Australian Cotton
Cooperative Research Centre

Knowledge Management in Cotton and Grain Irrigation

FINAL REPORT

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NATIONAL PROGRAM FOR Sustainable Irrigation

THE UNIVERSITY OF QUEENSLAND

UQ BUSINESS SCHOOL

"If you want one year's prosperity
grow grain.

If you want ten years' prosperity
grow trees.

If you want one hundred years' prosperity
grow people"

Chinese Proverb

"The wise see knowledge and action as one"

Bhagavad-Gita

CONTENTS

EXECUTIVE SUMMARY

Aims of the project. Knowledge is fundamental to improving the competitiveness, responsiveness and levels of innovation that we see in industries. This research project completed interviews with 90 growers of cotton and grains, consultants, extension workers, government researcher officers, and irrigation equipment suppliers to determine how information and knowledge about water management and water use efficiency is being used and managed in irrigated cotton and grains.

Key issues affecting water management. The project found that four issues in particular were currently impacting on water management:

1. The availability, continued security and cost of water
2. Returns per mega litre
3. Water quality
4. Water scheduling.

Growers of cotton and grains accepted that water would be a more restricted resource for them in the future. Consultants believed that water management had now emerged as a major focus in their work with growers. Giving advice to growers about water use and efficiency will be an increasingly large part of consultants' work with growers.

Information, knowledge and knowledge sharing. All groups believed that the industry was responsive to change, willing to continually learn, and that growers, consultants and extension officers were very willing to share information and knowledge. There was considerable information that was available to growers and consultants. A major concern, however, among growers and consultants, was the need for the information to have been tested and applied to determine its relevance and applicability to specific regions.

Major sources of information. Growers were accessing a large number of people and resources in making decisions about water management. The major "people" sources were:

- consultants
- researchers
- other growers
- own experience.

The major "resources" were:

- trial data
- field days
- *Cotton Tales*
- grower experiences
- case studies.

Growers preferred personal contact to gain information about water management. Growers accessed this range of people and resources over a number of seasons in thinking through major changes to water use and management. Consultants were the major source of information, and provided a close working relationship that could also bring into the growers' decision-making a variety of other information from research, trials and the consultant's experiences with other farmers in their region.

Consultants generally sourced information in very similar ways to how growers, but were able to make more use of accessing information from other consultants, especially those in their own companies. In addition, they made more explicit attempts to directly resource research and the views of researchers.

What influences decisions? The water reform process is playing a major role in shaping the context within which growers and consultants are making their current and future decisions about irrigated crops. Growers report that they are realistic and expect some form of cutbacks in water availability. However, they would like to see some reduction in the current levels of uncertainty about water security.

Own experience was a prime factor in decision-making. The driving forces for positive actions to improve water efficiency are: evidence from in-house and outside trials, cut backs in water availability, the introduction of soil water monitoring devices, the continued need to gain maximum financial returns per mega litre of water, and access to knowledgeable and supportive consultants and agronomists. New ideas in water management have been looked at for some time but it was not until forces like those above had emerged, as well as the recent drought, that growers began to re-think their attitudes about water management practices. The barriers to changing growers' water management practices are the lack of practical evidence that the changes

will actually work on their farms, and the financial and labour costs of introducing new technologies and farming practices.

Role of public and private service providers. Growers and consultants had similar perceptions, but with some differences in their emphasis. Growers described the public providers' (research and extension) role as being about identifying growers' needs, and to get research completed and communicated back to growers to address their needs about irrigated crops and related issues. Consultants spoke more about the role being limited to having research commissioned and communicated back to the industry, with the implication that the consultant's role was more about identifying growers' needs than it was for the public provider. Consultants believed that they played a more hands-on role or day-to-day role in working with the grower to decide and to implement the crop and water management strategies for the season. At the same time, growers expected to see a cooperative relationship between consultants and extension. In general, growers and consultants felt that there was a lot of cooperation though the sharing of materials and knowledge between research and extension providers and consultants.

Research, development and extension needs. Growers, consultants and suppliers identified a long list of issues that they felt required more in-depth research. Common to their lists were water scheduling, production and efficiency figures for different irrigation systems, salinity management, loss of water research and waterlogging.

Recommendations. Given this understanding of knowledge management, we put forward for consideration the following recommendations:

1. Ensure that information about water management is available through a variety of avenues. Develop and support a package of a range of information and learning mechanisms to suit the differing needs and interests of stakeholders. This package would include field days, newsletters, information resources, website, trials, computerised decision support models, training courses, for example.
2. Continue to promote as a major strategy the one-to-one interaction and personal contact between irrigators, consultants, suppliers and extension workers. Irrigators want practical, matter-of-fact information gained through personal contact. They learn by doing and seeing. The best face-to-face methods to promote access to new information and to promote knowledge sharing are field days, trials and grower groups. Access to

the experiences of other irrigators and consultants are especially valued as a part of both of these initiatives.

3. Irrigators want more information relevant to their particular set of farming conditions (i.e. soil type, location, climate). They want more crop trials, field trials and growers groups in their own districts, and write-ups of local case studies providing practical, accessible information relevant to their particular conditions. Therefore, more effort needs to be taken in research being trialled across different types of districts, and the outcomes of these trials being promoted through field days and short, practical publications like *Cotton Tales*. These need to draw together the water delivery and agronomic aspects of water management.
4. Provide detailed, practical training in irrigation measurement and management for consultants. Private consultants need to be better educated about irrigation management. While expert in pest management, many consultants believe that they lack the required levels of irrigation management knowledge to best assist growers. Identified experts (e.g. expert private consultants in whole-of-farm water efficiency management, successful irrigation farmers from various states and regions) need to be brought into all regions to train private consultants, extension officers and others in the numerous aspects of more effective water and irrigation management.
5. The public sector role and expertise needs to continue to be centred upon providing, in highly accessible formats, the findings of relevant research supplemented with practical examples of the local application of this research. Extension staff are perceived by irrigators, consultants and others as facilitators or "knowledge-brokers" who provide information that demonstrates best practice and technical support. They need to continue to promote this role, including greater efforts to promote information to private consultants who are the key individuals influencing irrigators' decisions about water management.
6. Research needs to be targeted to meet growers' needs. It is proposed that a grower review board be established in major regions to identify key areas for research, and secondly, to discuss with researchers at regular forums the practicalities of actually implementing the findings from their research. This body would assure that research that is required for specific regions is undertaken. Also this body needs to work with extension so that research findings are communicated in ways that maximise the

likelihood of uptake by growers and consultants in particular. This role may be a local adaptation of the ACGRA function.

7. Given their central role as a key source of information gathering and knowledge generation and sharing, consultants need to be better targeted in extension activities. A cooperative approach to information transfer is the best option, and one that is very possible given the existing positive relations between consultants and extension in most valleys.
8. Continue to send out short, concise, practical information to growers through *Cotton Tales* in particular. Include links to more detailed, useful information. Where possible, *Cotton Tales* should be modified by local extension officers to promote information of the most relevance to their particular region and those growers' needs. Similar formats would be useful for grain irrigators, although more work is needed in understanding their needs.
9. More work is needed into identifying potential vehicles for cross-industry cooperation in the area of sharing information and knowledge about water management, including forums devoted to innovative water management strategies, and greater incorporation of lessons from other industries into *Cotton Tales* and information paks given to growers.
10. There needs to be the development of more "one-stop" integrative information tools, such as for example, CD's that combine all of the information from different sources on water management (WATERpak is currently under development); a searchable database of all trials (including trial books); field days that only focus on one or two issues in-depth; and a catalogue of "who is doing what" in research.
11. Continue and increase the offerings of the courses such as the Cotton CRC's/UNE's Cotton Production course and the GRDC's/UNE's Sustainable Grain Productions course, and ensure a sufficient focus upon irrigation management.
12. Regularly prepare and place articles about more effective water management for specific regions in *Cotton Tales*, the *Cotton Grower & Graingrower* magazines and *Country Life*/*The Land* and promote these to growers and consultants as a resource for irrigation information.
13. Identify or appoint extension staff willing and able to develop greater technical and general expertise in water and irrigation management to be available to all key stakeholder groups, and most specifically, growers and consultants.

14. Investigate the potential and scope for an Irrigation Technology Resource Centre, and determine whether this Centre could service all irrigation sectors nationally.
15. It is recommended that a series of specific research projects be commissioned to investigate further various key aspects of irrigation management that are identified in this report. These projects respond to the information and knowledge needs of key stakeholder groups. The specific topics are detailed in various sections of this report. In addition, future research might benefit from the use of other research methods to investigate knowledge management and related issues. Again, such methods are identified in the body of this report.

INTRODUCTION

The Australian Cotton Cooperative Research Centre through this knowledge management project aimed to develop a better understanding of the knowledge pathways being used by irrigated cotton and grain growers, consultants and support agencies.

The current study focused on how cotton and grain irrigators and their consultants access information about irrigation and generate knowledge to make better irrigation decisions. Driving the project are observations like the following:

> *"It's important that we understand what triggers or prevents changes in management so we can figure out how to help growers use knowledge more effectively. Understanding this will help the ACGRA to invest well in future research and extension. There is a lot of good research being done here, there and everywhere. It's really important that this information is available to irrigators in a form that they can understand, otherwise we are not getting the most value from research."*
>
> (Glen Fresser, Chair, Australian Cotton Growers Research Association)

The specific objectives of the current project were to:

- assess existing frameworks and channels being used for the efficient, rapid transfer of new and timely information and knowledge to primary producers, consultants, resellers, extension networks and industry organisations, and through this exercise to develop new tools and strategies for knowledge management
- understand the factors that are influencing the decisions and use of research and extension information by primary producers, consultants, resellers, extension networks and industry organisations
- explore how public and private sector information service providers can more effectively partner to achieve enhanced water management outcomes.

The project's primary research questions were:

Q1. How is information about water management and water use efficiency being used and managed by stakeholders?

Q2. How does this use of information compare with the current extension methodologies being used to promote such research and related information, and where there is a mismatch, what needs to be changed?

This report firstly provides a brief overview of what is understood by the terms of knowledge and knowledge management. Next, we briefly review past research that provides important links to the current project.

The current study adopted a qualitative approach to understanding growers' and others' knowledge pathways, using a series of interviews and workshops to gather the major sets of information. The major parts of this report present the findings from our interviews towards addressing the research questions outlined earlier. Much of the methodology used is described in the Appendices.

The final parts of the report put forward a number of draft recommendations that need to be debated at future forums in 2004 being organised to discuss irrigation management practices.

Knowledge management

Knowledge is essential to the survival and success of any industry. The management of knowledge has many dimensions, including how to create, store and share knowledge. Most industry sectors today highlight that people need to think beyond just managing knowledge, and to think more about its creation, sharing and application. The current project shares this aspiration, in that we are examining how knowledge is shared, and ultimately used by growers and consultants in particular to make better decisions about water management with cotton and grain crops.

Also it is increasingly accepted that knowledge work does not happen by itself. It is a cooperative activity. Everyone needs to be given clear responsibility to ensure that when important knowledge, research, discoveries or innovations are found, that they are delivered, shared, integrated and used where it matters most (see Callan, 2003; Rylatt, 2000). As a result, a focus upon knowledge management leads naturally to a focus upon the importance of relationships and networks that allow new information and knowledge to be successfully shared.

There are numerous definitions of knowledge management and no single definition is widely accepted. However, there is strong agreement on its major elements. Knowledge management:

- is the creation of communal value from intangible assets (Svieby, 1986)

- involves not only the creation but also the distribution and use of knowledge, and in doing so, this knowledge is turned into value for those in the industry (Davenport and Prusak, 1998)
- is a process through which industries leverage their institutional or collective knowledge to improve their competitive stance, responsiveness and innovation (Hall, 2003; Koenig, 2002)
- allows industries to drive out costs from business and production processes, and to improve speed, quality and efficiency.

Knowledge is very difficult to quantify, unlike other assets such as buildings, land or farm equipment. Knowledge assets are mostly intangible. Knowledge about irrigation management, for example, will very much rely on interactions and relationships between people. As a result, often the major challenge with knowledge management in any industry is ensuring that key people and groups are in communication with other key people and groups, both within and beyond the industry so that opportunities for knowledge generation and transfer are available.

Changing attitudes, individual differences and personality

A focus of this report is upon how we change attitudes and how people prefer to receive new information that might challenge existing beliefs about water management. There is considerable social-psychological research on each of these topics that informs the current analysis of cotton and irrigated growers' attitudes to water management.

Summarising very briefly what past research reveals (see Callan et al., 1991), we know that:

- attitudes influence our behaviours. Social scientists talk about the belief-attitude-behaviour relationship. To change any attitude, we need to work at a number of levels. We need to alter the learned beliefs that the person has based upon existing information and their past experiences (i.e. introduce growers to new information that challenges their existing beliefs about what makes for efficient water management practices). Next, we need to recognise that changing attitudes is also about making people re-assess the positive and negative outcomes they feel from holding certain beliefs (e.g. changing from a negative feeling about water management ("it is too hard", "it will not improve our productivity") to a positive feeling ("it will save me money which will make me happy")
- we know that long-lasting attitude change is based on people seeing benefits from engaging in the new behaviours (e.g. more efficient water management practices results in higher levels of

productivity and lower costs), and in being praised, talked positively about or rewarded by significant others in their environment for these new behaviours. Behaviours that are positively rewarded (by praise, recognition, financial benefits) are the behaviours that will be repeated in the future

- attitude change takes time. It occurs when people begin to acknowledge that new information or experiences that they are gaining is actually inconsistent with their existing beliefs, practices or behaviours. This "cognitive dissonance" is uncomfortable psychologically for most people. They resolve this sense of dissonance by changing their attitudes to make their beliefs, emotions and behaviours relating to an issue consistent again
- to change attitudes, we need to recognise that there are strong individual differences in people. Each of us has preferences in how we like to access new information. The most successful communication strategies that alter beliefs use a variety of communication channels to get new information to people that might challenge their existing beliefs, and in turn, might alter their attitudes and behaviour. In addition, using various channels of communication or information-giving recognises differences in people's learning styles and how personality differences affect how we prefer to access information from our environment (e.g. introverts tend to prefer reflective more solitary learning, while extraverts want to engage in contact with others).

Previous research about water management attitudes and behaviours

A number of previous studies provided important background information for the present project. In particular, these reports highlight the range of resources used by irrigation farmers to make their decisions; the growing importance to growers and others of more efficient water use in irrigation; and the preferred methods of receiving information.

The findings from those projects are now summarised:

- in a report on changes in attitudes to integrated pest management, Coutts, Christiansen and the Cotton Extension Network (2001) found that decision-making about integrated pest management was moving towards a partnership between the grower and the consultant. Most growers rely heavily on their consultant for information to make their decisions, but at the same time, many growers were actively querying and discussing consultants' recommendations. Growers were using this process to set up the type of pest management practices they wanted.

- Bell and Harris (2001) in a report on the Rural Water Use Efficiency Initiative found that efficiency of water use in irrigation is a major issue among growers in the 5 regions surveyed. In achieving efficient water use in irrigation, important factors were, in this order, irrigation management, cost, soil management, and environmental factors. To improve water efficiency on farms, growers have altered their irrigation systems, redeveloped farm storages, engaged in irrigation system improvement and irrigation management and scheduling. Drip irrigation was mentioned most often in terms of a change in irrigation system. Land levelling was seen as a major way to improve water efficiency as part of irrigation system improvement. In looking to the future, growers reported that they intend to implement the installation of sub-surface drip irrigation, greater use of irrigation scheduling tools (e.g. self-moisture monitoring equipment), deepening of on-farm storages, and laser levelling of irrigation fields.
- Christiansen and her associates (2002) found that 90 percent of cotton industry participants surveyed had a copy of at least one of the resources provided by the Cotton CRC and the CRDC. The highest rate of take-up of resources was by agronomists. The most frequently used resources were *Cotton Tales*, newsletters, the insecticide resistance management strategy, the pest management guide, IPM guidelines, information updates and the insect pocket guide. The most frequently used resources were also judged to be the most useful. The most preferred methods for accessing information about cotton production were from an agronomist, *Cotton Tales* newsletters and the COTTON paks.
- Harris (2003) reported at the 2003 Farm Systems Forum that there is significant scope to improve further the overall performance of irrigation within the cotton industry. He has calculated that the overall whole farm irrigation efficiency averages 60 percent, with large variation between farms.
- Another report from the Farm Systems Forum notes that there is recognition of a wide scope for improvement in terms of a range of irrigation efficiencies in the industry. There is a need for better measurement and quantification to determine where the losses occur (Johnson et al., 2003). It is reported that grower and others would like to see a Water Use Efficiency program similar to the Integrated Pest Management program, operated by IDO's in the first place, and then a grower could choose to employ a consultant or not. The better management of water storages was important, as well as improved knowledge about how to reduce evaporation.

- In a survey of participants at the 2003 Farming Systems Forum, Dugdale and her associates (2003) reported on the research and extension needs in several areas of irrigation management. Their survey revealed that most growers and researchers were in agreement that water that could be saved most readily on a farm by reducing evaporation and leakages from storages and channels. In addition, there was agreement amongst both groups on the need for tools to monitor and assess on-farm water use efficiency and to schedule irrigations. Growers estimated their water use efficiency ranged from 50 to 70 percent. Under specific research topics, the report identified the need for better understanding of the best way to reduce evaporation; realistic and practical tax incentives for channel improvements by growers; research into benefits of lasering, slopes and run length; deep drainage, salts and water table impacts; sub-surface drip and issues of uniformity and germination; research into alternative row irrigation and most efficient use of systems; and comparisons of continuous monitoring versus scheduling. In terms of extension, the report identified feasibility studies and working with growers to get good data that can be used to support policy decisions; define a protocol for use when measuring efficiencies, and simple technology to easily measure water in and out of channels on a continuous basis; extension of ideas on how to optimise irrigation layout; case studies in irrigation management; extension of suitable soil types for drip and awareness that is not the only efficient irrigation option; and publications about what tools are available, the value and accuracy and where and when to use them.
- Plowman and his colleagues (2004) are currently investigating innovation across six primary industries, of which cotton is one. This interview and survey study will be looking at what makes various industries innovative, and the project complements the current project on knowledge management. Plowman will be asking various members of the industry about the quality of resources and services available; how well the industry is being promoted; the depth of specialisation in terms of the willingness of people to upgrade their knowledge and skills; the availability of experts for advice; attitudes to change; willingness of the industry to exchange information with outsiders; and evidence of innovation in the industry in recent times.

