Agricultural Science 2019 v1.3

IA3 high-level annotated sample response

August 2022

Research investigation (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of enterprise management or evaluation of an agricultural enterprise to develop research questions
3. analyse research evidence about enterprise management or evaluation of an agricultural enterprise
4. interpret research evidence about enterprise management or evaluation of an agricultural enterprise
5. investigate phenomena associated with enterprise management or evaluation of an agricultural enterprise through research
6. evaluate research processes, claims and conclusions about enterprise management or evaluation of an agricultural enterprise
7. communicate understandings and research findings, arguments and conclusions about enterprise management or evaluation of an agricultural enterprise.

Queensland Government
QCAA Queensland Curriculum & Assessment Authority
220770
For all Queensland schools

Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of enterprise management or evaluation of an agricultural enterprise to develop research questions
5. investigate phenomena associated with enterprise management or evaluation of an agricultural enterprise through research

The student work has the following characteristics:	Marks
• informed application of understanding of enterprise management or evaluation of an agricultural enterprise demonstrated by a considered rationale identifying clear development of the research question from the claim • effective and efficient investigation of phenomena associated with enterprise management or evaluation of an agricultural enterprise demonstrated by – a specific and relevant research question – selection of sufficient and relevant sources.	5–6
• adequate application of understanding of enterprise management or evaluation of an agricultural enterprise demonstrated by a reasonable rationale that links the research question and the claim • effective investigation of phenomena associated with enterprise management or evaluation of an agricultural enterprise demonstrated by – a relevant research question – selection of relevant sources.	3–4
• rudimentary application of understanding of enterprise management or evaluation of an agricultural enterprise demonstrated by a vague or irrelevant rationale for the investigation • ineffective investigation of phenomena associated with enterprise management or evaluation of an agricultural enterprise demonstrated by – an inappropriate research question – selection of insufficient and irrelevant sources.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis and interpretation

Assessment objectives

3. analyse research evidence about enterprise management or evaluation of an agricultural enterprise
4. interpret research evidence about enterprise management or evaluation of an agricultural enterprise

The student work has the following characteristics:	Marks
• systematic and effective analysis of qualitative data and/or quantitative data within the sources about enterprise management or evaluation of an agricultural enterprise demonstrated by – the identification of sufficient and relevant evidence – thorough identification of relevant trends, patterns or relationships – thorough and appropriate identification of limitations of evidence • insightful interpretation of research evidence about agricultural enterprise management or evaluation of an agricultural enterprise demonstrated by justified scientific argument/s.	5–6
• effective analysis of qualitative data and/or quantitative data within the sources about enterprise management or evaluation of an agricultural enterprise demonstrated by – the identification of relevant evidence – identification of obvious trends, patterns or relationships – basic identification of limitations of evidence • adequate interpretation of research evidence about agricultural enterprise management or evaluation of an agricultural enterprise demonstrated by reasonable scientific argument/s.	3–4
• rudimentary analysis of qualitative data and/or quantitative data within the sources about enterprise management or evaluation of an agricultural enterprise demonstrated by – the identification of insufficient and irrelevant evidence – identification of incorrect or irrelevant trends, patterns or relationships – incorrect or insufficient identification of limitations of evidence • invalid interpretation of research evidence about agricultural enterprise management or evaluation of an agricultural enterprise demonstrated by inappropriate or irrelevant argument/s.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Conclusion and evaluation

Assessment objectives

4. interpret research evidence about enterprise management or evaluation of an agricultural enterprise

6. evaluate research processes, claims and conclusions about enterprise management or evaluation of an agricultural enterprise

The student work has the following characteristics:	Marks
• insightful interpretation of research evidence about enterprise management or evaluation of an agricultural enterprise demonstrated by justified conclusion/s linked to the research question • critical evaluation of the research processes, claims and conclusions about enterprise management or evaluation of an agricultural enterprise demonstrated by – insightful discussion of the quality of evidence – extrapolation of credible findings of the research to the claim • suggested improvements and extensions to the investigation that are considered and relevant to the claim.	5–6
• adequate interpretation of research evidence about enterprise management or evaluation of an agricultural enterprise demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of the research processes, claims and conclusions about enterprise management or evaluation of an agricultural enterprise demonstrated by – reasonable description of the quality of evidence – application of relevant findings of the research to the claim • suggested improvements and extensions to the investigation that are relevant to the claim.	3–4
• invalid interpretation of research evidence about enterprise management or evaluation of an agricultural enterprise demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of the research processes, claims and conclusions about enterprise management or evaluation of an agricultural enterprise demonstrated by – cursory or simplistic statements about the quality of evidence – application of insufficient or inappropriate findings of the research to the claim • ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and research findings, arguments and conclusions about enterprise management or evaluation of an agricultural enterprise

