

Towards Sustainable and Profitable Water Use in the Australian Cotton Industry

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Cotton Catchment Communities **CRC**

The Cotton Catchment Communities CRC

The Cotton Catchment Communities CRC (Cotton CRC) commenced operations in November 2005 and has widened the concept of sustainability of our agricultural landscapes to include integration across farms, catchments and local communities. Although cotton farms account for only five per cent of total catchment areas in cotton growing valleys they occupy between 60 and 80 per cent of the riparian land in those valleys, so their land management and use of water are integral to catchment health – and integral to the work of the CRC.

The CRC is based at the Australian Cotton Research Institute near Narrabri, in the heart of the Namoi valley cotton growing region and has a wide range of participants including industry bodies, the CSIRO, state government departments, universities and private enterprise located all over Australia. Further information about the CRC's structure and programs can be found at www.cotton.crc.org.au.

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Water is critical to agriculture. Sustainable water use in Australia must encompass economic, environmental and community needs. The CRC's goals are to ensure the Australian cotton industry continually strives for high water use efficiencies using science and education to deliver profitable and practical outcomes.

In its first three years the Cotton CRC, with its partners, is investing \$17 million in water research, education and extension so that the Australian cotton industry can remain the world's leader in water management.

COTTON AND WATER

Water is the major limiting factor for the Australian cotton industry, so growing 'more crop per drop' is vital for the industry's environmental and economic sustainability. Some cotton growers have achieved significantly higher yields in recent years without using more water – in fact, leading growers have doubled their water use efficiency from one to two bales of cotton per megalitre. However, this does not apply across the industry and greater and more consistent gains are a high industry priority, as is good water quality and sustainable catchments.

An important part of improving water use efficiency is knowing how to measure it. This is easier said than done and caution should always be exercised when examining water use figures. Generally, farmers will refer to the amount of cotton grown per megalitre of irrigation water used in terms of bales per megalitre. When comparing crop water use figures, it is important to check whether the numbers include or exclude rainfall. Cotton is grown in northern NSW and south east Queensland so, unlike southern NSW and Victoria, summer rainfall is an important source of water during the crop growing season.

In order to achieve consistency of water use efficiency measurement, the cotton industry adopted standard measurements, outlined in the major industry resource *WATERpak* in 2004:

- Crop Water Use Index (CWUI): lint produced per millimetre of evapotranspiration from a field during the cotton season
- Gross Production Water Use Index (GPWUI): the lint produced per megalitre of total water used on a farm or field
- Irrigation Water Use Index (IWUI): the lint produced per ML of net irrigation water applied to a field or supplied to a farm
- Whole Farm Irrigation Efficiency (WFIE): the amount of irrigation water used by the crop for evapotranspiration as a percentage of that applied to the crop.

The Australian Cotton Industry

Australia's modern cotton industry progressed from modest beginnings in the 1960s to become a valuable contributor to rural exports by the 1990s. Prior to the major drought of recent years, Australia grew about three per cent of the world's cotton but was the third largest cotton exporter. Major buyers of Australian cotton are Indonesia, China, Japan, Thailand and South Korea.

Australian cotton farms are typically 500 to 2000 hectares, highly mechanised, capital intensive, technologically sophisticated and require high levels of management expertise. They usually consist of cotton, grain and livestock enterprises. About twenty per cent of the crop is dryland cotton, grown using only rainfall, although this figure varies according to seasonal conditions.

The average yield for irrigated Australian cotton over the last five years has been 1830 kilograms of clean lint per hectare: the highest in the world. This can be attributed to improved crop varieties, better crop management systems and technology adoption, which have been achieved over the last decade with a reduced impact on the environment.

Seventy per cent of Australia's cotton is grown in NSW, with the remainder grown in Queensland. In non-drought affected years, some 1,200 small and medium-sized enterprises grow cotton and more than 4,000 businesses are directly dependent on cotton production and employ around 10,000 people. Entering the 2006–07 season, Cotton Australia has revised the number of registered cotton growers down to 1000.

The Australian cotton industry is currently suffering a major production, economic and climatic trough. In the five seasons from 2001–02 to 2005–06, the area planted fell around 38 per cent and gross revenue slumped by around \$2 billion dollars, or 27 per cent, compared with the five years from 1996–97 to 2000–01. In addition, the industry faces a cost:price squeeze, with the cost of inputs rising while international cotton prices are stagnant or falling. Cotton remains the world's preferred clothing fibre, with world consumption of cotton rising, and the forecasts are that consumption will exceed supply.

