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Part 1 - Summary Details

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

CRDC Project Number: NEC1501

Project Title: Development of a pump efficiency monitor for use in the Australian cotton industry.

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CRDC Research Program: 1 Farmers

Part 2 – Contact Details

Administrator: Prof Craig Baillie, Director.
Organisation: National Centre for Engineering in Agriculture
Postal Address: P9 Building, USQ, West St, Toowoomba, QLD, 4350
Ph: 07 4631 2071 **Fax:** 07 4631 1870 **E-mail:** craig.baillie@usq.edu.au

Principal Researcher: Mr Gary Sandell, Research Engineer.
Organisation: National Centre for Engineering in Agriculture
Postal Address: P9 Building, USQ, West St, Toowoomba, QLD, 4350
Ph: 07 4631 5396 **Fax:** 07 4631 1870 **E-mail:** gary.sandell@usq.edu.au

Supervisor: Dr Joseph Foley, Senior Research Fellow.
Organisation: National Centre for Engineering in Agriculture
Postal Address: P9 Building, USQ, West St, Toowoomba, QLD, 4350
Ph: 07 4631 1559 **Fax:** 07 4631 1870 **E-mail:** joseph.foley@usq.edu.au

Signature of Research Provider Representative: ______________________

Date Submitted: ______________

Part 3 – Final Report

Energy costs are the second largest gross margin cost item for Australian cotton growers, after wages. Half of this cost is consumed in pumping water for irrigation. Therefore, small improvements in pump efficiency make significant improvements to the bottom line of cotton production. Pump efficiency improvements significantly reduce greenhouse gas emissions from cotton production. Improvements in pump efficiency can also result in increased water harvest volumes. Production and gross income is directly proportional to available water. Small improvements in water harvest volumes have a large, positive impact on gross income, profit and viability of the Australian cotton industry.

The primary aim of this project was to obtain a better understanding of the energy efficiency of pump installations in the Australian cotton industry. To do this, the project undertook a number of areas of investigation. Broadly, these areas are:

1. Characterise Pumping Systems in the Australian Cotton Industry.
2. Improve Pumping System Performance in the Australian Cotton Industry.
3. Increase industry awareness of pump operating parameters and opportunities for improvement.

This project is principally reported in the attachment: 'The performance of pumping systems in the Australian cotton industry.' (the report). This report outlines, in detail, the objectives, methods, results, outcomes and opportunities resulting from the project. The report is intended to be a document containing the current knowledge of pumps in the Australian cotton industry and present technical aspects in a reader-friendly manner. This report is intended for public release. The following section describes the report in broad terms.

The performance of pumping systems in the Australian cotton industry.

Part 1: Scoping Survey.

This part of the report characterises the pumping systems used in the Australian cotton industry. The scoping review identifies and quantifies the types of pumps predominately used in each region, the current setup and variation of pump stations, and identifies regional specific issues related to pumping water.

Data was collected from two main sources, which are: 1) a survey conducted in conjunction with Roth Rural, 2015 and Roth Rural (pers. comm.) and, 2) data collected directly from conversations with growers and from performing pump tests.

Part 2: Energy Benchmarks.

It is critical to be able to evaluate the performance of a pump in relation to the rest of the industry in absolute terms. To do this, it is critical that an industry pump performance benchmark is available. Pump efficiency drives the cost of pumping in the Australian cotton industry. (Pumping consumes approximately half of the second-largest gross margin cost item: energy.) Numerous pump assessments have been and are being performed. This part of the report establishes benchmark pumping energy use for the Australian cotton industry.

This analysis is based on the IPERT data set that is held by the NCEA. The IPERT data set contains 932 individual pump tests and is therefore a representative and valuable benchmark data set. Of these records, 296 records are tests on pumps used in Australian cotton production. This analysis focuses on this Australian cotton data set. This data set includes all makes, models and sizes of pumps tested in the Australian cotton industry.

Part 3: Pump Performance Evaluations.

