

## **Siphon-less Irrigation Project**

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### **Abstract**

Australian irrigated cotton growers are committed to improving their water use efficiency for economic, environmental, social and political reasons. The Australian cotton industry is predominantly irrigated by furrow irrigation with siphons. Increasing the performance of such systems generally requires an intensification of the existing labour requirements while the current labour force is dwindling. Various alternatives have and are being considered but there is a lack of data that exists about comparisons of alternatives to fully optimised furrow irrigated field and even more so a lack of data about the individual potential of each system to perform better. The siphon-less project was developed to address this knowledge gap by using the same methods to measure and the same water use efficiency indices to assess the performance of each alternative system and an adjacent furrow irrigated field. Four systems, located throughout the Border Rivers and Lower Balonne catchments, were assessed over the 2005/06 summer including: Overhead Irrigation (Lateral Move), Bank-less Channel, Bank-less Head Ditch and Pipes Through the Banks. The following water use efficiency indices were calculated: Gross production Water Use Efficiency Index, Application Efficiency and Distribution Uniformity. In addition final infiltration rates, gross margin including development, operational and input costs were generated for each field under investigation. Results have demonstrated that the siphon-less irrigation systems compared reasonably well and in one case exceeded the water use efficiency of the adjacent furrow irrigated field. The development of siphon-less systems is more costly while the operating costs vary between systems. All systems have shown that there is still room for improvement. While furrow irrigation with siphons remains the pre-dominant irrigation method of the Australian cotton industry efforts towards improving the performance of this system still remains of paramount importance.

### ***Keywords***

Bay, Overhead, PTB, Optimisation, Irrimate<sup>TM</sup>, Irrigation, Rainfall, Application Efficiency, Distribution Uniformity, WUE, Economics.

## **1.0 Introduction**

Australian irrigated cotton growers are committed to improving their Water Use Efficiency (WUE) for economic, environmental, social and political reasons (Breen et al, 2006). Furrow irrigation is the dominant irrigation system and is used by over 90% of the Australian irrigated cotton industry (Foley et al, 2001). Increased precision during furrow irrigation with siphons typically involves higher flow rates using larger or multiple siphons over shorter times than that observed across the industry (Purcell, 2004). Consequently, irrigators aiming to improve their WUE require further intensification of an already labour intensive system at a time when there is a dwindling labour force. As a result there has been an increased interest in less labour intensive irrigation systems.

The current commercial irrigation systems that do not require siphons employed throughout the Australian cotton industry include:

- Overhead (Lateral Move and Centre Pivot)
- Drip
- Pipes Through the Bank (PTB)
- Bank-less Channel and Bank-less Head Ditch.

Overhead and drip irrigation have been used for some time in order to combat the issues of limited water and labour (Raine et al 2002 and Foley et al 2001). PTB's have also been used as a less labour intensive furrow irrigated system. Bay irrigation, although quite prevalent in other industries (rice and pasture), has been used more recently by cotton irrigators with some modifications (Grabham et al, 2005). These bay irrigation systems were installed because they were expected to be less labour intensive and perform on par with current furrow irrigation systems in regards to WUE.

There are various amounts of data about the WUE of the alternatives and how they compare to traditional furrow irrigation (Raine et al, 2002). Even more importantly there is a lack of data about how these alternatives compare to a WUE furrow irrigated system and the potential for optimisation of each system (Raine et al, 2002). The siphon-less irrigation project was designed to address these knowledge gaps by using the same measurement method and the same WUE indices to assess the performance of each alternative system and an adjacent furrow irrigated field.

## **2.0 The Siphon-Less Irrigation Systems Under Investigation**

Four systems were assessed including overhead (lateral move), bank-less channel, bank-less head ditch and pipes through the bank, over the 2005/06 summer. The trial sites were located throughout the Border Rivers and Lower Balonne Catchments.

### **2.1 Bank-less Channel**

The bank-less channel field under investigation was 107 ha in total divided into three bays of roughly equal area (Figure 1(ii)). The bays are terraced with a 100mm drop between each (Figure 1 (i)). The bank-less channel is commonly referred to as the "roof top" system because it is graded from both ends on a reverse slope forming a peak in the centre of each bay (Figure 1 (iii)).

Water is delivered from supply channels to the drains on either side of the field and therefore runs parallel to sides A and C (Figure 1). The water is blocked off by checks on

both sides of the field about 500 m downstream and is forced to flow up the field to a peak in the middle. Once the water meets in the middle (half way up side B) the boards are pulled from the checks and the water rapidly moves into the next bay which is also blocked off and the process is repeated. When the water is let out of the last bay it is emptied into a tailwater system and recycled as normal.

## **2.2 Bank-less Head Ditch**

The bank-less head ditch field was a small trial field of 12 Ha in total with two bays of approximately equal area (Figure 2 (ii)). The system is an innovation by the irrigator. It involved removing the rotor buck side of the head ditch. The old head ditch is represented by side A in Figure 2. Checks are placed 100m apart in this modified head ditch and these 100 m sections are terraced with a drop of 100 mm between each (Figure 2 (i)). The water comes into the head ditch through the supply pipe and when checked by boards is forced to flow down the paddock. Once at the bottom of the paddock (Figure 2, Side C) the tailwater return system operates the same way as before.