A survey conducted in 2006 by the Institute of Rural Futures on behalf of the CRC, Cotton Research and Development Corporation (CRDC) and Cotton Consultants Australia Ltd, confirmed that a significant majority of growers regard improved water use efficiency as a high priority but still have difficulty measuring it accurately. As a consequence, the CRC's water extension team is undertaking a project to further improve the accuracy of water use efficiency monitoring and on-farm water use efficiency practice.

The Australian cotton industry's environmental management system, Best Management Practices (BMP), was enhanced in 2004 with the release of a Land and Water Management module, which has 17 objectives relating to irrigation efficiency.

COTTON CRC WATER RESEARCH

The Cotton CRC, its partners and growers are spending millions of dollars to improve water management. This involves a complex array of better cotton agronomy, new plant breeding varieties, good soil management, and efficient irrigation management.

CRC projects relating to water use and quality range from the field, to the whole farm and its groundwater, storages and wetlands, the river and the channels that connect the two. In other words, the catchment and its components. This work has been going on quietly for years, but is receiving even greater attention in the new Cotton CRC.

The CRC is also undertaking a Climate Change scoping study, due for completion in April 2007, to pull together what is known about climate change in cotton communities and establish the gaps and questions that require future research.

On the farm

Irrigation

Irrigation is the most significant factor involved in water use efficiency: how and when water is applied to the crop. In recent years, an increasing number of cotton farmers have moved to overhead spray systems (both lateral move and centre pivot systems) although furrow irrigation – in which syphons connecting each contoured furrow with the channel are reset by hand for each irrigation – remains the dominant method of delivery. A small number of growers apply water with sub-surface drip irrigation. This system delivers the benefits of negligible deep drainage (water lost below the plant's root zone) and less water runoff and soil surface evaporation; however, its adoption has been impeded by the significant setup costs. Sub-surface drip irrigation is particularly suited to light soils and a CRC project



Furrow irrigation is still the most common means of delivering water to the crop

examined its potential for winter-grown Bollgard II® crops on land in the west Kimberley that is unsuited to other irrigation methods.

A major CRC project is investigating the impact of different management strategies on the yield and quality of irrigated cotton. The data will be incorporated into existing crop models, which can then be used to develop information products and training packages. These will aid irrigators and their consultants faced with limited water to make water management decisions that maximise crop profitability where furrow, overhead or drip irrigation systems are used.

There are a number of siphon-less or bank-less irrigation systems in use in the cotton industry. The Cotton CRC, in collaboration with CRDC and the Queensland Government Rural Water Use Efficiency III initiative, Queensland Murray Darling Committee, Border Rivers-Gwydir CMA, funded research to determine the relative efficiency of these systems. Performance data to date indicates that the furrow system outperformed bank-less head ditch and bank-less channel systems on all indicators but that the 'pipes through the bank' system performed on a par with adjacent furrow irrigation.

Purchase of irrigation monitoring equipment to compare water requirements and optimal irrigation scheduling for both Bollgard II® (biotechnology varieties) and conventional cotton crops is enabling rigorous measurements in the CRC's irrigation research.

Water and cotton plants

Gaining an understanding the plant's responses to water and then optimising those responses is an important part of using water efficiently. A major project has investigated variations in the plant's response to the soil:water status under different soil and climatic conditions and the consequences for in-crop water management. This project provided a basis for optimising the irrigation strategy for cotton in different production regions. It also underpinned the development of *WATERpak*, now a major industry resource bringing together the latest irrigation-related research outcomes and an important tool in implementation of the BMP Land and Water Management module throughout the industry.

An ongoing project is seeking to understand and then optimise crop response to water with new technologies such as high boll-retention Bollgard II® crops (which have two genes of resistance to cotton's principal pest, *Helicoverpa* spp.) and changed irrigation application methods such as low deficit scheduling, overhead systems and drip irrigation. Preliminary results from CSIRO research indicate that Bollgard II® biotechnology varieties may be more water efficient, using ten per cent less water than an equivalent conventional variety under normal full irrigation and producing higher yields. Although Bollgard varieties retain more bolls (which require water), they have a shorter growing season and thus need fewer applications of irrigation water.