In addition, a number of other industries have completed research into growers' perceptions and needs that is relevant to knowledge management in irrigation. For instance, Dignam (2003) in a needs survey of wine grape growers, found that better water management was among the key

changes needed. Many of these wine grape growers expected the future to be tougher than it had been over the last decade. To grow and prosper, growers needed to improve grape quality, water management, and operational and production efficiency. Like cotton growers, wine grape growers used many sources of information. However, growers liked especially to learn and gain information through personal contact. Some 84 percent reported that they had implemented changes as a direct result of information received over the past five years.

Another report on behalf of NSW Agriculture has described irrigation habits and knowledge about irrigation (see Marston and others, 1998). About a quarter felt that nothing would make them change. For the majority, however, greater profits and higher costs of water were the major factors that irrigators said would encourage them to change their irrigation behaviour. The major barrier to change was the economic cost. Asked about preferred ways to receive new information and to improve communication, field days were very frequently mentioned. Another preferred way to acquire information about a new irrigation method was by a visit from a retailer, supplier or expert. Finally, any new information needed to be practical and straight-to-the-point.

Current extension models in the cotton industry

Overview. The Australian Cotton CRC's National Extension Network includes Industry Development Officers (IDO), District Agronomists and specialist staff in the areas of Water Use Efficiency, Irrigation, Integrated Pest Management (IPM), Spray Application Technology, Education, Evaluation and extension approaches. They are located in every major cotton-growing region. They and provide a close link between industry and research. In addition, Cotton Australia's grower services managers drive the implementation of Best Management Practices (BMP).

The cotton extension model used by the Industry Development Officers includes a range of approaches such as information transfer; trials and demonstrations; groups; benchmarking; and education. Through each of these is threaded evaluation to ensure that activities are reaching the mark and achieving positive outcomes for industry. Close industry engagement is a core mode of operation. Industry reference groups in each valley and for specific programs provide growers and consultants with the opportunity to set priorities for the extension program.

Trials, demonstrations, groups, benchmarking, education and extension focus teams. One of the key drivers for establishing the IDO positions was the need for on-farm, regional trials. Trials are utilised for ground-truthing and gathering local data, building confidence in recommendations or techniques, benchmarking and for developing technologies. Grower driven groups such as area wide management groups have rapidly gained momentum across the cotton industry as growers look to each other for support in implementing complex systems. Grower driven groups are most effective with the extension team providing support and coordination.

Benchmarking through physical trials or desktop data interrogation allow growers to view themselves on a continuum amongst their peers. Benchmarking also allows the extension network to focus efforts on elements that show the greatest variability between farms. The *Cotton Production Course* offered by the Australian Cotton CRC / UNE provides scientific and practical skills that promote sustainable and profitable cotton production. Its main purpose is to build technical capacity in the industry service sectors and it also attracts some growers. An *IPM Short Course* has been specifically designed for cotton growers. It comprises practical and theory session to give hands-on experience and knowledge about Integrated Pest Management. It is available for small, interactive groups in all regions on demand. A *Waterwise* course offered by NSW Agriculture focuses on the basics of irrigation management.

In addition to their local role, each member of the extension network contributes to a national extension effort through one of the Insects, Farming Systems, Environment, Diseases and Weeds or Water focus teams. These teams work closely with researchers and their ACGRA members to ensure that consistent messages are extended across the industry with minimal duplication of effort. They aim to take a strategic approach to developing and integrating information and extension methods for industry wide issues and to partner closely with the related research programs.

Sources of communication. Relevant, timely information is communicated to industry through a range of sources, including the COTTONpaks: ENTOpak, SPRAYpak, MACHINEpak, SOILpak, NUTRIpak, WEEDpak and IDM guidelines are a compendium of relevant information on their specific issue for the cotton industry.

In addition, other channels of extension involve:

1. Newsletters, includes regional fax-out or email newsletters such as Cotton Tales and WaterWorks provide timely, concise, locally relevant information.

2. Field Days and Farm Walks are a widely used forum for observing the results of trials, hearing from researchers and promoting discussion between industry participants.

3. Workshops on specific issues such as spray application technology allow the issue to be discussed and demonstrated in greater detail.

4. Collation, distribution and interpretation of regional data such as pheromone trap results for timely use through the season.

5. Web, the Cotton CRC website hosts a wide range of information resources and tools. Forums and chat rooms will soon be operational. www.cotton.crc.org.au

6. Computerised Decision Support Tools, in particular CottonLOGIC have been developed to aid the accessibility of research information and to make it more readily usable. Further tools such as the OZCOT crop simulation model, a water use efficiency calculator and HydroLOGIC, a decision support for irrigation management are under trial.

7. Cotton CRC's Technology Resource Centre acts as a central point for the development and distribution of information resources, maintains industry distribution lists and develops the CRC website.

8. Through links with research, the extension team provide a channel to enhance two-way communication between research and industry and between different regions of the industry.

METHOD

A total of 90 people were interviewed either face-to-face or by telephone for this project: 39 cotton and grain irrigators; 4 grain irrigators; 30 consultants and irrigation suppliers/designers; 10 members of the cotton extension network; and 7 members of government research bodies. The study focussed on cotton and grain irrigators in cotton regions – most irrigators in these regions grew both cotton and grains whilst a few grew grain but no cotton. As a result, the study focuses primarily on the mixed cotton and grain systems. Appendix A presents more details on the methods used to design the interview schedules, and to prepare interviewers. Appendix B presents copies of the various interview schedules. Appendix C provides a list of participants (i.e. consultants, resellers, extension officers, other industry figures) in the study, but does not list growers' names.

FINDINGS

Key issues affecting water management

It is important to understand the context at the time these interviews took place. Growers were in a period of prolonged drought. As a result, there was no doubt among those interviewed that water had become a more restricted resource than it had been in the past. A number of growers have quite large parcels of land developed for crops, but they did not have the water to allow them to use that land effectively. In the last few years as well, growers and consultants acknowledged that public opinion had focussed more upon the use and abuse of water, and irrigators, in particular cotton irrigators had been targeted as poor water managers. This public perception was important to many growers, and many mentioned that irrigators had to start to change their behaviours to avoid continued negative publicity for the industry.

Overall, farmers had taken fewer risks with their crops in 2003 compared to 2002. Queensland and many NSW regions had been in a long drought. Most regions had not been able to plant full areas of cotton due to a lack of water. Of those who had planted cotton without sufficient irrigation water and did not get enough rain, several had either ploughed out the area or double or single-skipped. In some regions, irrigated wheat had provided a reasonable income.

While there was a considerable range of issues cited by those interviewed, the key issues impacting on water management were:

1. the availability, continued security and cost of water
2. returns per mega litre to determine what is the best crop type to maximise profitability on the farms
3. water quality including the need for more information about issues such as the long term benefits and costs of using saline or bore water
4. water scheduling.

Irrigators, consultants and resellers highlighted these major issues. For each of these major issues, there was a strong emphasis upon the need for more information about each issue at a local level. A number of other issues related to water management were also frequently mentioned in their interviews. These issues included (in no particular order of priority):

- variations in climate and rainfall, and how these influenced decisions on irrigation management and crop type
- public attitudes about irrigators, and water conservation
- the use of cheaper ways to monitor more areas on farms using probes
- the need to better understand and manage waterlogging
- the relationship between soil types and irrigation choices
- more understanding of deep drainage
- ways to increase capacity to store water
- ways to minimise labour requirements around the most appropriate choice of irrigation method
- the management of losses due to deep percolation
- improved tail water reticulation
- managing irrigation and soil erosion problems
- alternative crops to cotton given changes in water availability and its cost.

Consultants believed that water has now emerged as the new area of focus for them. As one reported:

"With Bollgard® II we'll spend less time chasing bugs and more time working with water and nutrition management."

In addition, many consultants believed that they were less expert in giving advice about water than they felt in giving advice in other areas of crop and pest management. A large number of consultants wanted to develop their knowledge and expertise in water management. This was a major theme in our discussions with most consultants. Most felt that water and nutrition advice would become a key part of their consulting service, they also believed that there will be much more work for specialist consultants in the future. Most of their current advice about water management was related to the use of Diviners and neutron probes; advice about water scheduling; design of systems and equipment supply; dealing with distribution losses; and in general discussions with growers about ways to maximise returns per mega litre given the costs and availability of water. The vast majority of consultants believed that advice to growers on irrigation will be an increasing part of their consulting services.

Growers' and consultants' attitudes about change

There is a lot written in other contexts about the need for people to be "change-ready" if they are going to respond to new opportunities for innovation. It is argued that without this attitude, levels of innovation will be low, and the death of organisations and industries is more likely.

There were some growers who were clearly very resistant to any change. They were highly cautious and conservative decision-makers, and were very reluctant to alter any practices that were giving them acceptable returns per mega litre. Unfortunately, those returns were based on continued assumptions about continued good availability of water. Even a severe drought had not altered their thinking, and in the longer term, they will lag well behind others in changing their water management practices.

At the same time, they were clearly the minority. The vast majority of growers we interviewed were "change-ready", being open to new ideas but this did not imply that change was quick. Rather, they were open-minded, and they were building a case for change by accumulating over time new information from a wide variety of people and resources. Growers were definitely not flighty or in panic about potential changes to water availability. However, more correctly, they were growing in concern and were getting somewhat anxious about the lack of information in more recent times, especially about continued water security.

Consultants believed they were more open to change than were growers, especially as openness and constant challenging of their own ideas kept them up-to-date and commercially viable. They talked about the need to be open to new ideas. Idea generation and dissemination was central to their role and professional practice. Many mentioned that they felt that they were very influential in making growers more change-ready, mostly through the quality and length of their working relationship with growers. Some had been consulting to individual growers for a decade or more. As a result of a good track record of successful decision-making about many issues related to crop management in the past (i.e. mostly pest control), they were major sources of influence upon farmers' decision-making now about water management. As one consultant concluded:

> *"I have been working with some growers for several years, and we get to know each other and the individual concerns of the grower very well. We develop faith in each other, and see how successful we have been in past decisions. Growers are willing to change, but like me, they want to see some practical results before they commit to something that will cost a lot of dollars and time".*

Information, knowledge, knowledge sharing and learning in the industry

There was little evidence of any passivity among those interviewed in wanting to seek new information and knowledge. Indeed, the vast majority of growers and consultants were actively seeking information that would lead to improvements especially in the areas highlighted earlier as major concerns; that is, the returns per mega litre, and various aspects of water quality and water scheduling. Many growers were highly active in seeking new information to build their knowledge in these areas, doing their own searches through the web, telephone calls to researchers, consultants and other growers, looking for articles in local newspapers, and by attending farm trials that allowed them to see new initiatives at work, as well as to talk to key players.

Also consultants were very active in seeking new information and in building their knowledge about water. While they made mention of mostly the same sets of resources as growers, they made more use of research publications, discussions with other consultants (often in their own business) and researchers, and comparisons of trial data from within or across farms. As to be expected, they were active seekers of new information as such information gave them a competitive advantage over other consultants, and allowed them to better meet the needs of their grower clients. Also, they were highly aware of changing public attitudes and that if growers did not alter their

behaviours, threats could build that might challenge the continued viability of the industry and their role as consultants.

Growers, consultants, suppliers and extension officers rated the industry very positively in terms of its responsiveness to change, risk-taking, willingness to experiment, willingness to continually learn and judged its future to be a healthy one. Across all sectors, there was the general opinion that the cotton industry was an innovative one. The cotton crop could be regarded as a knowledge crop.

> *"Between us on this farm we read just about everything that's related to the industry, go to events, have trials on-farm and talk with other growers and agronomists. Then we talk about how these ideas fit with our systems and plan what we can do better."*

Driving innovation and the sharing of knowledge is the relative youthfulness of the industry, the good financial returns that have encouraged a willingness to share information, and an acceptance that good information is critical to successful change. The grower culture is clearly one focussed upon innovation and trail-and-error learning. A number of farmers talked of "giving it the acid test", about "getting a real buzz" from on-farm trials, often "pushing the boundaries" by experimenting with different options and how their own trials and small experiments built up their confidence for larger changes.

Most growers were experimenting each season and often paddock by paddock with a variety of infrastructure changes (e.g. pivot/lateral, recycling) and practice changes (eg siphons, double siphons, various sizes, stubble, minimum zero till, rotations, field redesign) that might maximise returns and profitability from irrigated crops. Trialing was central to working out the value and cost of a change. As a grower explained:

> *"Currently I just cannot justify the expense of putting in drip irrigation or laser levelling. But I might trial it in a few a paddocks once we get past this drought."*

There were very positive attitudes about the links between information sharing, knowledge generation, learning and innovation in the cotton industry. Similarly, the horticultural industry was judged as a leader in irrigation management and knowledge sharing by many growers, extension officers and consultants. Growers tended to transfer what was learnt about irrigation from the cotton industry to their grain crops.

Overall, there was a strong consensus that the cotton industry had excelled in getting information out to growers in a timely manner using a wide range of communication channels. However, despite this positive record, there were concerns in several areas:

- there was sometimes too much information and it was often very time-consuming to locate specific information. As two growers commented:

"Really there is plenty of information. I feel that we need more about the application of the information to see if it works. The scientists need to show us in practice some of their findings. I also want better access to information about specific issues, which is often the hardest information to get".

"While there is a lot of information out there, information about irrigation issues is extremely difficult to find. I wouldn't know where to go if I wanted to find something."

- growers wanted more specialised information brought together into one easily accessible form.

"It would be good to see case studies with the names and addresses of people involved in a COTTONpak on a CD. Good to have all of the research pulled together about important water management issues on one database."

- growers and consultants felt that a lot of findings from research had not been tested or applied to determine its relevance and applicability to specific regions. Farmers and growers were very "valley centric", and expected either consultants or extension officers in their valleys to select the information that was most useful to their conditions (eg type of soil, crop type, water quality and availability). To them, the best information had been tested out in farm trials that put theory into practice, with case studies of successful implementations, and discussion in growers' groups about what works or does not work for their regions.

"I want to see things actually work. The farm trials are good, and it does show me that these ideas might make a difference to my farm, and my conditions. Because of the expense, and the effort needed to introduce practices, I really do have to weigh up the evidence over a few seasons. And even when we (the consultant and I) decide to move on a change, we will usually go for a trial first."

Own experience and the experience of other growers was a key information source. On-farm trials were central to generating and sharing new information and knowledge, and in producing new learning. On-farm trials were important for building growers' confidence in innovations and new practices. Growers wanted to see new technology working before they used it themselves. Central to these needs was the considerable financial cost and time involved in implementing new

information and new technology. Talking about how he combined various sets of information, a grower explained:

> *"I build up my confidence about the value of changes to how I manage water by talking to my consultant and other farmers. I won't change unless I see it working elsewhere. It also depends on your view of risk. Do you just treat four furrows or double it to do a whole paddock? I need good advice and consultants, using research and other farmers and their experience, guides me a lot."*

Another explained:

> *"I gather as much information as possible before I make a decision. It is one that my son-in-law and I make together. Our challenge is to increase water use efficiency across the farm but in the most economical way. Our decisions usually take two to three years for a major change. We just keep 'looking over the fence' to build our confidence about the right way to go."*

Finally, while growers and consultants believed that those in the industry were mostly open to learning and were "change ready", change was adopted as an incremental process due to the considerable financial and logistical costs involved. There is also the political dimension. As one grower explained:

> *"There are currently problems and politics with water supply. There needs to be an incentive for water use efficiency. Farmers think at present that if they cut their water use by 20 percent then their allocation will be cut by this amount. If water use efficiency is such a government priority, they need to start giving funding and incentives. At present there is no water. Where there is water, my aim is to grow as much cotton as possible to take advantage of the price without being unrealistic or too risky."*

How growers, consultants, suppliers and others access information

Table 1 summarises the wide range of people and resources that growers accessed to gain information that was required to make a recent change to some aspect of their water management. Consultants, suppliers and extension workers generated highly similar lists of such people and resources.

Table 1 People and resources accessed by growers (in no order of preference)

People	Resources
Irrigation consultants	Trial data
Crop consultants	Field days
Researchers	Cotton Tales
Extension staff	Experience
Irrigation equipment suppliers	Legislation
Resellers	Case studies
Bankers	Benchmarking information
Other farmers	Magazines (The Land, Cotton Grower Magazine)
Family	Media
Farm workers	Soil characteristics/soil monitoring
Grower groups	COTTONpaks
Water suppliers	World Wide Web
Regulators	Decision support systems
Irrigation officers	Weather bureau
Chemical representatives	Cotton conference
Spray contractors	Formal courses (e.g. Irrigation Association of Australia)
Water suppliers	Knowledge resource directory
	BMP manual

A number of other general observations can be made about this list of people, resources and information nominated by growers, consultants and others:

1. they like a mix of contact
2. they are especially very positive about contact that is one-on-one
3. a lot of information was seen to be too general and not tested for the climate, soil type and water quality of specific regions. Again, growers and consultants emphasised the value of greater grower/consultant/extension staff partnerships to conduct farm trials to deal with local concerns. Growers wanted to see more research being funded for their own region. They wanted region-specific trials rather than the research being done on an experimental farm in a region with quite different conditions.

4. growers are clearly combining various sets of information over periods of 1 to 2 years to make their decisions. One farmer explained his decision-making as follows:

   "My decision-making usually takes about a season or two. I let the idea take shape in my mind, and before discussing it with anyone. I look for evidence from local and international research, using magazines, CDs and the internet. I then discuss this idea with my consultant and agronomist to get their feedback. I might also pick up feedback at growers' meetings, but not always."

Another talked about his decisions as follows:

"Our decision-making about planting takes time and preparation. Everything is prepared throughout winter to ensure we could plant everything if water becomes available. Country that came out of fallow was planted solid, and country that had a crop was planted double skip to hedge bets and make the decisions a bit safer. In the end there was no water from the river and we had to rely on bore. This reliance on bore ultimately limited what we could do."

5. local papers or cotton-specific media (eg *Cotton Grower* magazine) were seen to be a more significant source of useful information than the larger media (eg *The Land*, newspaper articles). The media and magazines were especially useful to consultants
6. many farmers felt that there had been too many courses and too many meetings to transmit information
7. growers would come together around tangible reasons (eg field trials, demonstration of a new technology)
8. many consultants, growers, consultants and extension officers believed that there is a real shortage of experienced irrigation consultants, particularly consultants who can merge the agronomic and engineering aspects of water management
9. growers judged resellers as being less useful sources of information than consultants
10. consultants were by far the major "people" source of information for growers, and consultants also believed that this was the case
11. resources like *Cotton Tales*, *COTTONpaks* and magazines needed to shift their focus more towards water management rather than pest management
12. while benchmarking was identified as a valued resource, growers felt that appropriate benchmarking was a highly complex and difficult task that needed to be managed for them by researchers and public providers. Consultants valued benchmarking as an activity more than did growers
13. growers called for short, concise information like in the form of dot-points that was relevant to what they needed at the time and that provided links to other information. Growers indicated that links to other information, including websites, could help growers to access and digest the relevant and trustworthy information from all that is available.