The current head ditch had some cross fall and with the objective of minimising the effect of this cross fall on uniformity a novel system of delivery to the bay was developed. Dirt was graded on a reverse slope from the toe of the old head ditch to a point that roughly corresponds to the end of the old rotor buck area and then graded flat for fifty meters. Allowing the water to build up to a consistent head over the flat area and run uniformly down the field. It was expected that if high enough flow rates could be maintained here then this would ensure a water advance that was as quick and uniform as possible. Once the water has reached the end of the first bay and is running water into the tail drain the check boards are pulled and water moves rapidly into the next bay which is also checked by boards and the process is repeated.

## **2.3 PTB**

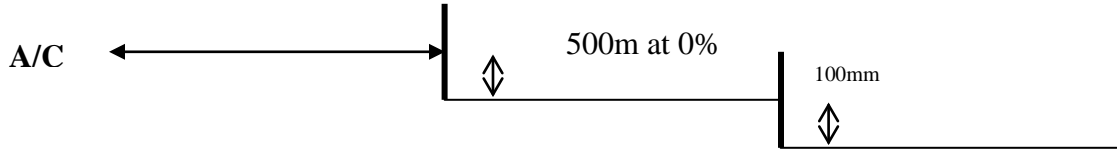
The PTB system consists of 250mm diameter pipes delivering water to 16 rows. Initially this was 32 rows but it has been reduced to half to minimise issues with uniformity. The PTB field is the same design as a furrow irrigated field, except there are 16 row rotor bucks compared to 2 row rotor bucks in the siphon irrigated field.

## **2.4 Lateral Move**

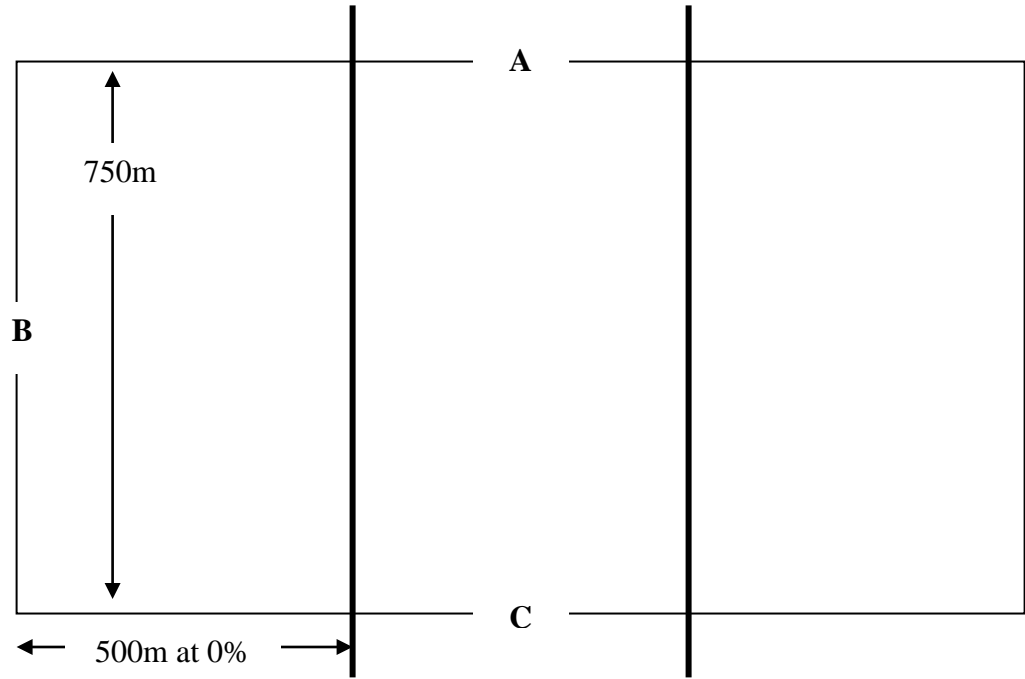
The lateral move is 500m long, with outlet spacings of 1m, each fitted with a Senninger Quadspray emitter and 15psi pressure regulator. The Senninger Quadspray has four application types, the two most commonly used are sprinkler and bubbler mode. The sprinkler mode is used in the establishment of the crop and the bubbler mode for all in-crop irrigations. The emitters sit approximately 250mm above the ground. The system has a designed system capacity of 14mm/day. The field was levelled to the contour of the land to provide drainage in the event of a storm. A tail water return system as per the furrow irrigated field was developed to reticulate stormwater, as the irrigations themselves do not generate tail water. The crop was grown on the flat.

**Figure 1: Illustrations of the Bank-less Channel Field.**

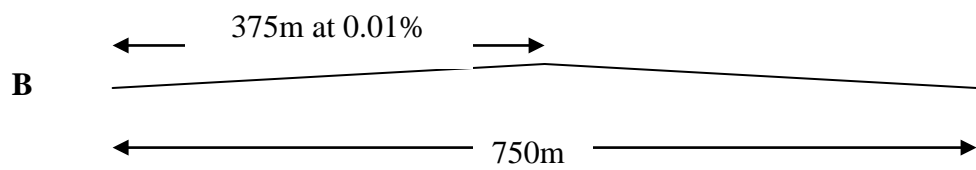
(i)



