Australian Government
Land & Water Australia

Final Report

Coordinating Deep Drainage Research in the Northern Darling Basin

Nicky Schick, Australian Cotton CRC

Project: Coordinating Deep Drainage Research in the Northern Darling Basin (CRD2)

National Program for Sustainable Irrigation

Product code PN21997

Published by Land & Water Australia

Postal address GPO Box 2182, Canberra ACT 2601

Office Location L1, The Phoenix
86 Northbourne Ave, Braddon ACT

Telephone 02 6263 6000

Facsimile 02 6263 6099

Email Land&WaterAustralia@lwa.gov.au

Internet www.lwa.gov.au

Disclaimer

Final report

Coordinating Deep Drainage Research in the Northern Darling Basin

Funded by Land and Water Australia through the National Program for Sustainable Irrigation (NPSI)

Project Reference	CRD2
Research Organisation	Australian Cotton CRC / CRDC
Program	Sustainable Irrigation Program
Project Title	**Coordinating Deep Drainage Research in the Northern Darling Basin**
Principle Investigators	Nicky Schick, Australian Cotton CRC
Project Duration	30/9/2003 – 1/07/2005
Report author	R.W. Vervoort, McCaughey Senior Lecturer Hydrology and Catchment Management, University of Sydney / Australian Cotton CRC
Collaborators	Vervoort, R.W. (U Syd), Silburn, M and McGarry D (NR&M Qld), Hulugalle, N (NSW DPI), Ringrose Voase, A (CSIRO), D Gibb/B Pyke (CRDC), G Fitt/ G. Roth (Cotton CRC)

Due Date for Final Report 1/10/2005

Project Objectives

1. Develop agreed understanding by peak stakeholders of deep drainage in the Northern Darling Basin.
2. Develop clear and agreed gaps in knowledge and how to overcome them.

Alteration to original objectives – none

List of acronyms

ACCRC	Australian Cotton CRC	DIPNR	NSW Department of Infrastructure, Planning and Natural Resources
ACRI	Australian Cotton Research Institute (Narrabri)	EM	Electromagnetic Induction
BMP	Best Management Practice	NMD – WBG	Northern Murray Darling Water Balance Group
CCC	Cotton Catchment Communities CRC	NSW DPI	NSW Department of Primary Industries
CRC			
CMA	Catchment Management Authority	NR&M	Natural Resources and Mines, Qld.
CRDC	Cotton Research & Development Corporation		

1. Abstract

A key issue identified by the research community working with the cotton industry was the lack of understanding and acceptance of the concept of deep drainage. The Northern Murray Darling – Water Balance Group (NMD – WBG) was conceived as a partnership of researchers and extension personnel to exchange ideas, create awareness and debate the issue of deep drainage in the Darling basin. The aims of this project were to achieve consensus and identify research gaps and opportunities to overcome these gaps. In the course of two years the members of the NMD – WBG held two major workshops, organised or attended 25 stakeholder meetings, gave a plethora of presentations to various groups, published papers, prepared extension materials and communicated with the wider public.

The key achievements of this project are: Broad agreement was achieved in the cotton industry about Deep Drainage as a management issue; key research gaps were identified; recommendations for research were formulated; initial projects were funded by CRDC/CRC, outcomes were communicated in papers, extension materials and the media; two major workshops were held and new collaborations established with researchers; links were established with other industries such as grains; research reviews were written; deep drainage was included as a management issue in the Cotton Industry's BMP Land and Water Manual; and a new coordinated research program which covers landscape impacts of cotton irrigation on ground and surface water has been established (Program 2 - The Catchment) in the new Cotton Catchment Communities CRC.

2. Introduction

A key issue identified by the research community working with the cotton industry was the lack of understanding and acceptance of the concept of deep drainage. Deep drainage is defined as the part of the water (applied to the surface and as rainfall or irrigation) that moves past the rootzone. In general the existing paradigm was "cotton soils don't leak". However, the research community related to the Australian Cotton CRC (ACCRC) was well aware of observations and simulations indicating significant deep drainage under irrigation. Examples of such studies include the PhD work by J. Montgomery in the Gwydir Valley, measurements by Willis et al. (1997) in the Macquarie valley and estimates by Weaver et al. (2004) in the Namoi valley. However, the estimates range widely and there was some disagreement about the magnitude of deep drainage and its impact. However, from logical considerations based on water quality and leaching fractions (Vervoort et al., 2003) it could be expected that at least 10% of the applied irrigation water is lost below the rootzone.

While it was unknown what the future implications of this deep drainage might be in terms of landscape salinity, it was agreed that there was a need for more accurate measurements and that there was a need to create awareness about deep drainage in the cotton industry and forge linkages with researchers from other industries. Rather than reinventing the wheel, it was important to link to research on deep drainage in other agricultural industries. But due to the differences in climate and soils between the northern and southern part of the Murray Darling Basin, not all established research was directly useful.

The Northern Murray Darling – Water Balance Group (NMD – WBG) was conceived as a partnership of researchers and extension personnel to exchange ideas, create awareness, and debate the issue of deep drainage. This project provided logistical support to help the group achieve these goals.