This part of the report presents an analysis of the collective results of all pump assessments to discern overall trends and outcomes. A total of 25 pumps were assessed under the current project. Each pump underwent rigorous performance measurement and assessment and this provides certainty in conclusions. An additional 14 pump assessments using the same methodology were completed during previous projects. These results, held by the NCEA, were added to the data set analysed in this part of the report to increase the certainty of the results.

Part 4: Validating the 'China' Pump Curves.

The objective of this part of the report is to present the pump performance data provided by the manufacturer and use the measurements from the many pump evaluations available to draw conclusions regarding the reliability and/or limitations of the performance curves.

Part 5: Case Studies.

This part of the report presents the case studies that were developed under the project. The topics of the case studies were identified through industry consultation. The case studies are:

5-1 Increasing the head on a pump – Is it desirable?
5-2 Suction pipe diameter.
5-3 Pump cavitation.
5.4 The performance of a worn pump.
5-5 Off-chart pump efficiency.

Part 6: Industry Actions.

Industry actions were developed from consideration of all parts of the report and all aspects of the project and are presented in this part of the report.
Principal industry actions derived from the quantification of the pump fleet are as follows:

1. Promote the economic return of proper pump evaluations.
2. Adopt the pump performance benchmarks developed in this project.
3. Properly validate common pump charts.
4. Address specific issues identified on the pump assessments

Pump performance assessments.

The 'De-identified pump performance assessment' document.

In addition to the report, a second document, entitled 'De-identified pump performance assessment.' is attached. This document presents, in a de-identified format, the standard pump performance assessment report that was delivered to each growers who participated in this project. This document:

- Outlines the assessment methodology used to perform an individual pump assessment.
- Presents measured performance results of the pump(s) tested at the site, such as head, flow rate and fuel or electricity use.
- Plots the performance of the pump the energy benchmarks presented in 'Part 3: Energy Benchmarks.' This uses consistent energy efficiency metrics quantifies to benchmark performance of the pump in absolute terms.
- Presents the best operating point and other critical operational factors.
- Presents the duty range of the pump(s) on their respective pump chart(s).
- Presents recommendations such as any operational or capital changes with a simple economic cost benefit analysis (CBA) is for each recommendation. This CBA takes different forms depending on the report. The cost of implementation can vary greatly depending on the individual circumstances of the grower. As is the case in the 'De-identified pump performance assessment' document, benefits are presented. In other cases, an IRR look-up table is presented, such Table 3.1, pp 38 in the report. In any case, adequate information is provided for the grower, who is in better position to know the costs associated with the recommendation, to evaluate the costs and benefits of each recommendation.

Individual pump performance assessments

The individual pump assessment reports were presented to the growers for each of the 25 pumps assessments. These reports contain individual grower information and are confidential.

Performance against project objectives and milestones (tasks).

The following section lists the stated project objectives and milestones and links them with the relevant sections in this report.

Pumping systems in use across the industry were reviewed during 65 regional site visits. Specific information, such as the age and make of pump and motor and the annual use, for example, was collected from all of these participants. At these site visits, tailored information was provided to address the needs and issues identified by the grower. Of these 65 participants, twenty sites were selected for pump assessments. The above information is contained in the report in Part 1 under the 'Direct collection data' heading, pp 6 and in Part 3 under the heading 'Methodology' pp 31. In addition to these site visits the industry was contacted more generally as part of the extensive survey data collected in conjunction with Roth Rural (2015). Survey responses covered 27% of the 2013-14 irrigated cotton production area and 35% of the dryland cotton area. This methodology is explained in Part 1 of the report under the heading 'The Roth Rural survey methodology' pp 5. These activities directly address Milestone '1.1 Review pumping systems in use across the Cotton Industry'.

A scoping report characterising pumping systems used in the Australian Cotton Industry is presented as Part 1 of the report. This fulfils Milestone '1.4 Report on pumping systems within the Australian Cotton Industry.'

As reported in the Introduction in Part 3 of the report (pp 31), a total of 25detailed energy assessments were performed on large mixed flow pump stations and reported to growers. These 25 pump performance evaluations exceed the combined total of 10 pump performance assessments listed in Milestones 1.2 and 2.1.