In other "mapping exercises" used in the interviews, growers, consultants, extension staff and others talked through the use of these people and resources in more detail. A categorisation of people and resources as "very important", "somewhat important" and "less important" emerged. Based on the various mapping and rating exercises, and group discussion sessions in the data gathering workshop, Table 2 presents a summary of the people and resources that were perceived by growers to be more important in shaping decisions about water management.

Table 2 Growers' perceptions of key people and resources that influence decisions about water management

Resource	Most Important	Somewhat Important	Less Important
People	Own experience	Farm staff	Resellers
	Researchers	Bankers	Chemical representatives
	Irrigation consultants	Water suppliers	Spray contractors
	Other growers	Other farmers	
	Crop consultants	Family	
	Other consultants	Grower groups	
		Extension staff	
Resources	Trial data	Benchmarking	Media
	Field days	Legislation	World Wide Web
	Cotton Tales	Magazines	Formal courses
	Grower experience	COTTON Paks	Cotton conference
	Case Studies	Soil characteristics	Knowledge research directory
		Soil monitoring	BMP manual
		Weather bureau	
		Decision support systems	

As Table 2 shows, growers felt that consultants (irrigation, crop, other) were the dominant source of information. Many other growers shared this grower's point-of-view:

> *"My consultant is a major sounding board. He suggests that I go to field days to see what can be done, and helps me think through the changes. I have irrigation scheduling tools like C-probes to help my day-to-day decisions along with regular visits from my consultant. The consultant works closely with me in planning our crops."*

A consultant reported his relationship with his group of growers as follows:

> *"I have direct day-to-day contact. Because of the water restrictions with growers, we do a review at the start of the season, look at crop types, look at 'what ifs', and I work closely with growers during the season advising on water."*

Growers reported that their consultants tended to have long-term relationships with individual growers built upon a deep understanding of the grower's experience, risk profile, soil and water conditions, as well as high levels of trust based on many years of contact and in making good decisions with those farmers. Consultants were a key resource in terms of bringing into the decision-making framework for growers the experiences of other growers in similar regions and conditions with the same issues. At the same time, growers also emphasised how they worked independently, accessing research findings either directly from researchers by email/telephone/reading reports, or through getting the assistance of other consultants and extension officers.

The ratings (see Table 2) again showed the perceived value of trials, field days and case studies as attractive and practical sources of information that shaped grower's water management decisions. Grower experience was a core resource. Field days were a great opportunity for growers to share their experiences, and to hear and most importantly to see what else was possible. There was a clear preference for short (2 hours to half a day), informal field days that focussed on a 1-2 issues in detail and gave an opportunity to looks at other growers systems and the application of research. One grower explained the impact of his experiences from a field day as follows:

> *"Here is an example of how a field day changed my mind. After going to a field day and hearing an irrigation consultant, and seeing results, I made some changes almost straight away. I split a field in half, and compared one siphon and two siphons. The whole farm went to two siphons. An improvement of about a bale to half bale has meant I've stayed with the new system."*

As also shown in Table 2, of all of the cotton extension publications available, *Cotton Tales* emerged as possibly the best-known and most respected source of information.

Many farmers mentioned the value of grower groups (see Table 2).

> *"I see great benefit in getting grower groups together to discuss irrigation methods. We have done this in the past and it has been quite effective. You get a good response from growers because they are the ones who are most interested."*

Another reported:

> *"We are currently doing benchmarking as part of a grower group. It is working quite well. So far 87 paddocks have been benchmarked. Grower groups with more field days, trials and benchmarking linked into them, are a good way to go in getting and applying new information."*

There was a lot of comment by growers about the value of the Cotton Conference held every two years, but at the same time some concern about the style of the most recent conference, and its immediate value for growers. A grower explained his concerns:

> *"The cotton conference has been a great source of information. However, I feel that the conference is drifting from research findings, and a different sort of conference strictly focused on research would be useful."*

We also completed the same mapping of major source of influence on decisions with consultants.

Table 3 present their judgements, which overall:

- were very similar to growers' perceptions, especially concerning the role of one's own experience, field days, trials, and other consultants
- consultants reported a much narrower set of people and resources than did growers
- they highlighted more the value of Cotton Grower magazine, formal seminars, formal courses, attendance at special workshops (e.g. Jim Purcell), publications from research groups, research stations and centres, accessing ideas from their consultants' networks and companies
- mentioned less the role of resources like COTTON Paks, *Cotton Tales*, farm workers, family, and bankers.
- irrigation resellers tended to be quite different in how they sourced information. Generally they tended to be less likely to access the industry specific information sources such as *CottonTales*, COTTONpaks or the Cotton Conference.

In talking to the providers of irrigation equipment, they believed that as cotton has traditionally used surface irrigation, the equipment providers have had less impact upon the decision-making of growers. Irrigation equipment suppliers are not installing the hardware (e.g. centre pivots, spray irrigation) that they do in other industries, and so are not building the close personal relationships and opportunities for knowledge sharing that they have with growers in other industries.

Table 3 Consultants' perceptions of key people and resources that influence decisions about water management

Resource	Most Important	Somewhat Important	Less Important
People	Own experience Irrigation consultants Consultants in own business Researchers Growers	Grower groups Extension staff	Resellers Chemical representatives Spray contractors
Resources	Trial data Field days Seminars Publications by research groups Benchmarking Formal courses Grower experience Soil monitoring Cotton Grower magazine	Legislation Decision support systems BMP manual In-house company training Weather bureau Case studies On-to-one extension Knowledge research directory	Media World Wide Web Cotton conference Cotton Tales COTTON Paks

Drivers and barriers to change

The water reform process is playing a major role in shaping the context within which growers are making their decisions. Almost all growers said that they had to be realistic, and prepared for some form of cutback. The uncertainty at present surrounds how much will this reduction be in water availability, and if there will be any compensation linked to the cutbacks.

Even in regions where no cutbacks have been announced, growers were uncertain about making any changes to their water management practices, as they feared that any savings in water would be a guide to the future level of cutback that they may incur. Growers were keen to save water, but until their production capacity had some sort of security, they will not spend the money on introducing further water management strategies or technologies.

Growers reported that the driving forces for introducing positive changes that would improve their water efficiency were:

- evidence of the benefits of a new practice, technology or strategy based on the findings or facts from in-house and outside trials and experimentation on their farm or other farms
- cutbacks in water availability
- the drive to continue to gain the best financial return for a farm, and now that pest management was under control, the focus was upon maximising returns through reducing the costs per mega litre of water
- the long-term sustainability of the farm and the soil
- the support, advice and experience of their consultant agronomist
- the need to save labour costs associated with irrigation
- the introduction of neutron probes.

In our interviews, growers mentioned more drivers for change than barriers to change in their water management decisions. The most frequently listed barriers were:

- not having enough practical evidence that the specific change will improve water use efficiency enough to improve the acreage grown
- the capital cost of introducing new technologies such as a change to an overhead or trickle irrigation system. In talking though the outcomes of some trial-and-error learning, a grower concluded:

  > *"If my on-farm trial or another in my area is successful, I will possibly put in a field and then see what the results are. Cash flow finally determines if we implement this on a farm scale."*
- being concerned about "change for change sake" or "following the herd", when really what was currently being done on the farm made the most sense given the soil, climate and water availability. A grower commenting on change for change sake responded:

  > *"If it is not going to give me an extra quarter of a bale or more per hectare, I won't bother. You need to show me the evidence that changes will make a real difference."*
- unknowns about the best choice of irrigation methods and engineering given the soil type.

Grain irrigators

Cotton growers were making irrigation decisions not only about cotton but also about other crops (e.g. chick pea, wheat, lucerne, sunflowers, sorghum), beef cattle and some horticulture (e.g. olives, oranges). The choice of crop was clearly made on the basis of the best returns per mega litre of applied water. In the cotton growing regions, there were few irrigators who did not include cotton as a part of their farming system. Therefore, our interviews focussed on irrigation knowledge in general, not specifically to cotton or non-cotton crops.

We interviewed four growers who did not grow cotton, but irrigated other crops (i.e. wheat, barley, mungbeans, sorghum) to determine if they had special issues that were different from the issues raised by growers of cotton and grains. In addition, we spoke to a consultant working primarily with wheat crops. Growers reported that the drought had made them intensify production on irrigated country. Water availability has not impacted dramatically upon their farming practices, but with proposed water reforms and the experience of the drought, both were looking at alternatives that will use less water in the future. These strategies included reducing or cutting out summer irrigation, only irrigating winter crops, putting in more bores, looking into alternative irrigation systems to sprays, with related changes in farm equipment to deal with stubble and minimum till. Mentioned more often by grain-only growers as a determining factor for any changes in water management was the markets for the various crops at different times of the year.

While the sample of grain only irrigators is small, at least for this sample there were very strong similarities in the key issues in water management (e.g. costs and continued availability of water), the range of people and resources that influenced decisions about water (e.g. own knowledge, field days, other growers, local agronomists), the barriers to change (e.g. financial costs), and the time frame for key decisions was also over a few seasons. This is consistent with the other growers who indicated that the issues in water management were similar across their whole cotton and grain farming system.

Notable differences were that the grain only farmers could not afford a regular consultant; they seemed to have increased reliance upon the knowledge of family, farm staff and water regulators about water and suitable crops; overall information that was available was described as “a little hit and miss in terms of quality and availability’; growers were just moving into soil monitoring

instruments; somewhat less understanding than cotton growers of what is available to assist them in terms of available information and resources; less frequency of field days than it seems for cotton crops; and evidence of somewhat less urgency and concern about the quantity of information that they need as their experience with their crops was so extensive, and the crops were less troubled by pests than cotton. In terms of improvements to getting access to information, growers wanted more access to publications and short (i.e. 2-3 hours only) field days.

A consultant who advised growers on their peanut crops commented that the grower transferred the knowledge gained from the cotton industry about irrigation to the management of his peanut crops.

Role of public and private sector service providers

First it is important to note that in discussing the public-private relationship, many growers explained that a "sea change" was quietly occurring. A third player had now joined the public and private providers in generating and sharing information and knowledge. This third player was the grower.

A grower commented:

> *"I see that extension staff in particular are now looking to the grower for answers. Through the innovations and ideas we are trying, growers know more about these issues than many researchers and extension people. We are now becoming much better in collecting information as well as data for our own farms, and extension can make good use of this."*

In addition, as a consultant explained it:

> *"As consultants, we find that growers are getting more sophisticated with water scheduling, C-probes and continuous recording of soil moisture. Consultants need to keep pace with growers who will lead the way now as they get their own data rather than us. Our task is now to problem-solve and brainstorm with them on the alternatives they might consider to maximise dollar returns per hectare."*

Another sea change is that on the larger farms there is a clear trend towards building an internal capability in water management among those on the farm. They are focusing upon building their skills and knowledge internally by employing two to three agronomists at each farm, and funding their professional development through the cotton production course, and consultants' seminars. Some large farms are holding in-house seminars to promote and to grow this knowledge about crop and irrigation management internally among their own staff. These farms are contributing to the greater knowledge base through commercial scale trials and economic analysis of changes.

The vast majority of growers and consultants believed that the public providers' role was about identifying growers' needs, and getting research completed and then communicated back to them to address those needs. The private consultant played the key "hands-on" role in working with the grower to decide and implement the crop and water management strategies for the season.

Overall, growers, consultants and extension officers considered that the current model of roles and duties was working well. A consultant put it like this:

> *"I see the public/industry extension role to be about getting data out and communicating this out to all of us. The private role is to get these messages out to the growers through one-on-one contact. The challenge is that we need to be more confident about the usefulness of the outcomes from research to be convinced that we can use it."*

Growers identified field days as an excellent forum that could showcase the cooperation between public and private providers. The more successful field days already had shown the value to farmers of the two groups working together to plan the purpose, location, timing and speakers for the field days.

Another opportunity for cooperation was in the organisation of benchmarking. Working together, it was felt that public and private providers could drive more opportunities for benchmarking that combined public funds and private sponsorship, with grower groups being central to these benchmarking partnerships. As one consultant commented:

> *"We need to work together by doing field trials on farms, like case studies and benchmarking. By working together, consultants have all of the information, and can exchange with extension staff to write it up and put it out there."*

Another consultant remarked:

> *"An enthusiastic extension officer is a very important bridge in this industry".*

Regional (and linked to this, historical) factors seem to have influenced the levels of public-private provider partnering in some regions. Generally, there is considerably more change in the extension staff in a valley than changes to the consulting staff. If an extension officer has developed good working relationships with local consultants, relationships generally have continued despite regular changes in extension staff. However, the increased movement and turnover of extension

staff in more recent times was making it difficult for co-operative relationships to be maintained, according to many consultants.

Possibly as a result of this increased movement of extension staff, a few consultants were critical of industry extension. Although a minority in holding these views, it is important to report their concerns. One of the more vocal among them complained:

> *"Overall, the extension system in the cotton industry in my view is almost non-existent in my region. IPM methods have clearly been adopted more in Queensland than NSW, so therefore the system is not working. Private consulting is now the paramount source of information for growers. Extension officers are not around long enough for you to build good working relationships*."

New and emerging issues were seen to benefit from extension work in developing local understanding, undertaking trials and benchmarking, and communication of findings to raise awareness on an issue. Once "the ball gets rolling" then it was considered that consultants would provide the services and day-to-day support needed for growers to manage it. Depending on the issue, this may take a year or two of extension input to develop the understanding and the capacity in the local industry. The focus of extension tended to be more about the bigger issues facing the industry. As one extension officer put it:

> *"Extension tends to work on the issue until it gets its own legs and then we move on to another issue. We tend to focus upon the bigger picture rather than the nitty gritty that consultants work with. Once an issue gets its own steam than we are able to cut back and move onto other issues, and other information as it becomes available"*

Finally, both growers and consultants saw the public provider as a potential source for funds that will bring financial benefits to the industry. A grower reported:

> *"I see the Government's role being about offering incentives for improved irrigation efficiencies".*

Role of the irrigation industry

A number of consultants and irrigations suppliers talked about the gradual growth of an irrigation industry that will in time be available to better serve the needs for information and knowledge of irrigated cotton and grain growers. They emphasised, as did many others we interviewed, that more expertise was needed in understanding how to reduce losses due to inefficient water management practices. People with more expertise in the engineering and equipment side of irrigation had a greater role to play in identifying and working through ways to more efficiently

manage the system. This role included using engineering knowledge to improve existing systems, the better engineering design of new systems, the impact of practices like increased flow rates, methods to reduce evaporation, efforts to reduce seepage, improved ring tank storage, furrow design and other developments.

Those interviewed, however, were concerned that universities were only now beginning to consider programs that will produce the numbers and types of irrigation engineers that are currently required by the irrigated cotton, grain and other industries. On a more positive note, recent developments in vocational education and training now mean that Certificate and Diploma qualifications are available in irrigation, as well as a training package and the recognition of prior learning, that will promote more traineeships and apprenticeships in irrigation. The graduates will be able to bring their new expertise to the industry either as irrigation suppliers or as irrigation managers on farms.

Research, development and extension needs of growers and consultants

In our interviews**, growers** identified the following issues for future research and extension:

- irrigating hard-setting soils
- water scheduling
- application efficiencies
- waterlogging and siphon times
- deep drainage losses
- siphon sizes and flow rates in compacted areas
- the costs of putting in trickle and drip systems, including installation, pump, filters, flexibility of the systems
- more research into salinity
- management of tail water – many growers are waiting for more information about this to emerge from the Water Use Efficiency Initiative project, and feel this dissemination has been very slow
- loss of water through open channels (calculations of amounts and management strategies)
- research into water storage, under and above ground.

Consultants when asked provided the following list of issues, which was similar in many areas:

- water scheduling
- results from trials using the SIRMOD system
- cost effective drip irrigation and how to make it work financially for crops like cotton
- production and efficiency figures for different irrigation systems
- results on rotations of cotton with other crops
- what crops to move to after cotton if water prices keep going up
- return on investment research
- better information and understanding about deep drainage
- salinity management
- more reports that integrate and adopt a more holistic approach, showing the inter-relationship between crop, water and management
- loss of water in channel losses, dam losses, and application efficiency
- irrigation choices and soil types
- shallow watering in furrow systems
- waterlogging and siphon times
- more case studies on change from furrow systems to pressurised systems
- the trend towards linear moves
- overhead irrigation for broad acre cropping.

Consultants gave examples of gaps that they felt existed in research that needed to be undertaken (e.g. irrigation under different conditions, soil types, drainage rates; water holding capacity, effects of compaction, irrigation internal stretches). A number of consultants also commented upon what they felt were delays in distributing the findings from the research (e.g. findings from RWUE initiative).

Many of these issues targeted for future research or as issues are highly interrelated, and growers and consultants did describe such issues as being influenced by each other. For instance, a consultant explained his needs as follows:

> *"As a consultant, there is a range of matters that I and others need to know more about. It is all inter-related. I'd like to see more research into Bollard®II needs for irrigation. I need to better understand how to make head ditches more efficient, along similar lines to research done on storages. More field days are required on how to measure water. A lot of people will be surprised at how much water they are using. Research into soil types and implications for irrigation is needed. Different irrigation systems and different soil types is a big issue for my work. The pros and cons of different moisture monitoring equipment is*

another topic. And more irrigation training for consultants as they move more into water as part of their services."

Education and training in water management

There was interest in practical, advanced level training in how to measure irrigation system efficiencies and how to manage these. Accreditation was not considered necessary for training, unless this was to become a government requirement for irrigators in the future. Across all the groups we interviewed, there was a strong emphasis on the need for courses to be practical, short, going deeply into an issue (rather than covering a lot of issues more generally), being linked into a farm trial or actual piece of research that could be seen, and in which there was a good mix of different types of people and interests (e.g. growers, consultants, extension, re-sellers, researchers). The list of issues raised earlier is clearly a guide to what such courses might be about.

Irrigation equipment suppliers

Four interviews were also completed with irrigation equipment suppliers. As a part of their sales service, they advise growers on irrigation design work and equipment supply. Advice on irrigation management is seen as part of their service to growers. They recognised the challenge of keeping up with technological changes, and the need for continued staff training. The top water management issues were similar to those identified by growers and consultants: availability of water; efficiency of water use; quality of water; salinity management more specifically; and the best crops for the type and availability of water.

Asked about the major influences upon the decisions that growers make about water management, suppliers mentioned the same individuals and resources, as did other groups. However, possibly as to be expected, water suppliers, re-sellers, equipment suppliers were placed in the "inner circle" of agents that most influence growers, while these three groups were not seen by growers or consultants to be as centrally important.

Suppliers believed that they could easily access information about water management from many sources. In particular, they had networks of suppliers through to advisers that could provide them with the information they required. At the same time, there did not seem to be the same depth of understanding about the people and resources actually available to provide information about water management that we found among growers and consultants, in particular.