Overhead irrigation systems such as this lateral move are increasingly water use-efficient and cost effective

Other projects have investigated ideas such as partial root zone drying and research also continues of crop physiology.

Biotechnology companies such as Monsanto Ltd are researching new water stress plant genes and the CRC will contribute to related commercialisation and agronomic research as these genes become available in a few years time.

Water quality

Although deep drainage, or the loss of water beyond the crop's root zone, occurs on-farm, it is a whole-of-catchment issue with implications for both water use efficiency and water quality. To put this issue into perspective, estimates are that prevention of 1.5 megalitres per hectare of deep drainage per season equates to annual savings of 324,000 megalitres of irrigation water across the industry.

As recently as 1999, deep drainage was not believed to be a major problem on cotton's typical cracking clay soils; however, more recent measurements on the Darling Downs and in the Namoi and Macquarie valleys showed it to be an issue of concern. New research has commenced to quantify deep drainage, using a network of seven lysimeters on cotton farms with varying soil types in northern NSW and southern Queensland.

The Cotton CRC continues major deep drainage research, aided by funding from CRDC. A project is under way to continue data collection from lysimeters at a total of 21 sites, including the seven sites used in earlier research and a major new lysimeter installed at the Australian Cotton Research Institute (ACRI) near Narrabri in 2004. This research will contribute to both on-farm water savings and off-site catchment-scale reduction of groundwater recharge with potential for rising saline water tables. It is investigating the link between changing aquifer levels and local irrigation practices, including deep drainage. The project aims to produce and trial Best Management Practices that provide practical control measures for on-farm deep drainage.

A CRC project is using the large ACRI lysimeter to quantify drainage under irrigated cotton/wheat rotations so as to understand how and when it occurs. This will allow the development of strategies for minimising drainage in different soil types and management situations. Importantly, it also aims to determine whether contaminants such as salt, fertilisers and agrochemicals are being transported by drainage. Piezometers installed near the lysimeter will be used to investigate linkages between drainage and groundwater.

A further project is seeking to develop an easy and inexpensive method for measuring the risk of deep drainage – a method that may be available to cotton growers, consultants and anyone else concerned with environmentally sustainable farming.

Ancient channels known as palaeochannels exist under irrigated fields and have been identified as having a higher risk of deep drainage because of their sandier nature. Little is known about the pathways and flux of this water after it infiltrates the palaeochannels or how changes in soil properties and sedimentary layering govern this movement. As an adjunct to wider deep drainage research, a recently completed project has identified water movement characteristics in palaeochannels, allowing hydrological modelling to help evaluate different irrigation strategies and management options.

The CRC has undertaken some water quality monitoring on farms. A three-year Australian Government Natural Heritage Trust project in the Gwydir valley monitored water quality in farm storages. Other smaller data sets have been collected in the Namoi and Dirrinbandi areas. In general, water quality on cotton farms is of good quality.

Salinity is commonly associated with irrigated landscapes so the Australian Cotton CRC undertook soil

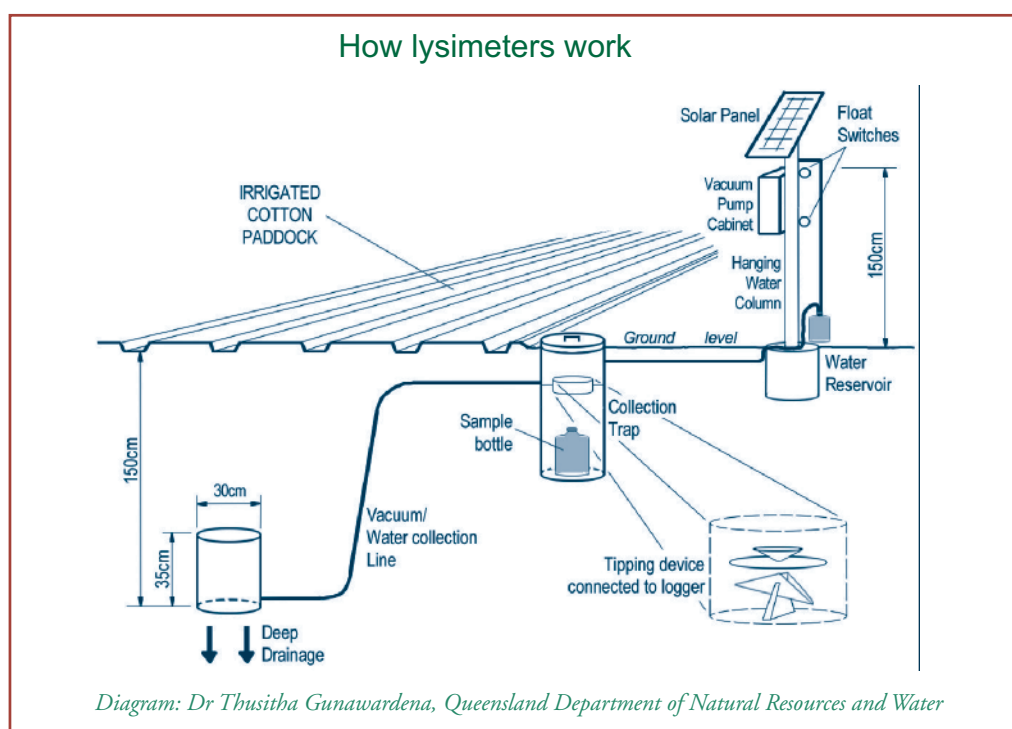
surveys for salinity in most growing areas. These surveys have all been made available to industry and published in both academic and rural journals. Salinity is not considered a major problem but the cotton industry remains active to ensure this remains the case.

