CottonInfo Extension Activity Report

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **CSD2201**

CSD: **CSD**

Project Title: **CottonInfo Field Demonstration Trial: Optimisation of application in tailwater backup systems**

Project Commencement Date: **01/10/2021**
Project Completion Date: **30/06/2022**

Recognition of support: The Research Provider CottonInfo and GVIA acknowledges the financial assistance of the Cotton Research and Development Corporation and Smarter Irrigation for Profit RRDP2004 in order to undertake this project.
Significant support was also received from Saunders Farming, Padman Automation, the University of Southern Qld and Glenn Lyons Pty Ltd.

Part 2 – Contact Details

Administrator: Peter White

Organisation: CSD Ltd

Postal Address: PO Box 117

Wee Waa NSW 2388

Ph: 0427 790 865 E-mail: pwhite@csd.net.au

Signature of Research Provider Representative:

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Part 3 – Final Report

Background

1. Outline the background to the project.

In recent years the industry has increased their adoption of bankless channel or siphon-less irrigation systems. This is driven by a need to address labour resourcing, energy use, management efficiency and the reuse of tailwater.

In most bankless channel designs, the field is split into bays and watered at a high flow rate. All furrows in a bay are irrigated at once without siphons or roto-bucks. While the most basic siphon-less systems principally remove the need for siphons and aim to minimise soil movement in the transition from siphon to siphon-less. There are different approaches being implemented, some with tail water reuse design and others that utilise existing tail drains and still pump tailwater.

The continuous reuse of tail water in adjacent bays can potentially reduce water loss from channels, reduce pumping costs and enhance efficiency of cultivation. Additionally, transitioning to a siphon-less or bankless channel design can enable higher flow rates through the field, this can minimise non uniformity and reduce deep drainage, but irrigations may be more frequent.

There has been limited research into the irrigation performance (application efficiency and distribution uniformity) of these designs, but the irrigators who are utilising some of these designs have found improved irrigation water use efficiency.

Objectives

2. List the project objectives and the extent to which these have been achieved.

The trial looked to collect detailed data and information on irrigation performance and efficiency of a siphon-less irrigation system, specifically the Siphon-less Head Ditch with Tail Water Backup (TWB) system developed by Glenn Lyons and increasingly adopted by irrigators.

The trial objectives are:

1. To evaluate the irrigation performance of the Siphon-less Head Ditch with Tail Water Backup (TWB) irrigation system including the application efficiency, distribution uniformity, and requirement efficiency.
2. To examine the water use efficiency (WUE) of the TWB system by measuring WUE indices including Gross Production Water Use Index (GPWUI), Irrigation Water Use Index (IWUI) and Crop Water Use Index (CWUI) and comparing to industry benchmarks.
3. Measure the water infiltration rate characteristic for the trial site and examine any changes over the irrigation season.
4. To investigate potential to apply the surface irrigation optimisation technology, SISCO to the Siphon-less Head Ditch with Tail Water Backup system.
5. To provide robust water measurements and indicators of irrigation performance and water productivity for siphon-less irrigation systems to growers, to help them make informed decisions around implementing a siphon-less system.

See conclusions for achievement of goals

Methods

3. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related projects.

Field Layout:

Thuraggi Overflow is located south of St George in Southern Queensland. Field 5 is a siphon-less tailwater backup design made up of 10 irrigation bays (See Field Plan). The field was designed by Glenn Lyons (GL) to improve irrigation efficiency from a labour and water perspective. There is a supply channel fed directly from the storage which runs along the top edge of the field, this feeds water into the distribution basin of each irrigation bay. The furrow elevations rise for 30-40m away from the head reaching the sill. This sill was used as the zero point for advance because the field downstream of the sill resembles a normal furrow field. Thereafter the field slopes down towards the tail end of the field. The furrows terminate in a bankless channel at the downstream end of the field. Each bay is supplied by an individual Padman Maxiflow culvert from a primary head ditch and gates between each bay ensure that water is applied to one bay. The bankless channel at the bottom end of the field also contains gates so that water can be backed-up into one bay at a time.

