than just tonnes of dry matter/Ha/yr in the different treatments.
- Knowing the milk production of the herd when the various pastures were grazed and the energy content of the pasture and other feeds we can calculate the amount of pasture consumed on a megajoule basis. There can be variance associated with this calculation as cows can gain and loose weight to maintain a constant milk production and milk produced on a day-to-day basis can be “buffered” by the amount of digesta in the rumen from the previous days intake. Cows intake on a day-to-day basis is also and the management issues involved will be examined.

4. Quantifying the runoff, deep drainage, nutrients and soil structure components of the project

The proposed research protocols for this work have been developed by members of the Department of Agriculture, Nutrient Management Project, who have extensive experience in the development of farm and catchment-scale research and monitoring programs for water and nutrients as well as in BMP development. The research has also been subject to formal peer review and approval via the Department’s Research Quality Management System.

Detailed monitoring of surface water flows and water quality is being achieved with appropriate discharge measurement structures, loggers, water height probes and automatic sampling equipment. Flow-weighted surface water sampling is being conducted with automatic samplers for the surface-irrigated portion of the trial and for a representative, small catchment area which will provide some indication of “whole property” nutrient fluxes.

Additional, periodic/opportunistic sampling of more regularly flowing watercourses is also being undertaken. This is supplemented with information from larger downstream watercourses sampled on a weekly/fortnightly basis to estimate contributions to downstream impacted sites. Sampling of the superficial aquifer via a nest of piezometers is being undertaken at the centre pivot site as there is expected to be minimal surface runoff during irrigation. Any excess irrigation water reaching the surface drainage system will, however, be captured by the surface water monitoring points described above.

Nitrogen and phosphorus will be assessed as well as physico-chemical parameters with occasional sampling for microbial contaminants. Detailed soil/nutrient surveys will be undertaken at the property, and have already commenced. These will allow mapping of nutrient distributions throughout the property, identification of locations of high nutrient flux and the development of nutrient budgets.

Simple management modifications or BMP implementation can then be targeted to the locations of greatest impact. Findings from the ongoing assessment of this property and of the DairyCatch Monitor farms and other participating farms will feedback into the understanding of change as a result of adopting best practice.

Tail water recycling
Tail water recycling with surface bay irrigation is not practised in the area. However, it will be considered and in all probability advocated as an irrigation BMP in DairyCatch and this project, subject to practical and benefit/cost constraints. We recognise it as a means of water and nutrient recycling and it may be subject to environmental regulations in future.

Outputs for Objective 1: Communication activities (see 15.3) and project reports**. Due date:** First progress report of Stage 2 – Q4, 2003/04; second progress report of Stage 2 – Q2, 2004/05; final report of Stage 2 – Q4, 2004/05.

15.2 Methodology for Objective 2
Demonstrate a model of partnership research that engages the key decision makers in research design, conduct and evaluation, and leaves a legacy of understanding and learning that allows on-going research in the same or other areas

The development of the partnership approach to the case study, including key issues that have arisen and their resolution is an important part of this project and is being recorded. The project itself is a learning experience for the partners and adaptive management processes are being used to respond to results and observations (eg, adjustments to irrigation scheduling, nutrition management or grazing rotations). Reports on the partnership approach and how it has developed will be provided in the milestone reports to NPSI so that the project leaves a legacy of understanding for other areas of Australia.

A project team has been formed over the past 18 months and is now well established and operating smoothly. As for Stage 1, the team members and their respective roles are:

- Ken Moore, the Principal Investigator, will ensure integration of all research, maintenance of acceptable research and case study standards and achievement of quality reporting.
- Rob Kuzich & Co. will undertake the research on WUE and operational performance of both irrigation systems.
- Dr Dario Nandapi will undertake the agronomy and milk production research.
- The Department of Agriculture - Mark Rivers (Research Officer) will undertake the environmental monitoring and contribute to irrigation BMP issues.
- Harvey Water will consider water supply issues including economic analysis in relation to gravity-fed piped system of water delivery and the operation/ordering procedures for managing such a system if there was widespread adoption of centre pivot sprinkler technology.
- Dale Hanks in association with the rest of the team and with contracted professional planning assistance as required will work on a whole farm planning framework that will accommodate changes to irrigation systems into farm operations and budgets. He will

also work with Rob Kuzich in the operation of the centre pivot and surface bay irrigation systems and collect pasture samples for measurement and analysis by Dario Nandapi.