These suppliers wanted to see more irrigation research and extension on the availability of water; getting better efficiency (i.e. channel losses, dam losses, application efficiency); waterlogging; efficiency of energy versus application efficiencies especially for smaller growers; the inter-relationships between water, crops and management; lower cost drip systems suitable for cotton; and the returns on investment of highest yielding crops given water availability, cost and quality.

Agency and funding bodies' perspectives

Major water management issues. A number of interviews were also completed with agencies and funding bodies to report their views about water management, as well as where public sector irrigation extension is heading. On the topic of the major water management issues, these groups had highly similar perceptions to other groups that were interviewed. To them the major issues were the continued access to water; including volumes and when growers will be able to use it; whole-of-farm water use efficiency; water use scheduling; and soil management to maximise use of fallow.

Current and future roles of extension and consulting. Their views about the extension role supported those expressed earlier. Extension is focused upon "public good" and providing a whole-of-industry benefit. Examples given were the greater attention that extension is giving than consultants to sustainability, water use efficiency on a catchment basis, and the recognition by extension of the social science issues and community interests that are integral to an understanding of the longer-term future of the irrigated cotton and grain industry.

In particular, government extension provided independent advice typically based upon access to solid research. As one person put it:

> *"There is a need for growers to have access to people independent of commercial interests, and who are able to adapt information for the regional areas. Extension also filters research so that consultants are accessing the best available research evidence".*

It was felt that extension has played a major role in "kicking-off" water management efficiency as a major issue among growers, and that consultants followed once they realised that improved water efficiency had been recognised by growers as the next big issue to manage more successfully to gain further improvements in production. Water management has now moved from being seen as "extension business" to being perceived as "the farmer's business".

In looking at the future of extension and water management, agency and research respondents talked about "almost going the full circle". Once extension provided most of the technical skilling. Next, consultants took on this role as extension moved more into information and research dissemination, using adult education principles and skills to get the right information to the right people. In the future, it is felt that effective extension will be a mix of sound technical skills and knowledge, together with facilitation and adult learning skills. Their focus is not on the day-to-day of farm management but on capacity building. As one senior officer summarised:

> *"The current and future role is about capacity building. We deal with people and need to show demonstrated people and communication skills. But also we need to gain client respect by having technical understanding, not about the finer arts of irrigation design but by promoting the benefits of adopting the more holistic picture about sustainable production systems that will be essential now and in the future".*

The consultants' role is seen to be focused "upon things", the "private good" and the technical side of farming, and less so about "people, community, and systems". Extension and consultants currently were seen to strongly complement each other in the roles they played. These complementary roles were seen to be at their best in trials, field days and related hands-on activities that brought together practice and research.

It is predicted that the consultant's role will be increasingly specialised. To a lesser extent, this was also predicted for extension with water specialists being developed for some regions. Specialisation that offered growth in technical knowledge was seen to offer young extension officers improved career opportunities that may keep them in extension longer and make them less likely to move to private sector interests. Specialisation was being driven by the need for more in-depth understanding and improved practices in irrigation system design, detailed design issues, how to best re-work existing systems, and in getting the efficiency right within the production system.

Factors that influence growers' water management attitudes. A number of key issues emerged here. First, many growers "did not know what they did not know" until their current practices were challenged by the right combination of new information and new practices. Egos can be big in this industry. Many growers believed that they had little to learn, as they had concluded that they had already highly efficient irrigation systems. As one person put it:

> *"The big challenge was that many growers already believed that they were efficient".*

However, recent advances in the science of water measurement (e.g. with better measurement of losses through seepage, ring tank storage, evaporation in channels, applications to fields) had surprised many growers in terms of how much improvement was still possible in their systems. Managing crops with the limited water available during the recent drought has also clearly challenged perceptions about irrigation management and waterlogging as some crops, managed with limited water, yielded very well.

These respondents from government and research agencies also argued that many growers today feel "embattled by water system reform on the one side, opponents of clearing of natural vegetation on the other, and the victims of changes in commodity prices". There is strong pressure to change attitudes and water management practices, and "the smart ones or the top 5 percent are moving quite quickly". Or as a number of respondents put it:

> *"A bales per mega litre thinking has replaced a bales per hectare thinking on farms".*

Another observation among these government agency and research respondents was that the vast majority of growers cannot afford to re-invent their farms. But growers are very willing to use new information and knowledge to continue to improve the returns on capital for each mega litre of water. As one researcher summarised the situation:

> *"Growers require a number of seasons, and a variety of sources of information and "the pain in the wallet from the previous season" to alter their water management practices".*

A major barrier to change was seen to be a general nervousness among growers as they tried to get an "understanding of what they are changing to, and what it means to them". To do this, they need time and access to information that they learn to value and trust as it proves to make a difference. Extension was seen to play a very valuable role in supporting growers through this process. The other major barrier was available capital, and returns gained in investing capital into improved water management efficiencies as against other strategies to improve farm production.

It was felt among these government and research respondents that a variety of sources of information were needed to assist growers in their decision-making about water efficiency. Key themes were making messages consistent; available through multiple channels of communication; "gently challenging"; and not making information too hard to access (e.g. avoid complex web searches, having "one-stop" sets of information). The vast majority of those connected with government agencies and research supported the continued use of a variety of information

channels. Many believed, however, that growers were "more comfortable" with field days, grower groups meetings, and concise readily useful information like that often presented in *Cotton Tales*. There was very strong praise for the outcomes of the plant production research by the Cotton CRC, but some felt that the Cotton CRC was deficient in providing insightful outcomes regarding water use efficiency strategies.

Government agency staff and researchers were very positive about the impact of initiatives like the Queensland Rural Water Use Efficiency Initiative. It had a lot of local input; challenged existing grower practices; used local extension; and had clear targets to achieve so highlighting its very practical focus. They welcomed news that additional funding will occur to re-commence the Queensland program. In contrast, respondents from both Queensland and NSW were somewhat more critical of the Waterwise initiative in changing grower practices. Growers had perceived the level of the materials to be below their existing levels of knowledge, covering what they already knew. Once this message was spread around among farmers, the success of the program was limited.

Overall, government and research respondents were critical of the "initiatives funding" approach that was being adopted rather than a focus upon recurrent funding. Initiatives funding paid less attention on how to maintain longer-term support for a water management issue once the funding had ceased. It was believed that Queensland Rural Water Use Efficiency Initiative was very successful, but by the time it had picked up a good level of momentum that may have led to even better outcomes, the funding had ceased. The program did not get private sector buy-in soon enough, which reduced the chances that private consultants would run with the initiatives once funding ceased.

CASE STUDIES

The aim of the two case studies was to illustrate the way in which a large cotton grower and a consulting and re-seller company access and promote information and develop knowledge about water management issues. In preparing both cases, the first author competed interviews with managers, agronomists and consultants based in both organisations.

Case Study 1: Large Cotton Farm

About the enterprise. The farm that was case studied is part of a large agriculture group. Its farms primarily use surface irrigation, although in the southern region it is undertaking trials of sprinkler irrigation. This agricultural group reports that it participates collaboratively with industry research programs and conducts a wide range of on-farm experimentation. Its research is focused upon gaining continued improvements in production and water efficiencies.

At the time of the interview, no cotton had been grown on the farms visited for the season due to a lack of availability of water. Historically, those farms have grown 12,000 hectares a year, but in recent times this has declined to about 7,000 hectares. The farms used to get supplementary flow that was cutback by 35 percent with the new water-sharing plan.

Nature of crops and water usage. The farm has both irrigated and dry land farming. It grows cotton together with chickpeas, sunflowers, wheat and barley. The mix of crops is aimed at trying to get a good rotation so maintaining soil health. Cotton is the major and most profitable crop.

Driving decisions about cotton and water management is the experience of those on the farm, including the farm manager, agronomists and farm staff. They operate as an irrigation team, and having full-time staff and staff that stay connected with the farm for some time has allowed the capture and growth of knowledge about cotton, other crops and pest and water management. At the start of each season, the irrigation team allocate water then set crops to this amount.

It is only in the last year that the operators of this farm have looked seriously at how much water they were using. Water was perceived to be plentiful, but also, the farm did not have the staff or technology to put a lot of time into monitoring water and its use. A major issue for a lack of measurement is that water is dragged off the river, and it is difficult to know how much water is being applied. In addition to water accessed from two rivers, the property has considerable on-farm storage. There are 12 large reservoirs between three irrigated farms. Where water is accessed

from depends on the season. For example, the water levels of the rivers determine when they can pump water or not.

Top water management issues. The top issues at the farms are dollar returns per mega litre used for crops, water salinity, long-term access to water and evaporation. The growers at the farms are open-minded about what is the best crop to grow now and in the future. They feel that costs and returns per mega litre will increasingly be a major factor in decisions about crop type. At present, the two crops that are seen as most profitable are cotton and wheat.

Accessing and sharing information. These growers feel that it is hard to access useful outside information, even though they themselves have adopted a highly proactive attitude to information search. They believe that access to an extension officer who was an irrigation industry development officer based in North-West NSW would make a difference in access to useful and practical information. *Cotton Tales* is very useful, but by its nature is not detailed enough on many issues, including water management.

These growers would like to see a similar type of facsimile newsletter to *Cotton Tales* from State Water, as such faxed information is typically short, concise and easily consumed. Overall, they were unclear about the benefits of Waterwise. They felt had not been sold well to cotton farmers, especially the larger growers. They were positive about the information that could be accessed from the NSW Agriculture web site. They have satellite internet connections that allows reliable links to the world wide web and specific internet sites. However, as the world wide web can be difficult to navigate and information is so widely spread across various sites, they would like to see CD's made available that were compilations of information from a wide variety of sources giving in-depth analysis and information about specific issues.

They felt that most of the outside information had come in recent times from consultants and their on-farm trials run by themselves or consultants like Aquatech; other work with a re-seller; their own and consultants' efforts into sourcing information from other growers' trials; and input from an outside agronomist. They shared information about the success or not of various innovations across their farms, and would like to have greater access to information about trials on other farms in their region. Information also came from other growers, but as mentioned earlier, a lot of information was in-house, gained from their own experiences and from their own people and on-farm electronic databases.

A lot of useful information had come from the Queensland Department of Primary Industries (QDPI), including a climate workshop organised by them. They would like to see this and similar workshops promoted more in the region. QDPI was seen to be providing more useful information than either NSW Agriculture or the Cotton CRC. They believed that bodies like QDPI, NSW Agriculture and the Cotton CRC could be even more active in accessing and disseminating the findings of various trails, and that further farm trials should be paid for by the Government.

Sharing on information between those on the farms occurs through a number of mechanisms. The use of irrigation teams assures that expertise is shared and gained from farm workers through to farm mangers. In addition, the farms employ at least three levels of meetings that facilitate the completion of more operational tasks about day-to-day farm management, but also the discussion and sharing of new information and emerging knowledge about more effective water management practices. On the farms, there are weekly meeting of members of the irrigation teams. At a regional level, farm managers get together to discuss issues every month, and to share experiences with current water management and other practices, as well as thoughts about potential new initiatives with water and other ways to improve yields. At another level, the farms hold winter and summer crop meetings with the irrigations teams, farm managers and agronomists to review crops. As a farm manager explained:

> *"We review our crops, and on the basis of this discussion and sharing of information and learning, we ask, where to from here, knowing what we now know?"*

Knowledge about water management. Until recently, most water management knowledge and irrigation knowledge was in-house. In the last 12 months, staff on the properties have been involved in field days run with the involvement of a consultant. Until the last 6 months, they did not know much at all about the availability and access to extension workers or water efficiency officers in northern NSW.

There were possibly at least two reasons for this. One reason is the perception by those on the farms that water efficiency officers only had expertise in rice and horticulture and not cotton. A second factor is the strong reliance until recently on in-house knowledge. Those interviewed were also unclear about the goals of the initiatives like Waterwise, and felt that the Waterwise program was mostly focused on horticulture. Reinforcing this perception was the lack of media and newspaper attention to cotton growers in the their region being involved in the Waterwise program.

Existing and new practices. Overall, there is a positive attitude about the need for continued and incremental changes to farming and irrigation practices on the farms. Asked about the timing of changes to current practices, those on the farm are willing to change, but change takes one to two years especially due to the amounts of capital that may be required. For instance, they have implemented a 10-year plan of field lasering, and are doing 10 percent of the county each year to manage the capital required to do this. A major driver for change was good evidence from field trials or other research that showed them that the changes were practical and worth the manpower and capital required.

Historically, the properties have used neutron probes and C-probes. C-probes have provided continuous feedback, the data are captured and analysed by their computers in 15-minute measurement periods for their on-farm database. Every week a water balance is done on farms when irrigating to assist decision-making. In the last 12 months, the properties have used in-house and outside information gained at field days to make a number of changes to current practices. First, they have found double siphon better than single siphon, and are now fitting this change into their structure. They took the bottom 10 percent of fields on yields and put them on double siphons. The subsequent performance placed those fields in the top 20 percent. Second, they are learning how to apply new technology to two metre rows and just not one-metre rows.

Third, they are cutting fields in half to improve irrigation efficiency. In addition, with siphon use, they are getting less tail water, and getting around the paddocks quicker. Other changes have included changing from pipes-through-banks to polypipes; higher head in ditches to push water though quicker; deepening storages to reduce evaporation; trialing with 15 inch rows as opposed to 1 metre row spacing; involvement in long term climate forecasting in order to plan the amount of cotton sown; and increased rotational cropping to prevent monoculture.

Asked about other initiatives like drip irrigation, the view was that the economics is still not right for this change. In addition, as mentioned earlier, till recently the view has been that water was plentiful. They have completed trials with drip irrigation, and in chasing higher yields, it is possible that drip will be seen as a more viable alternative in the future. Flooding is seen to stress plants, and theoretically they believe that drip should produce higher yields. Currently, however, they are "pushing the boundaries" in maximising water efficiency and crop yields by experimenting with different cotton varieties. Recent changes that allowed the carry-over of water across years has ended the "use it or lose it" mentality that had lead to a waste of water in the past

by growers in all regions. This new policy they believed would lead to more stability of water supply and better forward planning on their properties.

In looking to the future, those on the farm believe that they are good at collecting data about their water use and its effects. However, they need to be even more innovative about how they can use this information to influence their decision-making. Extension officers could play an even larger role in the identification and funding of significant farm trials about water management, and in promoting closer working relationships between the various bodies in NSW and Queensland to identify and disseminate useful information about water and irrigation management. They also felt that such bodies needed to identify more "good news" stories about growers and their innovations in water management to counter the negative publicity about the practices of less responsible cotton and grain growers.

Case Study 2: A Re-Seller

About the enterprise. This company is a re-seller that provides agronomy consulting advice and support to cotton growers. It is estimated that it checks approximately 45,000 acres of irrigated cotton, with approximately 25,000 acres out of one NSW office and about 20,000 acres out of its other branch. Its clients range from individual growers through to very large agricultural groups. The company provides agronomy support for clients, and has traditionally had considerable and demonstrated expertise in conventional and IPM insect control systems. The company has also been involved in developing the nutrition systems of cotton growing. This includes the use of water and liquid solutions and foliar liquid K applications to increase yields. Linked to its consulting advice are its own stores from which growers can purchase equipment, insecticide, and other materials.

In addition, the enterprise is active in working with its group of corporate farmers to engage in growers' groups; to promote visits to each other's farms; it plans and manages agricultural tours of cotton and other forms of Australian agriculture; runs benchmarking activities for cotton growers; has conducted "water hypotheticals" with grower and other groups to explore the challenges of growing cotton in limited water situations; and has completed aerial inspections of properties to show and to track concerns such as waterlogging, hail damage and Fusarium.

Activities undertaken with growers. As a re-seller business, the enterprise believes that it is very proactive, with its agronomists spending a lot of time visiting and talking to growers. Their consultants aim to develop long-term relationships with such clients to give them a broad range of

advice around issues ranging from pest management, to more recently a lot more advice being requested from growers about irrigation and water management. The business is finding that growers are becoming more sophisticated about water scheduling with many moving to continuous recording of soil moisture. C-probes are a major resource being used by growers, and growers now have access to a lot of information that is better assisting their water management decisions.

The consultant's role has changed. In the past, they were primarily responsible for gathering and interpreting such information that influenced irrigation decisions. Today, it is increasingly the case that growers bring consultants in to assist them after they have gathered this information. Consultants work with growers to brainstorm and problem-solve about how to use this information to gain maximum benefits for the farm. The consultant's role is also moving from a large focus on pest management to a much bigger focus upon irrigation practices and water efficiency. The low staff turnover at the re-seller has meant that they have been able to maintain and build considerably upon the in-house knowledge that they have developed primarily from their group of ten consultants and the practices of their more innovative cotton and grain growers.

The re-seller believe that they provide growers with a lot of information from industry, which combined with growers' experiences, is a major source of information to resolve key problems. They feel that they are fortunate to have access to a large number of innovators among their growers and these innovators are very willing to share their information about water management quite openly. Such innovators have become the focus of visits through bus tours and meetings or "water hypotheticals" to allow other growers to access this new knowledge.

Major water management issues. According to those interviewed in this business, among the major issues are water use efficiency, the long terms availability of water, water quality, water loss, and the effects of various practices upon soils again in the longer term.

Accessing information about key water management issues. The business reports that it makes considerable use of their network of 300 plus growers, as well as using various links into research groups, especially with the Cotton CRC. They feel that cotton is still a young industry in which people are very willing to share information and knowledge. Despite this, they feel that currently they need to chase up information on issues like water quality, salinity, sodacity, new nutrition practices, impact of different cotton varieties, and related issues as there is not a lot of detailed, highly accessible information in such areas.

Asked specifically how they access information to assist their advice about irrigation management, the major sources were the company's consultants; other groups outside of their company like Aquatech; industry groups such as Cotton Agricultural Products Association (CAPA) and Australian Cotton Council (ACIC); the internet to access information about cotton pricing, dam information and long-term weather; suppliers that provide information about new technology; growers, and in the larger farms their on-farm agronomists, including information gained through personal contact, informal growers' groups and networks, grower feedback and sharing of grower trial data; and research from journals, Cotton CRC, Myall Vale, *Cotton Tales*, NSW Agriculture and QDPI.

Monthly meetings at head office are being used to facilitate the sharing of information and new knowledge. These "regular agronomy" meetings cover both business topics but also lessons learned from current trails, experiences and materials that are being read. There is also an active transfer of new information between consultants in the company by emails and hard copy of new articles and reports about water management. Those in the business also attend the field days and related events being set up by others in the company to develop their understanding of crop and irrigation issues.