3. Activities

The key role of the NMD – WBG was in communication, that is, its members concentrated on communicating research about deep drainage to fellow researchers and stakeholders.
The activities of the NMD – WBG therefore fell into three categories:

- General communication (presentations, publications and press releases) and building relationships with other industries, for example, dryland counterparts such as grain growers (see Appendix 1);
- Active participation in around 25 stakeholder meetings in relation to deep drainage with NSW Catchment Management Authorities (CMA's) and Qld Regional Bodies to raise the issue of deep drainage;

- Organisation of 2 technical workshops in relation to (1) lysimeter studies and (2) consequences of deep drainage and groundwater-surface water interactions.

The major event was a 2 day workshop on consequences of deep drainage and surface water-groundwater interactions in relation to irrigated agriculture in the Northern Murray Darling Basin. The focus of the workshop was to identify knowledge gaps and find agreement on research needs and directions. The workshop was attended by more than 60 attendees from different organisations including Federal and State organisations and research providers and industry. A report on the findings of the workshop was prepared (Silburn et al. 2004, see Appendix 1) and distributed widely on CD's. 500 copies of the publication have been printed and distributed.

4. Achievements

Key achievements:

1. Achieved broad agreement in the cotton industry about Deep Drainage as a management issue in relation to the water balance at both field and catchment scale;
2. Identified key gaps and formulated recommendations for research during a workshop on groundwater and surface water interactions;
3. Communicated outcomes and published two chapters in the Cotton Industry's WATERpak Manual focusing on deep drainage measurement and review, and ensured that deep drainage was include in the Cotton Industry's Land and Water BMP module; and
4. Initiated and developed a new coordinated research program which covers landscape impacts of cotton irrigation on ground and surface water (Program 2 - The Catchment in the Cotton Catchment Communities CRC).

Achieved broad agreement

As a result of the presentations to and interactions with cotton growers, researchers and consultants, broad agreement has been reached that deep drainage does occur under irrigated cotton production, with measurements/estimates typically between 100 – 300 mm/year.

There is also agreement that deep drainage varies due to climate, soil type and management and that the range could be much wider. Field trials and modelling indicate there is considerable scope to control deep drainage and to improve water use efficiency by changing irrigation practices. It is also recognised that some deep drainage is beneficial under irrigation to flush out excess salts (the so-called leaching fraction). An adequate leaching fraction is probably provided by deep drainage during rainfall except where irrigation water is of high salinity. There is also some emerging evidence from the St. George area in Queensland that groundwater tables are rising due to cotton irrigation, evidence which is similar to that found much earlier in the Macquarie valley in NSW (Willis et al., 1997).

Figure 1 Animated discussion during the NMD - WBG workshop (Nov 2003) on groundwater and surface water interaction which was attended by 50 people representing 20 organisations.

Identified research gaps and recommendations

1. Spatial scaling

There is a clear need to have more focus on spatial scaling. Currently, several research projects, which collect measurements or estimates of deep drainage, are ongoing or have been completed. However many of the measurements are only representative for the research location, often a point, and cover only short temporal scales. A major question is how these local measurements translate to catchment scale and long-term predictions of impacts of deep drainage. This is not easy to estimate because catchments include different landuses and soil types. Given that some local deep drainage is beneficial, there is a need to identify the impact of the "minimum" amount of deep drainage on catchment targets for deep drainage and salt movement. At least two new funding proposals in the Cotton Catchment Community CRC (CCC CRC) focus on this aspect and suggest using simulation modelling approaches to identify how possible restrictions on catchment scale deep drainage impact the irrigation industry.

2. Vadose zone and interactions between groundwater and surface water

Estimates of deep drainage do not match up with estimates of groundwater recharge, both at the local and the catchment scale. This means that our understanding of what happens with deep drainage water once it passes below the rootzone is still very limited. This area, often called the vadose zone, is not very well researched (Fig. 2). The underlying shallow (and often saline) groundwater table is also less well researched and mapped than its deeper (productive) counterpart. This is because the vadose zone and the shallow groundwater table have been of limited interest to both crop (the water is lost) and groundwater managers (the water has not arrived or is not of any use). Except for a single detailed study in the Liverpool plains (Timms et al. 2001) there has been no research on this topic in the Northern Murray Darling Basin. Since this was identified as a significant gap, some recent work is being developed as part of CCC CRC project (Des McGarry) in Queensland. In addition, the work on ACCRC project 3.2.20 (Palaeochannels) around Moree and the shallow groundwater investigations in the Narrabri formation (DIPNR) west of the Newell Highway will collect valuable soils data. This will also assist in understanding the behaviour of the shallow groundwater system underlying much of this area.