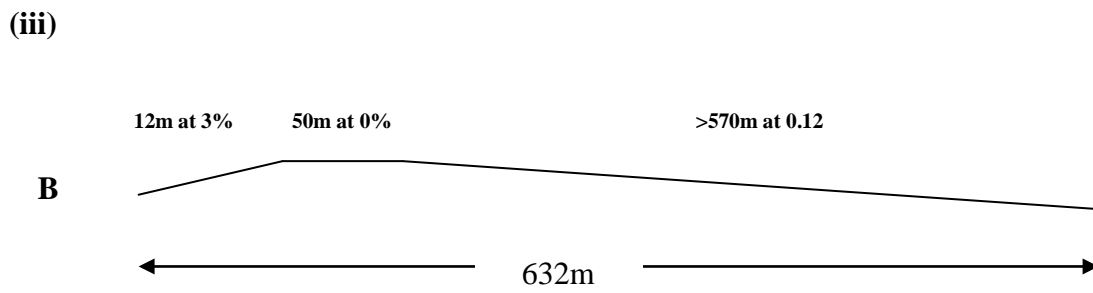
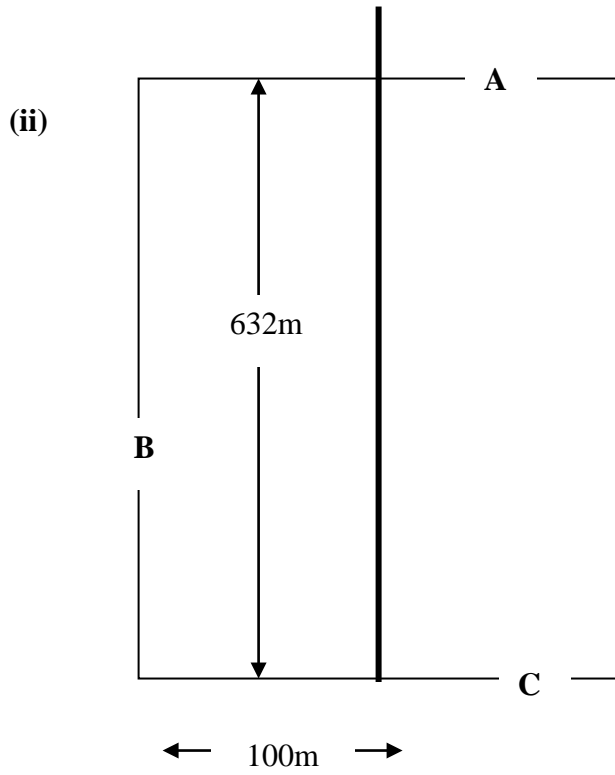
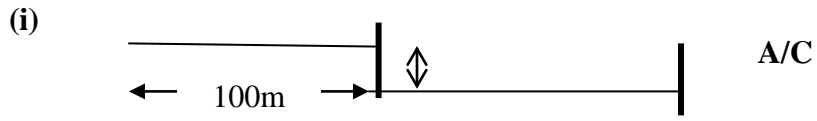
(ii)



(iii)



**Figure 2: Illustrations of the Bank-less Head Ditch Field.**



### 3.0 The Performance Indicators Used to Assess the Siphon-less Systems

The project was designed to measure the components required to assess the WUE of each system using several of the indices set out in WaterPAK (Table 1). These indices are related to water use, along with the application efficiency and uniformity of the irrigation applications. The WUE indicators are defined in Table 1.

**Table 1: WUE Indices Used to Assess the Performance of the Siphon-less Irrigation systems.**

<b>Water Use Efficiency Index</b>	<b>Acronym</b>	<b>Minimum Standard</b>	<b>Definition</b>	<b>Formulae</b>	<b>Relevant Sections in this Report</b>	<b>Relevant WaterPAK sections</b>
<b>Gross Production Water Use Index (bales/ML)</b>	GPWUI	>1.1	Yield per total water infiltrating the paddock including irrigation and effective rainfall	= Yield ÷ (Irrigation Water that Infiltrated the Field + Effective Rainfall )	4.4 Economic Returns 4.1.1 Irrigation Water Use 4.1.2 Rainfall	2.1 Assessing whole farm water use efficiency <b>NOTE</b> <b>Soil Moisture Used was not measured</b>
<b>Application Efficiency (%)</b>	E <sub>a</sub>	>80	Percentage of water applied that is used by the crop.	= (Water used to refill the deficit ) ÷ (Water Delivered to the field – 85% of the tailwater volume)*100	4.2 Application Efficiency and Distribution Uniformity	As Above <b>NOTE</b> <b>15% Tailwater losses are included to be consistent with all other industry data</b>
<b>Distribution Uniformity (%)</b>	DU	>90	Measure of how evenly the water is applied.	= (Average lowest 25% of infiltrated volumes) ÷ (Average of all infiltrated depths)	As Above	2.9

## 4.0 Data Collection and Analysis

### 4.1 Water Use

Water use can be divided into two components: irrigation water use and rainfall.

#### 4.1.1 Irrigation water use

Irrigation water use was measured two ways. Meters were installed in the head ditch and tail drain of every field under investigation to quantify the amount of water delivered to the paddock and returned as tailwater. The difference is the water used to irrigate the field. This volume includes the water infiltrated, evaporated and lost as seepage from the head ditch, tail drain and in field. Irrimate™ Irrigation Evaluations were conducted on every field except for the bank-less channel and the lateral move due to the limitations of the equipment on reverse slopes and overhead systems. The irrigation evaluations were used to quantify the amount of water delivered to the furrows through the siphons and leaving the furrows as tail water. The difference is the water infiltrating the paddock alone. The two water use measures were used to cross check each other and to calculate the infiltrated irrigation water for each irrigation.

