Final Report
Summary of Project Activities

A summary of the activities and findings of the project "Measurement to Improve the Water Efficiency of On-Farm Storages in the Cotton Industry"

Cotton Catchment Communities CRC
NCEA
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Introduction

This report provides a summary of undertakings and findings from the project Measurement to Improve the Water Efficiency of On-Farm Storages in the Cotton Industry. This project ran for three years from 2008 to 2011 with funding provided by the National Water Commission through its Raising National Water Standards Program.

The project aimed to:

1. Raise industry awareness of the quantum of losses, causes of problems and ways to measure and ameliorate losses from on-farm storages.
2. Assess the significance of storage losses in a whole farm water balance.
3. Measure the evaporation and seepage losses from at least 135 on-farm storages across the Australian cotton industry (representing all valleys).
4. Measure and monitor the impact on water losses of amelioration works on up to 65 storages.
5. Test and promote the use of cost-effective tools for measuring losses from on-farm storages.
6. Identify the characteristics of efficient and inefficient storages.
7. Gather essential information for the industry to develop a best management practice for efficient management of on-farm storages.
8. Build capacity for effective measurement and amelioration of storage losses.

The structure of the project was a novel approach to utilise the commercial sector to deliver a substantial proportion of the project. It was hoped that this approach would help to build capacity for ongoing measurement activity.

Project Activities

A number of specific project tasks are discussed below. The project was managed by a part time project manager, with the bulk of the project measurement activities completed by contracted consultants. A total of 6 consulting firms were originally contracted by the project, with the supplier of the measurement equipment (Aquatech consulting) providing additional measurement capacity in the final year of the project.

Report on existing data pertaining to the number, size and location of on-farm water storages within the cotton industry.

This report was produced in late 2008. The report found that data regarding on-farm storages across Australia varies in quality and abundance. Unfortunately, data for Queensland and New South Wales is largely poor; however recent studies in the Murray Darling basin have provided some more useful data for many of the major cotton growing regions.

One of these sources suggested that the volume of water stored in ring tanks within the cotton growing catchments of the Darling Basin is 3 150 GL. Another source suggested that the total number of dams within cotton growing catchments is 401 666, with a combined surface area of 223 343 hectares. However this number included dams of all sizes and would consist mostly of dams that are not used in cotton farming systems. Ultimately, there was insufficient reported data available to make any accurate estimate of the number, size or volume of storages within the cotton industry, either as a whole, or on a catchment by catchment basis.

The report therefore recommended that additional analysis of existing data sets should be undertaken, however funding for this analysis was not possible within the project budget.

Measure seepage and evaporation losses from at least 125 storages.

A total of 136 storages received an initial measurement. Whilst the required number of measurements was eventually exceeded, the storage assessment progress was delayed and a number of measures were implemented to ensure the final target was met. Delays were caused by:

- A delay in the provision of new measurement equipment, which was not available until March 2009.
- A lack of stored water in most regions during the first season of operation, which meant there were few storages available for measurement.
- Significant periods of rainfall (including flood affected areas) in many regions during the second and third seasons, which adversely impacted the period of equipment deployment during otherwise ideal measurement conditions.
- The period of deployment was generally much longer than the 5 weeks per installation that had been predicted when the project was designed. In some regions, deployment length was severely impacted by the frequency of pumping events, whilst in other regions the skills and commitment of the operator were more likely to cause delays.
- Fewer meters were in use on the project than originally hoped, due to some constraints of the tender process (discussed in more detail below).

In the first two years of the project, these issues were addressed by:

- Encouraging consultants to hire additional meters to increase the rate of measurement. Two of the six consultants hired equipment, although neither of these consultants found it economical to do so under the contracted payment arrangements. Therefore this approach resulted in few additional measurements.
- Providing telemetry for meters in use on the project. All of the consultants had telemetry systems funded by the project, which allowed the equipment to be checked remotely so that any issues could be identified and rectified quickly and interruptions to data collection would be minimised.

In the final year of the project, it was clear that progress was still delayed and the risk of not meeting the required number of evaluations was high. By this stage, two of the original six contract consultants had left their practices entirely, further reducing the capacity for the evaluations to be completed. Two additional steps were taken to ensure that all evaluations were completed:

- The equipment provider was contracted to undertake evaluations in the Bourke and Namoi regions, where the existing contracted provider had departed.
- Providers in other regions were permitted to borrow equipment where possible from other providers who were not part of the project (for example grower organisations).

These steps, combined with generally good measurement conditions in most regions over the last year of the project, allowed the required number of evaluations to be completed.