The student work has the following characteristics:	Marks
• effective communication of understandings and research findings, arguments and conclusions about enterprise management or evaluation of an agricultural enterprise demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and research findings, arguments and conclusions about enterprise management or evaluation of an agricultural enterprise demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

See IA3 sample assessment instrument: Research investigation (20%) (available on the QCAA Portal).

Sample response

Criterion	Marks allocated	Provisional marks
Research and planning Assessment objectives 2, 5	6	6
Analysis and interpretation Assessment objectives 3, 4	6	6
Conclusion and evaluation Assessment objectives 4, 6	6	5
Communication Assessment objective 7	2	2
Total	**20**	**19**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Research and planning [5–6]

a considered rationale identifying clear development of the research question from the claim

The rationale shows evidence of careful, deliberate thought. The sequence of ideas involved in the development of the research question from the claim is easily seen.

Claim

The claim chosen is 'Sustainable natural resource use is essential for the continuation of agricultural industries in Australia'.

Rationale

Agricultural industries in general are constantly faced with the ever-growing challenge of feeding, clothing and sheltering the world's population. To meet food demand expected by 2050, the sector must boost its capacity significantly in a relatively short period of time so that output grows by 70 percent or more over the next four decades, meets continuing future challenges in terms of protecting the environment and deals with changing climates (Motes, 2016).

Modern farming practices are being adopted to meet the challenges of increasing production demands using improved varieties of agricultural plants (food and fibre crops) which are better adapted to a changing environment; and using technologically advanced equipment which has enabled farmers to make sustainable management decisions. To investigate this claim, the term natural resources is referring to substances occurring in the Earth's biosphere (e.g. water, soil, air, etc.) which can be exploited for economic gain. For the purpose of this investigation, water will be the focus, as it is a vital natural resource for plant and animal agricultural industries that ensures high levels of food and fibre production.

Research and planning [5–6]

selection of sufficient and relevant sources

Sources are scientific and provide enough evidence for the development of a scientific argument that responds to the research question.

Research and planning [5–6]

a specific and relevant research question

The research question identifies the phenomenon to be investigated and allows for the collection of sufficient and relevant data.

The research question has been developed from the claim and is connected to the topics covered in the unit.

Analysis and interpretation [5–6]

identification of sufficient and relevant evidence

The evidence is adequate for the purpose of responding to the research question and can support a valid conclusion. The evidence is applicable to the formation of the scientific argument.

Communication [2]

fluent and concise use of scientific language and representations

Data is clearly represented so that the trends, patterns and relationships can be easily identified.

The Australian cotton industry has a high dependence on available fresh water (Cotton Australia, 2016). For the cotton industry to continue, water must be used in a sustainable manner. Water is critical to the cotton industry to maximise crop yields and fibre quality and the average irrigation requirement is 7.8 megalitres per hectare which is second only to rice (Cotton Australia, 2016). Figures released by the Cotton Research and Development Corporation (CRDC) and Cotton Australia (2014) state growers use 10 to 15 percent of the irrigation water annually used for agricultural purposes in Australia and hence the reason for choosing cotton as the focus industry for water use in agriculture.

Further research work is being carried out by the cotton industry to investigate the efficiencies of water management achievable by different irrigation systems. As such, this investigation proposes the following research question:

Research Question

How do centre-pivot and lateral-move irrigation machine systems (CPLM) compare with traditional furrow irrigation systems in terms of water use efficiency in cotton production?

Arguments and evidence

Cotton is only planted when sufficient water is made available from rivers and groundwater sources through government regulated water licensing schemes.

Irrigation is the most significant factor that impacts on water use efficiency in terms of how and when water is applied. Currently, at least 80 percent of the Australian cotton area is irrigated using traditional gravity surface furrow irrigation systems. However, there is increasing use of the centre-pivot and lateral-move irrigation machine systems, up from 10% in 2008 to ~17% in 2013 (9% lateral move and 8% centre pivots) (Roth et al, 2013).

