# National Centre for

# National Centre for

The National Centre for Groundwater Research and Training (NCGRT) was established in June 2009 as an Australian Research Council Centre of Excellence, co-funded by the National Water Commission. Its role is to advance understanding of Australia's groundwater resources, and to train the next generation of groundwater researchers.

Administered by Flinders University, with 25 Australian partner organisations, and formal linkages with some of the world's leading groundwater research organisations, the NCGRT enables nearly 200 Australian-based researchers to pool their knowledge and expertise.

The NCGRT's research is structured around five flagship research programs:

PROGRAM 1
Innovative Characterisation of Aquifers and Aquitards
PROGRAM 2
Hydrodynamics and Modelling of Complex Groundwater Systems
PROGRAM 3
Surface Water – Groundwater Interactions
PROGRAM 4
Groundwater–Vegetation–Atmosphere Interactions
PROGRAM 5
Integrating Socioeconomics, Policy and Decision Support

The NCGRT's industry training program offers a broad range of general and specialist courses, increasing Australia's groundwater management capacity.

This report summarises the NCGRT's performance between 1 January 2013 and 31 December 2013. It outlines progress towards achieving our strategic plan objectives.

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is to be an institution of national and international standing, which continually advances knowledge and management of Australia's groundwater resources.



is to enhance Australia's environmental, economic and social wellbeing, by undertaking the scientific research needed to improve our understanding of Australia's groundwater systems, and by training the next generation of expert researchers and groundwater professionals.

# Director's report

2013 has been an extremely exciting year for the National Centre for Groundwater Research and Training. With nearly five years of activity behind us, our hard work is truly bearing fruit, and our research is being recognised and applied throughout the world.

There are a myriad of current pressing issues in which groundwater is key. The impacts of unconventional gas and hydraulic fracturing on groundwater, the successful implementation of the Murray–Darling Basin Plan, mining and groundwater, the role of groundwater in water security, and the impacts of climate change on groundwater are just a few of the hugely important contemporary issues that demand groundwater investigation, science, management and policy. There are also so many fundamental and international research challenges we must address to progress groundwater research and to make the all-important transition from research to practice and policy. In short, now is a crucial time to be conducting groundwater research.

Across all five research programs, the NCGRT's research is proving outstanding. Chief Investigator Vincent Post's recent paper in *Nature*, revealing vast new freshwater resources underneath the ocean, is just one example. Over two thirds of our papers have been co-authored by external collaborators, an indicator of the esteem in which our work is held.

A major highlight for the NCGRT in 2013 was the International Association of Hydrogeologists' Congress in Perth. This was a major opportunity for us to showcase our work to the international groundwater community: our researchers gave three plenary addresses and several keynote speeches, on top of some 70 scientific presentations. We held our annual dinner in conjunction with the congress, inviting the 'who's who' of groundwater in Australia and internationally.

The NCGRT continues to build links with experts worldwide and locally. In 2013 we hosted the 2nd Australia and New Zealand FEFLOW User Group Meeting, promoted the Australian Groundwater Modelling Guidelines, provided expertise on coal seam gas to the Australian Office of Water Science, and worked with major stakeholders in the Namoi agricultural region. Our Advisory Board met with major Australian groundwater stakeholders, including the

CEOs of the Bureau of Meteorology and Geoscience Australia, and the First Assistant Secretary of the Department of the Environment, to discuss Australia's groundwater situation and future needs. This year, we commissioned Deloitte Access Economics to explore the economic value of groundwater. This was the first ever attempt to quantify the value of Australia's groundwater, and found that groundwater supports industry worth \$34 billion.

Our outreach activities have really ramped up this year and we have been working towards ensuring that as much research as possible is made available via our website. We attracted 35 international visitors to the NCGRT in 2013, including major groundwater figures such as Warren Wood, Jack Sharpe and Ian Duncan.

Our industry training arm has had a successful year, running 21 courses attended by nearly 600 people across Australia. Our training team has also cemented relationships with the Australian Water Association and the US National Ground Water Association and delivered courses in conjunction with these organisations.

Over its life so far, the NCGRT has appointed 73 postdoctoral fellows and 72 PhD students; of the PhD students, 6 have already completed, while 21 are expected to complete their work early in 2014. We are very pleased that those leaving are taking up positions at highly-respected organisations (Oxford University, the German Geological Survey, and the UNESCO International Hydrological Program to name a few); this reflects both the quality of the early-career training that the NCGRT provides and the culmination of the NCGRT's goal of increasing groundwater expertise nationally and internationally.

I would like to take this opportunity to thank the NCGRT's chief investigators, researchers, support staff, collaborators, partners and various committee members, all of whom work tirelessly to advance groundwater knowledge. I would also like to thank the Australian Research Council and National Water Commission for their ongoing support. I look forward to continuing to build on the major achievements of the NCGRT in 2014 and beyond.

Craig 1. Summers

Professor Craig T. Simmons, *Director*, NCGRT



# Research

In 2013, our researchers continued to cement the NCGRT's reputation as a global leader in groundwater research by translating their research into a range of journal articles, books, fact sheets, conference papers and more.

In 2013 our researchers published 204 journal papers, books, book chapters, conference papers and reports. Our journal papers were published in 68 journal publications, which is a positive reflection on the interdisciplinary nature of our research.

The quality of our scientific output continues to be recognised by the global research community with our annual citation rate of 8,744 significantly exceeding our target of 1,250. Moreover, nearly a third of our journal publications appeared in the top five global groundwater journals. These publication statistics underscore both the relevance and quality of our research, and the significant contributions that our researchers are making towards the resolution of critical groundwater research and management problems within Australia and across the globe.

In addition, 68% of the NCGRT's 2013 publication output involved collaborations with 401 researchers based at 226 organisations in 26 countries. We have also welcomed 30 international researchers to our research nodes (a full list may be found on page 34), and 28 NCGRT researchers undertook 65 visits to 48 research facilities in 15 countries.

For a visual representation of the NCGRT's research growth and output, please see pages 10–11.

The NCGRT has also been a major contributor to the development of Australia's new National Groundwater Strategy. Our Director, Professor Craig Simmons, has authored a major article on the complex challenges and approaches used to secure this agreement. The article, which was prepared in partnership with Mr Neil Power (who is the South Australian Director of State Research Coordination and an NCGRT Advisory Board member), was published by UNESCO in its prestigious *Free Flow* publication which celebrates the International Year of Water Cooperation.

The NCGRT's research has had a significant impact on the international stage with researchers

contributing to UNESCO discussions on the development of a Global Framework for Action to protect the Earth's imperilled groundwater resources. More information on the NCGRT's role in shaping the national and international research agenda can be found in the linkages and outreach sections of this report, on pages 30–33 and 36–39 respectively.

Other key research highlights have included the release of a major new report that the NCGRT commissioned into the economic value of groundwater in Australia. The study, undertaken by Deloitte Access Economics, estimated that Australia's groundwater reserves support approximately \$34 billion of economic activity each year. The study is the first of its kind to be undertaken in Australia and will inform high-quality evidence-based policy development for years to come. The NCGRT has also produced a brochure on the fundamental science challenges associated with coal seam gas exploration as part of our ongoing commitment to foster informed public debate.

Dr Vincent Post's groundbreaking discovery of vast new freshwater resources under the sea, published in the international scientific journal *Nature*, was another major research achievement. The article attracted significant global media interest and, despite not being published until December 2013, is already ranked in the top 5% of articles by interest in the Scopus database. See pages 40–41 for more information on Vincent's discovery.

Program 2 researchers Associate Professor Adrian Werner, Professor Craig Simmons, Dr Vincent Post, Dr Chunhui Lu and Dr Behzad Ataie-Ashtiani were also invited by the prestigious *Advances in Water Resources* journal to work with a number of international collaborators on a paper on 'Seawater intrusion processes, investigation and management: Recent advances and future challenges' for inclusion in its special 35th anniversary edition.

Congratulations also go to Program 1 Chief Investigator Malcolm Cox who co-authored a paper on 'Groundwater visualisation systems (GVS): A software framework for integrated display and interrogation of conceptual hydrogeological models, data and time-series animation', which was published in the *Journal of Hydrology* and has

entered ScienceDirect's top 25 list of the world's 'hottest' earth and planetary science articles at position number 10. Congratulations also to Program 5 leader Professor Tony Jakeman, whose co-authored paper 'Characterising performance of environmental models', published in *Environmental Software and Modelling*, has been cited 45 times since it was first published in February 2013 – a new record for the NCGRT.