Re-measure up to 65 of these storages once amelioration activities have been undertaken to determine the effectiveness of the particular solution

Unfortunately, only one follow up measurement was undertaken; to investigate the effect of storing water at different depths. An additional measurement was undertaken when Polyacrylamide (PAM) was applied to a storage in an effort to reduce seepage loss. However this storage had not been previously measured through the

project as it had not previously contained water. Therefore this measurement was both an initial measurement, in that it had not previously been measured, and an amelioration measurement, as an amelioration strategy was being applied during measurement. As an initial measurement, it was included above. Grower measurement prior to PAM application showed no difference in seepage rate due to PAM.

The lack of follow up measurements occurred because there was no implementation of storage amelioration during the period of the project. This was caused by three main factors:

1. Measured seepage losses were overwhelmingly low and therefore did not require amelioration in the vast majority of cases.
2. For the minority of storages where seepage amelioration was warranted, the project timeframe was too short to enable the works to be undertaken and follow up measurements to be performed. Effective seepage remediation typically involves earthworks, requiring the storage to be empty. Therefore, to be included in this project, perfectly suitable climatic conditions would have been required to ensure that storages initially contained water (so that the initial measurement could be completed), were then dry for a long enough period to have the works completed, and subsequently refilled for follow up measurement. Unfortunately, such conditions were never likely to occur within a three year period, even if the desired number of storages had required amelioration. Wet conditions over the last two years means that the handful of storages that might benefit from seepage remediation have rarely been dry enough to undertake the required works. Many growers also require a number of good seasons to build sufficient capital reserves to enable investment in these expensive operations.
3. Evaporation solutions remain uneconomical for cotton farms. When the project was originally designed, it had been hoped that development of new chemical monolayer technologies, being undertaken through other industry funded projects with commercial partners, would be complete and new products would be available for growers. However this has not been the case and no alternative products are yet available.

Whilst management solutions are cost effective in many situations, and are commonly employed by growers, implementation of these strategies does not require follow up measurement of seepage or evaporation losses, as they do not attempt to physically change these characteristics, only to minimise the surface area and length of time that water is available to be lost.

Analyse and report on the combined data from all seepage and evaporation measurements.

The data collected from all storage measurements has been analysed on an annual basis. The final analysis, which summarises all initial seepage and evaporation measurements, concluded that there were a wide range of seepage results, although the vast majority (88%) would be categorised as low (<4 mm/day). There were very few discernable trends within the data collected, indicating that both seepage and evaporation are influenced by a potentially wide range of local conditions and characteristics. A summary of this information was produced and is available on the Cotton Catchment Communities CRC website www.cottoncrc.org.au.

Produce 45 case studies of storage measurement and/or amelioration.

A total of 45 case studies were completed, with many of these published in a variety of industry publications. A booklet of seepage amelioration case studies was published during this Milestone period which has been well received by industry. This document summarised a number of examples of seepage remediation which had been conducted prior to this project. A total of 15 case studies of the cost effectiveness of potential storage structural modifications were also produced, with complementary funding provided by the Healthy Headwaters Water Use

Efficiency Project. The results of these case studies were also summarised in a separate publication. These publications are available from the Cotton Catchment Communities CRC website www.cottoncrc.org.au. These case studies were targeted specifically to provide as much data as possible on successful and unsuccessful amelioration strategies, as this data was not available from follow up storage measurements as had originally been envisaged.

Undertake 20 whole farm water balance case studies.

Whilst measured seepage losses from most storages were low, it is still widely acknowledged that storages are the major component of water loss on most farms. Whilst some research has previously been conducted on a small selection of farms, there had been little data collected across a reasonably large sample of farms from a number of cotton growing regions. The project employed two of the contracted consultants to undertake 20 whole farm water balance evaluations using the commercially available Watertrack Divider™, thus exceeding the original project requirements. Complementary funding for these case studies was also provided by the Healthy Headwaters Water Use Efficiency Project

The results showed that, on average, storages are the largest source of water loss on farm (25% of all farm water). However there was considerable variation between farms, where this figure ranged from 5% to 45%. An understanding of storage loss and regular monitoring of storage performance should therefore be of vital importance to all growers.

Compile key information for storage measurement and amelioration best management practices.

This activity had originally been specifically designed to capture the successes and failures that might be discovered when storages were ameliorated and follow up measurements were undertaken. As has been previously discussed, such amelioration did not take place and hence no new information was available from this source. Instead, a comprehensive review of existing information was completed to produce a publication summarising the best knowledge of storage measurement and amelioration available. The experience of growers who had been the focus of case studies was also extracted and included where appropriate. This information has been flagged for inclusion in an upcoming revision of the Cotton Industry WATERpak manual.