In the case of the bank-less channel system the meters in the supply and tail return pipes were used to generate the same data but were adjusted for evaporation and seepage using assumptions. For the lateral move the flow rate, speed and engine hours were used to calculate the amount of irrigation water that was delivered to the paddock.

#### **4.1.2 Rainfall**

Total rainfall was collected using on farm weather stations and on farm records in conjunction with SILO weather data. The proportion of rainfall that was infiltrated into the crop root zone, commonly referred to as Effective Rainfall, was estimated using HydroLOGIC. Grower observations were also used to validate these estimations.

#### **4.2 Application Efficiency and Distribution Efficiency**

During an Irrimate™ Irrigation Evaluation the inflow through siphon(s) and the total time of irrigation is measured with a flow meter and a data logger. To ensure representative measurements the monitored siphons are started and stopped at the same time as the rest of the siphons. The time it takes for water to advance down the field is measured at five, usually equi-distanced, points by advance sensors connected to data loggers. The advance and siphon flow data allow a volume balance to be generated which calculates how much water is moving into the soil profile over time. A flume with a flow meter and data logger is then inserted into furrow(s) at the tail drain end to measure the water leaving the paddock. This flume data can be used to validate the infiltration volume that has been determined using the flow meter and advance data. Once this data was collected and cross checked Application Efficiency (AE) and Distribution Uniformity (DU) was calculated using the Surface Irrigation Model (SIRMOD) computer program.

Continuously logging depth loggers were placed throughout each bay of the Bank-less Channel field to measure the time it took for water to advance up from the tail drain to the middle of the field and how long water was ponded for at each spot. The data was to be used to model the variation in infiltration throughout the bays and calculate AE and DU. Currently the method of interpretation is still being developed in collaboration with researchers at the National Centre for Engineering in Agriculture (NCEA) and The CRC for Irrigation Futures at the University of Southern Queensland.

A catch can evaluation of the lateral move would have provided the data to calculate AE and DU. Unfortunately an opportunity did not arise due to bubbler mode already in place prior to the trial.

### **4.3 Installation and Operational Costs**

A gross margin was developed based on grower estimates of operation, maintenance and input costs for each system over the season. Costs of development for each siphon-less system were estimated for comparison with the adjacent furrow irrigated field.

### **5.0 Results**

The trial design aims to reduce the impacts of variable such as management, soil type and weather conditions. Therefore it is only possible to compare each siphon-less system to its comparative furrow irrigated field, not to each other. The systems have not been optimised, with optimisation over future seasons it is expected that this comparison could be achieved.

#### **5.1 Bank-less Channel**

Total water use (infiltrated irrigation water plus effective rainfall) was the same for both the bank-less channel field and the adjacent furrow irrigated field (Table 2). However 2 ML/Ha more water was delivered to the bank-less channel field and consequently 1.8 ML/Ha more water needed to be recycled through the tail water system (Figure 3). This results in a significant difference in the operational costs due to an increase in pumping costs (Table 3).

It is most likely that this difference between the systems is a consequence of the need for higher delivery rates in order to over-come non-uniformity in the bank-less channel field. However because the bank-less channel field has been designed with this in mind it is possible to deliver enough water to greatly reduce irrigation time. When supply was maximised it took 24 hours to furrow irrigate 70 hectares, compared to 17 hours for 107 hectares in the bank-less channel. This has benefits in the reduced opportunity time for deep drainage and waterlogging. The bank-less channel system has twice the drainage capacity when compared to traditional furrow irrigation design which augers well for storm management.

Further work is required in terms of optimisation of the system to determine whether or not the high supply and return volumes and associated costs can be reduced by design and management that mitigates non-uniformity.

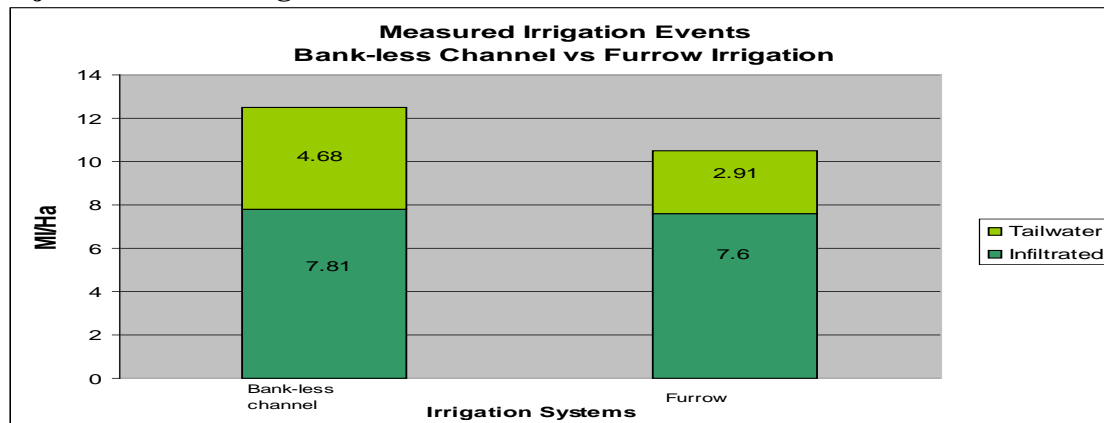
The total water use was the same for both systems but the yield of the Bank-less Channel field was 0.5 bales/Ha less than the furrow irrigated field. This meant that the GPWUI was slightly lower for the bank-less channel field (Table 2). At this stage there is not enough data to associate the difference with irrigation system or management.