From Figure 1, it can be identified that water saving is one of the major driving factors behind this increase (Roth et al, 2013: Smith et al, 2014), with other factors that contribute to water efficiency including reduced waterlogging and improved water distribution. However, most likely due to the increase in the number of CPLM systems being used since 2001, irrigators are now less worried about waterlogging and water distribution compared to other issues, due to the grower being able to respond to rainfall events more effectively with a CPLM system which provides a more direct path for water to the root system of cotton plants.

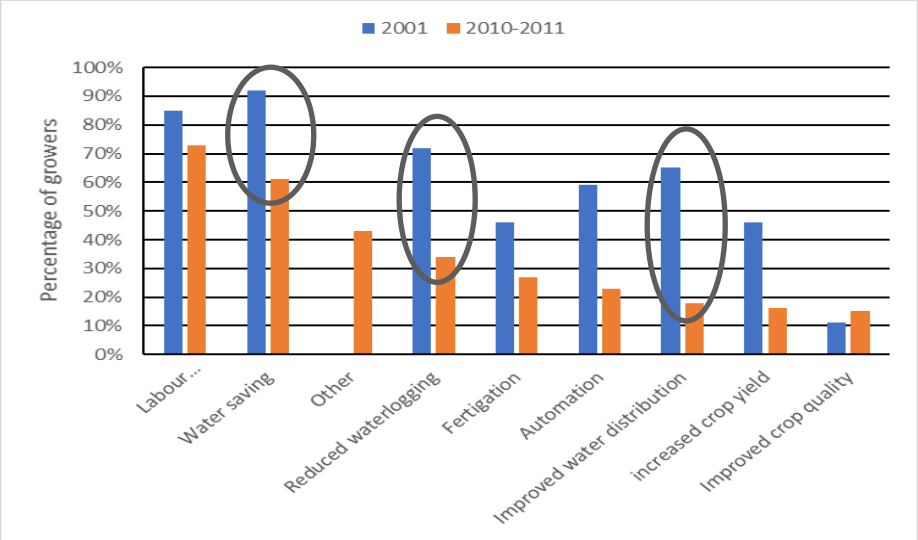


Figure 1: Issues driving adoption of CPLM systems (Smith et al, 2014).

Analysis and interpretation [5–6]

thorough identification of relevant trends, patterns or relationships

The response identifies relationships in a way that is not superficial or partial. Identified relationships are applicable and directly connected to the formation of the scientific argument.

The 2001 results in Figure 1 came from a survey comprised of interviews with 31 growers, encompassing approximately eighty percent of all CPLM users within the cotton industry at the time. The survey provided a detailed look at the performance of these systems, and where relevant, compared them to furrow irrigation. A second study (Smith et al, 2014) reported that the initial survey of 2001 was repeated with thirty CPLM system users in the Queensland Murray Darling Basin in 2011 (i.e. approximately fifty percent of all cotton growers in Queensland who used a CPLM system). To represent the cotton industry, a second survey of twenty-eight growers was conducted in New South Wales the following year. The size of the 2010–2011 survey supports the claim that the number of CPLM systems used within the cotton industry has significantly increased since 2001.

To support this anecdotal evidence for improved water efficiency of CPLM systems, data was collected to compare the water use efficiency and yield produced by growers using CPLM and furrow irrigation systems.

Smith et al. (2014) compared the water use efficiency and yield produced by CPLM and furrow irrigation systems over a ten-year period, using the 'Irrigation Water Use Index (IWUI)'. A second study, a 4-year farmer led trial in the Gwydir Valley, compared four irrigation systems on water efficiencies using the 'Gross Production Water Use Index Comparison (GPWUI)' (CRDC, 2016).

The 'Irrigation Water Use Index (IWUI)' uses total irrigation water applied, whereas the Gross Production Water Use Index (GPWUI) includes irrigation, soil moisture and rainfall. In both cases, the higher the GPWUI/IWUI, the more water efficient (i.e. number of bales produced /ML of water) the irrigation system.

Analysis and interpretation [5–6]

identification of sufficient and relevant evidence

The evidence is appropriate for the purpose of responding to the research question. It is applicable and directly connected to the formation of the scientific argument.