The NCGRT relished the opportunity to showcase its research talents on the global stage at the International Association of Hydrogeologists' Congress held in Perth in October. This is the first time the congress has been held in Australia since 1994, and the theme was 'Solving the groundwater challenges of the 21st century'. The congress brought together over 700 participants from 45 countries and we are pleased that a large contingent of the NCGRT's researchers delivered plenary addresses and keynote speeches, and were actively engaged in the congress's workshop and poster sessions. More information on the NCGRT's role in the congress is located in the linkages section of this report, on pages 30–33.

Tony Jakeman (who is the current President of the Modelling and Simulation Society of Australia and

New Zealand) also ensured that the NCGRT was well-represented at the 20th International Congress on Modelling and Simulation held in Adelaide in December. The congress brought together some of the world's leading modellers and this year's theme was 'Adapting to change: The multiple roles of modelling'. NCGRT researchers delivered a range of papers in the areas of:

- multi-decision support for natural resource management and sustainable development policy
- advances in modelling and control of large-scale water resources
- visualisation and modelling for sustainable urban development
- innovations in water engineering.

We are also extremely proud of the large number of NCGRT researchers whose scientific excellence was recognised by national and international awards in 2013. Award winners included:

 Program 1 Chief Investigator Ian Acworth, who received the International Association of Hydrogeologists' President's Award for outstanding international contributions to groundwater science

| KEY PERFORMANCE INDICATORS |   | 2013 TARGET | 2013 RESULT           | CUMULATIVE<br>TARGET | CUMULATIVE<br>RESULT |
|----------------------------|---|-------------|-----------------------|----------------------|----------------------|
| RES                        | RESEARCH  |             |                       |                      |                      |
| R1                         | Total number of publications appearing in quality journals (including book chapters)                              | 180         | 204                   | 460                  | 608                  |
| R2                         | Research quality (% of category A or A* journal papers)   | 50%         | 54%<br>(110 articles) | 37%                  | 56%                  |
| R3                         | Number of citations   | 1,250       | 8,744                 | 3,300                | 13,117               |
| R4                         | Number of inivitations to present talks, papers and keynote lectures at major national and international meetings | 90          | 229                   | 260                  | 586                  |

- Program 3 PhD candidate Sarah Bourke, who won the best oral presentation by an early career hydrogeologist at the 2013 International Association of Hydrogeologists' Congress
- Program 4 PhD student Zijuan (Rose) Deng, who received the best student poster award at the Asia Oceania Geosciences Society's annual meeting
- Program 1 postdoctoral fellow Adam Hartland, who, along with Program 1 chief investigators Wendy Timms and Andy Baker, received the Environmental Chemistry Letters Editor's Choice Award for 'Measuring dissolved organic carbon δ¹³C in freshwaters using total organic carbon cavity ring-down spectroscopy (TOC-CRDS)'
- Program 2 postdoctoral fellow Dr Daan Herckenrath, won the award for best poster by an early career hydrogeologist at the 2013 International Association of Hydrogeologists' Congress
- Program 2 PhD student Dylan Irvine, who received Flinders University's School of the Environment Postgraduate Award for Teaching Excellence
- Program 2 Research Associate Andrew Love, who was named the 2013 Unsung Hero of South Australian Science
- Program 2 postdoctoral fellow Chunhui Lu, who received Flinders University's 2013 Vice Chancellor's Early Career Researcher Award
- Program 1 Chief Investigator Grégoire Mariethoz, who was awarded the International Association for Mathematical Geosciences Andrei Borisovich Vistelius Research Award
- Program 2 PhD student Leanne Morgan, who in 2013 received Flinders University's best student paper award for the second year in a row
- Program 2 postdoctoral fellow Maria Pool who received the the International Association of Hydrogeologists' Alfons Bayo Award for a distinguished early career scientist.

We are also proud to share that the NCGRT, in conjunction with SKM, won the 2013 Leadership Award at the Water Industry Alliance Smart Water Awards for its work on the development of the Australian Groundwater Modelling Guidelines.

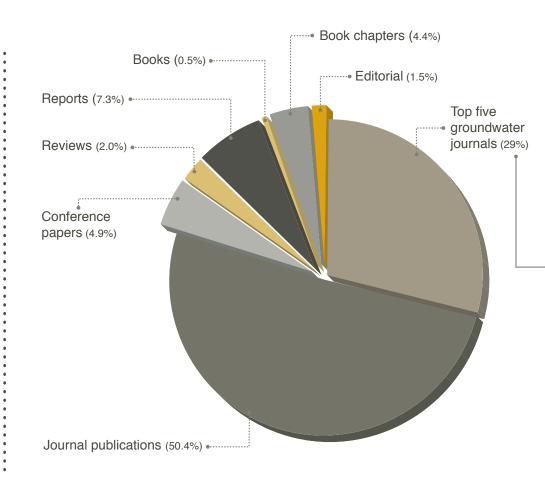
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### In 2013

29% of our scholarly articles were in the top five groundwater journals.

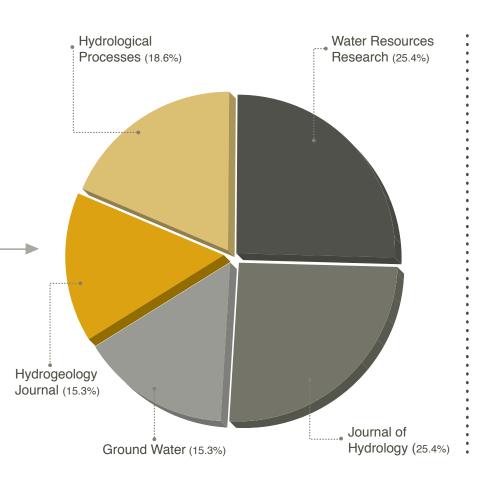




### 2009 FOUNDATION PARTNERS



From 21 Australian foundation partners in 2009, we have achieved vast linkages growth, now collaborating with over 200 organisations in more than 25 countries.



### In 2013

our research was featured by international news outlets such as:

Time

**The Huffington Post** 

NPR

**Forbes** 

**ABC News 24** 

The Times of India

giving our work a potential audience of tens of millions.



### 2013 INTERNATIONAL COLLABORATIONS Denmark **Netherlands** Canada **United Kingdom** Germany Belgium Austria **United States** Switzerland China Iran Spain Greece Israel Thailand Saudi Arabia Ethiopia French Polynesia >>>>> South Africa New Zealand

### Program 1 Innovative Characterisation of Aquifers and Aquitards



## Program leader: Professor Andy Baker

University of New South Wales

Andy has over 20 years of experience as an academic, having worked at the universities of Exeter, Newcastle and Birmingham. He is currently director of the Connected Waters Initiative research centre at the University of New South Wales.

Andy is an associate editor of *Water Research*, and a member of Britain's Natural Environment Research Council Radiocarbon Steering Committee as well as the scientific steering committee of the UK Royal Society. He has published over 150 internationally refereed papers, and has been awarded more than 50 research grants. Andy won the Philip Leverhume Prize in 2003 and a fellowship at the Institute for Advanced Studies at Durham in 2009.

Andy is a leading expert in the contrasting research fields of past climate change, and surface-water, groundwater and wastewater quality. His research interests include Karst hydrogeology; palaeoclimate reconstructions from cave stalagmites; the characterisation of organic matter in rivers, groundwaters and engineered systems, including potable and recycled water; and surface-water and groundwater quality monitoring.

In the NCGRT, Andy has a particular focus on characterising fractured rock aquifer systems using hydraulic, hydrochemical and geophysical tools.

### **Chief investigators:**

Professor Ian Acworth, UNSW
Dr Martin Andersen, UNSW
Assoc. Prof. Malcolm Cox, QUT
Assoc. Prof. Bryce Kelly, UNSW
Dr Grégoire Mariethoz, UNSW
Dr Wendy Timms, UNSW

### Partner investigators:

Dr Ross Brodie, Geoscience Australia Dr David Mitchell, NSW DPI

### Program 1 research addresses the innovative characterisation of aquifers and aquitards.

In 2013 we remained at full staffing capacity. Together with program partners Geoscience Australia and the NSW Department of Primary Industries, our researchers, PhD students and honours students are exploring new geophysical field methods and tools to gather data, building accurate 3D geological models that link hydrogeological processes, and using innovative techniques to trace water through complex systems.