In each of these cases, strategies to improve pump performance were developed. Pump performance was evaluated to identify opportunities for improvements in pump management and pump station design. This information was report to the grower in each case. Please refer to the document 'De-identified pump performance assessment' for specific details. These reports fulfil the requirements of Milestones 1.3 and 2.2 (which are associated with Milestones 1.2 and 2.1). These 25 pump performance evaluations for 20 sites exceed the combined total of 10 pump performance evaluations required under these milestones.

Part 4 of the report shows that there is was very limited set of data used in the development of the current commercially available pump performance curve for the 26HBC-40 model pump (and that this is the case for all pumps manufactured by Wuxi pump works). Refer to Figure 4.2, pp 47, of the report.

In fulfilment of Milestone 2.3 'Determine pump performance curves for the commonly occurring pump 26HBC-40', standard pump performance curves for the 26HBC-40 model of pump were determined from the pump performance assessment data. This methodology is discussed under the heading 'Measured performance points and accuracy of the pump curves'; pp. 49 of the report. These standard pump performance curves are presented in Figure 4.5; pp 52 of the report. The efficiency of the 26HBC-40 model of pump is also discussed under the heading 'Measured performance points and accuracy of the pump curves' (pp. 49) and presented in Figure 4.6; pp. 53. An additional, non-standard, pump performance curve was produced for the pump speed of 380 rpm and this is presented in Figure 4.7; pp. 54 of the report. Off-chart pump efficiency is explored in case study 5-5; pp. 77 of the report.

Milestone 3.1 'Increase industry awareness of pump station performance and energy efficiency' was addressed by:

- Presenting at the 18th Australian cotton conference.
- 'Improving Performance in Surface Irrigation' field day, Mungindi, 15th October 2015.
- 'Storage improvement options in St George' field day, St George, 11th March 2015.
- 'Water Use Efficiency Info Session', Mungindi, 25th March 2015.

In addition to these four grower-specific energy efficiency information sessions, industry awareness of pump station performance and energy efficiency also addressed by:

- Sixty-five individual grower discussions.

- The report entitled ‘The performance of pumping systems in the Australian cotton industry.’
- Five case studies.

Also, a presentation was made to an ACIAR group visiting from Africa under the ‘Farm mechanisation and conservation agriculture for sustainable intensification’ (FACASI) project. The presentation, which was entitled ‘Improving Pump Efficiency on Australian Irrigated Cotton Farms’ gave a general overview of the industry and pump performance.

There were more than 1,900 attendees at the 18th Australian cotton conference, 2 – 4 August, 2016. A ‘three-minute thesis’ was presented at the ‘Bright Sparks – Energy Frontiers’ session. This session was attended by approximately fifty people. The three minute thesis presented preliminary outcomes of the project and focused on the practical, grower outcomes of the project.

A field day, entitled ‘Improving Performance in Surface Irrigation’, organised by the Healthy Headwaters Water Use Efficiency project, was held in Mungindi, Qld. 15th October 2015. The field day, which was a day-long event, was attended by 24 growers. A presentation was made in one of the four segments in the day, which was entitled ‘Improving Pump Efficiency on Australian Irrigated Cotton Farms.’

A field day, entitled ‘Storage improvement options in St George’, organised by the Healthy Headwaters Water Use Efficiency project, was held in St Georg, Qld. 11th March 2015. The field day, which was a day-long event, was attended by approximately 20 growers. A presentation was made in one of the four segments in the day, which was entitled ‘Improving Pump Efficiency on Australian Irrigated Cotton Farms.’

A field day, entitled ‘Water Use Efficiency Info Session’, organised by the Healthy Headwaters Water Use Efficiency project, was held in Mungindi, Qld. 25th March 2015. The field day, which was a day-long event, was attended by approximately 20 growers. A presentation was made in one of the four segments in the day, which was entitled ‘Improving Pump Efficiency on Australian Irrigated Cotton Farms.’

A total of sixty five grower engagements were recorded. In each case, a discussion was held regarding the issues and experiences with their pump performance. This allowed for the provision of specific advice that is directly relevant to the actual pump station, rather than general, generic advice. Grower issues were often resolved during this discussion.