On-farm water storage

Many cotton farms have large water storages, also known as ring-tanks. The Namoi and Gwydir regions – the major NSW cotton producing valleys – have at least 20,000 hectares of storages on cotton farms and there are 18,000 ha of storages in south east Queensland.

The on-farm storages provide significant advantages in improving water use efficiency but have one major problem: evaporation. As with all large water storages, cotton farms are losing between 15 and 40 per cent of their stored water to evaporation, depending on a host of variables such as temperature. Although some technologies to reduce evaporation exist, very few are used because of their prohibitive cost and a range of practical problems. A major collaboration between the Cotton Catchment Communities CRC, CRC Irrigation Futures and CRC Polymers is seeking to develop and commercialise evaporation mitigation products and systems that can be applied successfully to storages larger than ten hectares. The focus is on both development of new monolayer (protective layers on the surface) polymer product formulations and sensor/monitoring/control/application systems to improve the performance of monolayers.

While the project's principal concern is irrigation, potentially it offers the community much wider water-saving benefits through application of the technologies and products it develops to storages used for mining, domestic and industrial water.



The storages provide opportunities to increase on-farm biodiversity and bioremediate chemicals from pesticides and fertilisers. In early 2006, the CRC released *Design principles for healthy waterways on cotton farms*, the outcome of a CRC research project in which scientists from The University of New England and The University of Sydney collaborated to bring together the outcomes of a series of research projects conducted by the Australian Cotton CRC between 1999 and 2005. These projects ranged from river water and storage water quality to pesticide bioremediation and the use of artificial wetlands for pesticide degradation. This publication provides a readily digestible summary of key design principles for on-farm storages, dams and reservoirs and how to link them into the farm irrigation system for optimal environmental and economic performance. Other research on birds has shown that these storages provide significant habitat to both wetland and woodland birds.

Another CRC project is examining aquatic biodiversity and the ecological value of water storages, identifying the aquatic species present in the storages and seeking to understand the effect of seasonal pumping in and out of water on their abundance and diversity. The project is comparing aquatic populations in the storages with those of nearby rivers and also looking at the influence habitat structure such as grasses, water weeds and reed beds, snags and bank slopes have on the populations.



On-farm water storages offer farmers the opportunity to improve water use efficiency, increase biodiversity, bioremediate chemical and – potentially – to farm fish



Research conducted by the Australian Cotton CRC identified the important role on-farm storages can play in bioremediating pesticide and nutrient residues. Two CRC projects now seek to further extend the benefits of remediation technologies developed through the earlier research and commercialised by CSIRO Entomology and Orica Australia Pty Ltd. A major project will provide information on pesticide threats for the next five years, with better insight into the use of wetlands and enzymes, and the associated benefit:costs. This will provide cotton growers with guidance on improving on-farm water quality in relation to pesticides and nutrient residues such as nitrogen. A second project is addressing an issue identified as a high priority in a CRC scoping study: development of an enzyme to degrade toxic metabolites of phenylurea herbicides such as Diuron.