Views on how growers access information about water management. Those interviewed believed that growers accessed their information using a similar mix of sources, preferring face-to-face contact where possible. That is, growers use their own experience, consultants' advice, access information from other growers, farmers' groups (ACGRA, Area Wide Management meetings), the CRDC Conference, extension officers, field days, and access research from *Cotton Tales*, reports, various web sites or other sources. In particular, the business has strongly supported the use by growers and consultants of the area-wide management group to break down any perceived barriers between private consulting and public extension to facilitate information transfer.

Use of extension and private consultants. Those in this business believe that the extension role was to facilitate meetings like the area-wide group, and to be seen to move across various parts of, and issues in, the wider industry. The extension role should be about channelling information to growers and consultants on water, pests, nutrition and sustainability issues. The extension role of giving more direct advice to growers may increase due to the movement of consultants out of the industry due to increased risks of litigation and the prolonged drought. However, extension was

also suffering from a loss of expertise, as there is movement among extension officers and a loss of their knowledge as they move often to supply companies.

The consultant's role was seen to be more hands-on, being at "ground level" in helping growers make better-informed decisions. Those interviewed emphasised the important role in terms of knowledge capture and transfer played by the top five or so consultants in each valley. Such individuals had between 20 to 30 years experience that they brought to assist growers' decision-making about pest and water management. At the same time, it was believed that currently the balance of consultants' expertise was more towards integrated pest management than an in-depth knowledge about many specific and very challenging aspects of water management.

Future topics for irrigation research and extension. This re-seller business reported that the Cotton CRC had been very proactive in constantly asking them and others about what issues and research topics were important to growers. At the same time, they believed that the identification of research topics would benefit from more contact between extension and the group of "expert consultants" with long-track records of successful innovation in various valleys in NSW and Queensland. Such experts are frequently talked about by growers and other consultants, and are readily identified. As industry is doing more of its own research, extension officers could play a greater role in facilitating the communication of government funded as well as industry funded research. A related issue is the introduction of various strategies and arrangements that would allow government funded and independent research bodies to cooperate more in the identification and completion of targeted research. Again, it was felt that extension should drive such initiatives.

In terms of specific topics for future research, members of the business identified areas such as water use efficiency and crop physiology, benchmarking water and soil quality on farms, measurement issues in water budgeting, drip irrigation applied to cotton, and more research into engineering and design aspects of fields to improve water efficiency.

FUTURE RESEARCH

Based upon our discussions with growers, consultants, re-sellers and other groups, the following issues emerge as potential areas for future research.

1. A survey of a representative group of stakeholders to determine water management issues and attitudes. In terms of the current topic of knowledge management, using the findings of this research it is now possible to design survey questionnaires that can be better focused upon the key water management issues facing the key stakeholder groups. A survey using a structured questionnaire can be designed that can more accurately quantify perceptions and levels of agreement/knowledge/importance of several issues, and across different stakeholder types and different regions. A survey of current levels of knowledge and key topics of interest in irrigation and water management also provides a baseline from which to measure and statistically test changes in attitudes over time as extension and related activities continue to raise levels of information and knowledge.

2. More in-depth investigation of selected issues. Previous sections in this report have identified many water management issues that could be investigated in more depth. A short list of such topics could form the basis of topics to be investigated further though in-depth interviews, focus groups and through the use of other qualitative methods. For instance, such topics might include the use of interviews to gain a deeper understanding of grower's and/or consultants' attitudes about future directions in the industry in terms of water management; recent experiences with innovative attempts to better use water; and how various groups would see themselves responding to a variety of scenarios that describe different changes to the industry, and the availability and cost of water.

3. Case studies of successful innovations in water management. Along similar lines, a series of case studies could be prepared that profile successful innovators in terms of new water management practices. These case studies could be built through the completion of interviews with a variety of people associated with the planning, design and implementations of the innovative water management practice, including growers, consultants of various types, farm workers, extension officers and others who played a role.

4. Action research into the identification of, and solution to, various water management issues.
A case study tends to be retrospective in that in reports on what happened, rather than being involved in the actual decision-making in real time that was applied to resolving an issue. More action-oriented research methods also bring together diverse mixes of people to identify and to solve a real problem, usually over a 2-3 month period, with members of the action learning team each paying various roles in researching and investigating the water management issue. There is both individual learning but also team-based learning as the group applies solutions, evaluates their outcomes, engages in reflective enquiry and then introduces other solutions to resolving the issue. The action learning teams should be a mix of grower, consultant and extension participants. Topics that might benefit from the application of action-learning principles and action-learning teams include:

- having a group identify, plan and implement a field trial or field day, documenting all aspects of the process and outcomes, including the learning, and the communication of findings to other parties
- using a team-based approach to identify a set of shared problems facing group members concerning water management, and then planning and implementing a set of solutions to the higher priority problems
- using the action learning team to develop a more holistic view of crop and water management.

PERSPECTIVES FROM OTHER INDUSTRIES

The Steering Committee requested that some understanding be developed of irrigation in other industries. For this purpose, people in other industries (e.g. grains, sugar, horticulture) were invited to be participants in the three-day workshop in Moree, and were also involved in the completion of interviews with cotton growers, consultants and others.

In addition, we contacted and invited members of other industries to be involved in interviews, meetings and focus groups. Appendix D provides as summary of the key findings to emerge from a series of meetings and focus groups with members of the **sugar and horticultural extension groups**. The Appendix reports on their perceptions about knowledge and knowledge development, attitudes to change in the industry, innovation and public-private partnerships in extension.

SPECIFIC REQUESTS AND IDEAS

A number of recommendations are provided in this report. In addition, certain issues were also raised more in the style of requests or ideas that needed some attention:

1. provide growers in the Moree region with access to an extension officer with irrigation and water management experience
2. update growers, consultants and others on the outcomes to date from the Rural Water Use Efficiency initiative
3. audit the current systems being used to get extension information out to consultants to improve efficiency and effectiveness of these dissemination channels
4. get a better understanding of what are the causes of some animosity between consultants and public providers in some regions, and work with both groups to identify practical solutions to build more cooperative relationships
5. promote the content and timetable for dissemination of the proposed Water Pak
6. provide more information and explanation about the proposed Rural Water Use Efficiency 2
7. provide wider dissemination of information about opportunities now available for irrigation workers on farms to do traineeships and apprenticeships
8. due to the very frequent mention by growers and consultants of his work, identify an appropriate forum to profile the ideas of Jim Purcell
9. investigate the evidence (for and against) the Mungindi region being perceived by some as a "forgotten valley" in terms of irrigation field days
10. develop an inventory of companies willing to give talks about irrigation methods and management and circulate this inventory to extension offices and consultants.
11. establish grower review boards to discuss with researchers the practical application of research.
12. enhance the linkages between the water/engineering aspects and the agronomic and soils components of irrigation management.

RECOMMENDATIONS

Knowledge management is about the provision of the right information to the right people at the right time and so creating a climate for continuous improvement. Also it is about creating the conditions that allow knowledge to flow freely between people. Given this understanding of knowledge management, we put forward for consideration the following recommendations:

1. Ensure that information about water management is available through a variety of avenues. Develop and support a package of a range of information and learning mechanisms to suit the differing needs and interests of stakeholders. This package would include field days, newsletters, information resources, website, trials, computerised decision support models, training courses, for example.
2. Continue to promote as a major strategy the one-to-one interaction and personal contact between irrigators, consultants, suppliers and extension workers. Irrigators want practical, matter-of-fact information gained through personal contact. They learn by doing and seeing. The best face-to-face methods to promote access to new information and to promote knowledge sharing are field days, trials and grower groups. Access to the experiences of other irrigators and consultants are especially valued as a part of both of these initiatives.
3. Irrigators want more information relevant to their particular set of farming conditions (i.e. soil type, location, climate). They want more crop trials, field trials and growers groups in their own districts, and write-ups of local case studies providing practical, accessible information relevant to their particular conditions. Therefore, more effort needs to be taken in research being trialed across different types of districts, and the outcomes of these trials being promoted through field days and short, practical publications like *Cotton Tales*. These need to draw together the water delivery and agronomic aspects of water management.
4. Provide detailed, practical training in irrigation measurement and management for consultants. Private consultants need to be better educated about irrigation management. While expert in pest management, many consultants believe that they lack the required levels of irrigation management knowledge to best assist growers. Identified experts (e.g. expert private consultants in whole-of-farm water efficiency management, successful irrigation farmers from various states and regions) need to

be brought into all regions to train private consultants, extension officers and others in the numerous aspects of more effective water and irrigation management.

5. The public sector role and expertise needs to continue to be centred upon providing, in highly accessible formats, the findings of relevant research supplemented with practical examples of the local application of this research. Extension staff are perceived by irrigators, consultants and others as facilitators or "knowledge-brokers" who provide information that demonstrates best practice and technical support. They need to continue to promote this role, including greater efforts to promote information to private consultants who are the key individuals influencing irrigators' decisions about water management.
6. Research needs to be targeted to meet growers' needs. It is proposed that a grower review board be established in major regions to identify key areas for research, and secondly, to discuss with researchers at regular forums the practicalities of actually implementing the findings from their research. This body would assure that research that is required for specific regions is undertaken. Also this body needs to work with extension so that research findings are communicated in ways that maximise the likelihood of uptake by growers and consultants in particular. This role may be a local adaptation of the ACGRA function.
7. Given their central role as a key source of information gathering and knowledge generation and sharing, consultants need to be better targeted in extension activities. A cooperative approach to information transfer is the best option, and one that is very possible given the existing positive relations between consultants and extension in most valleys.
8. Continue to send out short, concise, practical information to growers through *Cotton Tales* in particular. Include links to more detailed, useful information. Where possible, *Cotton Tales* should be modified by local extension officers to promote information of the most relevance to their particular region and those growers' needs. Similar formats would be useful for grain irrigators, although more work is needed in understanding their needs.
9. More work is needed into identifying potential vehicles for cross-industry cooperation in the area of sharing information and knowledge about water management, including forums devoted to innovative water management

strategies, and greater incorporation of lessons from other industries into *Cotton Tales* and information paks given to growers.

10. There needs to be the development of more "one-stop" integrative information tools, such as for example, CD's that combine all of the information from different sources on water management (WATERpak is currently under development); a searchable database of all trials (including trial books); field days that only focus on one or two issues in-depth; and a catalogue of "who is doing what" in research.
11. Continue and increase the offerings of the courses such as the Cotton CRC's/UNE's Cotton Production course and the GRDC's/UNE's Sustainable Grain Productions course, and ensure a sufficient focus upon irrigation management.
12. Regularly prepare and place articles about more effective water management for specific regions in *Cotton Tales*, the *Cotton Grower & Graingrower* magazines and *Country Life*/*The Land* and promote these to growers and consultants as a resource for irrigation information.
13. Identify or appoint extension staff willing and able to develop greater technical and general expertise in water and irrigation management to be available to all key stakeholder groups, and most specifically, growers and consultants.
14. Investigate the potential and scope for an Irrigation Technology Resource Centre, and determine whether this Centre could service all irrigation sectors nationally.
15. It is recommended that a series of specific research projects be commissioned to investigate further various key aspects of irrigation management that are identified in this report. These projects respond to the information and knowledge needs of key stakeholder groups. The specific topics are detailed in various sections of this report. In addition, future research might benefit from the use of other research methods to investigate knowledge management and related issues. Again, such methods are identified in the body of this report.

INTEGRATION AND ACTION PLANNING

Summary Of Issues Raised And Discussed At Cotton And Grain Irrigation Stakeholder's Workshop

A workshop of key stakeholders was held in Moree on 18 March 2004 with the aim of integrating and progressing the research findings to develop a model for knowledge services in cotton and grain irrigation. Key stakeholders participated, representing the sectors: Growers (Cotton and grain); Consultants; Irrigation suppliers; Extension; and Research and Development agencies.

Setting the scene

The workshop began with a "scene setting" by senior members of the industry who were in attendance. They were asked to comment briefly upon the role of extension, irrigation management and related issues that the forum needs to be aware of, or to consider during the workshop.

Summarising the key comments, Jim Moore (Grower, ACGRA) believed that one of the key issues in understanding the irrigation management practices of growers was that growers perceived that research should be disseminated through consultants. Cotton Tales was judged to be a good disseminator of information. In looking at the big issues, they included the need to draw information together in a concise way to disseminate research, and for growers, how to gain more returns pre mega litre of water. Next, Matthew Durack (CEO, CRC Irrigation Futures) emphasised that knowledge management will be critical to the future of the industry, and the focus is now upon delivering information to investors. Knowledge management will be critical to the new CRC Irrigation Futures. Also in addressing the major issues, Bruce Pyke (Research Manager, CRDC) emphasised that water availability and use is now critical to the industry at a national level. An environmental audit has identified high priority for water issues, and that there were strong parallels between current water management issues, and with IPM some 5 or 6 years ago when there was a recognition by the industry that it needed to do better research and extension.

Murray Chapman (Program Manager, NPSI) noted that the cotton industry is a leader in individual investment in its consultants, and also in the levels of public and private sector cooperation. A key issue will be how the industry engages with governments with respect to the long term and short term issues? For instance, he noted that in South Australia, irrigation has to

achieve 85% WUE. How do we get GRDC to invest in irrigation R, D and E given that there is $350 million of irrigated grain production p.a.? How do you grow the private sector consulting service as existing consultants get older and leave the industry? What are the mechanisms that support larger organisations sharing their knowledge?

Chris Joseph (Grower, GRDC Northern Panel) observed that there has been an 'us' and 'them' mentality, but this is breaking down as we all recognise that we are now farming water. We're moving to the next stage in irrigation management, and we need to maximise returns per mega litre. Guy Roth (CEO, Cotton CRC) talked about the need for people on the ground to move extension towards water issues. He felt that consultants would be requiring more knowledge on irrigation. In line with this, the Cotton CRC is moving down the track of more cooperation with GRDC and CRC IF. He also felt that the "Land and Water" module in BMP will help focus the industry on water issues.

Notes from Jim Purcell (a Irrigation Consultant who was unable to attend) mentioned the need for better integration between agronomy and irrigation engineering, and improved measurement of water use efficiency. Rob Holmes (Cotton Consultant), following on from these comments, noted that we do not know how efficient growers currently are or how good are their systems. He believed that consultants were thirsty for knowledge, and they are continuing to respond to growers' needs for their consultants to be expert in irrigation matters and to be available as sounding boards.

Presentation and Discussion of the research findings

An overview of the key findings of the report was presented (Appendix E). In response to this presentation, the following questions and observations were made by participants:

- We need more elaboration on 'dripping' away change in the industry. A significant change may be needed to make a transformational change
- Cotton farmers are seriously looking at alternative systems
- RWUEI1 achieved change largely through incremental changes, bigger changes are now needed
- Change starts slowly and then picks up momentum
- Change may be about best using the existing system – first, encourage growers to best utilise what they have got
- Need to understand what is the real impact of water reforms on change. Real reason for change is a better return on investment. Need to get better measurement happening.

- Must be driven by returns on investment. Some of the WUE information is supposition – need a concrete way to measure returns on investment
- How much is the process driven by behavioural change (due to water reform) vs. attitudinal change (value of water to broader community)
- Change comes about by adversity
- We may need a different model for incremental change vs. rapid change in our industry.

Innovation in Rural Industries

Following the presentation and discussion of the interview results, Ian Plowman (DPI&F/UQ) presented key findings from his PhD study on Innovation in Rural Industries. In summary, this study found that the cotton industry currently is a highly innovative industry. He implied that some of this may be due to the first generation nature of the industry. He gave warnings that as the industry matures, it is at risk of declining innovation and lower levels of knowledge sharing. This stimulated thought about the need to develop a knowledge system that recognises these risks and includes strategies to maintain innovation.

Progressing the recommendations

In the next part of the workshop, workshop participants were placed into various groups based upon their background (e.g. consultants, growers, extension) to discuss the major recommendations of the report. Each group was given a set of materials with each recommendation placed on the top of each sheet, with the same three questions listed on each single page. The three questions under each recommendation were: Practically, how would you see this working or not? What and who would help this to happen? What are the barriers and risks that need to be overcome?

After going though each of the recommendations, each group was required to pick the three recommendations that were of highest priority, and to answer each of the three questions with reference to their three selected recommendations. Appendix E provides a summary of the ideas generated about each of the recommendations selected by each group and the major issues discussed by group members. In summary, key thoughts from each sector were:

The first **Grower Group** reported that their priority recommendations were 2, combined with 3. They talked about the value of a Technology Resource Centre; the need for growers to share with other growers; and the need for consultants to disseminate information to other consultants. They

were not able to identify any specific barriers except that too much information was being provided or "bombarded". They talked about funding initiatives through catchment related funding.

A second **Grower Group** highlighted recommendations 8 and 11, and gave their top priority to recommendation 8. They supported the faxing out of newsletters on research projects and outcomes, but felt that reports were too long and some researchers were writing too much. For recommendation 11, they noted the utility of a short course modelled on IPM. Barriers included funding, and not all growers have had enough pain to be motivated to do the course.

The Consultants Group gave its top priority to recommendations 4, 2, and 3. They emphasised the need for one-on-one contact, and networking by consultants was very important, and being able to act as facilitator through CCA. They required more knowledge on soil types; better linkages with engineers, consultants and farmers; more research with 2 or 3 growers in each valley; and to develop better networks of consultants with irrigation people. It was felt that researchers found it time consuming to deliver one-on-one. Consultants were also participating in study tours to develop further their understanding.

R&D Group 1 gave their top priority to recommendations 4, 5 and 9. They reported upon the complimentary nature of the public and private sector. They reported upon the need for more practical training for consultants; more work for cross industry cooperation; the greater need for cross industry cooperation and interaction at multiple levels; and the possibility of exchange programs for growers. They referred to the value of a business model to provide irrigation consultancy business, and more work with CCA, CRCIF, IAA and to be engaged in Cotton Australia policy as well. Turning to barriers at the on-farm level, they believed that cotton growers were fairly open to information on how they are performing in water management efficiency. However, many growers focused on short-term issues rather than long-term skilling-up.

The **R&D Group 2** identified recommendations 4 and 15, with 4 receiving their top vote. They reported on the need for a small group of experts in this area who need to come from engineering and a practical background. There was a need for local people to participate, and to have long term staff to maintain relationships with growers and consultants. They referred to the value of a virtual centre for irrigation rather than a physical centre, and the need for

specific research projects to be commissioned to look at irrigation and extension. In terms of recommendation 15, consultants need to be more involved than they are at present. They asked where might resellers fit into this irrigation and extension model. Finally, they were concerned that there was not a single body to represent irrigation to lobby the government.

The **Extension Group 1** gave their highest priority to recommendations 1, 3 and 15. Their top priority was 3, and in addressing each of the three questions, they felt that irrigation trials were not being conducted at local level; more input was needed from local consultants and suppliers; more staff were needed on the ground; and the industry needed better partnerships between growers, consultants and suppliers. Major barriers were the lack of expertise in existing staff, and a lack of incentives for staff to work on 2 year projects and remain.