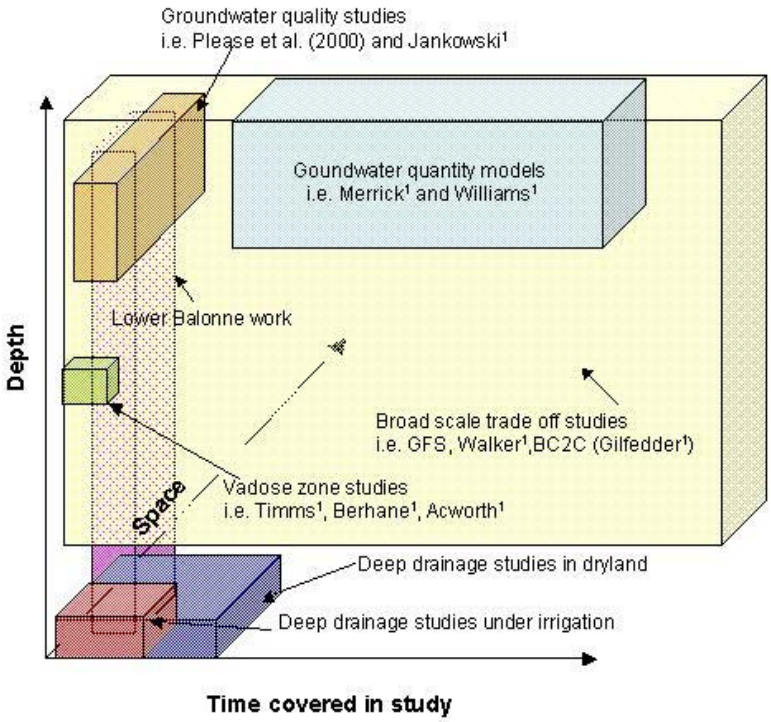


Figure 2. Overview of spatial and temporal coverage of current and completed studies on deep drainage and groundwater. As there is a trade-off in accuracy and detail with extend in space and time, this indicates a major gap in detailed studies in the vadose zone area and a gap in long-term detailed studies. For more detail and references mentioned see Silburn et al. (2004)

A related research gap is the interaction between surface water and groundwater in semi-arid areas and the location of recharge areas in the landscape. Earlier work by Triantafilis et al. (2003) has broadly identified areas of lighter soils and prior streams (palaeochannels) as areas of possible higher deep drainage and recharge. River channels and flood waters are also seen as a major source of recharge in some catchments according to groundwater modelling work by Williams et al. (1989). This work suggests that the recharge from these events and areas far outweighs the recharge from irrigated production. There is however little physical measurement or estimation of this process due to the spatial and temporal scales at which this process operates. Recent local estimates of deep drainage suggest a much greater contribution. In particular, the low frequency of bore and piezometer readings (2 – 4 times per year), a lack of monitoring in shallow aquifers and little knowledge of water movement through the unsaturated zone (discussed above) are major limitations. There is an urgent need for more frequent measurements at several locations to estimate the interaction between surface water and groundwater. Such measurements would also enable closing the "water accounting gap" suggested by Evans (2005). Further negotiations between the CMA's (stakeholders) and research providers should develop knowledge in this area. In addition, a funding proposal to program 2 in the new CCC CRC suggests looking at short temporal scale behaviour of groundwater levels and attempting to extract more useful information from existing data using advanced statistical techniques.

3. Measurement techniques

Measurement of deep drainage and recharge is still difficult, despite the development and documentation of a range of methods (for example the Zhang and Walker (ed.) 2002 series). Many of the existing methods have high uncertainties, with many of them better classified as estimates rather than measurements. This means that, apart from the labour and capital intensive lysimeter system, no single method is perfect. Considering that there is a trade-off between accuracy and cost (Fig. 3), it is important to validate different estimates. This is a task under current investigation by the Queensland Department of Natural Resources and Mines (NR&M) who have been collecting three concurrent measures of deep drainage over the past three-years. Direct measures of deep drainage from constant suction barrel lysimeters are compared to two indirect measures of deep drainage. One

using annually collected soil chloride data for mass balance calculations via the model SODICS, the other using irrigation flow rate and advance data via the model SIRMOD, and deep drainage gained as the difference between infiltrated water and Et. The current CSIRO "large" lysimeter project funded by the CRDC, also aims to create a benchmark for other methods. In the same field, several different methods for estimating deep drainage are being compared to the lysimeter results, including three of the NR&M barrel lysimeters. Such "cross validation" allows calculation of uncertainty in the measurements and more confidence in research outcomes.

Apart from this benchmarking of existing methods, there is also a need for the development of new methods of measuring deep drainage or changes in soil moisture. This is particularly true for further development of methods that can estimate deep drainage at larger scales. There has been some development in using EM and geophysics to estimate deep drainage (Triantifilis et al. 2004, Cook and Williams, 2002) and movement of soil moisture (Drs. B. Kelly and I. Acworth), but these methods are still not fully developed and are only rough indications or estimates. Further development of the existing methods to improve accuracy, or development of totally new methods is still very much needed.