In 2013, we focused on delivering conference presentations on our research, and submitting research papers. Program 1 was well represented at the International Association of Hydrogeologists' Congress in Perth: Mal Cox acted as scientific program co-chair, and postdoctoral fellow Gabriel Rau and chief investigators lan Acworth, Mal Cox and Andy Baker gave keynotes. Many other presentations were given by the majority of the Program 1 team.

At the congress we convened a session on aquitards, with a keynote given by our NCGRT international scholar, Professor Jim Hendry from the University of Saskatchewan. This session showcased many aspects of the NCGRT's aquitards research. Additionally, our research was presented at several other international conferences during 2013, including the world's largest geosciences conference, the American Geophysical Union Fall Meeting. Published journal

papers included both Program 1 specific outputs and cross-program collaborations. An example of the former is the development of novel geostatistical tools to represent non-stationary bedforms, published in *Environmental Modelling and Software*.

Collaborative work with the Program 3 team at Monash University on surface water – groundwater interactions was published in *Hydrology and Earth System Science* and with Program 5 on managed aquifer recharge using large floods in the *Australian Journal of Environmental Management*. As noted earlier in this report, a paper by postdoctoral fellow Adam Hartland with chief investigators Wendy Timms and Andy Baker was highlighted as Editor's Choice in *Environmental Chemistry Letters*. We put out media releases in 2013 on the use of heat as a tracer, on aguitards, and on caves as observatories.

In 2013, the 3D geological modelling group celebrated the International Association for Mathematical Geosciences (IAMG) awarding its prestigious Andrei Borisovich Vistelius Research Award to Grégoire Mariethoz. Grégoire was invited to collect his award and give a keynote presentation at the IAMG conference.

At the NCGRT centrifuge permeameter, the centrifuge DAS system was replaced and upgraded from fibre optic to wireless to better support a broader range of instrumentation for in-flight monitoring of a variety of parameters. Development and testing of new instrumentation that can 'plug' into the DAS system continues.

The Mountain Front Hydrological Observatory was made fully operational in 2013, led by Dr Martin Andersen and Program 3 postdoctoral fellow Josh Larsen (from the University of Queensland), with the help of NCGRT affiliate and Marie Curie Fellow Dr Mark Cuthbert from Birmingham University, UK. The observatory, funded by the Groundwater Education Investment Fund, is remotely collecting stream and recharge data from flow events in the ephemeral Middle Creek. The data will establish the importance of stream recharge in semi-arid environments.

Researchers from across Program 1 used the Wellington Caves to study recharge processes through a highly variable unsaturated zone. Using the 'cave as an observatory', the group successfully studied the migration of recharge water into the cave. The experiment is the first time heat and isotopic tracing have been applied to a controlled recharge experiment over fractured limestone. Two papers on this work were presented at the American Geophysical Union Fall Meeting.

In 2014, our focus is on producing research outputs, and continued PhD and honours student training. Researchers at the Queensland University of Technology and the University of New South Wales, working with ANSTO, CSIRO, the Queensland Department of Natural Resources and Mines, the University of Queensland, Royal Holloway and Leeds University, will be working towards advancing our understanding of the geology of the Walloon Coal Measures, Great Artesian Basin, and the Condamine Alluvium, using 3D geological modelling techniques.

Finally, we will host a research workshop 'Aquitards, aquifers and mining' in March 2014, with an international keynote speaker and invited speakers from the NCGRT and the University of New South Wales. Additionally, we will complete the second phase of centrifuge permeameter experiments of saline porewater and deuterium tracer breakthrough and nano-particle breakthrough experiments in aquitard materials, including quantification of dispersion effects at high gravity. New geocentrifuge instrumentation will be progressively deployed for these experiments.

# Program 2 Hydrodynamics and Modelling of Complex Groundwater Systems



### Program leader:

Professor Craig Simmons
NCGRT Director, Flinders University

One of Australia's foremost groundwater academics, Craig has been a significant contributor to global advances in hydrogeology in recent years. In particular, he is a recognised expert in variabledensity groundwater flow phenomena.

Craig has been a chief investigator on various large national and international projects, has published more than 200 scientific articles, and has served as editor on a number of journals. He is currently the inaugural Schultz Chair in the Environment at Flinders University. In 2011 he was elected a fellow of the Royal Society of South Australia and awarded the Australian Academy of Science Anton Hales Medal for research contributions to the Earth Sciences – a top research recognition.

In 2006 Craig joined six other pre-eminent hydrogeologists to write a position paper on the state of groundwater research, training and management, which has been a catalyst for major groundwater reform in Australia. During 2012 he was chair of the Australian Government's Interim Independent Expert Scientific Committee on Coal Seam Gas and Coal Mining.

In 2002, Craig won the Australian Award for University Teaching, and in the same year was named the Distinguished Oliver Lecturer by the University of Texas at Austin. In 2013 he was a finalist for the Eureka Prize for Leadership in Science.

### **Chief investigators:**

Professor Okke Batelaan, Flinders

Professor Peter Cook, Flinders

Professor Ling Li, UQ

Dr Vincent Post, Flinders

Dr Henning Prommer, UWA

Assoc. Prof. Adrian Werner, Flinders

### Research associates:

Professor John Doherty, Flinders

Dr Andrew Love, Flinders

Dr Michael Teubner, Flinders

Program 2 focuses on developing a general understanding of groundwater systems as well as on developing modelling practices and tools that can be applied across a range of issues. Our work addresses some of the most pressing challenges currently facing hydrogeology.

Program 2 has 14 postdoctoral fellows and 15 PhD candidates who are working on a number of major projects. At this stage, the focus is on completion of PhD and postdoctoral research work, and continued translation into relevant research papers as well as vital technology transfer, and knowledge and adoption outcomes. Program 2 has completed much of its core research work. Many students are completing their PhD theses and obtaining successful employment. Danica Jakovovic and James McCallum have submitted their final PhD theses, and many other thesis submissions are imminent.

A number of important international modelling publications have arisen from Program 2. Beyond those referred to in the research overview section, these include:

'Groundwater modelling in decision support: reflections on a unified conceptual framework', by chief investigators John Doherty and Craig Simmons, which was published in *Hydrogeology Journal*; the paper proposes a rigorous decisionmaking approach regarding model simplicity and complexity

- 'On the testing of fully integrated surface subsurface hydrological models', by PhD students Megan Sebben and Jessica Liggett and chief investigators Adrian Werner and Craig Simmons, which was published in *Hydrological Processes*; this paper discusses the current challenges for testing hydrological models and offers new approaches for important and rigorous model testing
- 'Simulating MODFLOW-based reactive transport under radially symmetric flow conditions' by postdoctoral fellow Ilka Wallis and chief investigators Henning Prommer, Vincent Post, Craig Simmons and colleagues, which was published in *Groundwater*; this paper demonstrates that radial transport models are capable of accurately reproducing a wide variety of conservative and reactive transport problems provided that an adequate spatial discretisation and advection scheme is selected
- 'Modelling of groundwater-vegetation interactions in a tidal marsh' by postdoctoral fellow Pei Xin along with Ling Li which was published in Advances in Water Resources; the simulation results revealed three characteristic zones of soil conditions for plant growth in tidal marshes
- a correspondence by chief investigators
   Chunhui Lu, Adrian Werner and Craig Simmons
   which has been accepted by the prestigious
   journal Nature Climate Change; this was a
   comment on and reply to an international paper
   on the relative importance of groundwater
   abstraction and sea-level rise on seawater
   intrusion processes.

Program 2 continues to communicate its research outputs through a range of publications and workshops, and by strengthening its external research relationships. A number of Program 2 highlights are listed here.

- The National Water Commission-funded Australian Groundwater Modelling Guidelines, to which Vincent Post, Adrian Werner and Craig Simmons contributed, was awarded the Water Industry Alliance Smart Water Award in Leadership in May this year.
- The program and wider NCGRT have run a number of highly successful short courses

- throughout the country on the Australian Groundwater Modelling Guidelines. Vincent Post and Henning Prommer also ran two short courses on reactive transport modelling.
- A number of students and researchers presented work at overseas conferences. PhD student Megan Sebben presented her work on model testing of fully-coupled surface water - groundwater interaction modelling at the MODFLOW and More conference, in Golden, Colorado. Postdoctoral fellow Juliette Woods gave a presentation on her work on recharge and perched aguifers below irrigation areas at the US National Ground Water Association Summit, in San Antonio, Texas. Postdoctoral fellow Maria Pool presented her work at the European Geophysical Union conference in Vienna. A number of Program 2 researchers including Daan Herckenrath and Maria Pool presented their work at the American Geophysical Union conference in San Francisco.
- With our partner, DHI, the NCGRT co-organised the 2nd Australian and New Zealand FEFLOW User Group Meeting. Chief investigators Craig Simmons and John Doherty gave invited plenary addresses and a number of Program 2 students presented their work. These talks catalysed an excellent discussion and debate on current challenges and opportunities in groundwater modelling.
- Craig Simmons and research associate
   John Doherty gave plenary addresses at the
   International Association of Hydrogeologists'
   Congress. Craig also gave a keynote address at
   MODSIM 2013, the 20th international congress
   on modelling and simulation.
- Chief investigators Craig Simmons, Adrian Werner, Vincent Post and Henning Prommer continue professional service on the editorial boards of major international journals including Hydrogeology Journal, Journal of Hydrology, Advances in Water Resources, Groundwater, Vadose Zone Journal, and Environmental Modeling and Assessment.