- The Steering Committee will oversee the project on provide advice on achievement of quality science outputs and outcomes.

As at the beginning of February, there are a number of legal and indemnity issues that require resolution to allow for the signing of the Research Agreement between Land & Water Australia and Harvey Water as the research organization. This is necessary to allow signing of agreements between Harvey Water and the other parties (ie, the Partnership Agreement).

The Steering Committee is a key contributor to the quality of this project and, in addition to formal meetings, frequent informal interaction occurs between members of the project team and the Steering Committee on issues as the arise. The project will liaise with DPI Tatura and Kyabram and the NCEA/CRC for Irrigation Futures on related activities. In addition, learning exchanges for irrigators will be developed involving a visit by Harvey irrigators to other irrigation regions in Autumn 2004 and 2005. We will also invite specialists from other regions to visit and conduct seminars or workshops in the Harvey Irrigation Area (eg, a workshop on SIRMOD presented by the NCEA).

Outputs:
Signed Research Agreement between LWA and Harvey Water. **Due date**: Q3, 2003/04
Signed Partnership Agreements between Harvey Water and the other project partners. **Due date**: Q3, 2003/04
Report on partnership development and performance. **Due date**: Q4, 2003/04.
Field trip by Harvey Water irrigators to other Australian irrigation areas. **Due date**: Q4, 2003/04 and 2004/05.
Visits by specialists to Harvey Irrigation Area (eg, SIRMOD workshop). **Due date**: during project duration.

15.3 Methodology for Objective 3

Demonstrate and leave in place, a communication and learning strategy that ensures research results are effectively communicated to end users in a way which allows their application, and creates openness to learning from other areas.

See table below in section 17 on the communication strategy and action plan for 2004.

Output: Reports on communication activities and results. **Due date**: Reports in Q4 2003/04, Q2 2004/05 and Q4 2004/05.

15.4 Methodology for Objective 4

Demonstrate the energy efficiencies and overall energy balance of a pressurized gravity-fed piped system of irrigation water delivery.

This case study raises issues which must be considered by Harvey Water in planning for the supply of water if there was multiple or widespread adoption of centre pivot technology.

The centre pivot case study will provide data on the water requirements for a dairy farmer to successfully operate a centre pivot system. Baseline information will be provided on system capacity in mm per day, ML per hectare per year and the pivot size limitations that might apply to the Harvey Irrigation Area on clay soils.

Based on this information, Harvey Water will need to develop a model, from extensive engineering calculations and also utilising theoretical data available, for a conveyancing and supply system that can cater for the requirements of a multiple and growing number of outlets for varying pivot sizes, multiple sites per farm and on-demand water supply.

Harvey Water's modelling needs to establish a requirement for a minimum pressure and a set flowrate for these centre pivots to operate. Its modelling will also need to consider the hydraulic demand through closed delivery pipes if the whole area irrigated with centre pivots. This modelling will also examine the energy requirements and associated costs involved and compare a base case of a fully gravity fed system with booster pumping involved in meeting pressure and flowrate scenarios.

This is likely to be a significant engineering and economic exercise and the project Steering Committee will provide advice on how this aspect of the case study could be approached in consultation with Harvey Water.

Output: Report by Harvey Water on its modelling and economic assessments involved in planning water supply with adoption of centre pivot irrigation. **Due date**: Progress report in Q4, 2003/04 and final report in Q4, 2004/05.

15.5 Methodology for Objective 5

Understand the issues surrounding the operation/ordering procedures for the water authority (managing a pressurized irrigation supply system) and irrigator if there was wide spread adoption of centre pivot sprinkler technology.

The capacity of Harvey Water to provide a certain level of delivery in terms of pressure and flowrates is critical to designing centre pivot installations. For example, if a particular delivery pipeline were to be supplying two centre pivots and at some later date 4 more centre pivots were added to the delivery pipeline, the pressure and flowrates available to all centre pivots is different, and changes would be probably be necessary to the nozzle package on the original two pivots and changes may even be necessary to booster pump operating characteristics.