4. Knowledge and data management

A gap still exists in the management of knowledge and data. There is an urgent need to capture existing knowledge in a better way. This will prevent "reinventing the wheel" and improving the training of new specialists in the area. Knowledge management consists of two components: Data and dissemination. Databases and publicly available data are still scarce, or contain little information that meets research needs. Data generated by researchers is mostly reasonably inaccessible and remains in a "grey" form. It sits on researchers' hard drives or on compact discs stacked away as backups. Sometimes reports are written in which part of the data is supplied, but generally the focus is on the publication of research papers, which often only contain summaries of data, rather than the actual data. There are only a few examples in which researchers have attempted to make the data publicly and widely available. The most recent example is probably the Australian Cotton CRC Soils database (Odeh et al., 2004). A project proposed in program 2 in the CCC CRC is intended to collate water balance and deep drainage data from past and current studies in the cotton industry and make it available for testing models.

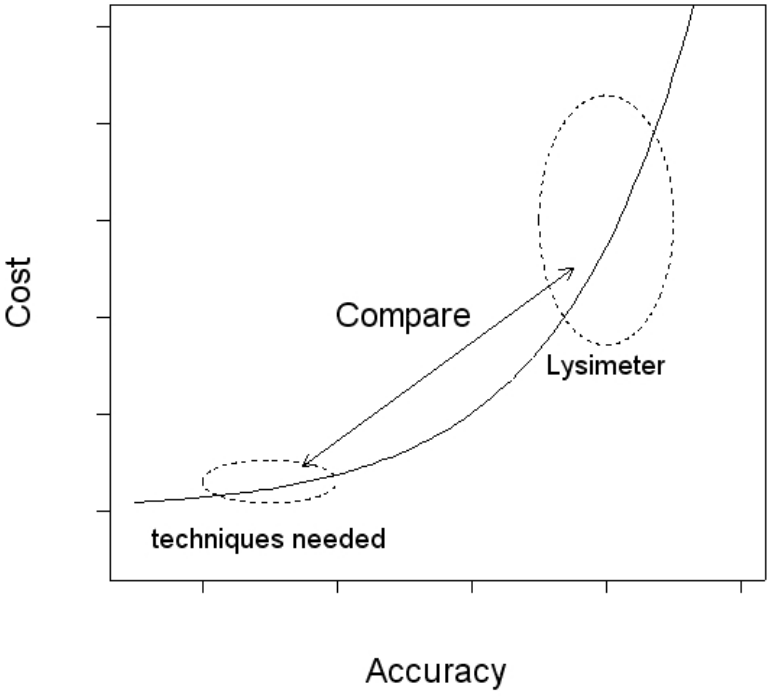


Figure 3. Schematic representation of trade-off in costs and accuracy for techniques for measuring and estimating deep drainage. Comparison of low cost - low accuracy methods with high cost - high accuray methods will increase confidence in the lower cost rapid assessment methods.

Developed coordinated research program

Through stakeholder meetings and workshops, the NMD – WBG effectively mapped the existing research on deep drainage in both dryland and irrigated agriculture. Based on identified gaps we set out to establish a range of connected research projects. The main project was based on the investment of the CRDC in a lysimeter facility at the Australian Cotton Research Institute at Narrabri. This was seen as the most accurate type of measurement and was needed to benchmark other estimates of deep drainage (i.e. Fig 2). In addition to this work, a series of other projects were identified and connected to the project. This "deep drainage under irrigated cotton" research program now includes:

1. The work on barrel lysimeters/Cl tracers/water balance (Dr. D. McGarry et al.) in NSW and Queensland, including the three barrel lysimeters recently installed in the field next to the CSIRO lysimeter (Fig. 4).
2. The electrical imaging work (Dr Acworth and Dr Kelly) to identify areas of high soil moisture and track water flow. Measurements of this type have been completed in fields containing barrel lysimeters and the main lysimeter.
3. The palaeochannel work (Dr. W. Vervoort and C. Vanags) to identify the extent of deep drainage in these features and management options. Electrical imaging work is planned for this site. There is also cooperation with DIPNR in the work to identify the behaviour and characteristics of the Narrabri formation. Piezometers have been installed at this site and similar piezometers are planned for the main lysimeter site.
4. Ongoing water balance estimations using chloride balance and water balance models in the cotton farming systems trials (T. Weaver and Dr. N. Hulugalle). The main lysimeter facility is located within the farming systems trial plots and thus allows cross validation of the results.
5. A CRDC project by E. Trainer/A.McBratney/B. Minasny (The University of Sydney) to develop a quick measurement of Deep Drainage potential was tested in the same field as the main lysimeter facility
6. Long stop and full stop drainage meters will be installed during the 2005-06 growing season adjacent to the main lysimeter at ACRI (Dr. R. Stirzaker)

Overall the lysimeter facility at ACRI has been developed into an active "field laboratory" site where different measurements of deep drainage are taking place.
The irrigated component has initially been linked to deep drainage investigations in dryland agriculture through informal relationships with NR&M, NSW DPI and DIPNR. However these informal relationships have allowed scoping of research issues during meetings and workshops and this has evolved into cooperation and investment into program 2 "the Catchment" in the new Cotton Catchment Communities CRC.
Within this new program, 10 research proposals in the area of deep drainage and groundwater surface water interactions are being considered. Many of the proposals focus on the catchment as a whole but use the information from the deep drainage under irrigation projects.