The furrow irrigated field was well managed by maintaining maximum head and therefore siphon flow rate and minimising irrigation shift length. This is evidenced by

the AE and DU (Table 2). Unfortunately the data is not yet available for a comparable AE and DU of the bank-less channel field.

The development costs are greater for the bank-less channel field (Table 3). Although the labour costs of the bank-less channel field is estimated to be one tenth of the adjacent furrow irrigated field the total operating costs are over \$100/Ha more due to the supply and pumping costs associated with the higher volumes of water being delivered to and returned from the field (Table 3). Although there is not a lot in it the furrow irrigated field out performed the bank-less channel in WUE, yield, and gross margin for a greater labour requirement. Further investigation is required to determine whether these systems can perform better.

**Figure 3: Comparison of the water use between the Bank-less Channel field and the adjacent furrow irrigated field.**



**Table 2: Irrigation performance – Bank-less Channel versus furrow irrigation.**

	Minimum Standard	Bank-less Channel	Furrow
Variety	-	71 Conv	71 Conv
Yield	-	10.9	11.4
Number of Irrigations	-	9	8
Irrigation Water Applied (ML/ha)	-	12.49	10.51
Infiltrated Irrigation Water (ML/ha)	-	7.81	7.6
Effective Rain (ML/ha)	-	2.44	2.65
Application Efficiency (%)	80		82 ± 6
Distribution Uniformity (%)	90		91 ± 4
GPWUI (bales/ML)	1.1	1.06	1.11

**Table 3: Economic Comparison - Bank-less Channel and furrow irrigated field.**

	Bank-less Channel	Furrow
Area – Green Hectares	107	70
Year of Development	2003	2003
<b>Development Costs (\$/ha)</b>		
System Purchase	\$112 (Structures)	\$57 (Siphons)
Land Levelling	\$588	\$485
Supply & Drainage	\$38	\$28

TOTAL	\$738	\$570
<b>Yield</b>	<b>10.9</b>	<b>11.4</b>
Water Applied (ML)	12.49	10.51
<b>Average Operating Costs (\$/ha)</b>		
Water Costs (\$14/ML)	\$175	\$150
Supply Pumping (\$26/ML)	\$325	\$273
Tail Water Pumping (\$26/ML)	\$122	\$76
Labour	\$1	\$10
TOTAL (A)	\$623	\$509
<b>Irrigation Repairs And Maintenance (\$/ha)</b>		
System Maintenance	=	=
Channel Maintenance	=	=
Channel Herbicides	\$6	\$6
Rotor Bucks	\$0	\$14
Laser Levelling	=	=
TOTAL (B)	\$6	\$20
<b>Input Costs \$/Ha</b>		
Input Costs	\$738	\$938
TOTAL (C)	\$738	\$938
<b>TOTAL COST(A+B+C)</b>	<b>\$1367</b>	<b>\$1467</b>
<b>Gross Margin (\$/ML/Ha)</b>	<b>\$274</b>	<b>\$340</b>

#### Assumptions

1. Siphons @ \$8 each, 6 weirs.
2. Water costs \$/ML of irrigation water applied plus cost of pumping source to storage/area (does not account for channel losses)
3. System pumping \$/ML of irrigation water applied from storage to field/area (does not account for channel losses)
4. Tail water pumping \$/ML of tailwater from field to storage/area (does not account for channel losses)
5. Irrigation labour hours/irrigation\*number of irrigations\*number of men\*\$22/hr
6. Rotor bucks labour hours/number of times per season\*\$22/hr
7. Chemical costs, Application costs and licence fees
8. Profit per ML of water applied is based on a (\$440 per bale\*bales/Ha – Total costs)/applied water ML/Ha.

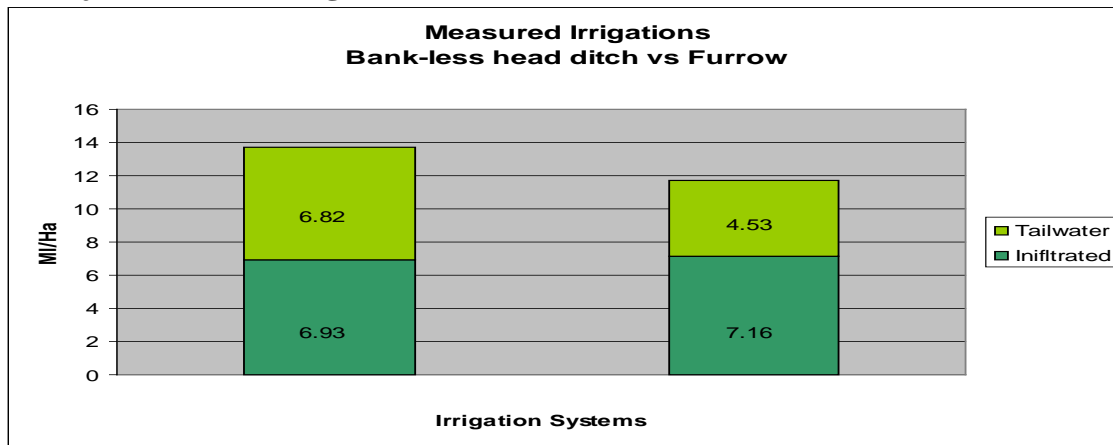
## 5.2 Bank-less Head Ditch

Total water use (infiltrated irrigation water plus effective rainfall) was similar for both the bank-less head ditch field and the adjacent furrow irrigated field (Table 3). However 5 ML/Ha more water was delivered to the bank-less head ditch field and consequently over 2.5 ML/Ha more water needed to be recycled through the tail water system (Figure 4). This results in a significant difference in the operational costs due to an increase in pumping costs. It is most likely that this difference between the systems is in response to the need to run water for a lot longer than optimal due to non-uniformity of advance in the bank-less head ditch field. Further work is required in terms of engineering design and optimisation to determine whether or not this can be mitigated and improved.