Without this modelling and planning, drastic reductions in the flowrate during the peak water requirement periods for a particular group of growers in a supply area could eventuate. This would be untenable for an irrigator owned cooperative. Worse still would be the scenario of needing to ration water supply to an area to modify demand.

Early planning considerations would need to include spacing of water supply outlets and the permissible flowrate on any of the existing and future pipelines and, therefore, the lowest possible pressures likely at the outlet.

Harvey Water may need to undertake a full assessment of the present system to define its present capabilities to supply water at a given flowrate and pressure that would be required should adoption of centre pivot sprinkler technology be taken up. Such an assessment would look at present supply design and future upgrade designs, which are part of the ongoing maintenance requirements of the present system to see if these were going to be adequate for future needs. It would need to design various delivery systems and undertake assessment of each system to define the most efficient water delivery system, cost effective, operator user effectiveness and which of these systems can be easily adapted to present system to meet possible future requirements.

In effect, it will probably turn out as a restricted on-demand system, where ordering water does not exist anymore, ie, growers could use as they require, at a flowrate restricted to some predesignated upper limit. The order would look like "I need 30 litres/second all day everyday for the next X weeks or until it rains substantially, and then 2 days later, will be requiring 30 l/s until next rainfall event."

A minimum outcome of this project would be for Harvey Water to undertake planning that quantifies proposed outlet positions upon its delivery pipelines along with given permissible flowrates at each outlet with guaranteed minimum supply pressures. With this planning in place, the Harvey Irrigation Area would be well set for the future in terms of expansion of centre pivot irrigation technology.

Output: Report on the issues that need to be considered by Harvey Water in modelling and planning water supply with adoption of centre pivot irrigation. **Due date**: Progress report in Q4, 2003/04 and final report in Q4, 2004/05.

16. Stage 2 Activity and Output (GANNT) Chart

TASKS	**Q2 03/04**	**Q3 03/04**	**Q4 03/04**	**Q1 04/05**	**Q2 04/05**	**Q3 04/05**	**Q4 04/05**
Steering Committee meeting 1	■						
Stage 2 plan submitted to NPSI		■					
Signing of contract for Stage 2		■					
Establishment of year 1 trials	■						
Conduct of year 1 trials		■	■				
Field days, farm & area visits	■	■	■				
Steering Committee meeting 2			■				
First progress report Stage 2			■				
Establishment of year 2 trials					■		
Steering Committee meeting 3					■		
Second progress report					■		
Conduct of year 2 trials					■	■	■
Field days, farm & area visits				■	■	■	■
Steering Committee meeting 4							■
Preparation of final report.							■

17. Project Communication Strategy and Annual Action Plan

Stakeholder and information needed.	**Desired Stakeholder Response**	**Actions**	**Outputs**	**Responsibility**	**Evaluation of success indicators**
Dairy farmers (and other producers) and agribusiness service providers – What irrigation and agronomy systems matched to local soil types, climate, land use and practical farm management will achieve best productivity, financial and environmental results, and how can these be effectively adopted into the farm business?	Evidence of analysis of best irrigation management practices on farms and adoption if justified	Field days at key times when data is available and meaningful to producers Quarterly newsletters Web updates Field trips to other irrigation areas at strategic times in the project when outcomes can be maximised.	Field days Farm walks Seminars Hard copy newsletters Research reports Web information.	Project team	Attendance at events and positive response. Hits on website. Evidence of adoption. (difficult to measure adoption & may be outside timeframe of project?)
Harvey Water (irrigation water provider) – What irrigation systems adopted on-farm	Strong support of boards, executive and irrigator members to the project.	Provision of research reports at appropriate times addressing the issues of interest to Harvey Water.	Research reports addressing issues of interest	Principal investigator and project team, especially Harvey Water	Evidence of support for project and adoption in planning