These activities place the NCGRT at the forefront of international groundwater modelling developments.

# Program 3 Surface Water - Groundwater Interactions



### Program leader:

# Professor Peter Cook NCGRT Deputy Director, Flinders University and CSIRO

Peter has joint appointments as a senior principal research scientist with CSIRO Land and Water and as professor in the School of Environment at Flinders University.

He is a world-leading groundwater scientist who specialises in hydrology, ecohydrology, isotope hydrology and unsaturated zone flow. His work is recognised globally and he was the National Ground Water Association Darcy Lecturer for 2009. This is one of the highest honours that can be given to a groundwater scientist and he was the first non-Northern American resident to be chosen for the role.

Peter was a member of the National Groundwater Committee between 2002 and 2007, and a member of the Victorian Government's technical audit panel for water resources between 2002 and 2008. In 2003, he was commissioned by the United States National Research Council to review the work of its Committee on Hydrologic Sciences on the interaction between groundwater and surface-water resources. During the mid-1990s, Peter was at the forefront of the development of chlorofluorocarbons as a groundwater dating tool.

Peter has written three books and has been an associate editor of leading international journals.

### **Chief investigators:**

Dr Martin Andersen, UNSW Professor Ian Cartwright, Monash

Dr Massimo Gasparon, UQ

Professor David Lockington, UQ

### Partner investigators:

Dr Glenn Harrington, CSIRO

Dr Marc LeBlanc, JCU

Dr Sébastien Lamontagne, CSIRO

Dr Axel Suckow, CSIRO

Program 3 seeks to understand mechanisms of water flow between groundwater and surface water, and to develop methods for quantifying the exchange.

In many systems there is a net flow of groundwater to surface water or vice versa; surface water and groundwater budgets are not independent. This interconnectivity of surface water and groundwater is often not fully recognised, and this can lead to double accounting and double allocation of resources.

The program is active at a large number of field sites, spanning all mainland states and the Northern Territory, with field studies of surface water - groundwater exchange in perennial and ephemeral streams supplemented by modelling studies. To date, 13 postdoctoral fellows and 13 PhD students have commenced in the program (three of these positions are joint with other programs), and one PhD student and three postdoctoral fellows have completed. Our alumni currently occupy positions at the United Kingdom's University of Bristol, Germany's University of Bayreuth, the University of Queensland and the University of Botswana. We have also trained 12 honours students, who are now working in the water industry in Australia.

One of the focuses of the program is on using temperature and natural chemical tracers to investigate the interaction between surface water and groundwater. In conjunction with Program 1,

UNSW PhD student Landon Halloran has been using temperature combined with other techniques to investigate infiltration during river floods in the Namoi catchment. Flinders University PhD students Roger Cranswick and Sarah Bourke have been using temperature to understand hyporheic exchange a process whereby river water moves into and out of riverbed sediments. The hyporheic zone is where groundwater and river water mix, and is an important zone for chemical reactions and nitrogen cycling in streams. Sarah is investigating ephemeral streams in the Pilbara region of north-western Australia that receive mine dewater, and has found that traditional methods for quantifying hyporheic exchange fail to capture very long, slow flowpaths. Postdoctoral fellow Margaret Shanafield has been burying fibre optic cables beneath irrigation channels in the southeast of South Australia to determine how rates of infiltration through the streambed vary spatially.

The Monash team has continued its efforts in using geochemical tracers to quantify groundwater inflows to rivers. A study of the King River in north-east Victoria, by postdoctoral fellows Ben Gilfedder and Harald Hofmann, has sought to better understand parafluvial flow and degassing in order to more effectively utilise the radon isotope as a tracer. Monash PhD student Alex Atkinson is examining groundwater inflows to the Gellibrand River, western Victoria and also the sources and residence times of water in the upper catchment. Fellow PhD student Nick Unland has used geochemical tracers together with continuous electrical conductivity and head measurements to examine riverbank exchange in the Tambo River, south-east Victoria. The Monash team has also been collaborating with University of Queensland PhD student Seng Chee Poh to investigate different geochemical tracers for detecting and measuring groundwater flow to estuarine wetlands in Moreton Bay, Queensland.

Program 3 and Program 2 are joining forces in a major collaborative project with Peking University, China, where Flinders University postdoctoral fellow Yueqing Xie is examining groundwater – surface water interaction in the Heihe catchment, northern China.

Program 3 is also examining flow through ephemeral streams. One of the main field sites is the Super Science site in the Ti Tree Basin, central Australia, where we are working closely with Program 4. In this area, infiltration between ephemeral streams creates a perched aquifer within the alluvial sediments, which provides a source of water for riparian vegetation. Research here is attempting to partition infiltration into that which is used by riparian vegetation and that which recharges the deep aquifer. Work on ephemeral streams is also occurring in some of the ephemeral headwater streams of the Namoi catchment, where stream and groundwater level data is being remotely collected. (NCGRT affiliate and Marie Curie Fellow Dr Mark Cuthbert, who is visiting the University of New South Wales from Birmingham University, is an important contributor to this project, which has also received funding through the Super Science program.)

Communication of research results is now a strong focus, and Program 3 is having a significant impact on the international stage. To date, the program has published 73 papers in leading international journals, and a number of additional publications are currently moving through the editorial process.

The 2013 International Association of Hydrogeologists' Congress was a major focus for the NCGRT, and Program 3 staff and students presented 19 papers at the meeting. In particular, Program 3 PhD student Sarah Bourke won the conference award for best presentation by an early career researcher.

Monash postdoctoral fellow Harald Hofmann and Chief Investigator Ian Cartwright organised a special session on measuring and modelling surface water – groundwater interactions at the 2013 European Geosciences Union general assembly, held in Vienna. Program 3 researchers also presented papers at the 9th International Conference on Environmental, Cultural, Economic, and Social Sustainability in Hiroshima, the 2013 National Ground Water Association Summit in San Antonio, the 4th Water Research Horizon Conference in Berlin, the 9th International Symposium on Applied Isotope Geochemistry in Budapest, and the American Geophysical Union Fall Meeting in San Francisco.

# Program 4 Groundwater-Vegetation-Atmosphere Interactions



### Program leader:

### Professor David Lockington University of Queensland

David is the head of the Department of Environmental Engineering and director of the Centre for Water Studies at the University of Queensland. David's expertise in vadose zone and coastal groundwater hydrology is recognised internationally.

His work is widely published and has been recognised through his appointment as an associate editor of two of the most prestigious international hydrology journals, *Water Resources Research* and *Advances in Water Resources*.

While David's research activity covers a broad range of topics, over the past decade he has been concentrating on quantitative groundwater dynamics at the land-ocean interface.

In the 1990s he helped establish the effect of tidal dynamics on basic seawater intrusion as well as identifying their generation of an upper circulation cell. The presence of this upper cell has become the focus of significant international research.

David has now extended this work to investigate other critical interactions as well as quantifying the hydrology and groundwater dynamics in important island systems.

### **Chief investigators:**

Professor Ian Cartwright, Monash
Dr Edoardo Daly, Monash
Professor Derek Eamus, UTS
Dr Huade Guan, Flinders
Professor Catherine Lovelock, UQ
Assoc. Prof. John Webb, La Trobe

### Research associates:

Dr John Hutson, Flinders
Dr Matthew McCabe, UNSW

Program 4 aims to understand interactions between groundwater, vegetation and the atmosphere. This includes quantifying evapotranspiration and groundwater recharge, and evaluating the sensitivity of groundwater-dependent ecosystems to changes in groundwater levels.