The field is split into management units of 3 bays. Each group of three has a common drainage point hence it is possible to determine the runoff from each set of three bays. The focus of the trial was Bays 7, 8 and 9, as they have a more uniform soil type.

The typical management involves supplying water to the top of Bay 7 with all downstream gates closed. After water reaches the end of the field, water backs up and irrigates the slow furrows. When irrigation of Bay 7 is complete the supply channel structure delivering water to Bay 8 is opened and the downstream gate between Bays 7 and 8 is opened such that water is applied to both ends of the field. The drainage water from bay 7 irrigates the bottom portion of Bay 8 and the remainder of this bay is supplied through the upstream inlet. When irrigation of Bay 8 is complete water flows into the top of Bay 9 and the tailwater from Bay 8 is permitted to flow into the bottom of Bay 9. Finally once irrigation of Bay 9 is complete the inflow into the top ceases and the gate allowing water to exit the field through the tail drain which is opened draining all remaining ponding water. Bays 4, 5 and 6, and Bays 1, 2, and 3 are irrigated in a similar fashion. Bay 10 is a special case because this smaller remaining bay is irrigated partially from the remnants of water in the upstream bankless channel.

The trial consisted of measuring and monitoring water use and movement in three bays of a siphon-less tailwater back-up system. The trial used various in-field sensors (storage meters, pump meter from storage, channel level sensors, water advance sensors, c-probes, weather station) information from these sensors can be used to schedule and automate irrigations. Additional water meters were installed to measure water flow onto and off the field. These sensors and meters were evaluated to assess, functionality, and suitability for use in an automated system. Additionally, they were assessed in measuring the required inputs to evaluate irrigation performance using SISCOweb.

This included:

1. Measure total water onto the field and total water off the field
   a. A transit time ultrasonic flowmeter installed downstream of the pump at the main storage, measured all irrigation water delivered to Field 5.
   b. The flowmeter logs (5 minute intervals) provided instantaneous flow data. The raw data is multiplied by a factor of 20 to produce flow in L/s. (refer USQ report).
2. Measuring water from the main supply channel into the distribution basin (head ditch) through bay inlets in bays 7, 8 and 9.
   a. Gate opening and closing information was available via the Padman Automation Management System (PAMS) providing details of irrigation start and stop times.
   b. StarFlow SDI-12 dopplers were installed on MaxiFlow culverts supplying bays 7, 8 and 9. These StarFlow sensors record velocity, temperature, water depth (ultrasonic), water pressure, and additional values describing the quality of the doppler signal. The Starflow sensors were connected to a Padman unit providing frequent data on velocity and depth.

c. Padman level sensors were installed in the main supply channel, side gates in the tail drain and the main drainage gates used to remove tailwater from the field.

3. Measuring water leaving the tail drain after irrigating three consecutive, uniform bays within the field.
   a. Tail drain outlet fitted with pressure transducer.
4. Assess used soil moisture, water advance, depth, and the infiltration characteristics in three bays.
   a. Soil moisture cores were taken pre planting. Post picking cores were not taken as significant rain prevented this from occurring
   b. Padman water advance sensors were positioned in field with 15 in bay 7 and five each in bays 8 and 9. Several of the Padman advance sensors were a modified version with two additional capacitance sensors to monitor adjacent furrows either side of the main unit. Water advance sensors were positioned to avoid tailwater backup, as the current SISCO evaluation process cannot use this data.
   c. Additional Taggle IrriMATE sensors were positioned in field to complement the Padman advance sensors. One each was positioned at the sill in bay 8 and bay 9. Additionally, 10 Taggle sensors were placed at the same position as to sets of five Padman sensors in bay 7. The taggle sensors transmitted to a mobile Taggle receiver tower.
   d. SISCO evaluations rely on data for inflow rates into the furrows where advance sensors are placed. In siphon irrigation, flows across the set should be uniform because this flow is determined by the internal dimensions of the siphon and the water head. In the tail water backup design, the flow is determined by the water level in the distribution basin, the elevation of the sill and the cross section of the furrow. The trial investigated the use of a Starflow sensor in the furrow at the sill. The sensor was fixed to a metal plate shaped with the same curvature as the furrow bottom so it could be installed and not influence the water velocity.
   e. Soil moisture sensors were positioned approximately 250m from the tail drain.