Ground and surface water

Irrigation water is returned to the river eventually via deep drainage and groundwater/surface water interactions, through a variety of factors such as channel and storage seepage, irrigation runoff and deep drainage.

There are considerable gaps in our knowledge of groundwater quality and availability. The University of NSW and University of Technology Sydney are leading groundwater research within the CRC. The recharge of groundwater systems can be directly linked to irrigation practices and CRC research is seeking to understand these systems and how best to manage them. Recently completed scoping projects assessed the physical and chemical status of aquifer systems in a number of regions, reviewed existing groundwater models for each aquifer and indicators that might be useful as simple measures of groundwater health. Studies covered the Upper and Lower Namoi, Border Rivers/Gwydir, Condamine and Balonne. These projects have provided information to guide future groundwater research and monitoring.

The cotton Best Management Practices program requires growers to monitor groundwater quality but this is hampered by a lack of formal indicators of groundwater health in Australia. A current project will develop and validate a 'toolbox' containing groundwater health indicators, instructions and benchmark criteria that will aid cotton growers and catchment managers in the monitoring, assessment and reporting of groundwater health and biodiversity.

Existing landscape scale models are essentially either groundwater-based or surface water-based. Using the Namoi as a test catchment, and building on existing catchment, groundwater and river models, a further project will develop a rigorous and transferable analytical framework to quantify groundwater/surface water interactions, with the aim of contributing more reliable water balance estimates. The project should be completed in time to provide information for the NSW Government's Namoi water sharing review processes.

A further project seeks to quantify the exchange of water between a river and groundwater along a stretch of the Namoi, south of Narrabri in north west NSW, with a secondary site on Cox's Creek to test the general applicability of findings from the main site. The information gained will be used to develop a 'tool kit' for the investigation of surface water and groundwater interconnectivity.

Rivers and wetlands

The lower Gwydir valley in northern NSW, comprises an extensive floodplain, multiple stream channels and two terminal wetlands of national importance. Floodplain



wetlands rely on inflows from catchments to maintain the flooding and drying cycles critical to maintenance of their ecology. The development of irrigated agriculture in the Gwydir valley over the past thirty years has significantly affected flow patterns into the key wetlands as have extensive grazing and, more recently, dryland cropping. In addition, the Gwydir Valley is the largest cotton-growing region in Australia.

A major CRC project involving the University of New England, Australian National University, NSW Department of Natural Resources and others, conducted with assistance from the Natural Heritage Trust, is seeking to determine the flow requirements of streams and terminal wetlands on the Lower Gwydir floodplain. The project will develop recommendations for future flow management, monitoring indicators and institutional arrangements for the Lower Gwydir aquatic ecosystem. It will also provide a model to guide environmentally effective management of flows from the Gwydir Regulated River Environmental Contingency Allowance (which is available to enhance river and wetland health) and other river flows into floodplain terminal wetlands. The CRC anticipates that this work will lead to enhanced water sharing plans for surface water across the Lower Gwydir ecosystem.

A CRC project through the Australian National University, with assistance from NSW Department of Natural Resources, aims to develop and implement a flood model of a floodplain wetland, using the Gwydir wetlands as a case study. A major outcome of the project will be a capacity to improve the ecological benefits of wetland

floods, through both the management of natural floods and the delivery of environmental flow provisions.

A CRC project is seeking to add to existing data from experiments undertaken in the 1990s on the spatial and temporal dynamics of the Gwydir wetlands and the impact of grazing on biodiversity and wetland health. The project will measure the response of key native and invasive plants to different environmental conditions and water regimes (through flooding and the release of the environmental contingency allowance) by undertaking comparative field studies, then linking these to grazing management.

Water sharing is a topical issue and it is important that decisions are underpinned by good science. CRC projects on groundwater and surface water, described above, will aid the water sharing process. Extraction of irrigation water in unregulated rivers in semi-arid catchments is also seen as limiting the amount of downstream overbank flows, limiting pasture production and grazing. A PhD project is examining the question of irrigation from unregulated rivers and the effect on floodwaters, with the final aim of developing a simple desktop computer tool that can be used by river water users and floodplain producers to investigate river flows, irrigation extraction and the extent of downstream overbank flooding.