Hold a workshop to discuss future directions.

This workshop was held in August 2011. An initial meeting of the consultant network provided significant outcomes in terms of future development of the measurement technology and changes to the delivery of the service. Whereas the project was originally designed to promote the discrete measurement of seepage and evaporation losses from individual storages, the project results and the experience of growers involved in the project suggests that a more integrated approach to ongoing storage performance monitoring is likely to be more useful to growers. Thus it is quite likely that future services in this area are designed and delivered in a different way. A subsequent meeting including steering committee members and other stakeholders provided feedback for the evaluation report and recommendations for future research. This information is summarised in the project evaluation report.

Undertake an evaluation of the project.

An external contractor was engaged to produce the project evaluation plan, provide support to the project team and produce the final project evaluation report. This report was provided in October 2011.

Project Design

The project was primarily designed to encourage the measurement of losses from on-farm storages using the recently developed Irrimate™ Seepage and Evaporation Meter. This technology allowed, for the first time, a cost effective and timely assessment of the seepage and evaporation losses from an entire storage. It was believed that this technology would be able to provide incredibly useful data to growers regarding their storage losses, which were known to be the major component of all on-farm loss in most cases (Dalton et.al, 2001).

Previous irrigation extension projects within the cotton industry were often based on a traditional technology transfer approach, whereby cotton industry extension personnel would demonstrate new technologies and practices in on-farm trials and then promote their use more widely. Whilst the results from these approaches had been very positive, the irrigation extension model within the industry was changing, with much greater emphasis on alternative approaches including the potential for one-on-one consultant/mentor relationships (Wigginton and Smith, 2008). The design of the Storages Project was in part influenced by the concepts trialled within the Irrigation Knowledge Management Project, which recommended that "projects that support capacity building of consultants should be investigated, such as funding for consultants to collect water use data thus providing industry data as well as data useful for on-farm decision making" (Wigginton and Smith, 2008).

The storages project involved consultants in the following ways:

- The delivery of the primary project activity, measurement of storage losses using the Irrimate™ equipment, was tendered to consultants.
- The successful consultants met on a number of occasions during the project to discuss the measurement technology, service delivery, results and future opportunities.
- Consultants were encouraged to identify case study opportunities for promotion of the value of storage measurement.
- Consultant feedback was collected and related to improve the service.
- Additional project undertakings, such as whole farm water balance calculations and the economic analysis of storage modifications were contracted to selected consultants in a similar fashion to the Irrimate™ measurements, with the aim of building additional capacity in these areas.

Whilst the project independent evaluation suggests that the involvement of consultants in this manner did improve capacity, there were a number of complexities and limitations involved with this approach. By the time the project was initiated (late 2008), the amount of budget allocated to undertaking measurements during the project design phase (2007) was insufficient to gain widespread engagement from a broad selection of consultants. During this time there had been a reported increase in equipment costs of 18%, but there may have also been changes to the project deliverables (number of evaluations required) where the associated budget had not been reallocated appropriately.

Consequently, some otherwise excellent tenders needed to be rejected as they were unable to meet the maximum allowable tender price. Of those tenders that were accepted, most (4 out of 6) were from existing providers of the service, who really had little alternative than to accept these terms, as they would have been unable to deliver the service to growers on a commercial basis when it was available through providers contracted to the project without charge.

The concept of mandatory grower co-contributions (even at the reasonably low price of $500) was discussed by the project steering committee, but was rejected as it was predicted that these contributions might markedly

reduce demand for the service, thus significantly increasing the risk that completion of the total number of required measurements might be unachievable. Comments from the independent evaluation report support this position, as a number of growers (38%) suggested that they would not have taken part in the project if the measurements had not been provided free of charge, despite general grower support for the quality and usefulness of the information they provide. This is a significant consideration for similar future projects.

The project also required consultants to purchase the required equipment up-front, and to then be paid for each evaluation they completed over the course of the project. This also shifted significant risk to the consultant, as the number of evaluations that could be completed during the project was highly dependent on local conditions such as the amount of water in local storages. These same challenges also provided difficulties in drafting tender terms of reference, as the project needed to ensure delivery of the contracted number of overall evaluations, which required flexibility within individual consultant contracts to ensure that this could be assured.

During project design, it had been hoped that the project would attract a variety of consultants, including irrigation consultants, agronomists and perhaps others who had little previous experience delivering irrigation specific services but significant potential to increase their role in this area. However the circumstances outlined above resulted in a limited selection of tender submissions, and those that could be appointed under the tender terms (within the required maximum price) were largely (all but one) existing irrigation consultants. Thus, whilst the project was able to increase the capacity within these consulting businesses to provide the storage measurement service, it was not possible to build the foundations of new irrigation consulting businesses as had been hoped.