The data from measurements was used to calculate Water productivity (bales/ML), water use efficiency (GPWUI, IWUI).
Where possible SISCO was used in an attempt to make some assessments of irrigation system performance, application efficiency and distribution uniformity.

Outcomes

4. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

When water was released to irrigate field 5, it took approximately six hours to get a stable supply channel level. Typically, irrigation of the field started before the channel level stabilised meaning flow rates into the first bays irrigated will be lower than expected for the first few hours of irrigation. Bays 7, 8 and 9 were the last set to be irrigated, so this is unlikely to be of concern for these bays.
An ideal irrigation layout is where water is uniformly delivered to each furrow in the bay. Poor uniformity in flows across the bay results in potential over watering and under-watering which will also potentially complicate irrigation management. In bankless systems, water is delivered to the distribution basin or bankless channel and is distributed amongst the furrows according to factors such as:

a) The elevation of the furrow in comparison to other furrows – lower furrows will have higher inflows.
b) The shape of the furrow – wider furrows may have higher inflows.
c) The infiltration of water along the length of the field – higher infiltration rates will cause higher inflows.

d) The water head driving water into the furrow – may differ across the width of the bay.

Designs with a sill (as with the siphon-less tailwater backup design), where the furrows rise up to a high point in the first 20-50m before dropping to a positive slope, minimises the impact of these factors by restricting the control point to that first part of the field. This means that the influence of furrow elevation or shape are restricted to the part of the field around the sill and (c) has a minimal impact.

For systems with a sill, the uniformity of elevations for the furrow bottoms along that sill across the bay are very important. The team at USQ surveyed the furrow bottoms along the sill in bay 7. In addition to expected scatter caused by measurement error and the ability to achieve uniform grade with earth moving equipment, the survey observed a general drop in furrow elevations on the eastern end of the bay. Care during design and construction resulted in minimal variation in the first 170 furrows of the bay. At the eastern end where the drop in elevation was observed, there was a higher head and an increase in the advance rate in this small part of the bay. These observations highlight the importance of selecting representative furrows in terms of sill elevations for irrigation evaluations. It also highlights the importance of striving to maintain the sill elevation as uniform as possible.

Water advance sensors were installed in field and were able to inform where the water front reached each sensor location. The Padman water advance sensors are pressure transducers and record the water depth over time, providing information on the recession of water leaving the bay. This provides the opportunity time which can be used by SISCOweb. The modified Padman advance sensors with the additional capacitance sensors were useful in providing a cost-effective solution to monitor multiple furrows.

The LoraWAN system supporting the Padman instruments was experiencing intermittent dropouts in the early part of the season. The Padman advance sensors were functioning correctly and recording at <5 minute intervals, but many of these readings were missed by the LoraWAN receivers. Frequent data is important because SISCO requires an accurate indication of when water arrives at each advance distance. To rectify this problem a duplicate set of Taggle IrriMATE® advance sensors was installed in Furrows 7_1 and 7_3. Taggle IrriMATE® advance sensors developed by CAE at USQ consist of a low-cost soil moisture sensor which is monitored on a 1 minute time interval. The instant water is detected, a signal is sent by the Taggle transmitter to the Taggle receiver tower positioned on the farm, which is then sent to the Taggle server, and this time is recorded as an advance data point for that known position. The resulting advance data (distance and time) is typically accurate to within a metre, and the nearest minute. A secondary LoraWAN base station was installed to address the issues with intermittent data transmission from the Padman sensors. There were no issues following this installation.

Water level sensors in the tail drain were looked at as an option to indicate when irrigation was complete. Data suggests that this was not consistent during the season and alternative options need to be considered.

Calculations of water applied, and runoff were determined by Glenn Lyon for each irrigation event using data from gate opening and closing times and from level sensors in the tail drain (details in Appendix).

