# SIP2 Snapshot Series
# Optimising irrigation system performance

Irrigate profitably using resources effectively and efficiently

**KEY POINTS**

With water availability becoming less certain and energy costs significantly increasing, irrigation system evaluations at commissioning and at regular intervals throughout lifespan should be usual practice.

System evaluation benchmarks have been established to ensure optimal season start-up and maximum efficiency and effectiveness of operation throughout the season.

Simple check-lists help to identify issues and trouble shoot solutions in periods between comprehensive performance evaluations.

The *Smarter Irrigation for Profit Phase 2* project (SIP2) found that 80% of pumps were outside optimal efficiency range, 100% of systems were under or over pressurised and 57% were under or over applying water when compared to the intended application rate set at the control panel. These statistics demonstrate lost opportunities.

## Irrigating with systems fit for purpose

Now more than ever, dairy irrigators are seeking to maximise yield whilst minimising water, energy, and labour use. These are all drivers of profitable dairying yet there is evidence of inadequate design, commissioning, maintainance and monitoring of irrigation systems.

The Smarter Irrigation for Profit Phase 2 project (SIP2) undertook pressurised irrigation system performance evaluations on eight *Dairy Optimisation Farms*. Additionally, it worked in partnership with four irrigation system specialists to analyse the outcome of a further 112 irrigation system evaluations and derive key guidance information for dairy irrigators to identify and address common problems.

**Figure 1** Catch-can tests are performed as part of a system evaluation to determine the current rate, depth and uniformity of application.

## Design

Each irrigation system has unique requirements depending on the site characteristics. These can include soil type, soil infiltration rates, readily available water (RAW), topography, local climate/weather conditions such as rainfall, evapotranspiration, or extreme event considerations. Water source/ allocation regulations (i.e. volume, quality, extraction restrictions) and the type of pasture or crop being grown also contribute to the irrigation system requirements. It is therefore important that irrigation systems are individually designed to meet these requirements, with flexibility for possible crop changes, without compromise to long-term effectiveness and efficiency.

DELIVERING *for* DAIRY

Australian Government
Department of Agriculture, Fisheries and Forestry

*This project was supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program.*

At commissioning, it is recommended that the system be inspected and tested not only by the provider, but by an independent *Certified Irrigation Designer* prior to hand-over. They can check that the installed system is in accordance with design specifications and operating to all benchmarks (see Table on page 3).

Flow meters should also be installed and tested by a *Certified Meter Installation and Validation* professional. Irrigation Australia Ltd is the training provider for certification and maintains a list of suitably qualified professionals. This can be viewed at **irrigationaustralia.com.au**

> While pump efficiency has improved between 2005 and 2022, on average there is still opportunity to save more than 20% on energy costs in most dairy irrigation operations. Pumps need to be properly selected to the system's duty and be well maintained to operate efficiently.
>
> *Peter Smith, Sapphire Irrigation (Irrigation Australia International Conference & Exhibition, 2022)*

## Monitoring and maintenance

No irrigation system is 'set and forget'. A system performance evaluation is recommended every two to three seasons to identify any issues that may be constraining the effectiveness and efficiency of operation. These evaluations include more complex field analysis not included in the industry's pre-season system checklists and can be undertaken by a *Certified Irrigation Systems Auditor.*

Field data collection includes:

- Catch-can tests
- Pressures – pump, centre and end of system
- Wetted footprint
- Pump flow rate
- Suction lift
- Power consumption
- Travel speed
- System length

From this data, the following performance measures are determined:

- Application uniformity
- Application depth
- Application rate
- System capacity
- Residual pressure
- Pump efficiency
- Potential for energy savings

Performance measures are compared against the irrigation system design specifications and/or benchmarks (see Table 1). Prepared reports will outline where there are issues in the system and recommend control actions to rectify or make improvements to monitor and maintain the system. Additionally, components of the system should be replaced when wear is evident or as per specification, usually provided in "hours of operation". Optimising irrigation system operating effectiveness and efficiency is both a short-term and long-term investment in more profitable business outcomes.

**Figure 2** Flow rate and flow-meters are checked as part of a system evaluation to determine whether specifications are being met and the installed flow-rate meter is reading accurately.