Therefore, future projects should be aware that a successful tender process can be facilitated through the allocation of appropriate funds and/or the opportunity for flexibility in project deliverables. Whilst many funding bodies are keen to ensure project deliverables are quantifiable and demonstrable, the value of capacity building outcomes, which may be harder to demonstrate, are of equal or greater importance in the long term.

As the project aimed to develop and stimulate the commercial measurement service, it was critical to include consultants in this process. In addition, consultants can offer a range of attributes that can be useful in the delivery of projects of this type, such as existing networks of grower clients and an established one-on-one delivery approach. However there are also challenges associated with this approach. For example the commitment of the contracted consultants varied, to the extent that at least one participant would have lost money by completing insufficient measurements to repay the cost of equipment. This made it very difficult to manage the progress of storage measurements, as the progress of some consultants could not be relied upon.

On the other hand, some of the consultants are, quite naturally, motivated by commercial realities which require that measurements be undertaken in the shortest timeframe possible. Whilst this means that progress from these consultants was much more reliable, it also means that should opportunities for more detailed data collection arise, this is difficult to facilitate, at least under the conditions to which consultants were contracted to this project.

Future Directions and Research

Whilst the evaluation report suggests that growers value the results from the measurement service, it is likely that the potential for the commercial service is limited as many growers are unwilling to pay for the service and others believe that they can use the measurements from one storage to benchmark the other storages on their property. The fact that most growers were able to give a close estimate of their seepage also tends to suggest that growers have a reasonable understanding of their storage losses. However, there are still a number of reasons to suggest that the measurement service should be pursued further:

- Although many growers were able to categorise their seepage with reasonable accuracy, the volumetric difference due to even small errors in seepage rate estimation can be immense. For example, volumetric loss is doubled if seepage is estimated at 1 mm/day but is in fact 2mm/day. For large storages, this difference can amount to hundreds of megalitres per year.
- Precision irrigation management on cotton farms can be assisted immensely through accurate monitoring of storage volumes and losses. This would suggest that a permanent monitoring solution would be more beneficial to growers than a stand alone loss measurement service.
- When seepage is moderate, the cost effectiveness of amelioration should be accurately determined before investing in a particular solution. Data on seepage and evaporation loss is vitally important for such analysis.
- Future reporting or regulatory requirements (e.g. BMP, LWMP) may require accurate storage loss assessments.

Discussion at the final project workshop suggested that future development of storage measurement services would potentially focus on integrating more detailed seepage and evaporation measurement technology into long term storage volumetric monitoring services, to provide a more comprehensive storage performance package at reasonable cost.

The project has also identified a range of potential future research opportunities.

1. Improved understanding of cotton industry storages.
    a. Existing spatial datasets (Geoscience Australia) should be analysed to determine the number and area of storages within the industry.
    b. Relationships relating surface area to volume may be applied to the above analysis, in order to estimate the storage volumes.
    c. Average seepage (from this project) and evaporation (from SILO) data could be applied across all cotton storages identified above to estimate the magnitude of losses across the entire industry (and the likely gains from implementing amelioration strategies).
    d. A project proposal which outlines this work in more detail has already been prepared.
2. Improved understanding of storage compaction as a seepage amelioration strategy.
    a. Undertake field tests (e.g. penetrometer, soil density, soil stress) during storage earthworks to compare the compaction provided by a bulldozer, scraper, tractor and sheepsfoot roller.
    b. Preferably include a Proctor test to determine Optimum Moisture Content and Maximum Dry Density for a range of soils.
    c. An appropriate infiltration test would also be useful.
3. Evaluate the effectiveness of impact rolling in order to develop guidelines for application of impact rolling as a seepage amelioration strategy.
    a. For a number of different soil types, apply a consistent testing procedure to determine the effect of impact rolling on infiltration and density when used for storage base compaction, especially the effects of adjacent roller passes.
    b. Subsequently develop guidelines for optimum moisture content, the number of passes required to apply specific compaction at a certain depth, the amount of overlap required between passes and the optimum travel speed.

4. Evaluate a range of soil imaging techniques (EM, resistivity, etc.) for their usefulness in the identification of storage seepage issues.
5. Continue the development of cost effective evaporation solutions. Evaporation remains the largest source of water loss, however current solutions are either too expensive or too ineffective. Whilst current research focuses on ways to make inexpensive solutions (chemical monolayers) more effective, there may also be scope to investigate ways of reducing the cost of known effective techniques (e.g. floating and modular covers).

References

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