The report itself and the case studies in Part 5 of the report form an important suite of information that is in a user-friendly format for dissemination to the industry.

Please refer to pp. 56 to 79 of the report for the five case studies, which fulfil milestone 3.2 ‘Identify 4 case studies for potential pump station management and infrastructure improvements.’ Analysis of all grower engagement and survey information identified common, reoccurring themes and issues that were critical to the industry. A total of 5 case studies for potential pump station management and infrastructure improvements were identified from this process. The case studies therefore target critical and relevant issues. The five case studies are:

1. Increasing the head on a pump – Is it desirable?
2. Suction pipe diameter.
3. Pump cavitation.
4. The performance of a worn pump.
5. Off-chart pump efficiency.

The report (entitled ‘The performance of pumping systems in the Australian cotton industry.’) fulfils the requirements of milestone 3.3 ‘Final Report – Improved performance of pumping systems in the Australian Cotton Industry.’ This report, which is described above, details the methodology and results and makes conclusions for each area of work. Industry actions and recommendations, presented in part 6 of the report, are made by considering the entire body of work in the project. The primary industry actions are:

1. Promote the economic return of proper pump evaluations.

2. Adopt the pump performance benchmarks developed in this project.
3. Properly validate common pump charts.
4. Address specific issues identified on the pump assessments

Understanding regional differences

Differences in the cost of pumping are driven by the way water is supplied to the farm and not by the cropping region that the farm happens to be in. It is therefore important that information on all type of pumping systems be available in all districts.

Extension Opportunities.

Extension opportunities are defined by the four industry actions that are presented in part 6 of the report, which are discussed below.

1. Promote the economic return of proper pump evaluations.

It is critical that pump assessments be conducted by accredited professionals. An increased cost of pumping of only 10¢ per ML pumped is a cost increase in the order of $600,000 (100 ML/hr for 60,000 hrs). Professional advice is in the order to thousands of dollars and this investment is returned thousands of times.

Pump assessments require specialised skills and equipment and will give misleading results if not carried out correctly. The industry has an ageing fleet and as pumps are replaced or upgraded it is important that they be upgraded to the most efficient units possible. A range of significant design issues were commonly encountered as these issues significantly increased the cost of pumping.

Pump performance evaluations will:

- Provide peace of mind for the owners of well-performing pump stations.
- Provide increased grower knowledge of their pump site through operational guidelines to maximise pump efficiency and through the pump report.
- Provide substantial cost savings with short pay-back periods.
- Identify and prioritise minor improvements.
- Identify and prioritise major capital upgrades.
- Increased volumes of water harvest.
- Increased grower knowledge of their pump site, enabling more efficient operation.
- Improved knowledge and performance of the industry as a whole.
- Improved future viability through increased pump efficiency.

2. Adopt the pump performance benchmarks developed in this project.

It is critical to be able to evaluate the performance of a pump in relation to the rest of the industry. The value of the cotton industry pump performance benchmarks is difficult to understate. The benchmarks presented in Part 2 of the report have been developed from an extensive data set and are accurate. It is therefore recommended to adopt and make available the pump performance benchmarks presented in Part 2 of the report. In particular, those resented in Figures 2.3, 2.4, 2.5 and 2.6. Figure 2.1 provides a useful explanation of these figures.

It is important that the industry understands that to properly compare systems, benchmark quantities must be expressed per megalitre pumped per metre of lift. This accounts for the fact that pumping energy is increased as either the volume of water of the height that the water is lifted increases. (Please refer to 'Benchmark metrics', pp 25 of the report for further explanation.)

3. Properly validate common pump charts.

Pumps should be designed to operate in the zone of highest efficiency (Figure 4.2, pp.47 of the report) for the majority of their operation.

Pumps in the industry often operate off the published pump chart. Efficiency is unknown in these areas although efficiency is known to generally decrease as duty points are pushed further to the right.