Table 1: Irrigation water use index (IWUI) for Cotton crops 2011–12 and 2001 (b/ML) (Smith et al, 2014)

Year	Type of Irrigation System	Irrigation water use index (IWUI) values			
		Mean	Median	Minimum	Maximum
2011–12	Furrow	2.0	1.81	0.82	5.7
	CPLM	3.14	2.50	1.0	16.7
2001	Furrow	1.1	-	0.6	1.6
	CPLM	1.9	-	1.4	2.6

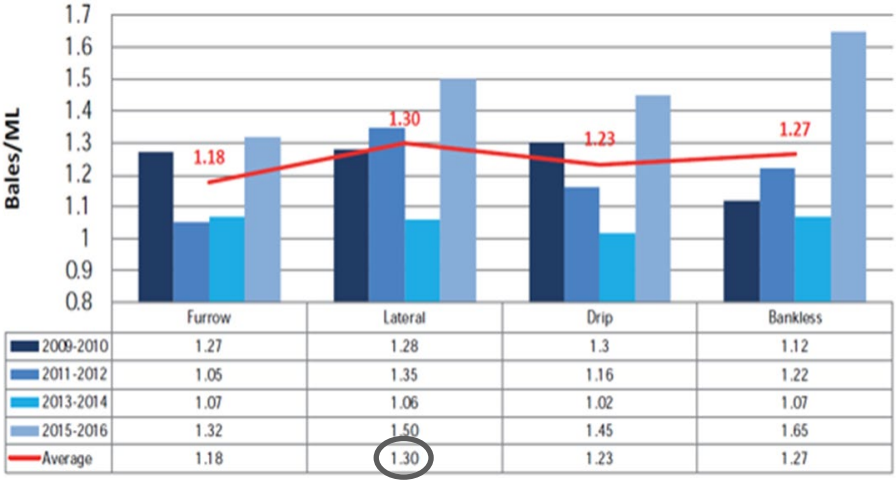


Figure 2: Gross Production Water Use Index Comparison (CRDC, 2016)

Analysis and interpretation [5–6]

thorough identification of relevant trends, patterns or relationships

The response identifies relationships in a way that is not superficial or partial. Identified relationships are applicable and directly connected to the formation of the scientific argument.

Table 1 shows an increase in the IWUI for both systems, demonstrating that Australian cotton yields are increasing with less water being used overall. There was an approximate increase of 1.25 bales/ML for the mean IWUI for CPLM systems (2001–2011/12) compared to an approximate increase of 0.9 bales /ML for the furrow system. This is also consistent with the 4-year study (Figure 2), with the lateral move having the highest average GPWUI of 1.3 bales/ML compared to the furrow system with an overall average of 1.18 bales/ML (CRDC, 2016).

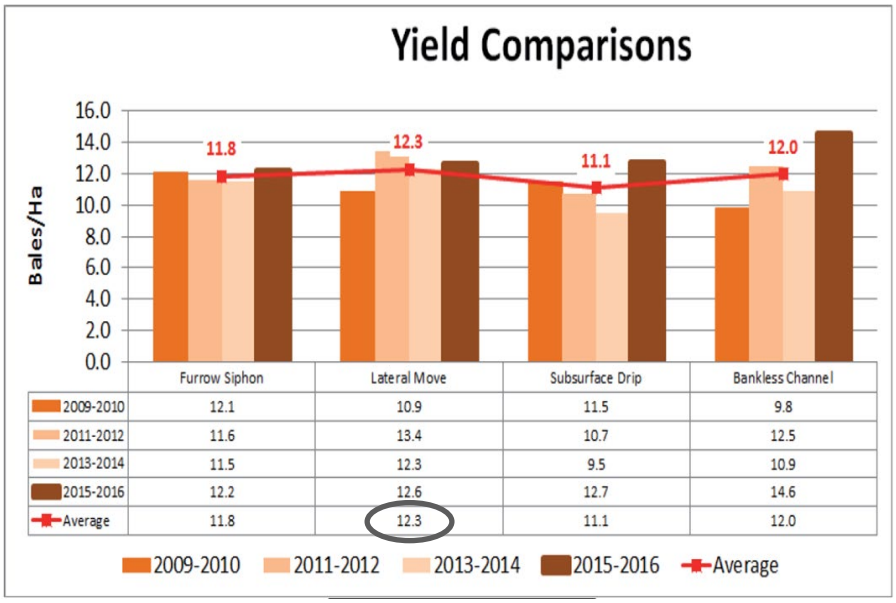
Table 2: The average yield and water applied to cotton 2011–12.