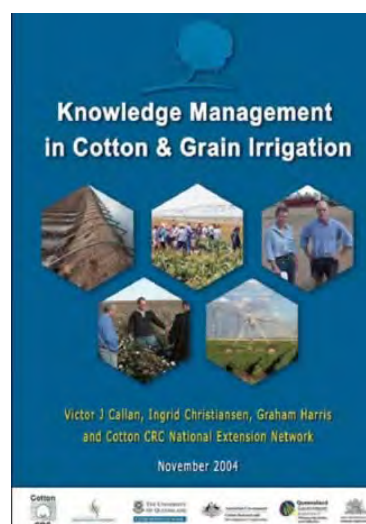
In dryland cropping and pastures, water balance studies have been used to inform models, which are now commonly used to address catchment-wide issues such as salinity risk and water quality while retaining explicit links back to paddock level land use and management. For such methods to be used in catchments with significant areas of irrigation, we need to be confident that the water balance, particularly runoff and deep drainage, can be modelled with reasonable confidence. A CRC project is addressing these issues by capturing data from past experimental studies on a range of related issues, including measurement of soil properties, then developing models for use in the spatial/catchment context.

Recent reviews of the principles underlying the management of large rivers stress the need for a better understanding of the relationships between elements of the flow regime and ecological processes. A recently completed University of Technology, Sydney scoping study of river flow measurements reviewed methods of measuring river flow. It incorporated a summary of the NSW Department of Natural Resources' techniques and research and reviewed the concerns of irrigation farmers, Catchment Management Authorities and environmental organisations and reported to the CRC on future research needs.

A CRC PhD project is using high-resolution remote sensed data to map riverine habitats in-channel, floodplain and floodplain wetlands and quantifying the influence of rivers flows on riverine metabolism and nutrient budgets as measures of river health. The

ultimate aim is to build a GIS-based model of the relationship between river flows, habitat inundation and riverine metabolism and develop conceptual and predictive models for optimising the delivery of Environmental Contingency Allowance releases in floodplain rivers for environmental benefits and economic sustainability.

While there is a considerable amount of other research under way an urgent need remains for greater attention to the Darling River catchments so that policy makers and the community have better monitoring data and benchmarking of the river and groundwater systems as a basis for water management decisions.



THE ADOPTION OF IMPROVED PRACTICES

Research projects are not serving their purpose unless their outcomes are delivered to end users and put into action. In the case of CRC water research, this means principally cotton farmers and their consultants, catchment managers and, to a lesser extent, other water users. CRC researchers are required to include a plan for extending the outcomes of their projects to the industry before the project is approved.

The CRC National Cotton Extension Team as a whole and the team's water-related specialist members in particular also undertake extension of CRC water research. The Cotton Extension Team, particularly the environment and water team members, provide technical support for Cotton Australia in delivering the BMP Land and Water module, helping to improve the breadth and depth of the cotton industry's on-farm environmental management.

The Australian community is entitled to information on how the cotton industry is addressing water issues. The CRC, in collaboration with other industry partners, has developed a 'Water Wise' exhibition at the Australian Cotton Centre – an award-winning tourist destination in Narrabri that delivers key cotton industry messages to the general public. Water Wise demonstrates how water is used in catchments and river systems, how water from rivers, dams, bores or natural rainfall is used and recycled on the farm, how irrigation water use compares to domestic use – and how all water use can be improved.

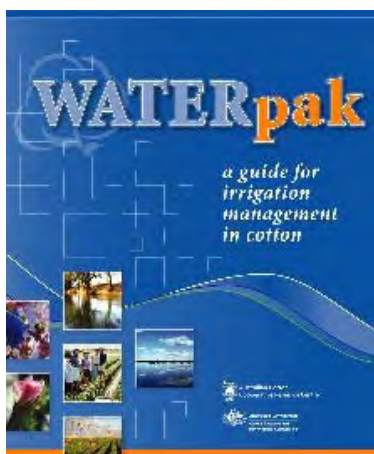
Phase One of the National Program for Sustainable Irrigation (NPSI) resulted in *Knowledge Management for Irrigated Cotton and Grain*, a publication which demonstrated that farmers wanted local and personal contact, regional research, practical training for consultants and concise information products. The CRC, in conjunction with a range of partners, is putting in place a new knowledge and information system that

will further improve the adoption of better water management practices by developing public and private sector partnerships, as well as training and certification. It will encourage collaboration with on-farm trials, as well as strategic communications.