Figure 4 On the left - Grant Millar and (NR&M) installing one of the NR&M barrel lysimeters - close to (on the right) the large (shelve-type) CSIRO lysimeter at ACRI, Narrabri (May 2005). Picture courtesy of Dr. Des McGarry.

Des McGarry QNRM, Anthony Ringrose-Voase CSIRO and Lloyd Finlay NSW DPI preparing for the installation of mini lysimeters and other instrumentation. (Photo courtesy of Guy Roth)

Mark Silburn QNRM working on the GRDC funded lysimeter work that has formed linkages to the cotton work.

Ian Acworth UNSW and Bryce Kelly UTS testing electrical imaging techniques who have become part of the Cotton Deep drainage group as a result the improved coordination (Photo courtesy of Guy Roth).

5. Cited references

Evans R (2005) Double accounting of surface water and groundwater resources – the tyranny of the time lag. Paper presented at ABARE Outlook conference 2005.

Odeh IOA Cattle SR McBratney AB (2004) Soil Database Assistant Version 1.6: Summary and Users' Guides. CDROM Publication, Australian Cotton Cooperative Research Centre, The University of Sydney, Sydney NSW.

Timms W Acworth RL Berhane D (2001) Shallow groundwater dynamics in smectite dominated clay on the Liverpool plains of New South Wales. Australian Journal of Soil Research 39, 203-218.

Triantafilis J Huckel AI Odeh IOA (2003) Field-scale assessment of deep drainage risk. Irrigation Science 21, 183-192.

Triantafilis J Odeh IOA Jarman AL Short MG Kokkoris E (2004) Estimating and mapping deep drainage risk at the district level in the lower Gwydir and Macquarie valleys, Australia. Australian Journal of Experimental Agriculture 44: 9, 893-912.

Vervoort R.W, M. Silburn and M. Kirby. 2003. The near surface water balance of the Northern Murray Darling Basin. Water, Science and Technology **48** (7):207-214

Weaver, T. B. Hulugalle, N. R. Ghadiri, H. (2004) Comparing deep drainage estimated with transient and steady state models in irrigated vertisols. *In*: Hydrology: science and practice for the 21st century, Volume II. Proceedings of the British Hydrological Society International Conference, Imperial College, London, July 2004: 168-176.

Williams RM Merrick NP Ross JB (1989) Natural and induced recharge in the lower Namoi valley, New South Wales. In 'Groundwater Recharge, Proceedings of the symposium on groundwater recharge, Mandurrah 6-9 July 1987'. (Ed. ML Sharma) pp. 239-253. (Balkema: Rotterdam)

Willis TM Black AS Meyer WS (1997) Estimates of deep percolation beneath cotton in the Macquarie valley. Irrigation Science 17, 141-150.

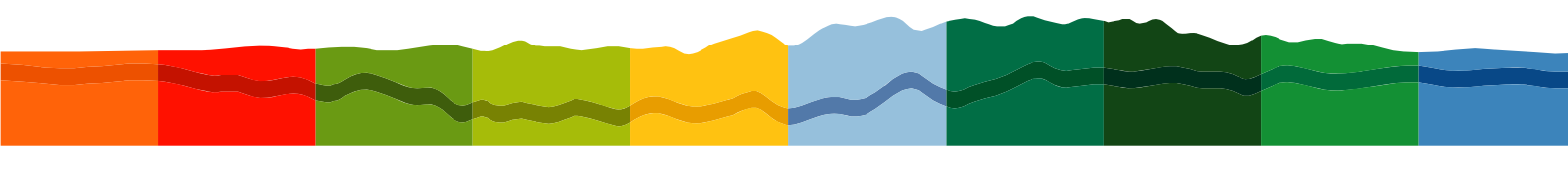
Zhang L Walker G (ed). (2002) The basics of recharge and discharge, Part 1 – 10. CSIRO publishing, Collingwood VIC.

6. Funding

This project is greatful of the $50,000 received from LWA – National Program of Sustainable Irrigation to help facilitate the group activities, communication and travel. The Australian Cotton CRC, CRDC, NSW DPI, CSIRO Land and Water, QNRM, UTS, UNSW all contributed many hours of time and other resources to this project, which had an estimated value of $150,000.