Program 4 personnel researching groundwater-vegetation-atmosphere interactions and groundwater-dependent ecosystems has peaked and 2014 will see the departure of several of our PhD students. We have now had two PhD completions (Nadia Santini from the University of Queensland and Parikshit Verma from Monash University) with several other students under examination or close to submission.

Our ability to assess groundwater-vegetation—atmosphere interactions is extremely limited and in Australia, as elsewhere, robust tools have not yet been established to support appropriate management of vegetated groundwater systems. Consequently we have worked hard to establish a variety of research sites. The main sites – Moreton Bay in Queensland, Baldry and Kangaloon in New South Wales, and the south-west Victorian forests – are now complete. In addition, significant infrastructure has been developed at the Ti Tree Basin in the Northern Territory, Baldry in New South Wales, North Stradbroke Island in Queensland and Willunga in South Australia.

With long-term monitoring of groundwater–vegetation–atmosphere interactions at these sites, researchers will be able to substantially improve our ability to sustainably manage groundwater resources; Program 4 researchers have already made significant advances in our understanding of groundwater–vegetation–atmosphere interactions.

At our Moreton Bay sites we have established that mangroves not only exploit groundwater as a source of freshwater for growth, but that they can also opportunistically take in rainwater through their canopy. PhD students Yanxi Xiao and Amy White are looking at groundwater-dependent wetland vegetation at our coastal sites; results in 2013 suggest the species studied have some intra-seasonal resilience and can withstand short-term water stress.

Access to plantation forests has given our researchers an excellent opportunity to test various methodologies. At our conifer stand on Bribie Island, we have established that care needs to be taken in the application of all sap-flow methods when dealing with conifers in particular. This work is currently being written up and has led to a strong relationship with the Laboratory of Plant Ecology at Ghent University in Belgium.

Catchment-scale research on Blue Gum plantation transpiration and groundwater recharge in Victoria has been the subject of Josh Dean's PhD at La Trobe. Josh is expected to submit his PhD this year; journal articles are also being prepared from the research.

Chief Investigator Derek Eamus and his team (particularly PhD student Sepideh Zolfaghar and postdoctoral fellow Randol Villalobos-Vega) have established that a threshold in tree ecophysiological performance occurs across a number of species and sites. This is an important discovery for groundwater managers as they seek to abstract water without negatively impacting vegetation. This group has also joined Program 3 researchers at the arid zone Ti Tree site. They have been able to show that River Red Gums, known to be accessing groundwater, have a different <sup>13</sup>C content to Acacia aneura, which isn't accessing groundwater. More interestingly, the River Red Gum data provide a significant point of difference for a larger, Australiawide data set.

At larger scales, our researchers have been investigating the applicability of physically-based models coupled with remotely-sensed hydrological observations in order to quantify the hydrological cycle and groundwater-vegetation-atmosphere interactions in particular. The Baldry site is a core study area for this work. However, as the development of the site is still being finalised, collaboration with Danish researchers has provided an immediate data set for protocol testing. Postdoctoral fellow Hoori Ajami has been central to this exercise.

Research in the Program 4 group at Flinders is primarily based on a well-instrumented native vegetation catchment in the Willunga Basin. Quantifying atmospheric forcing and estimating vegetation change impact on groundwater recharge continue to be focuses of this group. The group collaborates with postdoctoral fellows at other partner institutions including Hoori Ajami at the University of New South Wales and Adrien Guyot at the University of Queensland. The research methodology developed at Willunga has been applied to study the impacts of vegetation changes in the Lake Dongting catchment in central south China.

Finally, our researchers have presented their work at a number of conferences this year: the Asia Oceania Geosciences Society Meeting (Rose Deng from Flinders was awarded best student poster); the European Geosciences Union General Assembly in Vienna; and the 2013 International Association of Hydrogeologists' Congress in Perth.

At the NCGRT Annual Dinner, two Program 4 researchers received awards: PhD student Josh Dean received the service award and postdoctoral fellow Adrien Guyot received an award for excellence in research.

### Program 5 Integrating Socioeconomics, Policy and Decision Support



Program leader:

**Professor Tony Jakeman** Australian National University

Tony is a professor at the Fenner School of Environment and Society and director of the Integrated Catchment Assessment and Management Centre at the Australian National University.

For the past 30 years Tony has been at the forefront of international research in environmental modelling methods and practice. His work in hydrology is extensive and includes a variety of important new models. He is president of the Modelling and Simulation Society of Australia and New Zealand and was the foundation president of the International Environmental Modelling and Software Society. In 2012 he was awarded the Ray Page Lifetime Simulation Achievement Award by Simulation Australia.

Tony's work is distinctive in that it attempts to combine formulations of key processes and drivers in statistically rigorous ways. He pioneered the development of the IHACRES dynamic water balance model which has been applied worldwide to hundreds of catchments in most hydroclimatologies.

He routinely undertakes joint research projects with CSIRO, government agencies and other organisations and has a particular passion for research training. Tony's research is widely published and he is editor-in-chief of the prestigious journal *Environmental Modelling and Software*.

### **Chief investigators:**

Dr Barry Croke, ANU
Professor Allan Curtis, CSU
Assoc. Prof. Alex Gardner, UWA
Professor Neil Gunningham, ANU
Professor Jennifer McKay, UniSA
Assoc. Prof. Wendy Merritt, ANU

Professor David Pannell, UWA

Dr Sondoss El Sawah, ANU

Program 5 undertakes research to help understand and support decision making for different policy issues related to managing groundwater and dependent ecological and socioeconomic systems.

Program 5 had a successful year in 2013. Neil Gunningham, postdoctoral fellow Darren Sinclair and research affiliate Cameron Holley obtained an ARC Linkage Grant on compliance and enforcement of non-urban water extraction in partnership with the NSW Office of Water, while Allan Curtis developed a memorandum of understanding with the North Central Catchment Authority to underpin ongoing NCGRT research activities.

Postdoctoral fellow Marian Patrick, along with Professor Geoff Syme from Edith Cowan University, presented research ideas on the quantification of cultural flows in the Pilbara to the Yamatji Marlpa Aboriginal Corporation in Exmouth, and have received an endorsed invitation by the committee to visit the Pilbara for further discussions on this topic. They also met with CSIRO, the Western Australian Department of Water, and the Western Australian Chamber of Minerals and Energy with Alex Gardner and PhD student Natalie Brown.

2014 will see a number of PhD and postdoctoral completions. Mun-Ju Shin submitted his thesis in 2013 while Joseph Guillaume and Rachel Blakers will submit in early 2014; we anticipate others will follow throughout the year.

In Willunga, Sondoss El Sawah and postdoctoral fellow Joseph Guillaume collaborated with Dr Tatiana

Filatova (University of Twente) to develop and apply a modelling methodology for incorporating decision making into water assessment and planning. In 2014, the team will focus on sharing findings with the project stakeholder groups to examine their impacts on improving stakeholders' capacity to understand and negotiate outcomes of water allocation policies. They aim to produce a series of publications to report the modelling process used throughout the project.

The final report for the Namoi Project has been submitted to the Cotton Research and Development Corporation. Stakeholders included Namoi Water, the Namoi Catchment Management Authority and the NSW Office of Water. The project developed an integrated model to study the environmental and socioeconomic impacts of reduced water availability, and the potential for adaptation by farmers. Also in the Namoi, postdoctoral fellow Baihua Fu and PhD student Joseph Guillaume developed a computationally efficient uncertainty assessment approach for index-based habitat suitability models where limited data are available and expert opinions differ significantly. The Namoi and Willunga projects continue to be used to extend our framework for managing uncertainty in groundwater management by creating a 'closed question modelling' methodology.

The Lachlan project, under the leadership of Wendy Merritt and postdoctoral fellow Baihua Fu, is focused around developing hydro-ecological models and tools for the Lachlan catchment that incorporate groundwater–ecosystem interactions. A web-based data management system is being developed and integrated with an adaptive modelling framework to synthesise and demonstrate environmental outcomes of environmental water releases. The system is being developed for two major assets within the catchment: the Booligal Wetlands and Great Cumbung Swamp. In 2014, we will focus on completing development of Bayesian network models of the wetlands and integration with the web-based tool.

The Campaspe project primarily investigates the economic and ecological impacts of Murray–Darling Basin Sustainable Diversion Limits at the subcatchment level. In 2013, the data collection and model design phases of the integrated model were

completed. The results of this research to date were presented at the International Congress on Modelling and Simulation (MODSIM). In 2014, the focus will be on finalising the model, running a workshop to share results and recommendations with stakeholders, and on publishing.