Extension Group 2 gave their priority picks to recommendations 3, 4, 13, 14 and 15. They asked for greater scientific rigour in local crop trials; the need for staff continuity among extension; the appointment of extension staff to deal with Recommendation 13; and supported the concept of an Irrigation Resource Centre.

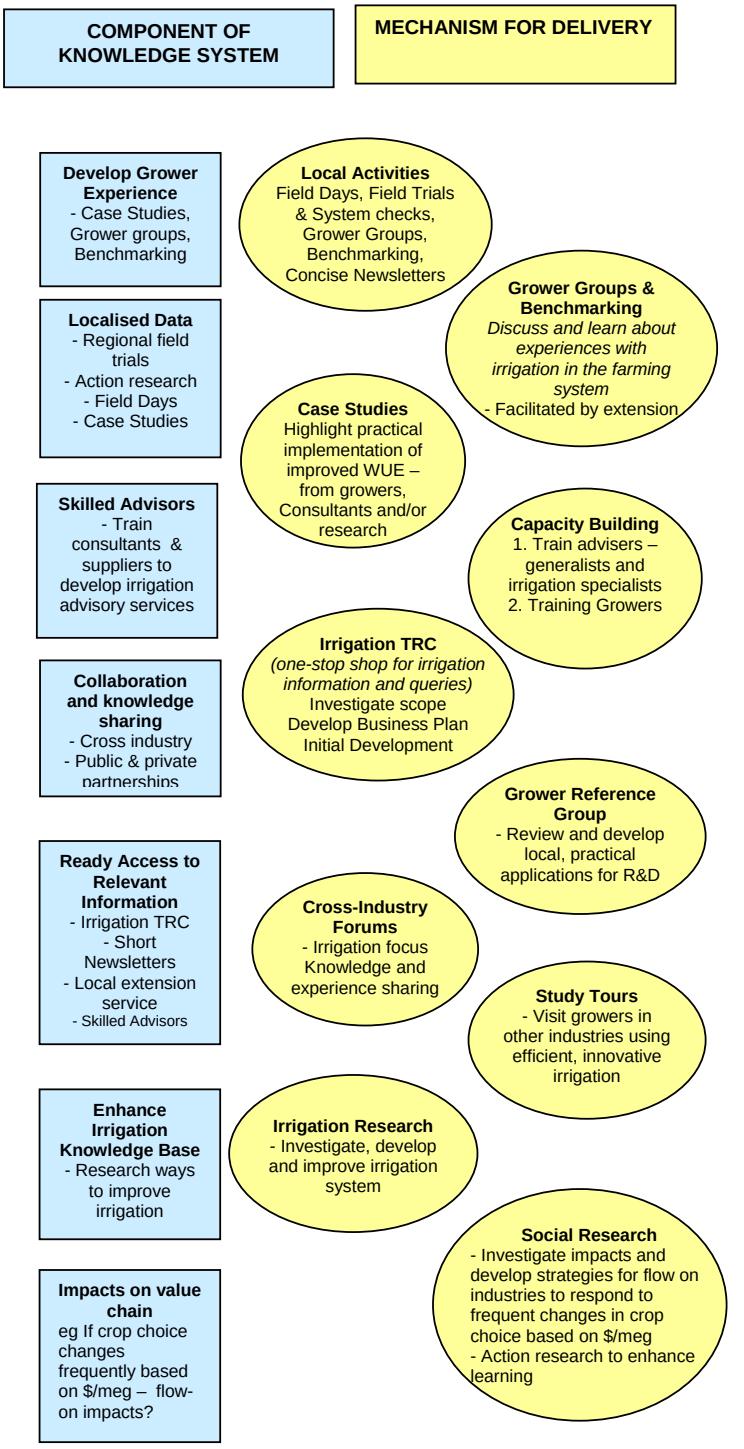
Final comments about issues raised at the workshop. It is important to comment upon two significant issues that emerged during the workshop. The major issue is the belief that the cotton and irrigated grains industry has dealt with the need to respond to change to its environments mostly though incremental change. This is not unusual, in that most industries respond to the economic, environmental and social drivers for change slowly and preferably by fine-tuning what they do rather than by a transformational radical form of change. Workshop participants recognised this, but now given the belief that water will never again be as plentiful and cheap as it once was, the industry may need to respond to future pressures for change in a much more dramatic fashion. This transformational change will possibly require a major re-thinking of how the industry has approached water use efficiency. South Australia was raised as an example of this new mind set about water and its use. This State has already set a high standard for its irrigation users with the need for irrigators to not only measure accurately what amounts of water they use, but also it has set a target of 85% water use efficiency. It was felt by some workshop participant that the irrigated cotton and grain industry might be among the next targets for governments increasingly aware of the politics of water, and the negative attitudes of many communities to the water use habits and practices of cotton growers.

The other observation is view that, while the cotton industry currently is perceived to be innovative and willing to share information, there was a growing belief that over time it will become less innovative and willing to take risks. Participants believed that there was already some evidence of this in the lower levels of perceived risk tolerance among the new generations of cotton growers. The key issue will be how the industry continues to create a climate for innovation and knowledge sharing, and as many pointed out, extension through its partnerships with growers and consultants will play a critical role in keeping the industry open to new ideas, innovation and the sharing of ideas and new practices either from the practices of more innovative growers or from research.

A potential model for irrigation knowledge services

Taking the recommendations and discussion from the workshop, the authors developed a potential model for knowledge services that identify the components of the knowledge systems, some mechanisms for delivering knowledge services and a possible outline of project components that could meet these needs. This hypothetical model has been used as a basis for further discussion and development of research in this area by the steering committee.

A Model for Knowledge Services for Irrigation Management in Cotton and Northern Grains



NPSI	= National Program for Sustainable Irrigation *(NB CRDC contribute $ to NPSI)*
CRDC	= Cotton Research & Development Corporation
GRDC	= Grains Research & Development Corporation
Cotton CRC	= Australian Cotton Cooperative Research Centre
CCC CRC	= Cotton Catchment Communities Cooperative Research Centre
CRC IF	= Cooperative Research Centre for Irrigation Futures
RWUEI	= Rural Water Use Efficiency Initiative – funded by Qld NRM&E
TRC	= Technology Resource Centre

NB at the Moree workshop it was decided that "extension" includes both public and private sector delivery.

MAKING IT HAPPEN	
Resources	**Possible partners and funders**
KNOWLEDGE BROKER - Coordinate TRC and Develop Resource Materials - Coordinate and facilitate training course development and delivery	NPSI
TRAINING RESOURCES Specialist training providers Training modules – review, refine, redevelop Cotton & Grain Post-Graduate courses	RWUEI, NPSI, NSW Agriculture, Cotton CRC, NPSI, CRC IF, IAA, UNE Dalby Ag College?
PRINTING, DELIVERY and PROMOTION 1. Design, Layout and printing 2. Delivery and promotion 3. Maintain distribution lists 4. Fax-out timely, regional newsletters	1. & 2. NPSI and CRDC (WATERpak) 3. & 4. Cotton CRC
WEBSITE - Development and Maintenance - Linked from Cotton CRC; CRC IF & NPSI/LWA	CRC Irrigation Futures
REGIONAL EXTENSION SERVICES - Coordinate and facilitate local activities - Central Qld, Darling Downs, SW Qld, Border Rivers, Gwydir, Namoi, Macquarie, Sth NSW	RWUE (to Feb 06) NSW Agriculture GRDC CMAs
EVALUATION & ACTION RESEARCH - On-going review, focus and improvement of program - Review of impact - Support action research process in regions	GRDC Cotton CRC/CRDC
PROJECT LEADERSHIP Coordinate across regions Lead Water Extension Team for Cotton & Grains	QDPI &F NSW Agriculture
IRRIGATION RESEARCH Mechanisms to improve irrigation Understanding of crop-soil relations. Economics.	CRC IF CRDC NPSI GRDC CRC CCC
SOCIAL RESEARCH Impacts on flow-on industries Action Research methods	CRC CCC GRDC NPSI
CROSS INDUSTRY LINKS Regular cross-industry forums on irrigation Encourage growers and consultants to apply for study scholarships	NPSI CRDC GRDC HAL Study - DAFF, et al

REFERENCES

Bell, K., & Harris, G. (2001). *Summary report of cotton/grains mid-term survey of growers.* Toowoomba: AFFS farming Systems Institute, Department of Primary Industry.

Callan, V. J., Gallois, C., Noller, P., & Kashima, Y. (1991). *Social psychology (2nd Edition).* New York: Harcourt Brace Jovanovich

Callan, V.J. (2003). *Innovative VET organisations.* Melbourne: Australia National Training Authority.

Christiansen, I., Larsen, D., Dugdale, H., & Price, J. (2002). *Cotton information resources – are they being used?* Toowoomba: Australian Cotton Cooperative Research Centre.

Coutts, J., Christiansen, I., & Cotton Extension Network (2001). *Changes in attitudes to integrated pest management in the Australian cotton industry: 1997-2001 and attitudes to area wide management.* Toowoomba: Australian Cotton Cooperative Research Centre.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Dick, B. (1990). *Convergent interviewing: A technique for qualitative data collection*. Brisbane: Interchange. Also available at: www.scu.edu.au/schools/gcm/ar/arp/iview.html

Dignam, M. (2003). *Winegrape grower information needs survey, 2003*. Glen Osmond: Cooperative Research Centre for Viticulture.

Dugdale, H., Roth, G., & Roberts, G. (2003). *Improving water management on farms*. Survey and brief report from Farming Systems Forum, Moree, November 26-27.

Hall, R. (2003). *Knowledge management in the new business environment.* Sydney: ACIRRT, University of Sydney.

Harris, G. (2003). *Water use efficiency in irrigated cotton and irrigation knowledge management.* Paper presented at 2003 Farming Systems Forum, Moree, 26-27th November.

Johnson, A., Smith, B., & Brown, E. (2003). *Highlights/comments from each of the discussion sessions on Day 2.* Summary provided of Farming Systems Forum, Moree, 26-27 November.

Koenig, M. (2002). The third stage of knowledge management emerges. *KM World*, 11 (3), pp. 1-3.

Marston, D., Hitch, L., & Ely, E. (1998). *NSW agriculture communications study*. Sydney: McGregor Marketing Pty Ltd/AACM.

Plowman, I. and associates. (2004). *Innovation in rural industries*. Work in progress. University of Queensland Business School.

Rylatt, J. (2000) *Learning unlimited*. Melbourne: Business + Publishing.

Sveiby, K.E. (1986). *The new organisational wealth: Managing and measuring knowledge-based assets.* San Francisco: Berrett-Koehler.

APPENDIX A – Research Methods

Three-day workshop. The project initially began with interviews by the authors with five growers and two consultants to trial the interview questions. Next, the redrafted questionnaires were taken to a three-day workshop in Moree with members of the Cotton Extension Network on 28-30 October 2003. On day 1 of the workshop, extension workers interviewed each other using the questionnaire to share their perceptions and understanding of the factors that were assisting or hindering the decision-making of growers about water management. Interviews on average took one and a half hours. This session captured the attitudes of extension workers, helped us to revise parts of the questionnaire, confirmed the convergence process on day 2 of the workshop, and also prepared participants for their face-to-face interviews with growers, suppliers and consultants on day 2.

Appendix B provides copies of the structured interview questionnaires that guided interviews in our meetings with irrigators, extension workers, and suppliers/resellers. All groups were asked generally similar sets of questions, but also specific questionnaires were designed for each group.

On day 2, these extension interviewers were then allocated interviews with growers and irrigation consultants and suppliers in various regions of NSW and Queensland (i.e. Darling Downs, Goondiwindi, Gwydir, Mungindi, Lower Namoi, Hay, Hillston, Upper Namoi, Macquarie, Moree, St George). Those completing the interviews were allocated to regions that they were unfamiliar with. This was designed to ensure that they would interview growers or consultants in regions that may face different conditions to their own local area. Thus, they were expanding their own knowledge base about irrigated crops and the issues facing growers and consultants in other regions. Depending on the distance to be travelled, interviewers either travelled by car or light aeroplane on day 2.

In the middle of day 2, after all members of the extension network had completed at least one interview, we held a teleconference in which we discussed with interviewers the initial findings and the additional questions that would be asked in interviews later in the day. As a result of this teleconference, and subsequent discussions on day 3, it was agreed that interviewers would stay with the main set of questions used for growers for all interviews, and include the additional questions mostly in interviews back in the local areas after the workshop. Again, each face-to-face

interview was completed in about one and a half hours. Telephone interviews required 30-40 minutes, and were conducted in a few cases where weather or other factors did not make it possible for personal contact with respondents.

Day 3 of the workshop was spent back in Moree. This half day involved interviewees in small groups providing a de-briefing of the findings from their from day 2, as well as planning the next stages of the project, including the questions to be asked back in their local regions. On return to their local regions, extension officers were encouraged to expand their own knowledge base and networks by interviewing growers, consultants or irrigation suppliers whom they did not usually meet in the normal course of their duties. The final phase of the research in 2004 will involve workshopping the findings of this report with irrigation stakeholders to assist in the development of an irrigation extension and capacity building framework.

Appendix C provides a list of the names of the extension and other workshop participants who completed interviews. Also included are the names of consultants, suppliers, re-sellers and others who were interviewed. It was decided not to publish a list of the names of growers' names to ensure continued confidentiality.

Interviewing and convergent interviewing. A structured interview working from a list of pre-determined questions (see Appendix B) was the major method used to gain the perceptions of irrigators, consultants and suppliers about water management. A structured, in-depth interview is a useful tool in the early stages of any research project, particularly when the research is focused upon gaining some initial understanding about the pattern of issues and factors that shape decisions and behaviours.

In this case, these issues were the awareness, knowledge and practices about water management and irrigation; how they process this information; and what determines which information is more credible, practical, useful and so on. Interviews allow participants to feel empowered to talk about a topic as content experts, and so interviews were an excellent choice with these highly experienced irrigation farmers and consultants. Overall, our respondents enjoyed the interviews and felt comfortable talking through how they access and use various knowledge pathways. Many said that they had learned a little more about what shaped their behaviour by talking through the issues with our interviewers.

Because of the wide range of issues that we wanted to cover in this exploratory type of interview, we also employed an adapted version of convergent interviewing (see Dick, 1990). This technique involves the continued use of in-depth face-to-face interviews, but rather than asking all respondents all of the same questions, once interviewers believe that an issue is "saturated" (i.e. that is we have a good idea of the range of issues that respondents will talk about), we introduce new questions in later interviews. Interviewers stop asking a set of questions about an issue when successive interviews seem to produce no new insights or evidence. The relevance of the additional questions is decided through meetings between interviewers. As mentioned earlier, our teleconference on day 2 determined that most of the second set of interview questions (see Appendix B) would be asked in the final stage of interviews in the local regions of the extension team members.

In the first set of interviews, we used a small index cards upon which participants were asked to firstly identify those people and resources that came in to play in making a recent change to a water management practice. This "mapping" exercise proved to be a very successful and highly visual way for interviewees to identify the people and resources that they brought together to make key decisions about altered water management practices.

In all interviews, interviewers wrote their notes on each structured questionnaire to capture the major issues raised by respondents. They also provided a one-page summary of the major themes to emerge from interviews completed by day 2 of the workshop, and also upon return to their regions.

Feedback from the interviewers. At the completion of the three-day workshop, all participants were asked to address the following question: "What did you learn or what skills did you develop from being involved in this workshop that you do not think you would have gained from reading the report?"

The major outcomes were:

- more knowledge about particular regions that were not their own - including a better understanding of the issues and priorities for growers in that region; the awareness among these growers and consultants of impending and on-going water-related impacts and their

understanding of this; and the differences in the priorities of different consultants and growers

- a better appreciation of how growers develop their ideas and make decisions about water management – including the complexity of issues, emotion and frustration growers face in making decisions; and how growers can operate on quite different levels of knowledge and skills
- an opportunity for members of the extension group to identify and share with each other their experiences and knowledge about irrigation management and related matters

The benefits of specific training and experience in completing more formalised interviews - including more confidence in doing formal interviews; learning how to use interviews and related processes to capture a lot of detailed information quite quickly and efficiently; exploring new techniques such as the card sorting and convergence methods in interviewing

Critique of the research methodology

Interviews provide a rich source of in-depth qualitative information. They are a very valid method to use when a topic is not well understood, and when there is not a great deal of prior research. For these reasons, interviews were used in this study of knowledge management in cotton and grain irrigation.

On the other hand, interview data are open to a number of shortcomings. While our interviewers were asked to cover a number of broad themes, and for many issues they took the opportunity to elaborate upon specific issues often with direct examples of their personal experiences from growers and consultants, this is not a quantitative report that has counted the frequency of issues or comments. No statements can be made that a certain percentage or proportion of respondents held a particular opinion. In addition, interview studies such as this one are typically explorative, and rely on a cross-section of respondents who are not necessarily representative of all cotton and grain irrigators, consultants and others. Sample sizes, as in this study, are small and unrepresentative.

However, exploratory research interviews provide a rich source of perceptions, allowing interviewers to probe and follow-up new issues that emerge. The face-to-face interaction also

builds trust and rapport with the target groups, and from this base it is now possible to complete more quantitative research in the future that can examine specific issues in more depth and with larger samples of respondents. The current study has identified a wide range of new issues that can be examined through future qualitative and more quantitative research.

APPENDIX B - Questionnaires

Available from the second author

APPENDIX C - Lists Of Persons Consulted

Extension Officers/Workshop Attendees
Annie Johnson, Austin McLennan, Bec Smith, Dave Kelly, Dave Larsen, David Williams, Evan Brown, Graham Harris, Henrik Christiansen, Ingrid Christiansen, Julie O'Halloran, Kirrily Rourke, Margaret Cover, Michael Grabham, Mitchell Carter, Penny van Dongen, Steve Ginns, Terry Campbell, Toni Anderson, Tony Campbell, Tony Koch, Tracey Fassell, VJ Wigney

Consultants/Designers/Surveyors/Suppliers/Resellers/Government and Research Bodies
Alison Young, Alister Colquhoun, Brain Baird, Chris Maunder, Gerrit Nehrkorn, Jim O'Connor, Jim Spain, John Zeller, Lindsay Tuart, Lisa Fairweather, Mat Wales, Mick Ryan, Noel Dinsmore, Pablo Vega, Paul Covell, Peter Birch, Peter Moore, Peter Morre, Peter Weal, Rick Thomas, Rob Collins, Rob Evans, Rob Long, Scott Commens, Steve Hoy, Steve Warden, David Thompson, Duane Evans, Amanda Noone, Bruce Pyke, Guy Roth, Alister Colquhoun, Murray Chapman, Eddie Parr, David Hamilton, Jim Purcell, Bruce Pyke, Greg Constable, Merv Jessen, Jamie Street, John Mulholland, John Barber, Jo Oliver, Michael Brosnan.