## System Performance Guidance

Table 1 has been prepared to guide dairy irrigators on the common performance issues that have been identified across the industry and how these may be impacting the effectiveness and efficiency of the system. Information on ways to address these is by no means comprehensive and may be dependent upon system design and site characteristics. Most often, an identified performance issue may require several actions to deliver improvement. Due diligence must be undertaken to investigate and evaluate the likely outcome of implementing actions as there may be flow-on effects to other components of performance measures of the system.

**Table 1** Irrigation performance issues found from dairy irrigation evaluations and recommended actions.

| Performance Measure | Description | Benchmark | Common Issues | Benefit of addressing the issue | Recommended Control Actions |
|---|---|---|---|---|---|
| **System Capacity (mm/day)** | Pump flow rate (L/d) ÷ irrigated area (ha) | Must at least meet peak plant water use [3] | System cannot keep-up with plant water demand during peak $ET_0$ events.<br>1 Irrigation required during peak power windows to meet plant water demands.<br>2 System cannot "catch-up" after downtime incidences.<br>3 System has been lengthened (increase span numbers) reducing system capacity. | 1 Water applications will maintain soil moisture content within the ideal readily available water (RAW) zone for optimal pasture/crop growth.<br>2 Allowing capacity to irrigate during specific windows may reduce energy costs (but not necessarily energy use).<br>3 Allowing some capacity to increase soil moisture after a longer than anticipated soil moisture decline will provide for plant demand + replenishment of the RAW "bucket". | 1 Increase flow rate<br>2 Decrease irrigable area<br>3 Minimise non-pumping time<br>4 Design system to allow for "windows" of operation, not 24 hour operation.<br>5 Avoid system failures through regular inspection and maintenance.<br>6 Retro-fitting of spans requires a full system re-design to ensure capacity is maintained. |
| **Flow Rate** | Measured flow v specified (Potential for meter error) | ±5% [1,2] | 1 Flow rate too high causing excessive depth of application (above soil infiltration rate) and water losses (surface and drainage).<br>2 Flow rate too low reducing depth of application and therefore causing underwatering of the pasture/crop.<br>3 Non-uniformity of application (Co-efficient of uniformity (CU) and Distribution uniformity (DU))<br>4 Flow-meter errors- trouble measuring accurately for billing and management. | 1 (1-3) Improve accuracy of AAR and uniformity of application to ensure the pasture/plant is receiving effective irrigations most efficiently.<br>2 Accurate flow meter readings for appropriate management response and billing. | 1 Adjust flow rate to meet specification, options include installation of a gate valve or variable speed drive (VSD) at the pump.<br>2 Have a certified meter installer and validator check accuracy of the system flow meter. Recalibrate meter, if required.<br>3 Install a new meter to required standards, and auditing requirements of certain States. |
| **Average Application Rate (AAR)** | Measured from high output sprinkler at outer end of centre pivot (mm/hour) | Should not exceed soil infiltration rate | 1 Too high causing water movement within the paddock (saturated areas) or run-off onto laneways and into local catchments.<br>2 Wastage of water and power resources. | 1 Reduced excess water applied, lower running costs. | 1 Install modified sprinkler pack with greater coverage.<br>2 Decrease the application depth for each irrigation and return more frequently.<br>3 Adjust end-gun angle<br>4 Investigate spreader bar and/or dual emitter options.<br>5 Undertake paddock practices to minimise water movement down slopes (i.e., drainage, tillage). |
| **Control Panel v Actual Application Depth (AAD)** | Measured depth applied compared to set depth applied | ±5% | 1 Excessive variation from measured depth causing operating to under or over irrigate each event.<br>2 Uneven application depth resulting in uneven growth. | 1 Pasture or crop receive precision irrigations to match water use requirements and maintain soil RAW.<br>2 Water and energy are used efficiently. | 1 Recalibrate panel/setting; adjust speed control. |