In Western Australia, PhD student Madeleine Hartley will shortly complete her thesis on water use efficiency. Alex Gardner and Madeleine hope to co-author two papers by early 2014, one on integrated modelling in the Namoi, and the other on groundwater and the legal case of ICM Agriculture v the Commonwealth. Natalie Brown will progress her PhD, co-funded for the first year by the NCGRT, and will produce papers on mining and dewatering. Finally, Michael Bennett will finalise his work on managing groundwater in a drying south-west by the end of May.

Work has continued throughout 2013 in north central Victoria. Allan Curtis and postdoctoral fellow Emily Mendham have met with the North Central Catchment Management Authority to discuss implementing a social benchmarking survey. This survey will explore groundwater and groundwater-dependent ecosystems. The new MOU covers a number of other ongoing research activities, including support for Theresa Groth and Saideepa Kumar's PhD research. In general, publications have focused on risk and trust, including those related to groundwater, based on analysis of the 2011 Social Benchmarking survey in the Wimmera region.

In 2013 a variety of work investigated opportunities for managed aquifer recharge at large catchment scales. In South Australia, research focused on institutional risks related to implementing managed aquifer recharge projects, particularly those surrounding ownership and entitlements to water. In 2014, the Centre for Comparative Water Policies and Laws Annual Workshop will focus on the potential regulatory responses to the issue of coal seam gas extraction, including related-aspects of governance and institutional participation.

# Super Science

The Super Science Initiative was an Australian government program funding scientific infrastructure. Super Science provided funding to a variety of fields, including space and astronomy, marine and climate — and groundwater.

\$15 million from Super Science was set aside as the Groundwater Education Investment Fund (GEIF) to develop a series of world-class groundwater infrastructure sites. This investment recognised that efforts to understand and manage Australia's groundwater systems have been hampered by a lack of data.

The strong relationship between the NCGRT and the GEIF maximises the value of both projects; NCGRT researchers are involved in setup and design of the sites, utilise the infrastructure, and contribute to long-term data sets.

There are seven main groundwater monitoring sites:

- Willunga, South Australia
- Namoi, New South Wales
- Wellington, New South Wales
- Ovens Valley, Victoria
- Ti Tree, Northern Territory
- · North Stradbroke Island, Queensland
- Fowlers Gap, New South Wales.

The initial installation of groundwater research infrastructure at these sites is now largely complete, and ongoing funding is maintaining the sites into the future.

Data collected from the sites is being made publicly available on a Super Science Groundwater Database. It may be found at http://groundwater.anu.edu.au, with more information available at http://www.connectedwaters.unsw.edu.au/groundwater-eif

### Willunga

Infrastructure at the Willunga site focuses in five main areas: surface water – groundwater interaction, monitoring of seawater intrusion, mountain front recharge (and flow across fault zones), managed aquifer recharge, and leakage through aquitards.

This site is used by Program 5 researchers, including PhD students Rachel Blakers and Joseph Guillaume, and Chief Investigator Sondoss El Sawah, who

are building a socioeconomic model and decision support model to complement the hydrological model used by decision makers in the region.

The site is also used extensively by Program 3 researchers, including PhD student Michelle Irvine and postdoctoral fellow Eddie Banks, who are working with CSIRO to develop tracer methods for measuring leakage through aquitards, and postdoctoral fellow Jordi Batlle-Aguilar, who is studying infiltration from intermittent streams. Program 4 researchers, including PhD students Hailong Wang and Xiang Xu, and postdoctoral fellow Hugo Gutierrez, are using the site to explore vegetation change impact on groundwater recharge; more information can be found on page 19.

Studies of the water resources within the Willunga Basin involve strong collaboration with the local natural resource management board and the South Australian state government. Data from stream gauging stations is currently publicly available on the Adelaide and Mount Lofty Ranges Natural Resource Management Board website, and City of Onkaparinga have used streamflow data for flood mapping in McLaren Vale.

### Namoi

The Namoi Valley contains some of the best agricultural soils in Australia. Concern about the reliability of the underlying groundwater resources has become a political issue as the pressure to develop coal seam gas, open cast coal and agriculture is felt at local, state and federal levels.

The Namoi region is a major research site for programs 1, 3 and 5. Program 1, led by Chief Investigator Martin Andersen, is working on better understanding the transfer of water, both to and from the Namoi, in response to natural floods, dam releases and groundwater pumping from adjacent abstraction bores. NCGRT postdoctoral fellows Gabriel Rau, Hamid Roshan and Josh Larsen and PhD student Landon Halloran have focused their research at this site.

Program 5 researchers, including postdoctoral fellows Baihua Fu and Joseph Guillaume, have been working with the Cotton CRC, looking at the environmental and socioeconomic impacts of reduced water availability, and the opportunities for

adaption. More information may be found in the Program 5 report on page 21.

### Wellington

The Wellington site allows investigation and monitoring of groundwater in fractured rocks. Less is known about the water resources available in fractured rocks than practically any other aquifer system, yet fractured rocks cover approximately 20% of the land surface of the world and it has been estimated that approximately one third of all bores drilled in Australia are into fractured rock systems.

Long-term monitoring and investigations at these sites will allow firm predictions of the locations of useful groundwater resources in a variety of fractured rock types as well as the responses of these systems to climate change. These systems are particularly important for understanding dryland salinity and for supporting the increasing demands for groundwater as the well-developed existing sources become over-committed.

The Wellington site has been widely utilised by national researchers from a variety of institutions, but Program 1 researchers – including postdoctoral fellows Helen Rutlidge, Gabriel Rau, Hamid Roshan and PhD student Monika Markowska – have been particularly active in conducting research in this area. More information about their work may be found in the Program 1 report on page 13.

### Ovens Valley

Activity in the Ovens Valley, a region with nearnatural surface-water flow, has centred around the extension of the existing state-owned bore network to provide more detailed monitoring near the Ovens River and its major tributaries.

Research in this area is led by Program 3 Chief Investigator Ian Cartwright, and is the basis for the work by postdoctoral fellows Harald Hofmann and Ben Gilfedder. The infrastructure is also being used in collaboration with ANSTO for research on timescales of groundwater movement in floodplains.

### Ti Tree

Infrastructure at the Ti Tree site focuses on recharge processes in arid climates, and the interaction between groundwater and vegetation; it is utilised

primarily by Program 3 and Program 4 researchers. The Northern Territory Department of Land Resource Management is using results from this site to further develop their groundwater model of the Ti Tree Basin.

Program 3 PhD student Cameron Wood is studying groundwater flow and recharge processes, and the importance of the ephemeral rivers as recharge sources. Program 3 postdoctoral fellow Margaret Shanafield and research assistant Stephanie Villeneuve are studying evaporation processes and salt lake systems, and infiltration processes from ephemeral rivers. Program 3 is also collaborating with ANSTO to measure carbon isotopes to determine groundwater residence times.

Program 4 research at the Ti Tree site is led by Chief Investigator Derek Eamus, and focuses on groundwater usage by arid-zone vegetation. PhD student Sepideh Zolfaghar has been working in this area. More information on this work may be found in the Program 4 report on page 19.

### North Stradbroke Island

North Stradbroke Island is a large sand-mass island near Brisbane, and has hydrological features representative of many coastal groundwater systems around Australia, including groundwater-fed lakes, springs and wetlands, and the associated groundwater-dependent ecosystems.

Work at this site is led by Program 4, with ongoing research on coastal groundwater–vegetation interactions, the sensitivity of groundwater-dependent trees and wetland species, and evapotranspiration from key land uses. This work is led by Program 4 leader David Lockington, and contributed to by a number of postdoctoral fellows, including Adrien Guyot and Nina Welti, and PhD students including Michael Gray and Matt Hayes.

### Fowlers Gap

Infrastructure at Fowlers Gap focuses on recharge processes in arid environments, at a site with historical climate and surface-water hydrology datasets.

New bores, gauging stations and weather stations, with telemetry and real-time cameras, were installed. This site was the last to be established in late 2013, and is available for new research opportunities.

# Media release: Saving Earth's toxic waste



### Derek Eamus

Scientists have devised a better way to protect groundwater from acids, heavy metals and toxic chemicals, helping to secure the Earth's main freshwater supply.

The advance is a major step towards shielding groundwater from mining, industrial and domestic waste, all of which can contaminate the water for decades, rendering it unusable and the soil soaks up rain water, alundrinkable.