Stakeholder and information needed.	Desired Stakeholder Response	Actions	Outputs	Responsibility	Evaluation of success indicators
and across the farming community will achieve the most effective and efficient use of available water resources, and meet the economic, social and environmental objectives of the South West Irrigation Area? What sustainable practices are required in present industries? What opportunities exist for the sustainable expansion of irrigated agriculture in the area? What are the energy efficiencies and energy balance of pressurised gravity fed piped irrigation systems and what are the lessons for other Australian irrigation areas?	Use of knowledge generated from the project in planning and services provided to members.		especially objectives 4 & 5.	member.	and service provision activities. Articles in Harvey Water newsletters & website
NPSI – What models of research, extension and adoption will produce the best results for the commercial and community stakeholders involved? What changes in practices are required for the sustainability of present industries	Awareness and knowledge of details of project. Continued support for the project.	Involvement of coordinator and PMC member in project steering committee and project communication activities Submission of milestone reports.	Milestone reports Steering Committee meetings.	Program management committee, project steering committee, Project team.	Milestone reports accepted. Support for project continued.
Other researchers – What methodologies will produce robust and scientifically credible results? What are the findings of this research?	Awareness of project. Interest in project.	Writing of articles for relevant research publications.	Articles and research reports.	Project team.	Publication of articles in relevant journals.

Annual action plan for communication activities

Key activities to be undertaken in 2004 include:

Q3, 2003/04

- Project included on Harvey Water's website and linked to the NPSI website.
- Report on Stage 1 posted on website.
- Stage 2 plan posted on website.
- Quarterly e- newsletter distributed to Harvey Water members and included on website.

- Hard copy Information sheet on Year 1 case study distributed to Harvey Water members.
- Second field day and field walk.

Q4, 2003/04

- Quarterly e- newsletter distributed to Harvey Water members and included on website.
- Hard copy information sheet on Year 1 case study results distributed to Harvey Water members.
- Articles for farm and irrigation press on Year 1 case study results, including ABC rural radio and TV interviews.

Q2, 2004/05

- Third field day and field walk for commencement of Year 2 case study.
- Possible study tour of irrigators to eastern states.
- Hard copy information sheet on Year 2 case study distributed to Harvey Water members.
- Quarterly e- newsletter distributed to Harvey Water members and included on website.
- Articles for farm and irrigation press on Year 2 case study plans, including ABC rural radio and TV interviews.
- Presentation to NPSI Investors Forum and ANCID on Year 1 case study results.

18. Logframe

See Appendix 2.

19. References

- Adam, A.C., Norton, S.W., and Sparrow, D.K. *Site and engineering guidelines for centre pivots* (NIRF Project 91-S15), Irrigators Cooperative Management Services, 1993.
- Bethune, M., Wood, M., Finger, L., and Wang, Q.J. *Sprinkler, sub-surface, drip and surge irrigation experiment* (Final report of Project DAV11163 – an extension of DAV422), Department of Primary Industries, Tatura and Kyabram, June 2003.
- Clemmens, A.J., *Measuring and improving irrigation system performance at the field level*, US Water Conservation Laboratory, USDA
- Foley, JP and Raine SR, *Centre pivot and lateral move machines in the Australian cotton industry*, NCEA, University of Southern Queensland, December 2001
- Fairweather, H., Austen, N., and Hope, M., *Water use efficiency: an information package*, National Program for Sustainable Irrigation, Irrigation Insights No. 5
- *The Al Khadra NE Core Development, Large farm irrigation equipment study*, Libyan Government, December 1989.
- Department of Primary Industries and Heuperman Consulting, From “border check” to “Sprinkler” (Draft information pamphlet).

Appendix 1. Field site and data collector

Recorded by Dale Hanks
CP = centre pivot paddock
SB = surface bay paddock

	Day grazing site				Night grazing site				production		Ration			
date	Paddock (CP or SB)	pregrazing		post grazing	Paddock (CP or sB)	pregrazing		post grazing	cow numbers	calf milk	grain/ cow	grain mix	hay	silage
		height	leaf stage	height		height	leaf stage	height						

Appendix 2. Logframe

Project Title: **SOU3 Changing Irrigation Systems and Management in the Harvey Irrigation Area**
Principal Investigator: Ken Moore
Goal: To **provide the tools and information to assist the irrigation industry in South West Western Australia substantially improve its sustainability**