The limiting factor in the performance of the GPWUI of the bank-less head ditch field was the lower than average Pima yields and a poor market price. Although price is uncontrollable to an extent there is some evidence to suggest that yield was affected by system design and management.

A direct comparison cannot be drawn due to a significant varietal difference and a poorer than expected pima yield. The limits in the current design have been identified and are currently being worked on for next season. Further investigation is required in order to determine whether these systems can perform better.

**Figure 4: Comparison of the water use between the Bank-less Head Ditch field and the adjacent furrow irrigated field.**



**Table 4: Irrigation Performance – Bank-less Head Ditch versus furrow irrigation.**

	Minimum Standard	Bank-less Head Ditch	Furrow
Variety	-	PIMA	71BR
Yield (bales/ha)	-	4	9.94
Number of Irrigations	-	8	9
Irrigation Water Applied (ML/ha)		16.75	11.69
Infiltrated Irrigation Water (ML/ha)		6.93	7.16
Effective Rain (ML/ha)	-	2.22	2.2
Application Efficiency (%)	80	84 ± 3	88 ± 5
Distribution Uniformity (%)	90	97 ± 3	95 ± 5
GPWUI (bales/ML)	1.1	0.45	1.06

### 5.3 PTB

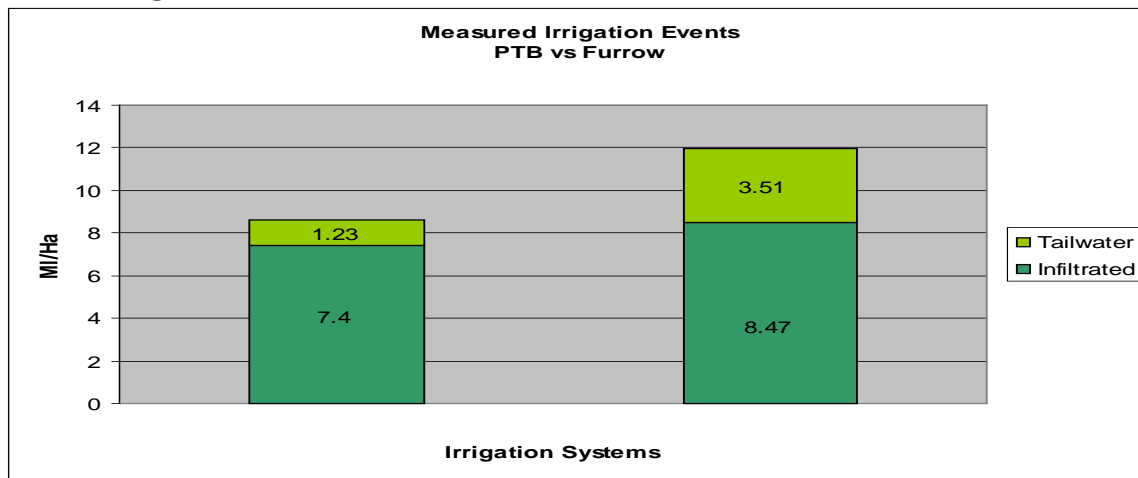
Total water use (infiltrated irrigation water plus effective rainfall) of the furrow irrigated field was 1 ML/Ha higher than the PTB (Table 5). As such 3.5 ML/Ha more water was delivered to the furrow field and over 2.5 ML/Ha more water was recycled through the tailwater system (Figure 4). This difference in water delivery, reticulation and usage significantly impacts upon operational costs (Table 6).

The yield was significantly different between the fields highlighted in the GPWUI (Table 5). Although yield is determined by a number of agronomic factors there is some

evidence to suggest that this is system related. The AE and DU was much higher for the PTB field and it also received one less irrigation (Table 5).

There is a 60% labour savings recorded for the PTB's compared to the furrow system. The labour using the PTB as reported by the grower was less physical and a logistically easier system to manage. Both systems have been improved through the season and planned changes to irrigation practices will result in further improvements next year. It would be great to be able to monitor and document this progress towards optimisation.

**Figure 5: Comparison of the water use between the PTB field and the adjacent furrow irrigated field.**



**Table 5: Irrigation performance – PTB versus furrow irrigation.**

	Minimum Standard	Pipe Through The Bank	Furrow
Variety	-	289BR	71BR
Yield (bales/ha)	-	10	8.6
Number of Irrigations	-	8	9
Irrigation Water Applied (ML/ha)		8.63	11.98
Infiltrated Irrigation Water (ML/ha)		7.4	8.47
Effective Rain (ML/ha)	-	2.62	2.62
Application Efficiency (%)	80	87 ± 9	79 ± 5
Distribution Uniformity (%)	90	93 ± 2	91 ± 6
GPWUI (bales/ML)	1.1	0.88	0.78