A team led by Professor Derek Eamus at the National Centre for Groundwater Research and Training (NCGRT) and the University of Technology, Sydney (UTS) has developed a cheaper and more efficient way to test the optimal and requires a lot of work, Prof. design of 'store-release covers' Eamus says. "To build a cover, we - layers of soil and plants that have to know what type of soil prevent water from leaking into and plants to use, and how thick the waste and contaminating the the soil layer should be. aquifers underneath.

"Globally, mining produces millions of tons of waste known as tailings that are often stored above ground," says Prof. Eamus. "Industrial and domestic waste are buried as landfill, with Australia alone burying over 21 million tonnes in 2010."

This waste poses a big threat to groundwater, which makes up 97 per cent of the world's fresh water and is thus a major element in global water security, Prof. Eamus explains.

When rain water travels through waste, it leaches toxic chemicals from discarded electronic equipment, batteries, detergents, solvents and pesticides. The contaminated water then drains into the aquifer below, which may be used for drinking or watering crops. Once polluted, groundwater is expensive and difficult to clean up.

One way to minimise the contamination is to cover the waste with a layer of soil, trees and plants, Prof. Eamus explains. Known as store-release covers, lowing the vegetation to use it and release it back into the atmosphere. This siphons off enough water to prevent it from reaching the waste.

However, building store-release covers is expensive, slow

# groundwater from

"Also, every site has a different climate, vegetation and soil, so a lot of it is guess work, followed by hundreds of experiments. It can take years and years to optimise the design of a store-release cover."

To solve this problem, the researchers ran a soil-plant-atmosphere model with different climate scenarios to test its effectiveness in designing storerelease covers. To find out which covers work best, they looked at four factors: the depth of the soil layer, how much water it can hold, how much water a plant will use and the local rainfall.

They then applied the model to three different Australian climates: cool, wet winters with hot, dry summers in Perth; the monsoonal climate in Darwin; and distributed rainfall across the year such as in Sydney.

"We found that an effective store-release cover has to have disposal industries: results enough capacity to store any additional rain that falls in wetter years. The trees have to grow leaves that cover the entire ground, and their roots have to recently published in the jourreach the bottom of the soil cover," Prof. Eamus says.

"We don't want the lower half of the store-release cover to have no roots, because water will gather there and seep through the waste. Also, having more leaves that cover the ground means more water will be used and transpired by the plant."

"Now we know what makes an effective store-release cover, we can gather the information for these factors, as well as the rainfall average and extremes for any location, to optimise the design of a store-release cover anywhere in the world," says Prof. Eamus.

"This model removes a lot of quesswork and decreases the number of experiments that we have to carry out. So not only are these covers cheaper to build, they will also be more efficient. This will encourage mining as well as waste management companies to build better covers for their waste."

The model can also be used anywhere in the world to help tackle the global problem of groundwater pollution, Prof. Eamus says.

The study "Design of store-release covers to minimize deep drainage in the mining and wastefrom a modelling analysis based on ecophysiological principles" by Derek Eamus, Isa Yunusa, Dan-iel Taylor and Rhys Whitley was nal Hydrological Processes.





The International Association of Hydrogeologists' Congress in Perth in October was the NCGRT's major research and training event for 2013, replacing our usual Summer School program. Our researchers were able to choose from a comprehensive program of 425 presentations which provided genuine professional development opportunities to enhance their skills in a range of groundwater research disciplines.

The congress also provided a unique opportunity to showcase the NCGRT's research and industry training operations, with over 70 of our researchers and students delivering presentations to distinguished groundwater scientists and industry professionals from around the globe. We would also like to recognise the notable achievements of PhD student Sarah Bourke and postdoctoral fellow Daan Herckenrath who both received awards at the congress.

In addition, our chief investigators have continued to provide direct one-to-one supervision and mentoring to researchers and students which has been complemented by lectures, seminars, workshops and visits from experts organised by the NCGRT and their 'home' universities. In addition, a large number of researchers and students have visited research facilities within Australia and across the globe with the support of NCGRT funding. These visits assist us in identifying and capitalising on emerging groundwater research opportunities. They also lay the foundations for future research collaborations that will help transform our students and early career researchers into world-class scientists.

One of the key highlights of 2013 was Professor Andrew Boulton's workshop series, held alongside his Distinguished Lecturer series, discussed on page 37, which looked at the characteristics of successful journal articles and grant applications.

The NCGRT's marketing and communications team has partnered with a number of our PhD students and early career researchers to translate their research projects into media releases. This process has provided important, practical media training and has the added benefit of bringing our research

to a wider audience. For example, successful media coverage was achieved on the work of PhD candidates Josh Dean and Sepideh Zolfaghar, and postdoctoral fellow Matthias Raiber.

Our industry training team has also worked hard to create opportunities for our early career researchers to present on our 2013 professional short course program. Our training courses provide an important knowledge transfer mechanism and enable our researchers to forge strong relationships with key stakeholders and end-users from the outset of their careers. In addition to presenting on the training program, 44 postdoctoral fellows and PhD students accessed the general and specialist courses offered by our training team, taking advantage of significant knowledge extension opportunities. More broadly, our industry training team has had a successful year, holding 21 short courses (six above the target of 15), and attracting well over 500 attendees. The full list of industry training courses held in 2013 may be found on page 29.

The NCGRT attracted 13 new postdoctoral researchers in 2013, which reflects our ongoing commitment to developing the next generation of groundwater researchers. The majority of these researchers are on fixed term contracts that will expire in 2014; however, a number have secured external funding which will enable them to continue their research beyond the life cycle of the Centre's Australian Research Council/National Water Commission grant. This is a positive reflection on the quality and relevance of our researcher's work.

The NCGRT's senior research leaders have also continued to invest significant effort in supporting our PhD researchers to complete their theses. We would like to congratulate Seng Chee Poh and Parikshit Verma who had their PhDs conferred in 2013 as well as the 10 PhD researchers who submitted their theses to deadline and are currently awaiting the results.

The NCGRT also welcomed 13 new honours students in 2013, 11 of whom have successfully completed their project work. The two remaining students enrolled on a part-time basis and remain firmly on track to complete their studies in 2014.

The quality of our training environment has enabled a number of our early career researchers to secure positions in world-leading research centres, including:

- Dylan Irvine (a Flinders University Program 2 PhD student), who is currently working as a research associate and part-time lecturer at Syracuse University in New York
- Dr Chunhui Lu (a Flinders University Program 2 postdoctoral fellow), who secured a permanent research position at Monash University
- Dr Ilka Wallis (a Flinders University Program 2 postdoctoral fellow), who is taking up a research scientist role with the German Geological Survey
- Dr Joshua Larsen (a University of New South Wales Program 3 postdoctoral fellow), who has taken up a lectureship at the University of Queensland
- Dr Harald Hofmann (a Monash University Program 3 postdoctoral fellow), who has taken up a lectureship at the University of Bayreuth in Germany

- Dr Adrien Guyot (a University of Queensland Program 4 postdoctoral fellow), who has succeeded in obtaining a three-year postdoctoral fellowship at the University of Queensland
- Dr Samantha Grover (a Monash University Program 3 postdoctoral fellow), who has joined the Soils Research Group at AgriBiosciences, La Trobe University
- Dr Andrew Ross (an Australian National University Program 5 postdoctoral fellow), who has secured a position as a senior groundwater specialist at the UNESCO International Hydrological Programme in Paris
- Dr Sondoss El Sawah (an Australian National University Program 5 postdoctoral fellow), who has secured a role with the Bureau of Meteorology
- Ms Emily Barbour (an Australian National University Program 5 PhD candidate), who has taken up a research position on the ESPA Deltas project at Oxford University.

| KEY PERFORMANCE INDICATORS |   | 2013 TARGET | 2013 RESULT | CUMULATIVE<br>TARGET | CUMULATIVE<br>RESULT |  |
|----------------------------|---|-------------|-------------|----------------------|----------------------|--|
| CAP                        | CAPACITY BUILDING   |             |             |                      |                      |  |
| C1                         | PhD completion rate   | 95%         | 88%         | 95%                  | 92%                  |  |
| C2                         | Number of new honours students  | 6           | 13          | 49                   | 70                   |  |
| C3                         | Honours student completion rate   | 100%        | 92%         | 100%                 | 96%                  |  |
| C4a                        | Number of professional training courses run by the Centre for non-NCGRT staff and students                  | 15          | 21          | 50                   | 72                   |  |
| C4b                        | Number of people attending professional training courses run by the Centre for non-NCGRT staff and students | 500         | 582         | 1,950                | 2,194                |  |

The NCGRT in 2013 continued with its internal awards program, which aims to both encourage and recognise exceptional performance. The full list of awards may be found on page 35.