Growers

Their names were not recorded to further maintain confidentiality.

Participants and groups in the Stakeholder Workshop – Moree 18/3/2004

Growers (1)
Lyndon Mulligan, ACGRA
Cleave Rogan, ACGRA
Nick Barton

Growers (2)
Chris Joseph, GRDC
Jim Moore, ACGRA
Greg Morris, ACGRA
Ben Stephens, ACGRA

Consultants
Rob Holmes, Crop Consultant
Rob Long, Crop Consultant
Merv Jessen, IAA
Stuart Moxham, T-Systems
Dirk Murell, Netafim

Extension Group 1
Penny van Dongen, Cotton CRC/NSW Ag.
Rebecca Smith, Cotton CRC/DPI&F
David Wigginton, Cotton CRC/DPI&F
Edwina Dreverman, Conservation Farmers
Mitch Carter, NSW Agriculture
James Neilsen, Cotton CRC/CSIRO

Extension Group 2
Dave Larsen, Cotton CRC
Jane Fisher, CSIRO/APSRU
Peter Smith, NSW Ag./CRC IF/Cotton CRC
Julie O'Halloran, Cotton CRC/NSW Ag.
Traci Griffin, CRC Greenhouse Accounting
David Thompson, Austgrain
Dirk Richards, Cotton CRC/CSIRO

R&D Group (1)
Guy Roth, Cotton CRC
Chaseley Ross, Cotton Australia
Greg Kauter, CRDC
Murray Chapman, NPSI
Matthew Durack, CRC Irrigation Futures

R&D Group (2)
Dan Galligan, Cotton Australia
Bruce Pyke, CRDC
Geoff McIntyre, Cotton CRC/DPI&F
Eddie Parr, NSW Agriculture
Dick Browne, CRDC, Cotton CRC & Condamine Alliance

APPENDIX D - Perspectives From Other Industries On Knowledge Management

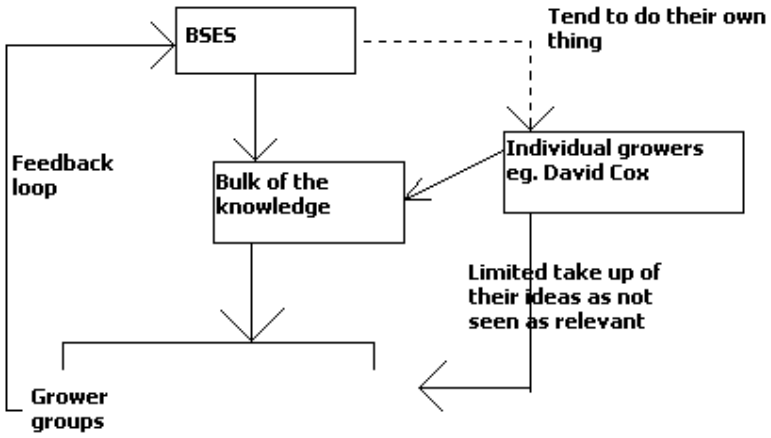
Extension Perspectives of Knowledge in the Sugar Industry

Focus groups with Extension staff
Facilitator: Graham Harris

Overall, how would you view innovation and learning amongst sugar producers?

How is knowledge built?

- Word of mouth
- Slowly
- Farmer innovations are not always promoted through normal extension channels
- Knowledge built by trial
- select key growers and then diffusion to other growers
- Innovators need to adopt
- Others will follow
- Individual grower groups – more active
- Dissemination via grower groups
- The written forms or education are not particularly attractive
- Spoken/seeing/demonstrating are received well – good shed meeting, farm walk attendance
- Knowledge mainly built through personal contact, with people they trust



Innovation
Change from normal that is big quantum leap
Value leap
Not constant or continuous improvement
No different to rest of society. Range of innovation across communities
Slow in irrigation relative to other areas (eg strong in machinery)
Tends to not vary too much across different regions. Drivers may make it change

10 – 20 % of growers are considered innovators and accept/push change. Main constraint is funding at the moment
Need drive to change eg. Bundaberg little water therefore change
Innovation and learning are limited by resources in Industry Bodies as well as growers
Can be driven by particular personalities
Bulk of new knowledge generated by BSES central development
Relative to some other primary industries sugar not particularly innovative

Attitude to change
Risk adverse
Human reactions, especially to complex changes
Economic constraints to adoption
Demographics
Attitude to change for younger growers is open
Becoming more innovative now compared with 4 years ago owing to pressure
Scepticism of growers to some recommendations
Fairly reluctant towards change – slow but will change if need demonstrated (eg. GCTB)

What are the key issues in water management in the sugar industry?
Industry and individual survival
Limited water supply and competition for water
Best use of limited water
Some aspects of BMP can never be adopted due to lack of infrastructure (high cost of changing to more efficient systems)
Efficiency of delivery systems (on farm) affects economics
Efficiency of delivery system (to farm)
Infrastructure – quantity of water available
Capability of equipment and knowledge
Environmental pressures
Provides production and environmental outcome
Off-site impacts/accountability/monitoring of environment
Monitoring
Farm size impacts irrigation
Understanding of system
Lifestyle – time taken to irrigate
Water quality/salinity
Time management/timelines of operations
Information overload
Costs and benefits of water use (economic analysis)
Understanding cost of water relative to economic returns eg is it more profitable to use less water and get a smaller crop?
Economics of whole industry and water specifically
Very difficult to calculate marginal return/ML of water
Right amount, Right time, Right place
Key in measurement to understanding
Limitations to infrastructure to achieve the above
Growers not clear on what is the best performance indication for their system
COAG – implications for districts/ feel action plan etc
Policy

Infrastructure
Enforcement of legislation
Lack of reality with situation by policy makers

What do you see as the public/private sector roles in the sugar industry? (In relation to water)
Public
R and D
Policy – avoid conflicts of interest
Communication policy
Incorporate wider community aspirations into policy
Monitor/measure catchment scale
Infrastructure, education on value storage
Irrigation scheduling and impacts on environment
Take/provide leadership in balancing social/economic/environmental outcomes
Delivering effective policy
Research/innovation extension
Farmer training in irrigation techniques
Generic guidelines clearly spell out what BMP's are and promote them and evaluate success

Private
D and E
Accurate knowledge to provide farmers with right advice
Communication of information management
Monitor/measure farm scale
Equipment supply, advice (mainly with hardware), schedule
Opportunities emerging
Effective/efficient delivery of value adding services
Service dam and that delivers benefits
Intensive agronomic management
Equipment suppliers should get their act together and provide factual and accurate advice and follow-up support
BSES Ltd – is it public or private?
Is there a real opportunity for command delivery in cane?
Public perception of environment damage – needs to be addressed
Need to move from public sector dependence to private sector delivery/benefit

Is there anything that surprises you about these points or anything that you think might be different in the sugar industry? (participants given 2-page briefing on results of NPSI Knowledge Management project prior to answering this question)

Surprises
Surprise – BMP manual is in "Less important" category. How info is accessed. This seems to conflict with statement that 85% of cotton growers changed practices directly because of BMP manual/course.
85% BMP adoption → results showed growers considered it "less important" → why then adoption?
"Researchers" listed in "most important" you wouldn't expect this to be so in the sugar industry
Surprised to see that point 4 on rule of public sector

Differences

Different – How is info accessed → in sugar extension staff would be rated in the "most important" category
We don't have irrigation, let alone general consultants
Under information, knowledge and knowledge and knowledge sharing. Growers in the sugar industry are risk adverse due to the economic situation
In the sugar industry there's little consideration for alternate crops in some areas
Under "Role of public/private providers" very different resources used in sugar industry and focused on one-on-one consultation in these points
Private – sugar industry funded → grower miller funded
Cotton more responsive to change and learn
Sharing information between mills, growers and research bodies needs improving
Less information sought from primary source i.e., BSES, CSIRO etc
Issues much the same
1 – 1 extension sought in both inclusive but sugar can't afford it (largely) due to entity size and $ turnover
Cotton has different environmental issues
Consultants not seen as "most important" in sugar yet
Sugar is monoculture (mainly)
Spray contractors would be seen as more important
Please note – BMP manual is "less important" just like ours
Cane grower less flexible regarding crop options and area
Cane is nearly permanent planting in relation to wait demand (4 year cycle)
Cotton – has much higher rates service personnel/grower means can get message out faster
Cane crop cycle slows down change
Extension information similar
No/very few consultants in cane
Greater reliance on group activities in cane (resourcing issue)
Lack of access to researchers and consultants
Researchers not as available and proactive in talking and giving advice
Farm staff not an info source except for farm managers
Chemical reps are most often giving advice which farmers follow

Based on this, what are the key similarities and differences between cotton/grains and the sugar industry?

Are there key people/resources that you use in the sugar industry that we are missing/not valuing?
Are there any of our people/resources that you think might work in the sugar industry?
Roles of different sectors
Less resources for training and info dissemination to EO's in sugar
More resources for training in cotton
Cotton puts more value on integrating EO's and suppliers with research and priority setting (industry involvement)
Teams working across regions on issues
More involvement with industry bodies with R and E than sugar
Role of industry bodies to bring together and lead industry BMP process
Cane
ET based scheduling
Simple schedule tools eg mini pan
CSIRO – Eddie Correlation ET evaluation

Easy
Cotton
Consultants
Paying attention to better environmental management
BMP process – particularly how to get level of adoption
Extend audit process
Consultants role is nearly non-existent
The unique role the BSES in the industry over a long time
The dependence of the industry on the BSES a culture of receiving and not seeking
BSES, CPPB, Sugar services, CSIRO, CANEGROWERS we are not valuing
The use of consultants may work in the sugar industry
We rely more heavily on the public sector. Have the advantage of partnership with the private sector.
Larger farms in cotton building own resources eg. Own consultants, agronomist
Cane growers may be reluctant to pay for advice as they have previously only paid levy. (BSES) but not normally so "specific" advice
Cotton growers make money and cane does not currently
Cane growers less likely to invest in things (eg consultants, innovation etc) than cotton growers. Related to culture or the two industries
Sugar industry is very factional and it's difficult to get cohesion

Extension Perspectives on Irrigation Knowledge in Horticulture

QDPI&F Horticulture Extension staff – Caloundra, 17 February
Facilitated by Ingrid Christiansen.
Notes: Austin McLennan and Christine Cox

Overall observations:
Some questions and thoughts were difficult for the group to answer. It was evident and commented that as a group they hadn't had this level of review and study of how growers access information and build their knowledge about irrigation. Irrigation was not a particular focus for this group (the RWUE project in Horticulture had been managed through QFVG).
The different horticulture commodities as well as the regions were clearly quite different in how they interacted.

Just as in Cotton and Grains there is a wide range of avenues by which growers access information and develop their knowledge.

Table 2 from the Cotton and Grains draft report was presented to the group for discussion.

Notes of discussion
Is there anything that surprises you about these points or anything that you think might be different in Horticulture?
The scale of infrastructure development and cost in cotton/grains and therefore the immobility of changing practices;
Horticulture not on same scale – more feasible to use trickle irrigation;
BMP manual not primary information source a process total – on 'less important' lists
Growers prefer field days over conferences in avocado growers
Australian Macadamia Growers News Bulletin – well used. Everyone contributes – industry, research, up-to-date with current knowledge – every second month. Similar to cotton tales
Agrilink similar to COTTONpaks – important for people new to industry
Useful to some people especially new to industry soaking up information
Grower experience – irrigation farmers found it important
Learnt a lot in dry period. "Unlearning" in wet times – some going back to old practices. Subtle change
Best prac groups – growers learning from other grower's experience
Scale of water development/cost in cotton
Immobility of infrastructure once established
Interesting that conferences lower than field days → similar to avocado industry (growers don't go to conferences)
Macadamia → did survey about learning. Came back showing strongly learning from other growers
Irrigation resellers very important in horticulture
Irrigation consultants mostly in set-up of system
Scheduling used more in vege crops then the crops (i.e. more critical)
Researchers are an important source only for those few growers who know them personally.

Based on this, what are the key similarities and differences between cotton/grains and Horticulture?
Irrigation resellers – most important in Horticulture

Trickle – lifestyle motivation
Crop Tech consulting group – sensors gives the tools to do own monitoring irrigation system for initial set up. Not so for ongoing monitoring. Vegetable growers use more that tree crop growers.
Craig Henderson's (DPI Irrigation Researcher) game – decisions on irrigation
Researchers – not on broad scale – some specific people resources – industry field days and publications most important conferences useful – not so much for growers level pitched
Collaboration from researchers having trials on-farm intense training available
Project specific communication plans crop specific
Not specific research in irrigation
Growers look for summary
Newsletters for some crops and generic like case studies – Good Fruit and Vegetable
Growers up front talking
Collaborative researchers limited to involved growers
Conferences more for top growers, resellers and researchers
DPI would not be doing a lot in water research

Overall, how would you view innovation and learning amongst the Horticultural growers?
Trickle – highly efficient. Most growers have been using it for a while
Tertiary efficiency and monitoring
Overall attitude – need incentive eg. Drought as catalyst for change
Competitive nature of industry – trust quality, cost yield and management
Subsidy greet for monitoring tools
Competitive nature of industry
Less labour intensive

What are the key issues in water management in horticulture?
Case of management
Quality
Cost
Lifestyle
Availability – yes and access
Impact of water reform – probably will have impact
Insecurity of investment in cotton
Each horticultural industry is different
Recycled water as another source
Reliability of industry in the future
Cost of water not a big issue
Variability to industry
Recycled water another issue for horticulture (Lockyer only?)

What do you see as the public/private sector roles in horticulture?
Private sector – increasing contact
DPI – built skills of consultant
NRM issues
Working with growers for efficiency of water → profitability
NRM needs to be profitable
Management of whole farm not just water
Strategic important issue to manage problem
Chase the research $ through R & D

Service filled by private consultant
Public/private partnership happening – strong but some exceptions in horticulture eg. Macadamia
Hard to work collaboratively with consultants
Level of sharing low in horticulture
Nutrition and irrigation hand in hand in horticulture
Build knowledge of consultants
Talking with each other farmer to farmer
Management team – farmer agreement
Actively try new things
Shortage of rigour in on-farm trials
Ease of management trial and incorporate control path
Not a homogenous industry
Marketing pressure is dominant issue - not pest pressure as in other
There are other areas to make savings
Roland Holmes – Mango project looks at knowledge
What is present nature of partnership? (Very strong in some issues IPM/Macadamias/Bananas)
Consultants can be difficult to work with collaboratively (diff needs)
Issue of personal satisfaction
A DPI moderated email discussion group with macadamia group is quite active

How do you think growers build knowledge?
Talking with each other
Management team talking – weekly meetings (farmer and agronomist)
Try new things (shortage in rigour of evaluation)
Data free observations
Ease of management of trial (more likely)
DPI influence is for growers to use a control in trials
Horticulture – not a homogenous group
Mounting pressure not negotiable, post harvest pressures
"Most growers would see irrigation as minor cost, identify other areas for saving/upping profits"
But a small saving can be a significant profit
i.e. 3% cost reduction → 10% profit
Resources – MacMan group email discussion group
Yields/quality chat
Also Aussie Avo Man
Recording too

APPENDIX E - Summary Of Results Presented At Stakeholder Workshop

OHT 1.Knowledge management in cotton and grain irrigation
Four authors (Ingrid Christiansen, Graham Harris, Cotton CRC National Extension Network, Victor Callan)
Key findings and highlights
Interactive session
Work more on specific recommendations after morning tea

OHT 2. Project builds upon our understanding of
how people and communities get and share information to build knowledge, and then apply it to alter water management practices (pp. 10)
how we change attitudes (pp.11)
a body of knowledge we are now developing across industries about water use, attitudes and key issues (pp. 12-14)

OHT 3. Current cotton extension model
what are the key elements of the current model? (see pp. 15-16)
trails, demonstrations, groups, benchmarking, industry/UNE courses
channels of communication including newsletters, field days, farm walks, workshops, web, computerised decision support tools, links to research

OHT 4. Method (pp.17)
interviews with 90 people (growers of cotton and other crops, consultants, re-sellers, extension, funders)
various literature reviews
3 day Moree workshop in late 2003
today continues this process of consultation

OHT 5. Key issues (pp17-19)
availability, continued security, and cost of water
returns per mega litre – best crop to maximise profitability
water quality
water scheduling
broadly similar issues across irrigators, consultants and resellers
for consultants it is a new area of focus

OHT 6. Attitudes about change (pp.19-23)
majority of growers are change ready
consultants are even more open to change
consultants are a major influence upon growers' decision-making about pest and now water management
operating in an industry that has been good at sharing knowledge, willingness to experiment and continuously learn
importance of the "acid test"

OHT 7.Grower comment (pp. 22)
"I build up my self-confidence about the value of changes to how I manage water by talking to my consultant and other farmers. I won't change unless I see it working elsewhere.…I need good advice and consultants, using research and other farmers and their experience, guides me a lot"

OHT 8. General comments about sources of information (pp. 23-25)
mix of contacts
one on one
about their valley
1-2 years to make decisions
like demonstrations that are short and focused
short concise and focused faxed information
benchmarking is complex and needs to be done for them

OHT 9. Key people and resources for growers (pp.25)
People – own experience, irrigation consultants, researchers, other growers, crop/other consultants
Resources – trial data, field days, Cotton Tales, case studies

OHT 10. Consultants views (pp.27)
People – own experience, irrigation consultants, researchers and growers
Resources – trial data, field days, seminars, publications of research, benchmarking, formal courses, special workshops, Cotton Grower magazine
mentioned less than growers role of Cotton Paks, Cotton Tales

OHT 11. Forces for and against change (pp 29)
Many factors for change – evidence of trails, field days, cutbacks in water, best financial returns, long-term sustainability of farm, reducing labour costs
Fewer barriers but included – not enough practical evidence that changes will work, capital costs, complexity and uncertainty ("what is best for my soil types, climate and water availability")

OHT 12. Grain growers (pp. 30)
very similar issues in water management
actions include reducing summer irrigation, more bores, minimum till
differences – less dramatic impacts of water reform; less use of consultants due to costs; more use of family/farm workers; more "hit and miss" in getting information; taking knowledge gained from irrigated cotton to grains (e.g. wheat, barley, sorghum, peanuts)

OHT 13. Public and private sector roles (pp. 31-33; pp 36-37)
growers having access to data and more control over decisions
public good – growers see extension being focused on understanding grower needs, getting research completed and communicated back to address their needs
private good – consultants as the hands on, day to day role
field days highlighted the public-private partnership

OHT 14. Role of irrigation industry (pp. 33)
Experiences in sugar and horticultural industries (pp. 61-71)
highlights similarities and differences with cotton in more detail
Areas for future research
long list of water and irrigation issues for growers (pp. 34), consultants (pp. 34)
ideas on how to do the social science side of this research (pp. 47-48)

OHT 15. Pulling it all together
Case studies (pp. 40-47)
12 ideas to consider (pp. 49)
15 recommendations to debate and advance (pp. 49-52)

OHT 16. Overview of recommendations

develop and support a package of information and learning mechanisms
one-to-one contact to learn by doing
crop trials, grower groups in own districts
train consultants in irrigation measurement and management
public and private sector roles to complement each other
grower review board in major regions
OHT 17. Recommendations.