A SISCO analysis was conducted for several of the irrigation events. It included details from both slow and fast furrows. For further information please refer to the research report developed by USQ.

5. Please report on any:-

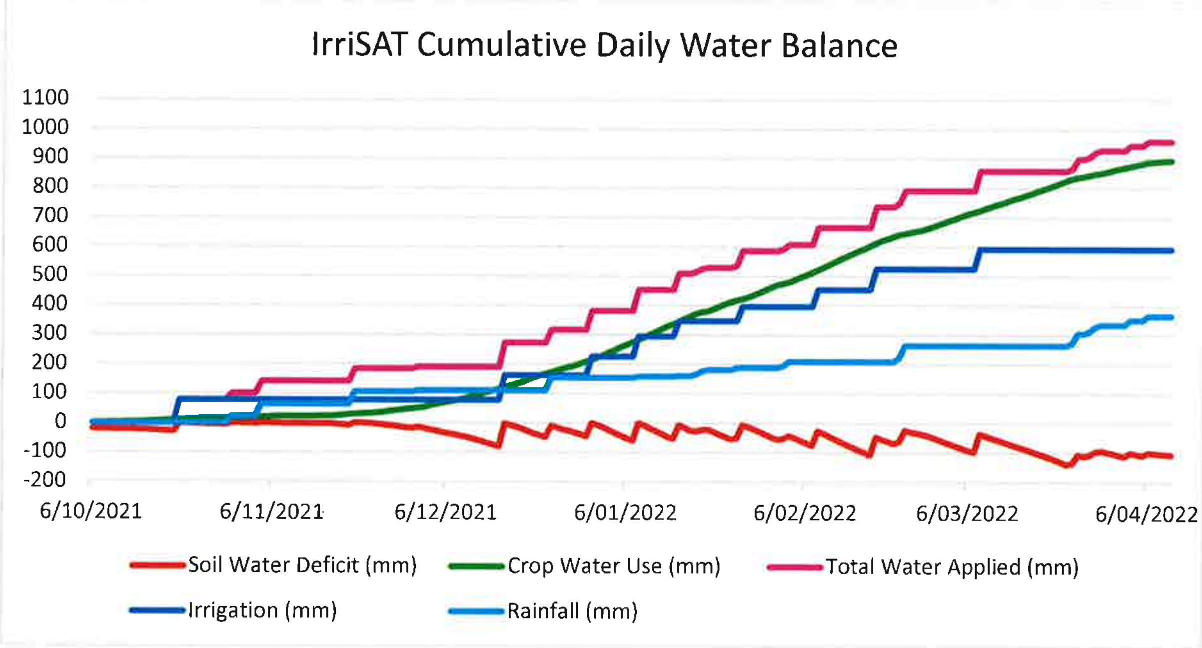
a) Feedback forms used and what the results were
b) The highlights for participants or key learnings achieved
c) The number of people participating and any comments on level of participation

Key learning:

Data collected on irrigation performance suggests that as indicated by the grower the siphon-less tailwater backup design has produced a result which is comparable to other designs used in the industry (GVIA Keytah System Comparison: Gwydir Valley Irrigators Association Inc - Keytah System Comparison (gvia.org.au)).

Table 1: Field Scale Benchmarking TO field 5	
Area Grown (ha)	89.7
Yield (bales/ha)	13.94
Irrigation water applied (ML/ha)	6.62
Irrigation Water Use Index (bales/ML)	2.10
Rainfall	398
Gross Production Water Use Index (bales/ML)	1.24

An analysis of the seasonal irrigation using IrriSAT suggests that bays 7, 8 and 9 may have had more water applied that crop water use. This may be correct as the field was watered as a whole with irrigations scheduled to meet the needs of the sandy lighter soil types in Bays 1 and 2. This is typical across the industry. As the grower has the capacity to automate the field he is planning on adjusting irrigations to avoid this issue.



Connectivity: Issues associated with LoraWAN experiencing intermittent dropouts are an ongoing concern for producers. Manufactures such as Padmans are actively working to ensure that the sensors installed in field are robust and reliable. The challenge however is not the sensors themselves, but the network that is being utilised. The issue identified with the network was not known until the trial and has since been rectified.