| Performance Measure | Description | Benchmark | Common Issues | Benefit of addressing the issue | Recommended Control Actions |
|---|---|---|---|---|---|
| **Coefficient of Uniformity (CU)** | Measures of evenness of application | 85% centre pivot, solid-set [3] | 1 Benchmarks are not achieved<br>2 Individual sprinklers are not operating as specified or whole sprinkler packs have been replaced outside specification of the designed system. | 1 More accurate water application across irrigated area.<br>2 Increased uniformity of yield across irrigated area.<br>3 Reduced pondage/saturation/ dry areas. | 1 Repair/replace damaged sprinklers.<br>2 Install sprinkler packs in accordance with specification.<br>3 Check end-gun performance |
| **Distribution Uniformity (DU)** | Measures of evenness of application | 80% centre pivot, 75% solid-set [3] | | | |
| **Pump Efficiency** | Measured efficiency of motor-pump unit | 75% [4] | 1 Generally, pump efficiency is lower than that specified on the pump performance curve. Average efficiency is 62%, but ranges from 37%-91%.<br>2 New irrigation systems are installed or adjusted (e.g., new sprinklers) without upgrading the pump to meet increased duty requirements. Pumps need to be 'fit for purpose' to meet system demand.<br>3 There are pressure leaks in the system requiring the pump to work harder (more energy) to achieve the same amount of pressure.<br>4 Pumps may be specified in the design phase to operate multiple irrigation systems concurrently. If a single system is operated, the efficiency of the pump is decreased. | 1 By ensuring the pump performance is in accordance with specification, energy and cost efficiency is optimised.<br>2 Overall system performance is improved as the correct amount of water is delivered to the irrigator.<br>3 Cost-benefit investigation to repair or replace pumps has determined a cost recovery period of between 1 to 5 seasons.<br>4 Greater flexibility to operate single or multiple irrigation systems from a single pump. | 1 Undertake pressure leak checks along the entire system and rectify (pipes, hoses and hydrants).<br>2 Ensure pipe sizing is adequate, especially the suction pipe, ensure the foot-valve and strainer are not blocked and check inside the pump for partial or full blockages.<br>3 Investigate cost-benefit of pump replacement to better meet system demand.<br>4 Investigate options to renovate an existing pump to improve performance to within benchmarks.<br>5 Install a VSD to provide greater flexibility and efficiency to operate single or multiple systems from one pump without risk to efficiency. |
| **Energy Efficiency** | Allows comparison between electric pumps of differing system/ location scenarios | 3.8–4.5 kWh/ML/m head [5] | 1 Above the benchmark range<br>2 Poor system design contributing to excessive Total Dynamic Head (TDH).<br>3 System requires double-pumping (i.e. bore to dam, dam to system)<br>4 Pump efficiency issues (as above).<br>5 Operating at pressure above requirement. | 1 Optimise energy use and cost. | 1 Important to get system design right first e.g., adequate pipe sizing<br>2 Investigate options to reduce the depth from which water is pumped or need to double pump.<br>3 Improve pump efficiency<br>4 Investigate cost-benefit of VSD at the pump.<br>5 Reduce unnecessary operating pressure.<br>6 When investigating options, weigh-each against cost effectiveness. |

| Performance Measure | Description | Benchmark | Common Issues | Benefit of addressing the issue | Recommended Control Actions |
|---|---|---|---|---|---|
| **Sprinkler Flow Rate** | Measure flow from selected sprinklers (L/ sec or min) | ±5% [2] | 1 Flow-rate insufficient overall or individual sprinklers demonstrating excessive flow.<br>2 Additional sprinklers added/ removed outside specification.<br>3 Sprinklers with nozzles smaller than specified.<br>4 Blocked nozzles | 1 Improved uniformity of application | 1 Check and ensure system pressures are as specified.<br>2 Sprinkler package installation to be as per specification. |
| **Centre Pressure** | Variation from specified pressure at centre of pivot | +10% | 1 System pressure too high, especially residual pressures at the end of the system.<br>2 Variation of pressure from centre to end of system. | 1 Reduced energy use/ costs<br>2 Reduced water use/ costs<br>3 Improved uniformity of application | 1 Check the hydraulic design of the system and rectify identified issues (e.g., wrongly selected or located components).<br>2 Investigate installing/changing VSD based on operating pressure.<br>3 Remove all blockages throughout the system.<br>4 Check sprinklers for damage and wear, replace as necessary in accordance with specifications. |
| **End Pressure** | Variation from specified pressure at end of pivot | +10% | | | |
| **Sprinkler Package Inspection** | Variation from specification and general wear and tear. | In accordance with specification. | 1 Often old and worn.<br>2 Variation from specification at commission, when replacing individual sprinklers nozzles or whole package replaced outside specification. | 1 Improved uniformity of application<br>2 Increased accuracy of application depth. | 1 Update sprinkler package |