APPENDIX F - SUMMARY OF DISCUSSION OF RECOMMENDATIONS AT MOREE WORKSHOP

Recommendation 1

Ensure that information about water management is available through a variety of avenues. Develop and support **a package of a range of information and learning mechanisms** to suit the differing needs and interests of stakeholders. This package would include field days, newsletters, information resources, website, trials, computerised decision support models, training courses, for example.

Practically, how would you see this working or not?
Extension Group 1
It will work because it has worked in other issues
Industry wide coordinator – not valley wide

What and who would help this to happen?
Extension Group 1
Obtaining information from researchers etc
Profile raising of water issues and continuing this when water is plentiful

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Extension Group 1
Highlighting issues
Lack of awareness of the importance of water
Lack of awareness of info that is currently available
Seasonal dependent

Recommendation 2

Continue to promote as a major strategy the **one-to-one interaction and personal contact** between irrigators, consultants, suppliers and extension workers. Irrigators want practical, matter-of-fact information gained through personal contact. They learn by doing and seeing. The best face-to-face methods to promote access to new information and to promote knowledge sharing are field days, trials and grower groups. Access to the experiences of other irrigators and consultants are especially valued as a part of both of these initiatives.

Practically, how would you see this working or not?
Grower Group 1
Area wide
RWUE
Grower Group 2
Growers showing growers (sharing information)
Growers encouraged to innovate with support (IDO, irrigation offices)
Field days
Consultants showing consultants (passing on what individuals best growers are doing)
Dissemination of knowledge
Consultants
Networking
Stakeholders addressing consultants through their association
All stakeholders can't have one-on-one contact = need consultants

Can only work if agronomy is linked to irrigation and understanding of water/plant and soil relationships
Consultants could be facilitators of irrigation knowledge
Through the CCA possibly
Pushed by growers
Need more knowledge on soil types
Better links with irrigation engineers, consultants, soil scientists, growers and extension staff

What and who would help this to happen?
Grower Group 1
Grower driven/consultant
Grower Group 2
Individual industry specialists teaching local consultants and growers → other side is a one stop shop for gaining of information as well as dissemination of information to back up local projects
Consultants
All stakeholders must be involved = channelling through the consultant
Pushed by the grower on what info he requires
Study tours → broaden the consultants horizons
Empower the consultants with info, contact points, irrigation specialists, resellers at least with the skeleton and the links/contacts to
Pick 2 or 3 growers, consultants, resellers in each valley and do research or extend research then let masses come to field days

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1
Enough pain/return of investment
It is happening in RWUE
Need industry wide
Grower Group 2
Non-specific information being bombarded on growers, "What specific to my farm will really have an impact?" - so localised knowledge
Duplication is a problem
Having to pay extra for possible solutions is a barrier for widespread adaptation
Sharing across regions
Consultants
Consultant is the facilitator - bring expects to the grower
Networks
Researchers can't operate one-on-one
Consultants can't be experts in everything → reliant on networks
Consultants may feel threatened if other people talk one-on-one and not say the same thing
Consultants are getting older
Lack of networks
Repetition on extension (consultants, specialists, extension people) - thus strain on researchers

Recommendation 3
LOCAL INFORMATION
Irrigators want more information relevant to their particular set of farming conditions (i.e. soil type, location, climate). They want more **crop trials, field trials and growers groups in their own districts, and write-ups of local case studies** providing practical, accessible information relevant to their particular conditions. Therefore, more effort needs to be taken in research being trialled

across different types of districts, and the outcomes of these trials being promoted through field days and short, practical publications like *Cotton Tales*. These need to draw together the water delivery and agronomic aspects of water management.

Practically, how would you see this working or not?
Grower Group 1
RWUE
Grower Group 2
Growers showing growers (sharing information)
Growers encouraged to innovate with support (IDO, irrigation offices)
Field days
Consultants showing consultants (passing on what individuals best growers are doing)
Dissemination of knowledge
Consultants
All stakeholders need to be involved
Documentation is important
Use them as case studies
On-farm case studies need to be documented
Extension Group 1
Existing model already in place ie groups formed
New methods for facilitating labour intensive processes so that they can be undertaken more broadly
Greater emphasis on collaborative responsibilities
Extension Group 2
Works well
Brings people together

What and who would help this to happen?
Grower Group 1
CRCs
Grower Group 2
Individual industry specialists teaching local consultants and growers → other side is a one stop shop for gaining of information as well as dissemination of information to back up local projects
Extension Group 1
More staff on the ground in regional areas
More collaboration and facilitation of trials etc (more partnerships)
More efficient use of staff
More relevant expertise and infrastructure
More resources and more appropriate resource targeting
Extension Group 2
Trials need to be set up to answer the questions rigorously
Local Department Agriculture
QDPI course
Look at: Birchup Cropping Group – winegrape industry, grains industry

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1
Funding
Grower Group 2
Not specific information being bombarded on growers, "What specific to my farm will really have an impact?"

So localised knowledge
Duplication is a problem
Having to pay extra for possible solutions is a barrier for widespread adaptation
Sharing across regions
Consultants
Difficult to manage → easy to lose control
Success of such trial are very dependent on growers – easy to let it become second fiddle to every day farming issues
Extension Group 1
Lack of expertise in existing staff
Technological barriers
Lack of staff
Lack of in-kind labour provision (this is not widespread, most are good providers of assistance) from collaborators i.e. growers, consultants
Extension Group 2
Yes it is happening now
Issues with rigour and relevance – there are practical issues around having growers run their own trials with data collection
Use other people to run trials
See CSE review – in press
Important that trials are developed locally – "sell" areas trial needs to be do-able and needs to be done over several years to make sure that it has significant outcomes
Employment continuity

Recommendation 4

Provide detailed, practical training in irrigation measurement and management for consultants. Private consultants need to be better educated about irrigation management. While expert in pest management, many consultants believe that they lack the required levels of irrigation management knowledge to best assist growers. Identified experts (e.g. expert private consultants in whole-of-farm water efficiency management, successful irrigation farmers from various states and regions) need to be brought into all regions to train private consultants, extension officers and others in the numerous aspects of more effective water and irrigation management.

Practically, how would you see this working or not?
Grower Group 1
Will work well, lots of consultants wanting to expand their business
Grower Group 2
Identified experts
Consultants
More info on water scheduling for different irrigation systems
Train the consultant = by other stakeholders eg. suppliers, researchers etc.
Consultants lack the info correctly
Networks and links
Focus initially on measurement of water
Networking
Extension Group 2
NSW Ag Waterwise course – short course 4 day
IAA learning guides through eg. TAFE – get Cert II, III, IV, V, longer course
Accreditation (crop, industry specific) eg IAA courses on cotton
Modular course – to allow selection
R&D Group 1

Industry scholarships – then roll out learning
Develop a business model which encourages high quality professional irrigation measurement and management services
Developing appropriate tools by engaging manufacturers and resellers
Certification model for consultants in this area
Gaining info and resource requirements from those few people currently out there who are doing some innovative work in this area
Encouraging undergrad and postgrad involvement and education
Use expertise (eg Jim Purcell) as train the trainer
R&D Group 2
Industry need 1 or 2 engineer irrigation extension specialists (cotton/grains focus)
Training provided to consultants
Need peer support
Need to involve existing cotton extension team → revitalising
Provide a pathway for professional development
Goal – multi-skilled consultants

What and who would help this to happen?
Grower Group 1
Consultants and industry consultants having a short course set up
Consultants
Suppliers, researchers, extension (government)
Universities – provide courses focused on the issues that matter to industry
Could get extension to train consultants
Private sector training
Short courses linked with formal courses
Formal courses
Focused specific courses on irrigation
Universities to facilitate courses
Extension Group 2
Industry works with education provider eg CRC cotton and NSW Ag, TAFE
R&D Group 1
Industry grabs hold of the reform process and links into it
Course @ AOF level 4 for irrigation
CCA
CRDC
CRCIF
IAA
CA policy – linking in to the reform agenda
R&D Group 2
Cotton extension team
Consultants
USQ (uni) courses
WUE
Existing training available IAA
Based at Technology Resource Centre
CRC IF
Cotton CRC

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1

Private vs. public sector, seen to be "hogging" the info
Need to have people disseminating this info, so if consultants are interested than train them up
Consultants
Lack of whole industry total understanding of irrigation methodology. Pro's and con's plant, water, soil relationships > $ benefit > need more research = practical
Formalised training not specific enough
Relying on strength of link between growers and consultants
Lack of knowledge about irrigation – growers, government, consultants, environmentalists – need more research and coordination
Extra costs to growers
Extension Group 2
People think they know more than they do
Course maybe need specific to systems, crops, etc
Quantifying people's relative experience – RPL?
Modules to fill the gaps
People don't want subjects in things they already know
R&D Group 1
Capturing the data i.e water use could be considered by some as risky
Sorting out the expertise provider
Regulation overtaking us before we get the skills
Growers too focused on immediate issues eg. drought rather than looking out 3 – 5 years
R&D Group 2
Make sure people involved have a good mix of skills / knowledge
Providing enough skills and ability in a short period of time → long term results / long term staff
Maintaining staff skills

Recommendation 5

COMPLEMENTARY PUBLIC AND PRIVATE SECTORS

The public sector role and expertise needs to continue to be centred upon providing, in highly accessible formats, the findings of relevant research supplemented with practical examples of the local application of this research. Extension staff are perceived by irrigators, consultants and others as facilitators or "knowledge-brokers" who provide information that demonstrates best practice and technical support. They need to continue to promote this role, including greater efforts to promote information to private consultants who are the key individuals influencing irrigators' decisions about water management.

Practically, how would you see this working or not?
R&D Group 1
Ensure that government and departments are aware of the importance of role of public sector expertise
Strategic agreement b/w industry and government as to who supplies what

What and who would help this to happen?

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?

Recommendation 6

Research needs to be targeted to meet growers' needs. It is proposed that a **grower review board be established in major regions** to identify key areas for research, and secondly, to discuss with researchers at regular forums the practicalities of actually implementing the findings from their

research. This body would assure that research that is required for specific regions is undertaken. Also this body needs to work with extension so that research findings are communicated in ways that maximise the likelihood of uptake by growers and consultants in particular. This role may be a local adaptation of the ACGRA function.

Practically, how would you see this working or not?

What and who would help this to happen?

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?

Recommendation 7

Given their central role as a key source of information gathering and knowledge generation and sharing, **consultants need to be better targeted in extension activities**. A cooperative approach to information transfer is the best option, and one that is very possible given the existing positive relations between consultants and extension in most valleys.

Practically, how would you see this working or not?

What and who would help this to happen?

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?

Recommendation 8

Continue to send out **short, concise, practical information** to growers through *Cotton Tales* in particular. Include links to more detailed, useful information. Where possible, *Cotton Tales* should be modified by local extension officers to promote information of the most relevance to their particular region and those growers' needs. Similar formats would be useful for grain irrigators, although more work is needed in understanding their needs.

Practically, how would you see this working or not?
Grower Group 1
Fax, newsletters highlighting, research projects – very lucidly and outcomes
Field days to "wet appetite"
Farmers don't' have time to read lots of information
Researchers love to talk about themselves – take home messages
Easy to do, must be relevant and short. References needed if further info required

What and who would help this to happen?
Grower Group 1
IDO, industry hierarchy – co ord
IDOs, WUE officer, industry and consultants, region based

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1
Producing information that is "rubbish" → meets needs

Printed vs. Electronic media – links to point that farmers don't have time to read lots of information

Recommendation 9

More work is needed into identifying potential vehicles for cross-industry cooperation in the area of sharing information and knowledge about water management, including forums devoted to innovative water management strategies, and greater incorporation of lessons from other industries into *Cotton Tales* and information paks given to growers.

Practically, how would you see this working or not?
R&D Group 1
Cross-industry working groups to plan activities at multiple levels
Exchange program (residential) at the various levels of industry and various sectors of industry – regular industry sabbatical → must have a sharing extension component so the info is shared
Encourage diversity of tertiary learning i.e. ag colleges send students away to another to broaden experiences

What and who would help this to happen?
R&D Group 1
Organisations and associations that both represent these sectors and also cross industry i.e. IAA, CRCIF, RDC's
Our industry would need to approach these other groups
DAFF possibly

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
R&D Group 1
Time
Possibly a mental barrier

Recommendation 10

There needs to be the development of more **"one-stop" integrative information tools**, such as for example, CD's that combine all of the information from different sources on water management (WATERpak is currently under development); a searchable database of all trials (including trial books); field days that only focus on one or two issues in-depth; and a catalogue of "who is doing what" in research.

Practically, how would you see this working or not?

What and who would help this to happen?

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?

Recommendation 11

Continue and increase the offerings of the courses such as the Cotton CRC's/UNE's **Cotton Production course** and the GRDC's/UNE's **Sustainable Grain Productions course**, and ensure a sufficient focus upon irrigation management.

Practically, how would you see this working or not?
Grower Group 1
More short courses – 2-3 days max – consultants/growers
Using scientists Uni
Uni – supply of industry personnel – consultants/researchers
Specialists IDOs
Model of IPM short course bringing together Industry research
Farmer driven

What and who would help this to happen?
Grower Group 1
Extension – network – Uni's specialists - CRCs
IDO/RWUE CRC
Consultant
Farmer driven

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1
Getting people involved – need to involve
Funding
Enough pain/return of investment

Recommendation 12

MEDIA ARTICLES

Regularly prepare and place articles about more effective water management for specific regions in *Cotton Tales*, the *Cotton Grower & Graingrower* magazines and *Country Life/The Land* and promote these to growers and consultants as a resource for irrigation information.

Practically, how would you see this working or not?

What and who would help this to happen?

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?

Recommendation 13

Identify or appoint extension staff willing and able to develop greater technical and general expertise in water and irrigation management to be available to all key stakeholder groups, and most specifically, growers and consultants.

Practically, how would you see this working or not?
Grower Group 2
Good communication

Driven person (enthusiastic/positive)
Funding → RDC's, CMA's, Government – based on politics of water reform (all agricultural industries)
Extension Group 1
It will work if you can get staff
Recognition of the requirements of irrigation staff and avenues for developing appropriate staff resources
Extension Group 2
Happening now

What and who would help this to happen?
Grower Group 2
WUE – Federal Government
Need a key researcher
team/issue leader
credible
one stop shop for consultants/IDOs
Extension Group 1
Training
People who are willing and able
Incentives
Extension Group 2
Some long term positions to attract and maintain quality staff

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 2
Personalities – respected
Funding
Currently – there is enough extension but needs to be better focused
Extension Group 1
Where do you source staff
Staff retention
Overcoming the perception it is too difficult (daunting)
Career advancement and incentive
Recognition of the importance of water work
Extension Group 2
Funding and political will dependant
Extension staff trained in water enough to work with farmers
Career path for water extension officers
Short term contracts; nowhere to go

Recommendation 14

Investigate the potential and scope for an **Irrigation Technology Resource Centre,** and determine whether this Centre could service all irrigation sectors nationally.

Practically, how would you see this working or not?
Grower Group 2
Not keen on this – need information to be locally tailored
Extension Group 2
Database of research, trials, etc completed and in progress

R&D Group 2
Not associated with a specific industry
Under the CRC Irrigation Futures / people attached to it → advice, resources
Should be a centre of knowledge (under a uni)
Could be a virtual centre not a physical structure
Decision support systems
Knowledge bank
Books
Case studies
Training packages
Contacts
Repository for all information
Provide a focus for link of irrigation industries (cotton tech centre)

What and who would help this to happen?
Extension Group 2
CRCIF auspice at USQ NCEA (Steve Raine) seconding Dave Larsen to get it going
R&D Group 2
Who → collaboration of other CRCs
Existing industry structures
Cross industry funding and co-operation

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 2
Diversity across regions too streamlined
Local adaptable knowledge
"growers showing growers" in locally adapted areas. This is the real avenue for change
to back up the above point a one stop place for knowledge to answer questions. This includes industry information indicating what other growers are doing
R&D Group 2
How to ensure the knowledge is used
Industry cooperation vested interest elsewhere
$ / Resources
Start small as extensive irrigated field crop and perhaps expand Northern Murray-Darling Basin

Recommendation 15

It is recommended that a series of **specific research projects be commissioned to investigate further various key aspects of irrigation management** that are identified in this report. These projects respond to the information and knowledge needs of key stakeholder groups. The specific topics are detailed in various sections of this report. In addition, future research might benefit from the use of other research methods to investigate knowledge management and related issues. Again, such methods are identified in the body of this report.

Practically, how would you see this working or not?
Grower Group 1
Easy to implement or gather information and disseminate it
Extension Group 1
Highlighted as need
Gaps in knowledge
Confidence building in research (growers and consultants)

Extension Group 2
Could be externally funded
Could be separated geographically (national and local)
Could be long or short term
Identify appropriate research question
R&D Group 2
Under the new Cotton CRC / CRC Irrigation Futures
Funnel for cotton is through Cotton CRC
Crop trials
Grower groups
Local write ups
Case studies
Sets priorities/targets → short/long term
Do we need a water target (Efficiency)

What and who would help this to happen?
Grower Group 1
Qld good, NSW lacking
Extension Group 1
Long term strategy and resource allocation
Grower direction and involvement
Extension of research critical
Open minded adoption of research findings from other areas
Extension Group 2
Corporate support in eg Moree area
Agency staff
Farmer co-operators
Grow groups could employ private consultants (i.e. not necessarily agency)
R&D Group 2
New Cotton CRC link to CRC Irrigation Futures → key player
NPSI / L and W Australia
University / State departments
CRDC

What are the barriers and risks that need to be overcome?
eg Is this happening now? If not, why not?
Grower Group 1
Move the border
Extension Group 1
More research staff and expertise
Balance b/w proportion of findings compared to importance
Attracting and retention of staff in regional areas
Extension Group 2
Who will put up dollars?
Dedicated people i.e. research staff, needed
Maintaining staff over project life
Intellectual property
R&D Group 2
CRC bid does not get up
Yes but not coordinator focused