Furrow			CPLM		
Sample Size	**Average Yield (b/ha)**	**Average water applied (ML/ha)**	**Sample size**	**Average yield (b/ha)**	**Average water applied (ML/ha)**
44	10.4 (7.0–13.0)	6.2 (1.8–10.5)	50	10.1 (6.5–14.0)	4.3 (0.6–10.0)

Data in brackets represent the range in measured values (Smith et al, 2014).

Table 2 shows a similar average yield for CPLM systems and furrow systems (10.1 and 10.4 b/ha respectively), but there is a greater variability (6.5–14.0) in recorded yields for CPLM systems compared to furrow irrigation (7.0–13.0). The yield comparison graph (figure 3) below shows the eight-year average and the seasonal yields for each system. As seen in, over the eight years the lateral move produced the highest average yield of 12.29 bales per hectare compared to the furrow system with an overall average of 11.8 bales per hectare (CRDC, 2016).

There is also a significant difference between CPLM systems and furrow irrigation in terms of the amount of water applied (see table 2). This would indicate water savings by CPLM systems of around 30% compared to furrow irrigation systems (Smith et al, 2014).



	Furrow Siphon	Lateral Move	Subsurface Drip	Bankless Channel
2009-2010	12.1	10.9	11.5	9.8
2011-2012	11.6	13.4	10.7	12.5
2013-2014	11.5	12.3	9.5	10.9
2015-2016	12.2	12.6	12.7	14.6
Average	11.8	12.3	11.1	12.0

Figure 3: Yield comparisons between different types of irrigation systems (CRDC, 2016).

Analysis and interpretation [5–6]

thorough and appropriate identification of limitations of evidence

The response identifies limitations of evidence that affect how well it can be used to develop a response to the research question.

Results reported by (Smith et al, 2014) show a large variation in the yield results (Table 2) collected, which may be due to the wide area that data was collected from. There would have been environmental factors (e.g. different rainfall amounts, soil types, levels of available surface water and slope) that contributed to this variation. However, a strength of the methodology is the large sample size (i.e. sample size used for data collected during 2010–11) relative to the total number of actual CPLM system users in the cotton industry.

The large variation in this study, however, may also be due to CPLM management issues identified in a smaller study (Pendergast, 2012). It was concluded that variable IWUI/GPWUI values could indicate optimisation problems with the management of pressurised irrigation systems like centre pivot and lateral move. While this study had a small sample size and other environmental conditions are unknown, the results

still highlight the importance of management in the efficiency of CPLM systems.

Table 3: Summary of irrigation benchmarks for CPLM systems for Australian Cotton (2010/2011) (Pendergast, 2012).

IWUI $_{field}$ (bales/ML)	Average	Range	Sample Size
Lateral move	5.09	1.80-17.5	21
Centre Pivot	3.41	2.00-5.50	19
GPWUI $_{field\ effective}$ (bales/ML)			
Lateral move	1.4	0.70-1.90	21
Centre Pivot	1.33	0.98-1.88	19

Analysis and interpretation [5–6]

justified scientific argument/s

The scientific argument uses a process of sound reasoning and draws upon valid and reliable evidence.

This Gwydir Valley trial showed the ability of CPLM (i.e. lateral movement) irrigation systems to deliver precise amounts of irrigation in a timely manner to be a major contributor to achieving improved water use efficiency and yields. Refill points can be more readily adjusted in anticipation of rainfall as the system is able to add water to the profile on short notice when required.

Conclusion and evaluation [5–6]

insightful discussion of the quality of evidence

The discussion shows understanding of the features of the evidence that affect its ability to be used to respond to the research question.

A strength of the study was that the water efficiency and yield data was collected across four harvests with each growing season experiencing varying rainfall and soil moisture to allow a benchmark value (i.e. 1.30 bales/ML) to describe water use efficiency (i.e. GPWUI). Further investigations need to be done in different growing areas with different environmental conditions to allow growers to draw comparisons between types of irrigation systems and make decisions regarding the performance of CPLM systems in terms of water use efficiency and yield. Another strength of the project was the use of a gross production water use index value which includes irrigation water applied, soil moisture and rainfall. These values give a clearer indication of the total amount of water used to produce cotton (i.e. more reliable indicator of water use efficiency) rather than using irrigation water use index values which only includes the amount of irrigation water used.