**Footnotes**

1 NSW DPI 'Introduction to Irrigation Management' Day 2 course notes
2 Irrigation New Zealand Piped Irrigation Systems Design Standards
3 Irrigation New Zealand Piped Irrigation System Performance Assessment Code of Practice
4 Sprinkler Irrigation Systems, Mid-West Plan Service, Iowa, 1999
5 P. Szabo, Pump and Energy Specialist, Saturn Engineering Group, pers. comm. 2020
6 Irrigation 6th Edition, Irrigation Assoc., Iowa

## Suggested Resources

### Irrigation System Selection and design Guidelines, Agriculture Victoria:

Web tool to assist irrigators and service providers when selecting new systems or considering improvements to exiting infrastructure. The site answers more than 90 Frequently Asked Questions.
Found at: **bit.ly/ISSDG2022**

### Energy Assessment Tools (Centre Pivots & Travelling Systems), Agriculture Victoria and NSW DPI:

Web tool for farmers to identify energy use and cost efficiencies of their systems, including irrigation pressures and uniformity. The tool requires minimal input and has a graphical display.
Found at: **bit.ly/3kgC8uR**

### Dairy Australia Pre-season Checklists:

Series of system 'off' and system 'on' checks for each irrigation system type used by the industry.

Found at: **dairyaustralia.com.au/SIP2**

## About Smarter Irrigation for Profit

Dairy Australia's Smarter Irrigation for Profit research, development and extension project was designed to help farmers across Australia make better irrigation decisions which improve water use efficiency and lead to greater profit. Smarter Irrigation for Profit was a partnership between the dairy, cotton, sugar, rice and grain sectors, supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program and each of the industries involved.

For further information go to
**dairyaustralia.com.au/smarterirrigationforprofit**
**smarterirrigation.com.au**

## References

Craw, A., Glass, C. and Mulcock, C. (2011), *Guide to Good Irrigation Part 1: good irrigation practices on farm*, DairyNZ, Hamilton, New Zealand.

Dairy Australia (2020), *Pre-Season Irrigation System Check-list Series*, https://www.dairyaustralia.com.au/ja-jp/land-water-and-climate/water/irrigation/smarter-irrigation-for-profit, Southbank, Melbourne.

O'Donnell, D. (2020), *Centre Pivot Evaluation for Rob and Will Russell, Jelgowry Dairy*, Dave O'Donnell Consulting, Bega, NSW, Australia.

O'Donnell, D. (2022), *Centre Pivot Evaluation for Stephen Smith, Mepunga East*, Dave O'Donnell Consulting, Bega, NSW, Australia.

O'Donnell, D. (2022), *Centre Pivot Evaluation for Shelley Field, Yarram*, Dave O'Donnell Consulting, Bega, NSW, Australia.

Smith, P. (2019), *Centre Pivot Evaluations Tocal College 2-span Centre*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. (2019), *Centre Pivot Evaluations Tocal College 3-span Centre*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. (2019), *Centre Pivot Evaluations Tocal College 4-span Centre*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. (2020), *Centre Pivot Evaluations "7-span and 4-span" Centre Pivots, Mepunga East Report*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. (2020), *Centre Pivot Evaluations "7-span and 4-span" Centre Pivots, Mepunga East Report*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. (2021), *Solid-Set System Evaluation, Brian Chappell, Fairdale Dairy, Coraki Report*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P. and O'Donnell. D. (2022), *SIP2 Irrigation System Evaluations Report*, Sapphire Irrigation Consulting, Tamworth, NSW, Australia.

Smith, P., O'Halloran, N. and Braden, J. (2022), *Water and Energy Efficiency of Centre Pivots – are we improving?*, Irrigation Australia International Conference & Exhibition, October 2022, Adelaide



Dairy Australia Limited ABN 60 105 227 987
**E** enquiries@dairyaustralia.com.au
**T** +61 3 9694 3777
**F** +61 3 9694 3701
**dairyaustralia.com.au**