7. Further Information

Cotton Catchment Communities CRC
Locked bag 1001
Narrabri NSW 2390
02 6799 1500
www.cotton.crc.org.au



Appendix 1 Knowledge Assets and Communicated Results

Refereed conference papers:

- Vervoort, R.W., Glendenning C. and Odeh, I.O.A. (2004). Development of deep drainage risk maps for the Border rivers area of NSW and Queensland. In: Singh B et al. Supersoil 2004: Program and Abstracts for the 3rd Australian New Zealand Soils Conference, University of Sydney, Australia, 5 – 9 December 2004. Published on CD and www.regional.org.au/au/asssi/

Reviews and Book Chapters:

- Two chapters on deep drainage were included in "WATERpak – a guide for irrigation management in cotton".
    - Ringrose-Voase, A. (2004) Water Balance and deep drainage under irrigated cotton pp 17-28.
    - Silburn, M. & Montgomery J. (2004) Deep drainage under irrigated cotton in Australia: a review pp 29-41. (These are in print as well as on the Cotton CRC website).
- Silburn, M., Vervoort R.W. and Schick, N. (2004) Deep drainage – so what? Part A & B. Report on 2nd NMD – WBG workshop, 19-20 November 2003, Narrabri. Cotton Research and Development Corporation. ISBN 1 87635498 4.

Conferences Presentations:

- Vervoort, R.W *et al* . (June 2005) A review of Deep Drainage and Water Balance Work. Annual Cotton CRC Review (attended by 150 scientists, research managers and some growers).

Seminars, Workshops & Trade Shows:

- Vervoort R.W. (2004) Outcomes of the Deep Drainage Workshop–2003 Annual General Meeting of the Irrigation Association of Australia North West
- Vervoort, R.W and Silburn M. (June 2004) Water Balance – progress and outlook. Australian Cotton CRC 5th year Review, Narrabri, NSW.

Grower Magazines and Articles:

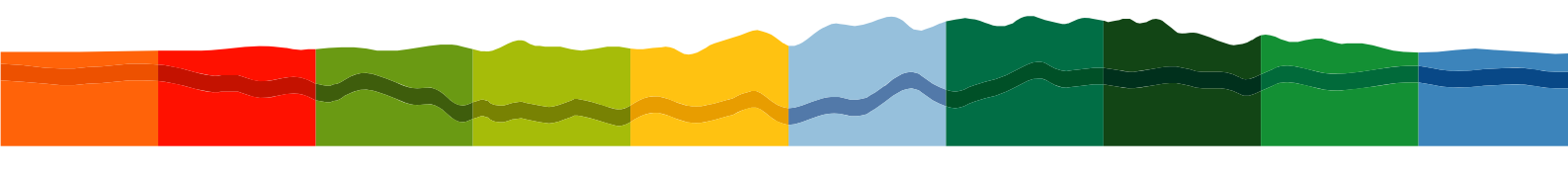
- Triantafilis, J. Odeh, I. Short, M. (2004) Identifying deep drainage risk areas in the lower Gwydir, The Australian Cotton Grower Feb – March pp 19-22.
- Triantafilis, J. Buchanan, S. Short, M. Malik, R. (2004) Mapping subsurface saline material at Bourke, The Australian Cotton grower pp Feb March 59-61
- Hood, S. Hulme, P. Harden, B. Weaver T. (2004) Methods for measuring deep drainage. The Australian Cotton grower Dec-Jan pp 28-31

Media Release

- Deep Drainage Studies to Improve Cotton Water Management, June 2005
- Concerned Growers Cotton On, May 2005
- Major Deep Drainage Forum in Narrabri, Nov 2003

Other:

Tim Lester of Land and Water Australia used the report as a background to a one page glossy flyer of the project – which was one of two projects LWA promoted at the 12th Annual Cotton Conference attended by 1400 delegates.



Appendix 2 - MEDIA RELEASE

DEEP DRAINAGE STUDIES TO IMPROVE COTTON WATER MANAGEMENT

A major study measuring deep drainage under irrigated cotton in the northern Murray Darling Basin could have important implications for water use efficiency and management in the cotton industry.

The Cotton CRC project now involves collaboration between CSIRO Land and Water in Canberra and Narrabri, the NSW Department of Primary Industries and Queensland Natural Resources and Mines.

By utilising equipment and techniques developed by the project team, cotton irrigators will better comprehend and understand the fate of irrigation water during application, and ultimately be able to improve irrigation practices to minimise drainage.

The focus on drainage has increased because of concerns about both the efficiency with which irrigation water is used and about environmental damage caused by excess drainage through waterlogging, salinity and the movement of agrochemicals into waterways.

Previous work on drainage has either used indirect measurements based on calculation of fluxes from the soil water profile measurements, chloride mass balance, or modelling to estimate its magnitude.

This current Cotton CRC project at ACRI Narrabri attempts to directly measure drainage under an irrigated cotton system using an equilibrium tension drainage lysimeter comprising six trays installed at 2 m depth which collect drainage over 1.5 square metres, installed via a horizontal tunnel projecting from the side of a 2 m diameter × 4 m deep concrete access shaft.

In addition to the collection trays, the facility includes two vertical arrays of tensiometers; one of 'Echo probes'; four neutron probe access tubes and a weather station. A siphon meter and wetting front detectors will be used to measure the amount of irrigation water entering furrows above the lysimeter.

The lysimeter facility has three objectives.

- The first is to measure drainage and better understand when it occurs during the crop rotation.
- The second is to act as a benchmark against which to test other, less expensive methods of measuring or estimating drainage, which can be used in many more locations.
- Finally, data from the facility will be used to improve water balance models that can be used in conjunction with farming systems models to estimate drainage at a range of locations over long time periods (decades) and under a range of management systems. Such models can then be used to design more efficient and environmentally benign irrigation systems.