Construction: Many growers have or are making changes to their field designs/layouts. The trial has confirmed that it is very important that there is attention to detail with regard construction and earth moving, getting sill and slope levels right will improve application uniformity and irrigation performance.

Participation and Collaboration:

Collaboration was a critical component of this project. The CottonInfo team (Janelle and Andrew) worked very closely with the producer (Saunders Farming), designer (Glenn Lyon Pty

Ltd), the GVIA (SIP2), the University of Southern Qld (Malcolm Gillies and Joseph Foley) and the commercial supplier Padman Automation (Grant Oswald).

Field Day: A field day was held on site in early March, where all collaborators participated. There were 48 people in attendance, many of whom were growers or farm employees. The field day included a trip to look at other similar field designs in the St George region.

Feedback:

A survey was distributed at the field day. Following is a selection of the findings.

Q7. Following the presentations today, are you likely to work to optimise your irrigation efficiency by

	Yes	No	Unsure
changing flow rates into fields	44%	11%	44%
adjusting irrigation run times	44%	33%	22%
adjusting field length	33%	67%	0%

Q8. Thinking about the Thuraggi Overflow siphon-less trial. How would you rate the value of commercial scale research? (zero is not valuable and 100 is extremely valuable).
Average = 89

Q9 Thinking about the information presented: Please rate the likelihood of you making changes or adopting the following technology into your operations.

	EXTREMELY LIKELY	VERY LIKELY	NOT SURE	SOMEWHAT UNLIKELY	UNLIKELY
Automated gates (eg Padman stops)	10.00%	30.00%	40.00%	10.00%	**10.00%**
	1	3	4	1	**1**
Transitioning fields to siphon-less designs	30.00%	40.00%	20.00%	0.00%	**10.00%**
	3	4	2	0	**1**
SISCOweb irrigation optimisation	0.00%	20.00%	60.00%	10.00%	**10.00%**
	0	2	6	1	**1**
Channel level sensors	20.00%	50.00%	20.00%	0.00%	**10.00%**
	2	5	2	0	**1**
Improved monitoring of water in fields	40.00%	40.00%	10.00%	0.00%	**10.00%**
	4	**4**	**1**	**0**	**1**

Q10 With regard technology and automation what do you see as barriers to adoption.

	EXTREME BARRIER	MAJOR BARRIER	SOMEWHAT OF A BARRIER	NOT A BARRIER
Reliability of technology	33.33%	11.11%	44.44%	11.11%
	3	1	4	1
Cost	37.50%	12.50%	37.50%	12.50%
	3	1	3	1
Service provider support	20.00%	30.00%	40.00%	10.00%
	2	3	4	1
Understanding the value of the technology	0.00%	12.50%	75.00%	12.50%
	0	1	6	1

Understanding what the technology does	0.00%	12.50%	62.50%	25.00%
	0	1	5	2

Conclusion

6. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?

There are a number of take home messages for industry from the project.
It has demonstrated the importance and value of collaboration between research, commercial industry and producers.
It highlighted that there are still some issues associated with IoT networks which can cause problems with automation and optimisation.

The project has enabled some evaluation the irrigation performance of the siphon-less tailwater backup (TWB) irrigation system with regard application efficiency and distribution uniformity in the top sections of the field. The results are not conclusive as SISCO cannot account for parts of the field where water moves two directions.
The project has successfully examined the water use efficiency (WUE) of the TWB system by measuring WUE indices including Gross Production Water Use Index (GPWUI) and Irrigation Water Use Index (IWUI). This information is comparable to data collected from Keytah since 2009. In addition, it has demonstrated that siphon-less designs can be effectively automated to reduce labour.
It was possible to collate some information on the water infiltration rate characteristic for the top of the trial field. The surface irrigation optimisation technology, SISCO was applied to the top section of the trial field, it however was not possible to utilise the model in tailwater backup regions of the design as water moves two directions.
The project has provided robust water measurements and indicators of irrigation performance and water productivity for siphon-less irrigation systems to growers, this information has been communicated to producers through CottonInfo and SIP2 to help extend information to growers.
The project team is actively working to continue the assessment of the siphon-less tailwater backup design. As protocol is under development and has been incorporated into the CottonInfo Annual Operating Plan.