In summary, the evidence collected supports the reasons why growers are continuing to switch to CPLM systems for their potential to save water to maximise rainfall capture and minimise waterlogging (i.e. maximise water use efficiency). A higher GPWUI value indicates a higher yield of cotton produced per ML of water. The evidence collected demonstrates that there are significant water savings to be had by using either a centre pivot or lateral move irrigation system (i.e. CPLM) compared to the more traditional furrow irrigation system.

Evaluation of the claim and recommendations

This research question focussed on sustainable resource management in terms of water management techniques in cotton. Specifically, the comparison of Centre Pivot and Lateral move irrigation systems to

Conclusion and evaluation [3–4] application of relevant findings of the research to the claim The findings have been applied to the claim. However, the findings have not extended beyond the water resource situation considered in the research. **Conclusion and evaluation [5–6]** justified conclusion/s linked to the research question The response uses sound reasoning and valid and reliable evidence to support conclusions that directly respond to the research question. **Conclusion and evaluation [5–6]** suggested improvements and extensions to the investigation that are considered and relevant to the claim The suggestions are connected to the claim and take into account the limitations of the evidence. **Communication [2]** fluent and concise use of scientific language and representations The response is easily understood, avoids unnecessary repetition and meets the required length. **Communication [2]**	traditional furrow systems, in terms of water use efficiency (i.e. higher yields with less water used). The evidence available was limited to a range of sources from the Cotton Australia website, Cotton Research and Development Corporation and the Australian Bureau of Statistics. Research has occurred in the cotton sector around water efficiencies for both types of irrigation system being investigated. The claim can be partially supported through the evidence provided to indicate that 'Sustainable natural resource use is essential for the continuation of agricultural industries in Australia'. CPLM systems certainly have a role to play in water efficiency savings in cotton growing (i.e. a thirty percent saving in water use compared to furrow irrigation systems and higher GPWUI values for CPLM systems compared to furrow irrigation). Based on the evidence, CPLM systems can produce higher yields with less irrigation water used compared to furrow irrigation systems. Increasingly there is more competition for water due to the rising demand from other crops, mining, urban communities and environmental flows. It is imperative farmers continue to strive to improve water use efficiency and productivity (Sustainability report, 2014). A range of water efficiency methods has improved both efficiency and yields in cotton crops grown in Australia. Decreasing availability of surface water for irrigation will encourage more cotton growers to change to more precise irrigation methods like centre pivot or lateral move to maintain existing production levels. Whilst CPLM systems have showed improved water efficiencies across study sites, what has not been factored into this investigation is the initial capital outlay for the systems as well as the ongoing running costs including electricity and maintenance compared to furrow or other ground irrigation systems. Further investigations could look at the cost benefits in energy saving for growers in other areas, such as reducing machinery operations through minimum tillage practices. Soil types also have a significant role to play in water efficiencies and as such separate studies across multiple soil types would be required to assess if CPLM systems are more efficient compared to furrow irrigation across a range of soil types. Cotton varieties grown were also not considered in terms of the relationship between more efficient water use on farms. Further research using the same varieties across both furrow and CPLM systems, across different soil types and across multiple seasons and then assessed for yield, would be required to see if this was also a significant impact on water efficiencies on cotton farms. Word count:1982 # References Cotton Australia (2016) Sustainability Fact sheet – Water Use Efficiency in the Cotton Industry CRDC (2016) Grower Led Irrigation System Research in the Gwydir Valley System Comparison Trial 2009 – 2016 Motes, W.C. (2016) Modern Agriculture and Its Benefits – Trends, Implications and Outlook

acknowledgment of sources of information through appropriate use of referencing conventions Sources of information are acknowledged using a referencing style that is suitable for the purpose of the essay.	Pendergast (2012) In Cotton Catchment Communities CRC (2005–12) The Australian cotton water story… A decade of Research & Development 2002–12 Roth, G, Harris, G, Gillies, M, Montgomery, J & Wigginton, D (2013) Water-use efficiency and productivity trends in Australian irrigated cotton: a review. P Smith, J Foley, S Priest, S Bray, J Montgomery, D Wigginton, J Schultz, R Van Niekerk (2014) A Review of Centre Pivot and Lateral Move irrigation installations in the Australian Cotton Industry