Project Objective	Impact outcomes	Adoption Outcomes	Outputs	Inputs $, people and activities
Specific statement of what the project intends to achieve	Need to quantify	Need to quantify	*These are the products being produced and should be in the milestones. Need to link to the objective*	These are all resources going into the project
Bring innovation to irrigation agriculture on-farm in the South West Irrigation Area that will increase water use efficiency and farm productivity, and reduce ecological impacts of water and nutrient seepage to the water table, downstream nutrient run-off and soil structural problems.	Changed practices and systems that fit the socio-economic and institutional context of the irrigation area **Performance Indicator** By 2010 there will be widespread adoption of WUE technology that suits the environment and community Documented off-site impacts and measures to reduce the effects from centre pivot irrigation **Performance Indicator** By 2010 there will be lower levels of nutrient run-off in waterways and less deep drainage from introduced sprinkler technologies	Irrigation systems that optimize productivity and minimize ecological impacts **Performance Indicator** By 2006 there will be widespread interest and planning to adopt best practice irrigation systems Pasture crops that are optimal for the irrigation system and the biophysical and economic situation of the farm **Performance Indicator** By 2006 pasture optimum pasture crops will be adopted at the same time as efficient irrigation systems	Synopsis of relevant research and experience on use of centre pivot technology and changes to irrigation systems and practices **Performance Indicator** By the end of stage 1, learnings and implications of relevant Australian research and experiences will have been used to inform the objectives, methodology and proposed outputs and outcomes of the project. Report on the considerations that are necessary to develop a whole farm plan that covers financial, biophysical and farm operations and how centre pivot technology may be integrated **Performance Indicator** Report produced Report on the characteristics of the trial sites **Performance Indicator** Report Produced **Expected Stage 2 (to be confirmed at the end stage one) Outputs a,b,c,g,k**	**Stage One** $25,000 plus inkind from Rob Kuzich & Co, Dale Hanks, Harvey Water, Dept AG WA, Boorara Research % of Program Evaluation Project Mgt , KM incl Communication **Stage Two** $617,200 from Rob Kuzich & Co, Dale Hanks, Harvey Water, Dept AG WA, Chemistry Centre WA., Boorara Research % of Program Evaluation Project Mgt , KM incl Communication

Project Objective	Impact outcomes	Adoption Outcomes	Outputs	Inputs $, people and activities
Demonstrate a model of partnership research that engages the key decision makers in research design, conduct and evaluation, and leaves a legacy of understanding and learning that allows on-going research in the same or other areas.		New knowledge and models for sustainable irrigation built from latest thinking and research **Performance Indicator** By the end of the project new models for improving the sustainability of irrigation will be documented for the South West Irrigation Area. R&D that fits the operational environment of decision makers and leads to change on-going learning from reviews **Performance Indicator** By the end of the project there will be a mechanism in place for continued learning	Development of a communication and adoption strategy **Performance Indicator** By the end stage one a strategy produced development of a communication and adoption strategy **Expected Stage 2 to be confirmed at the end of stage one Outputs h,i,j,l of the project proposal**	
Demonstrate and leave in place a communication, adoption, and learning strategy that ensures research results are effectively communicated to end users in a way which allows their application, and creates openness to learning from other areas.		Knowledge of and interest in the project from other producers learning and knowledge generation **Performance Indicators** By the end of the project interstate irrigators from at least 2 states will have requested and received information	Summary report on the characteristics of the South West Irrigation Area derived from previous work **Performance Indicator** Report produced Development of a learning and information strategy with other regions **Performance Indicator** Strategy Produced **Expected Stage 2 to be confirmed at the end of stage one Outputs e,f of the project proposal**	
Demonstrate the energy efficiencies and overall energy balance of a pressurized gravity-fed piped system of irrigation water delivery.		Irrigation systems that optimize productivity and minimize ecological impacts **Performance Indicator** By the end of the project new irrigation models will have been developed on the basis of a triple bottom line approach for the South West Irrigation Area.	**Expected Stage 2 to be confirmed at the end of stage one Outputs d of the project proposal**	

Project Objective	Impact outcomes	Adoption Outcomes	Outputs	Inputs $, people and activities
For a water authority understand the issues surrounding the operation/ordering procedures for the water authority (managing a pressurized irrigation supply system). For irrigators understand their issues if there was wide spread adoption of sprinkler technology.		Changed practices and systems that fit the on-farm biophysical and operational context **Performance Indicator** By 2006 at least 30% of the dairy irrigators in the South West will have adopted some changes due to the project.	**Expected Stage 2 to be confirmed at the end of stage one Output m of the project proposal**	

** For full milestones refer to Project Schedule