**Table 6 - Economic comparison - PTB and furrow irrigated field.**

	Pipe Through the Bank	Furrow
Area – Green Hectares	61	70
Year of Development	2000	1975
Development Costs (\$/Ha)		

System Purchase	\$378 (PTB's)	\$118 (Siphons)
Land Levelling	=	=
Supply & Drainage	=	=
<b>TOTAL</b>	<b>\$378</b>	<b>\$118</b>
<b>Yield</b>	<b>10</b>	<b>8.6</b>
Water Applied (ML/Ha)	8.63	11.98
<b>Average Operating Costs (\$/Ha)</b>		
Water Costs (\$35/ML)	\$302	\$419
Supply Pumping (\$10/ML)	\$86	\$120
Tail Water Pumping (\$8/ML)	\$10	\$28
<b>Labour</b>	<b>\$20</b>	<b>\$50</b>
<b>TOTAL (A)</b>	<b>\$418</b>	<b>\$617</b>
<b>Irrigation Repairs And Maintenance (\$/Ha)</b>		
System Maintenance	=	=
Channel Maintenance	=	=
Channel Herbicides	=	=
Rotor Bucks	\$0	\$4
Laser Levelling	=	=
<b>TOTAL (B)</b>	<b>\$0</b>	<b>\$4</b>
<b>Input Costs (\$/Ha)</b>		
Input Costs	\$902	\$932
<b>TOTAL (C)</b>	<b>\$902</b>	<b>\$932</b>
<b>TOTAL COST(A+B+C)</b>	<b>\$1320</b>	<b>\$1553</b>
<b>Gross Margin(\$/ML/Ha)</b>	<b>\$357</b>	<b>\$186</b>

*Assumptions*

1. Siphons \$8 each, 31 \*10" PTB @ \$741 each
2. Water costs \$/ML of irrigation water applied plus cost of pumping source to storage/area (does not account for channel losses)
3. System pumping \$/ML of irrigation water applied from storage to field/area (does not account for channel losses)
4. Tail water pumping \$/ML of tailwater from field to storage/area (does not account for channel losses)
5. Irrigation labour hours/irrigation\*number of irrigations\*number of men\*\$22/hr
6. Rotor bucks labour hours/number of times per season\*\$22/hr
7. Chemical costs, Application costs and licence fees
8. Profit per ML of Applied Water is based on (\$440/bale\*bales/Ha-Total cost)/ ML Water applied

## 5.4 Lateral Move

The total water use (infiltrated irrigation water plus effective rainfall) was 30% less for the lateral move field compared to furrow irrigated field (Table 7). The water delivered to the furrow field was 50% more than the lateral move system. This resulted in significant operational costs associated with increased pumping costs for water applications and tailwater reticulation (Table 8).

This dramatic difference in total water use with little yield variation results in the lateral move being assessed to perform much better than the furrow irrigated field in terms of GPWUI (Table 7). In fact the lateral move exceeded the minimum standards for both indices. The significant difference between the two fields highlights the advantages of an overhead system. The lateral move is a closed system and applies small amounts of water to the plant so that the profile is never fully saturated and tailwater is never

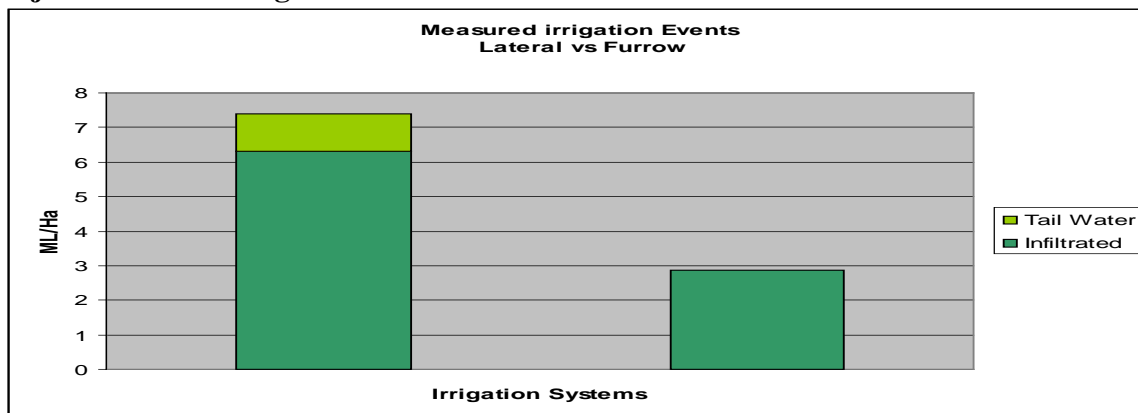
produced. This minimises losses to deep drainage and the impacts of waterlogging. As such these systems generally make better use of in crop rainfall and sub soil moisture (Table 7).

The significant difference also highlights the importance of optimisation of furrow irrigation. The furrow irrigation involved shifts of 20 hours and the AE and DU was consequently low. Furthermore it could be assumed that losses associated with deep drainage and waterlogging may have impacted upon performance. Improvements in management may reduce the difference in the system performance between the lateral move and the furrow irrigation and it would benefit the industry if this could be monitored and documented.

The overhead and furrow system have performed on par in bales returned per hectare but the lateral move resulted in much better dollar per megalitre (Table 8). This is driven by the better use of in crop rainfall and most likely a greater use of sub soil moisture resulting in significant water savings which immediately results in a 50% reduction in costs associated with water alone (Table 8). The significantly higher development costs for the overhead system need to be accounted for. There was a 30% reduction in labour requirements but the irrigator did note that the type of labour required also changes from a physical role to more of a technical role (Table 8).