4. Address specific issues identified on the pump assessments

The project found that one-third of pumps in the Australian cotton industry are performing well below par and offer the potential for major improvements in efficiency /cost reductions. Extension activities should target the specific issues listed in this section of the report. These are:

- Pump wear typically increased cost, through increased energy consumption by 6% and up to 10%.
- The following knowledge gap was identified during the grower consultation process: An efficiency gain or improvement in the pump or motor equates to an equivalent reduction in energy use and is, therefore, a cost benefit.
- The following knowledge gap was identified during the grower consultation process: Specific Fuel Consumption is important in engine selection and operation. It is recommended that industry knowledge of the meaning and significance of specific fuel consumption (which is discussed in Part 3 of this report) be enhanced.
- Significant performance gains of 5% to 10% are available for those systems powered by older electric motors.
- Upgrading to a more efficient diesel engine is a low-cost investment that pays dividends immediately and increases system reliability.
- Cost benefits and cavitation free operation of a pump are achieved through correct suction pipe diameter, correction pipe entry and correct static suction lift.
- Partial closure of discharge valves increases pumping costs substantially. Pumps should always be operated with discharge valves fully open.
- A well on the suction side needs to be an absolute minimum of four times the diameter of the suction pipe.
- It is important to have correctly sized engines, motors and drives. Electric motor control systems are worthy of investigation.

Part 4 – Final Report Executive Summary

Energy costs are the second largest gross margin cost item for Australian cotton growers, after wages. Half of this cost is consumed in pumping water for irrigation. Therefore, small improvements in pump efficiency make significant improvements to the bottom line of cotton production. Pump efficiency improvements significantly reduce greenhouse gas emissions from cotton production. Improvements in pump efficiency can also result in increased water harvest volumes and this increases gross production and income.

The primary aim of this project was to obtain a better understanding of the energy efficiency of pump installations in the Australian cotton industry. To do this, the project undertook a number of areas of investigation. These areas of investigation are reflected by the primary project outputs, which are:

- A scoping review characterising pumping systems used in the Australian Cotton Industry. Survey responses covered 27% of the 2013-14 irrigated cotton production area and 35% of the dryland cotton area.
- Pump performance was benchmarked across the cotton industry in terms of energy, emissions and cost.
- Detailed pump performance assessments were conducted for 25 pumps. Discussions were held with a total of 65 growers as part of this process.
- Commercially available pump charts are based on a very limited amount of measured information. The validity of these pump charts is important given their scale of use and was investigated.
- Case studies were developed to address common grower issues highlighted by this process.
- Industry actions were developed by considering all project outputs.

Principal industry actions derived from this work are as follows:

1. **Promote the economic return of proper pump performance evaluations.**

Approximately one-third of pumps in the industry present opportunities for major efficiency improvements and therefore cost savings. It is critical that pump assessments be conducted by accredited professionals. Pump assessments require specialised skills and equipment and can give misleading results if not carried out correctly. Pump

2. **Adopt the pump performance benchmarks developed in this project.**

It is recommended to adopt and make available the pump performance benchmarks developed by this project. It is important that the industry understands that to properly compare systems, benchmark quantities must be expressed per megalitre pumped per metre of lift.

3. **Properly validate common pump charts.**

Pumping water consumes, on average, 46% of all energy directly consumed on Australian cotton farms. Pump curves are the keystone item when designing and installing pumping systems so their accuracy is economically important. A large degree of uncertainty remains regarding the validity of these common pump curves. Secondly, approximately one-third of test points are outside of the range covered by these pump charts. It is recommended that the pump chart for common pump models be properly validated.

4. **Address specific issues identified on the pump assessments**

A range of significant design issues were commonly encountered as these issues significantly increased the cost of pumping. Key items were:

- Knowledge gaps limiting uptake were identified as: 1) that improved efficiency reduces costs in direct proportion. 2) Specific Fuel Consumption is important in engine selection and operation.
- Pump wear typically increases costs by 6% to 10%
- Replacing older engines and motor offers 5% to 10% cost gains.
- Undersized suction pipe diameter, poor suction pipe entry and high static lifts were common and costly.
- Pumps should always be operated with discharge valves fully open.