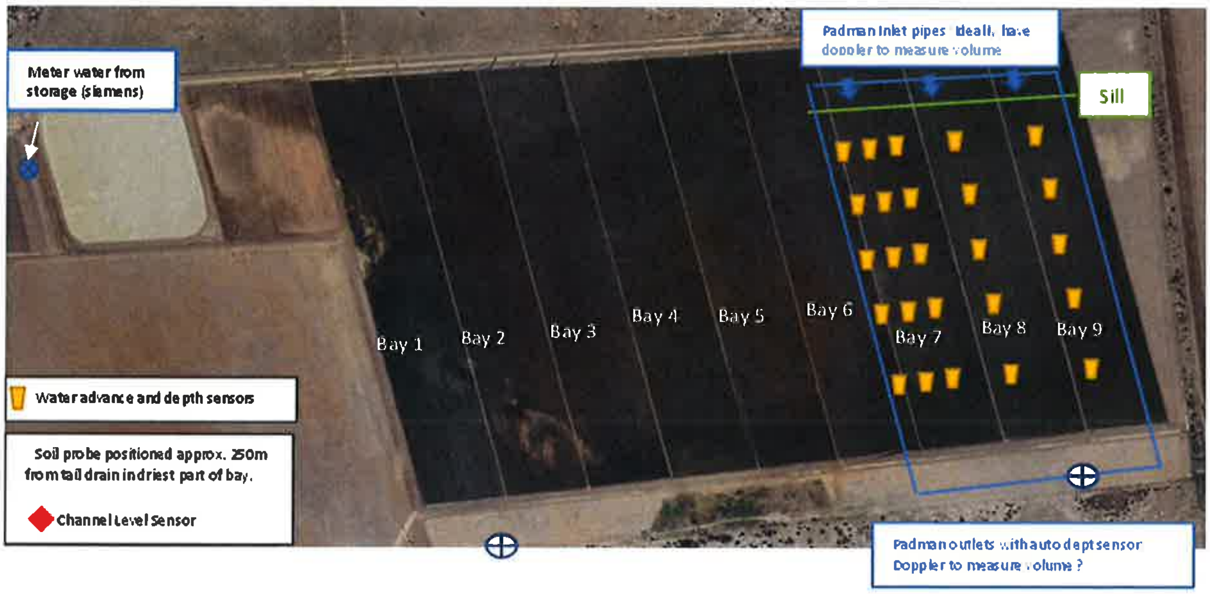
Extension Opportunities

7. Detail a plan for the activities or other steps that may be taken:

(a) To tell other CGAs/growers/regions about your project.
(b) To keep in touch with participants.
(c) For future projects.

The project has been extended with a field day where a booklet was also produced, and article in the Australian Cotton Grower, videos and a podcast.
Videos:
https://www.youtube.com/watch?v=Mv0BkCAhtjY
https://www.youtube.com/watch?v=xLacaTN0o3k
https://www.youtube.com/watch?v=teye8tJ1TTk
https://www.youtube.com/watch?v=D5GCtCcj304
https://www.youtube.com/watch?v=YJXfe73H6c0
https://smarterirrigation.com.au/optimisation-of-siphon-less-tail-water-back-design-in-2021-2022/
Field day Booklet:
https://smarterirrigation.com.au/sip2-cottoninfo-optimised-tailwater-backup-field-day/
Podcast:
https://smarterirrigation.com.au/st-george-bankless-channel-podcast/

Field Plan


Meter water from storage (siemens)
Padman Inlet pipes Ideally have doppler to measure volume
Sill
Bay 1
Bay 2
Bay 3
Bay 4
Bay 5
Bay 6
Bay 7
Bay 8
Bay 9
Water advance and depth sensors
Soil probe positioned approx. 250m from tail drain in driest part of bay.
Channel Level Sensor
Padman outlets with auto dept sensor Doppler to measure volume ?