The overhead and furrow irrigation system where both managed under limited water, resulting in lower than average yields. The furrow irrigated field was picked a week to ten days early.

**Figure 6: Comparison of the water use between the Lateral Move Field and the adjacent furrow irrigated field.**



**Table 7: Irrigation performance – Lateral Move versus furrow irrigation.**

	Minimum Standard	Lateral Move	Furrow
Variety	-	289BR	DP611BR
Yield (bales/ha)	-	8.12	8.1
Number of Irrigations	-	17	5
Irrigation Water Applied (ML/ha)	-	3	7.4

<b>Infiltrated Irrigation Water (ML/ha)</b>	-	3	6.3
<b>Effective Rain (ML/ha)</b>	-	3.31	2.34
<b>Application Efficiency (%)</b>	<b>80</b>		75 ±17
<b>Distribution Uniformity (%)</b>	<b>90</b>		89 ± 14
<b>GPWUI (bales/ML)</b>	<b>1.1</b>	<b>1.3</b>	<b>0.93</b>

**Table 8: Economic comparison - Lateral Move and furrow irrigated field.**

	<b>Lateral Move</b>	<b>Furrow</b>
Area – Green Hectares	82	56
Year of Development	2004	1986
<b>Development Costs (\$/Ha)</b>		
System Purchase	\$3414	\$45
Land Levelling	\$741	\$1482
Supply & Drainage	\$360	\$540
<b>TOTAL</b>	<b>\$4515</b>	<b>\$2067</b>
Yield	8.12	8.1
Water Applied (ML/Ha)	3.0	7.4
<b>Average Operating Costs (\$/Ha)</b>		
Water Costs (\$26/ML)	\$78	\$192
Supply Pumping (\$14/ML)	\$42	\$104
Lateral Move pumping costs	\$90	
Tail Water Pumping (\$8/ML)	\$0	\$10
Labour	\$42	\$60
<b>TOTAL (A)</b>	<b>\$252</b>	<b>\$366</b>
<b>Irrigation Repairs And Maintenance (\$/Ha)</b>		
Service	\$18	\$0
Maintenance	\$30	\$0
Channel Maintenance	\$50	\$50
Channel Herbicides	\$24	\$35
Rotor Bucks	\$0	\$4
Laser Levelling	=	=
<b>TOTAL (B)</b>	<b>\$122</b>	<b>\$89</b>
<b>Input Costs (\$/Ha)</b>		
Input Costs	\$937	\$1025
<b>TOTAL (C)</b>	<b>\$937</b>	<b>\$1025</b>
<b>TOTAL COST(A+B+C)</b>	<b>\$1311</b>	<b>\$1480</b>
<b>Gross margin (\$/ML/Ha)</b>	<b>\$754</b>	<b>\$281</b>

*Assumptions*

1. Siphons @ \$8 each, lateral move approx \$280,000.
2. Water costs \$/ML of irrigation water applied plus cost of pumping source to storage/Ha (does not account for channel losses)
3. Lateral move (17 irrigations\*30hrs/irrigation\*12l diesel/hr\*\$1.2)/Area
4. System pumping \$/ML of irrigation water applied from storage to field/Ha (does not account for channel losses)
5. Pumping costs/ML of Lateral move (30hrs\*17 irrigations\*Diesel12l/hr\*\$1.2)/Ha
6. Tail water pumping \$/ML of tailwater from field to storage/Ha (does not account for channel losses)
7. Irrigation labour hours/irrigation\*number of irrigations\*number of men\*\$22/hr
8. Rotor bucks labour hours/number of times per season\*\$22/hr

## **6.0 Conclusions**

The investigation is in a preliminary phase. None of the alternative systems have been fully optimised. Better measures of effective rainfall are required and the amount of soil moisture used needs to be measured to improve comparisons in the future.

The siphon-less and furrow systems evaluated have shown potential to benefit from optimisation and further investigation into “how far the systems can go” is needed to provide a greater understanding of what is achievable for each.

Although the field performance was similar the furrow out performed the bank-less channel system in all irrigation performance indices. Running costs were higher for the siphon-less system as a direct result of the tail water generated driven by the need for high head heights to maintain DU.

The results of the comparison of furrow and bank-less head ditch system (although not conclusive due to varietal differences) highlighted the limits in the current design of the bank-less head ditch. This system is expected to mirror the performance of the bank-less channel system with an increase in costs associated with high rates of applied water and tailwater generated because of non-uniformity.

PTB performed on par with the furrow field. Both systems would benefit from further optimisation.

The lateral move significantly outperformed the furrow irrigated field in terms of WUE indicators, and gross margin. This was most likely a result of the ability of the lateral move to make better use of in crop rainfall and sub soil moisture but may also be determined by the fact that the furrow irrigation system has not been optimised. Optimisation is critical for a fair comparison.

The gross margin (based on growers estimates) of all the systems confirmed that a significant cost saving in labour can be achieved through the adoption of a siphon-less system at a higher cost of development. The operational costs for each system were influenced predominantly by the amount of water applied and tailwater generated by the system, having a greater effect on overall costs than either, repairs and maintenance or input costs. However, while furrow irrigation with siphons remains the dominant irrigation method in the Australian cotton industry efforts towards improving the performance and profit per megalitre of this system still remains of paramount importance.

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