The Narrabri study is complementary to a similar project in Queensland funded by the Queensland Government and backed by the Australian cotton industry, the Cotton Research and Development Corporation (CRDC), and the Cotton CRC.

Seven growers around Pittsworth, Dalby, Goondiwindi, Dirranbandi and St George are working closely with Queensland's Department of Natural Resources and Mines (NR&M) to monitor deep drainage that wastes water, and which can contribute to rising water tables and salinity problems.

With these recent installations, there is now more than 25 barrel lysimeters under cotton fields across southern Queensland and northern New South Wales, placing the Australian cotton industry at the global forefront of deep drainage research.

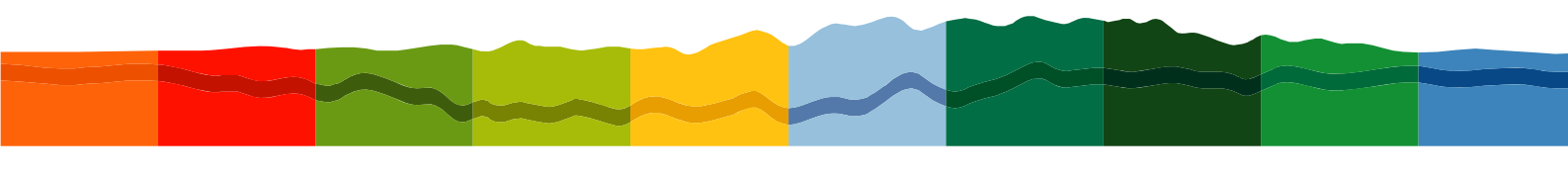
CRC personnel involved in this deep drainage research project include Dr Anthony Ringrose-Voase, CSIRO Land and Water, Canberra, Tony Nadelko, CSIRO Land and Water, Narrabri, Dr Nilantha Hulugalle, NSW DPI, Narrabri and Dr Mac Kirby, CSIRO Land and Water, Canberra, Dr Des McGarry NR&M and Dr Thusitha Gunawardena, NR&M. The collaboration is being supported by the National Program for Sustainable Irrigation .

Further information: Dr Des McGarry, NR&M 07 3896 9566, Dr Anthony Ringrose Voase CSIRO 02 6246 5956, Dr Nilantha Hulugalle NSW DPI 02 6799 1500.
June 5 2005

Appendix 3 - Research Updates and Technical meetings.

Date	Meeting	Detail
26 – 27/11/03	CRDC & Cotton CRC Farming Systems Forum	Presentation of outcomes from the Northern Murray-Darling Water Balance Workshop 2 "Deep Drainage – so What?"
15/12/03	Meeting with Mick O'Fynn EPA, NSW – Sydney	Outcomes and gaps of the workshop formed some of the basis for an EOI for a large integrated program - Integrated Environmental Program – Environmental Trust

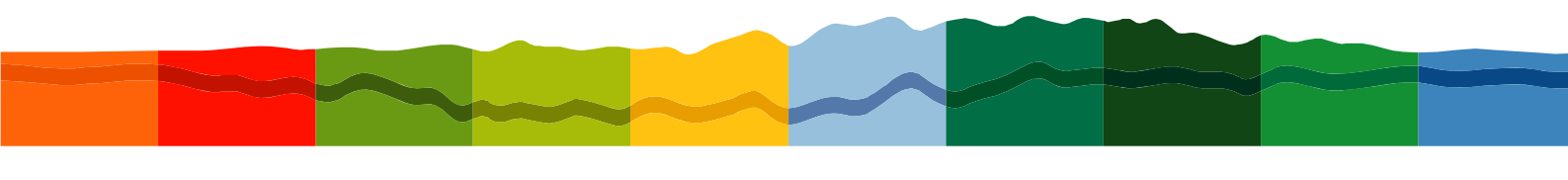
15/12/03	Meeting with WWF – International cotton water program Sydney	Outcomes and gaps from workshop were discussed in relation to future collaborative efforts – commitment to partner in a water project pending Cotton CRC's rebid success
5/02/04	Meeting at UNE with CSIRO SE, DEC, USYD, DIPNR, UQ	Discussing future collaborations with regard to Cotton Environmental gaps from soil/ water gaps through to links to terrestrial biodiversity. If any biodiversity study is to be done there needs to be a good understanding of the connection to DD and Groundwater quality.
9/02/04	Large Technical meeting of research providers CRCIF, CRCFE, UTS, UNSW, USYD, NSW AG, QDNR, DIPNR, CSIRO L & W, CSIRO SE.	Meeting to discuss commitment to future integrated water research including Deep Drainage and its interaction with Ground water and surface water and risks associated. – both environmental and production related
19/02/04	Cotton CRC workshop for commercial partners	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities and resource possibilities
24/02/04	CSIRO L&W and indirectly CRCCH - Canberra	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
24/02/04	CRCFE - Canberra	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
18/03/04	NW NSW IAA – AGM - Narrabri	Willem Vervoort Presented a Summary of the Workshop outcomes as a guest speaker.
29/03/04	Condamine Alliance - Toowoomba	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities – Subsequently put forward a written submission on their Blue Print outlining the gaps and outcomes of the workshop that need to be incorporated. Since then they have been.
8/04/04	Pratt Water - Gunnedah	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
04/04	Namoi CMA - Gunnedah	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
20/04/04	CSIRO L&W, CRDC, NSW AG, QDNR - Narrabri	Meeting to finalise placement details and measurements to be taken from Lysimeter to be installed at ACRI Narrabri
6-7/05/04	MDBC – Committee - Narrabri	John Triantafillis presented the Gaps and outcomes of the workshop which were discussed in light of future collaborative opportunities
18/05/04	Namoi CMA Board Meeting - Tamworth	A presentation was made including gaps and outcomes of the workshop and discussions were had in light of future collaborative opportunities
21/05/04	CW CMA – Dubbo	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
	DIPNR Northern NSW Technical Workshop - Tamworth	Presentation made including Gaps and outcomes of the workshop
25/08/04	CRCIF & CRCE Water	Gaps and outcomes of the workshop were discussed in light of future collaborative opportunities
22/09/04	CRCIF Workshop Deep Drainage – Sydney	Gaps and outcomes of the workshop were discussed