An important aspect of adoption is the development of decision-making tools incorporating cutting edge research findings for cotton growers. Such tools are being developed by both public and private organisations and range from improved weather forecasting, crop models and irrigation scheduling tools such as (now widely used) neutron and capacitance probes. CRDC and CSIRO have developed HydroLOGIC, a software package that helps growers decide on optimum water management strategies.

Other organisations such as the National Centre for Engineering in Agriculture and CRC Irrigation Futures have also conducted research on alternate irrigation systems such as centre pivots and lateral move machines. The adoption of lateral move irrigation systems is increasing due to improved water use efficiency and returns on investment. A few growers who have appropriate soil types and other management aspects that justify the high cost of investment have adopted drip irrigation.

Value-adding water use is essential for maximum economic returns. All cotton growers grow grain crops in the rotation for agronomic advantages such as disease and pest breaks and for soil management. Projects being conducted in partnership with the Grains Research and Development Corporation (GRDC) are looking to enhance the irrigated cotton and grain crop farming systems. A small value-adding project is looking at integrating aquaculture: using the water in storages to produce fish at the same time as it being used for crop irrigation management.



Advancing water management in NSW and the Queensland Rural Water Use Efficiency projects are helping growers and consultants build their capacity and skill to better manage and measure water use and movement around the farm. The projects, which are lead by the NSW Department of Primary Industries and Queensland Department of Primary Industries and Fisheries, focus on regional demonstrations and trials developed in consultation with irrigators and their consultants. They will also develop education and training services.

WATERpak: a guide for irrigation management in cotton contains 400 pages of information on 30 topics for irrigators and their advisers. The manual is available in hard copy format and each chapter is downloadable from the Cotton CRC website www.cotton.crc.org.au

FUTURE OPPORTUNITIES

The largest steps forward can be made by:

- Good agronomy, including improved cotton varieties, good soil management, crop rotations, crop protection, and best practice irrigation and nutrition management.
- Improving delivery (from river or storage) to the field
- Maximising storage and distribution efficiency, reducing evaporation and drainage
- Maximising application efficiency
- Monitoring water use and calculating efficiency
- Achieving uniform application
- Planning, installing and operation of alternative irrigation systems (where applicable) as well as upgrading farm design.
- Use the Cotton BMP Land and Water Management module to enable a systematic approach to management.
- Local science information is needed in the Darling River Catchments on both surface and ground water to better inform decision makers.

OUR WATER RESEARCH PARTNERS



CRC WATER-RELATED PROJECTS

Program 1 THE FARM

Water-related Goals

- Improved water use efficiency with goal of a 20 per cent increase in cotton yield per megalitre of water supplied to farms
- Increased on-farm water use efficiency across the industry to achieve a benchmark of 80 per cent or higher

Current Research Projects	Principal Researcher	Organisation
1.1.37 Irrigation scheduling for drip irrigated Bollgard II® cotton in the west Kimberley	Geoff Strickland	AGWA
1.2.01 Quantifying deep drainage using lysimetry	Dr Anthony Ringrose-Voase	CSIRO
1.2.02 Water relations of the cotton plant	Dr James Neilson	CSIRO
1.2.03 Optimum production and water use of high retention cotton and other new technologies	Stephen Yeates	CSIRO
1.2.04 Deep drainage under irrigated cotton – surface and groundwater implications	Dr Des McGarry	QDNR&W
1.2.06 Development of a field method for measuring deep drainage potential	Prof. A McBratney	USYD
1.2.07 Hydrological and geophysical characterisation of palaeochannels in northern NSW	Dr Willem Vervoert	USYD
1.2.09 Assessing limited water management strategies in cotton farming systems	Dr Jose Payero	QDPI&F
1.2.11 Irrigation monitoring system for comparative water requirement and optimal scheduling of Bollgard and conventional cotton systems	Stephen Yeates	CSIRO
1.2.12 Quantifying deep drainage using lysimetry in an irrigated cotton landscape	Dr Anthony Ringrose-Voase	CSIRO
1.2.13 Development of new technologies for reducing evaporation losses from large water storages	Dr Ian Dagley	CRC Polymers

Program 2 THE CATCHMENT

Water-related Goals

- Improve river health and sustainable use of groundwater while sustaining acceptable profitability in cotton production
- Understand surface and groundwater interactions in selected catchments, such as the Namoi Valley
- Assist in identifying ways to increase the efficiency in delivery of water allocations to industry
- Develop a workable set of catchment and farm planning tools that are consistent with good science, practical adoption and catchment goals
- Develop practices and processes which help filter irrigation water for reuse on the farm, including farm wetlands, and in the environment generally

Projects	Principal Researcher	Organisation
2.1.01 Development of a model of flood dynamics for water management in the Gwydir Wetlands	PhD: Sue Powell Supervisor: Dr Rebecca Letcher	ANU
2.1.02 Capturing our understand of soil water balance and deep drainage under irrigation in models – a basis of design of efficient farming and for assessing impacts on catchments	Dr Mark Silburn	QDNR&W
2.1.03 Optimising river flow management for environmental and economic sustainability	PhD: Debbie Burgis Supervisor: Dr Paul Frazier	UNE

Projects	Principal Researcher	Organisation
2.1.05 A scoping study of river flow measurements	David Allen	UTS
2.1.06 Development of a negotiation tool to improve water sharing and environmental flows in semi arid unregulated rivers	PhD: Floris van Ogtrop Supervisor: Dr Willem Vervoort	USYD
2.1.07 Managing environmental flows in an agricultural landscape: the Lower Gwydir floodplain	Dr Glenn Wilson	UNE
2.1.09 Gwydir wetlands: environmental flows, grazing and biodiversity	PhD: Peter Berney Supervisor: Dr Glenn Wilson	UNE
2.2.03 Surface water groundwater interconnectivity investigation – Upper Namoi, NSW	Dr Ian Acworth	UNSW
2.2.04 Robust and sensitive indicators of groundwater health and biodiversity	PhD: Kathryn Korbel Supervisor: Dr Grant Hose	UTS
2.2.05 Groundwater modelling projects – scoping studies of Namoi, Gwydir, Condamine	Dr Noel Merrick	UTS
2.2.06 Groundwater modelling projects: Cox's Creek Coupled Surface Water/Groundwater Model (Upper Namoi study)	Dr Bryce Kelly	UTS
2.2.10 Groundwater scoping studies, Queensland	Dr Bryce Kelly	UTS
2.3.01 Aquatic biodiversity and the ecological value of on farm ring-tank water storages on cotton farms	PhD: Susan Lutton Supervisor: Professor Stuart Bunn	Griffith Uni
2.3.04 Pesticide and nutrient remediation: assessing application and integration with on-farm storage systems	Dr Angus Crossan	USYD
2.3.06 Publication of Irrigation Storage Design Guidelines: Design principles for healthy waterways on cotton farms	Professor Ivan Kennedy	USYD
2.3.07 Development of bioremediation enzymes for residues of Diuron herbicide metabolites	Dr Robyn Russell	CSIRO

Program 5: THE ADOPTION

Water-related Goals

- Up-to-date specialist short courses and vocational training for cotton consultants, cotton growers and their staff
- Delivery systems and tools that facilitate communication, awareness and rapid adoption of research outcomes
- Provide technical support to enhance development and adoption of the cotton industry's Best Management Practices (BMP) system

Projects	Principal Researcher	Organisation
5.1.02 Water Wise Exhibition at the Australian Cotton Centre	Sandy Young	Australian Cotton Centre
5.1.03 Knowledge management systems in irrigated cotton and grains	Peter Smith	NSW DPI
5.1.05 Rural Water Use Efficiency III – Improved water use efficiency in irrigated cotton and grains	Graham Harris	QDPI&F
5.1.13 Advancing water management in northern NSW	Eddie Parr	NSW DPI
5.2.03 Delivering science to agribusiness: Smart approaches to cotton irrigation management	Dirk Richards	CSIRO
5.2.12 Water Use Efficiency of siphon-less irrigation systems	Emma Carrigan Sarah Hood	QDPI&F SIS

ACRONYMS

AGWA	Department of Agriculture and Food, Western Australia
ANU	Australian National University
CRDC	Cotton Research and Development Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GIS	Geographic Information System
GRDC	Grains Research and Development Corporation
Griffith Uni	Griffith University
NSW	New South Wales
NSW DPI	NSW Department of Primary Industries
QDNR&W	Queensland Department of Natural Resources and Water
QDPI&F	Queensland Department of Primary Industries and Fisheries
SIS	Sustainable Irrigation Systems
UNE	The University of New England
UNSW	University of New South Wales
USYD	The University of Sydney
UTS	University of Technology Sydney