25-26/10/04	Science in Parliament - Sydney	John Triantafillis & Sam Buchannan Hosted a stand outlining among other water soil issues – the importance of addressing the Gaps and outcomes of the workshop
26/10/04	UTS & UNSW – Narrabri	Further discussions into the detail of future collaborations aimed at addressing the gaps and outcomes of the workshop
16/11/04	Northern MDB Freshwater Forum – Goondiwindi	Presentation made including Gaps and outcomes of the workshop
16/12/ 2004	CRDC, QNRM, Cotton CRC, Usyd, NPSI, Aquatech Consulting.	Face to Face meeting in Narrabri – Lysimeter Research Science Panel - Measuring and Assessing the Risk of excessive Irrigation induced Deep Drainage – Minutes distributed to all participants. Email follow up – collaborative opportunities – potential funds leverage source – Cotton Catchment Communities Ongoing correspondence with all researchers.
15 / 04 / 2005	Various organisations	Expressions of Interest (EOI) due to CCC CRC – 28 EOI's that were submitted fell in the area of Deep Drainage and the interaction with Groundwater.
21/04/ 2005	Face to Face meeting in Narrabri - Groundwater and Groundwater-Surface Water Connectivity	Face to Face meeting in Narrabri - Groundwater and Groundwater-Surface Water Connectivity researchers (potential new sub-program CCC CRC) Minutes distributed to all participants.
5 / 05/2005	Various organsiations	10 Full applications were received by the CCC CRC
19 /05 / 2005	Phone hook up of all the various organisations.	Phone Hook up to discuss further collaboration and coordination of full applications for consideration of the CCC CRC
1 - 2 / 09 / 2005	Technical meeting of deep drainage group in Sydney of peak stakeholders.	About 27 people attended from various organisations. Future projects were refined.

Appendix 4 - Key Meetings with Catchment Authorities In NSW and Regional Bodies in Qld

Dates	CMA	Details
8th March 2005 1st April 2005 26 July 2005 1st September 2005	Namoi CMA	The Namoi CMA agreed that deep drainage is important and they have agreed to fund a Water Use Efficiency officer at Gunnedah for 3 years. The CMA management advised that they had applied for a large project on drainage using multiple pieziometer sites over a catchment that if this were to be successful there would be much opportunity for value adding with new projects.
3rd Aug 2004 13th Sept 2004 5th August 2005 17th October 2005	Gwydir / Border Rivers CMA	Since the new CMA board was appointed we have had much correspondence discussing areas of research collaboration. Follow up email, phone conversations and further correspondence (4th June 2005) has not yet provided a position regarding investment into water balance / deep drainage work with the Gwydir. However, there has been a commitment to further discuss collaboration. More recent meetings 5th August, 17th October have lead to potential funding of a water use efficiency officer to extend deep drainage information in the Gwydir Catchment/



March 2005	Central West CMA	As a result of two meetings with the new chairperson and general manager there is an indication of interest and discussions are continuing.
12th May 2005 31st May 2005 29 August 2005 30th September 2005	Condamine Alliance	After many discussions and meetings the Condamine Alliance agreed to fund extension related activities to improve water use efficiency and water balance calculations/ improved grower awareness. They regret that they are not in a position to fund research per se although they recognize the importance of deep drainage and its consequences and therefore will investment in extension activities.
Date 31st May 2005 1st Sept 2005 30th Sept 2005	Queensland Murray Darling Committee	QMDC visits. Met and discussed collaboration resulting in submitting proposals for their consideration. Some financial commitment is likely to deep drainage work of McGarry/Silburn et al.