The NCGRT's annual and cumulative PhD completion rates are slightly below target. This is due to the fact that six PhD students have withdrawn from their studies to take up paid employment opportunities, and one converted to Masters by Research. The attrition rate remains extremely low overall due to the exceptional quality of our training environment. Consequently, the high-level completion trend is positive.

The completion rate of 92% for honours students is a fraction below the 100% target. However, as noted earlier, this is because the 2013 cohort included two students who are undertaking their studies on a part-time basis.

| COURSE   | LOCATION        | ATTENDEES         |
|--|-----------------|-------------------|
| NCGRT 2013 INDUSTRY TRAINING COURSES                           |                 |                   |
|  | Melbourne       | 31                |
| Australian Groundwater School                                  | Brisbane        | 40                |
|  | Perth           | 37                |
| Fractured Dook I hydrogoology                                  | Brisbane        | 17                |
| Fractured Rock Hydrogeology                                    | Perth           | 29                |
| Advanced Aquifer Testing Techniques and Hydrogeologic Analysis | Brisbane        | 20                |
| Groundwater in Mining  | Adelaide        | 19                |
|  | Perth           | 49                |
|  | Melbourne       | 13                |
| Groundwater Modelling Guidelines Workshop                      | Sydney          | 25                |
|  | Canberra        | 14                |
|  | Brisbane        | 39                |
|  | Perth           |                   |
| Harana Anna Cara Thau abh Landarahin                           | Adelaide        |                   |
| Unconventional Gas: Thought Leadership                         | Melbourne       |                   |
|  | Canberra        | 123 (total for 4) |
| Understanding Groundwater Legislation                          | Sydney          | 18                |
| Haramantianal Cas and Water                                    | Brisbane        | 35                |
| Unconventional Gas and Water                                   | Perth           | 27                |
| Caluta and Danatina Transport Madalling                        | Rottnest Island | 25                |
| Solute and Reactive Transport Modelling                        | Sydney          | 21                |
|  | 21 courses      | 582               |





The NCGRT has two objectives in its linkages strategy:

- to be an effective resource for the Australian groundwater sector by establishing and developing strong, collaborative relationships with the research, education, industry and government sectors and serving as a point of interaction among these sectors
- to establish and develop international networks and linkages.

In 2013 we have focused on anchoring and leveraging our linkages both nationally and internationally.

We have undertaken training activities with the Australian Water Association and internationally with the US National Ground Water Association. We have continued our research collaborations with the University of Texas and the University of Neuchâtel in Switzerland while also establishing relationships with Eawag (the Swiss Federal Institute of Aquatic Science and Technology) and Peking University in China.

Staff and researchers from the NCGRT have organised 24 workshops over the course of 2013 and were heavily involved in the International Association of Hydrogeologists' 2013 Congress held in Perth.

We continue to attract leading international researchers for visits, with 32 scholars visiting in 2013 (a complete list is provided on page 34), while our researchers undertook 65 visits to overseas research organisations.

The NCGRT has continued to demonstrate strong industry linkages in 2013. There were 189 meetings held in 2013, and researchers have participated in significant industry bodies 120 times. The success of this continued interaction is highlighted by the 24 joint grant and/or scientific applications that were approved.

Through its linkages, the NCGRT continues to be a leader in groundwater policy development in Australia and internationally. We continued contributing to the development of Australia's national groundwater policy priorities including taking a lead role in the development of a national

strategic plan. We also participated in the National Groundwater Sub Group, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development and were recently invited to participate in the US National Research Council's unconventional hydrocarbon roundtable.

In 2012, the NCGRT formalised its research relationship with the University of Texas. Building on the memorandum of understanding with the Jackson School of Geosciences at the University of Texas at Austin, Professor Jack Sharpe visited Australia to work with NCGRT researchers and also made a public presentation on the effects of urbanisation on shallow surface waters and groundwater systems.

Dr lan Duncan, a research scientist at the Bureau of Economic Geology at the University of Texas at Austin also visited the NCGRT in 2013 and participated in our thought leadership seminars on unconventional gas. Dr Duncan's recent research has focused on the scientific, environmental and public policy aspects of unconventional natural gas production and his participation provided Australia with an excellent opportunity to get closer to the research that has already been undertaken on this contentious issue in the USA. More information on this may be found overleaf.

A number of NCGRT researchers visited Austin as part of their trip to the US National Ground Water Association (NGWA) Groundwater Summit. In particular, Program 2 postdoctoral fellow Juliette Woods presented on her research during her visit. There are also numerous ongoing collaborative research projects between the two institutions.

The NCGRT, along with the School of the Environment at Flinders University, has been working on developing links with Peking University. Initially, this collaboration focused on evaluation of the water resources in the Heihe River Basin, in northern China. The Heihe Research Program is an ongoing major research program with over A\$100 million of core funding. One of the key science issues is groundwater – surface water interactions and their ecohydrological effects, and Professor Peter Cook, Professor Craig Simmons and postdoctoral fellow Dr Yueqing Xie are working

with Professor Chunmiao Zheng and other staff from Peking University. Dr Xie travelled to China for an initial field assessment and collection of water samples in August 2012, and a follow-up meeting with Professor Craig Simmons and Professor Chunmiao Zheng was held in Hong Kong in June 2013. Postdoctoral fellows Yueqing Xie and Margaret Shanafield and technical officer Nicholas White visited China for a second fieldtrip in August 2013.

In 2013, the NCGRT continued to support the Australian chapter of the International Association of Hydrogeologists (IAH) through a number of activities. The NCGRT continued to undertake a secretariat function for the IAH in Australia, ensuring that this important industry association, which is run by volunteers, continues to have a solid base on which to grow.

NCGRT researchers play an important role in IAH Australia with NCGRT Chief Investigator Wendy Timms from the University of New South Wales taking on the role of Vice President (Australiasia–Pacific). A special acknowledgement goes to Chief Investigator Ian Acworth also from the University of New South Wales, who in 2013 was presented with

the IAH President's Award for his research contributions to hydrogeology and his service to the IAH.

The NCGRT played a major role in the organisation of the 2013 International Association of Hydrogeologists' Congress held in Perth in September. The congress attracted over 700 international hydrogeologists. Professor Henning Prommer (Program 2 chief investigator) and Laki Kondylas from the Centre management team represented the NCGRT on the conference organising committee, while Professor David Lockington (Program 4 leader) chaired the technical review committee.

The NCGRT has also partnered with the IAH in South Australia to run a series of groundwater modelling best practice workshops, which has provided researchers in Program 2 with the opportunity to interact with industry practitioners. It has also functioned as a good medium for direct technology transfer.

The NCGRT has a memorandum of understanding with the Australian Water Association that focuses on delivering groundwater training to the Australian Water Assocation's 7,000 members. In 2013 we

| KEY PERFORMANCE INDICATORS |  | 2013 TARGET | 2013 RESULT | CUMULATIVE<br>TARGET | CUMULATIVE<br>RESULT |
|----------------------------|--|-------------|-------------|----------------------|----------------------|
| LINK                       | AGES   |             |             |                      |                      |
| L1                         | Number of international visitors and exchanges (of at least one week)                              | 30          | 32          | 78                   | 133                  |
| L2                         | Number of national and international workshops organised and managed by the Centre                 | 20          | 24          | 42                   | 61                   |
| L3                         | Number of visits to overseas laboratories and research facilities                                  | 50          | 65          | 135                  | 223                  |
| L4                         | Number of joint grant and/or scientific applications with national and international collaborators | 20          | 24          | 46                   | 69                   |
| L5                         | Number of industry engagement meetings per year  | 125         | 189         | 277                  | 534                  |
| L6                         | Participation on significant national and international bodies (including editorial boards)        | 60          | 120         | 105                  | 337                  |

jointly ran a thought leadership series focused on unconventional gas. With the controversy surrounding unconventional gas exploration and mining, this event provided an opportunity to explore, discuss and debate the effects that unconventional gas extraction has on water.

Held in a half-day format in Perth, Adelaide, Melbourne and Canberra, the thought leadership series provided state, national and international perspectives from the leading industry experts on unconventional gas.

Speakers varied with location but always included:

- Dr Ian Duncan, who leads the Earth Systems and Environment group at the Bureau of Economic Geology at the University of Texas at Austin
- Professor Peter Flood, who is a member of the Australian Government's Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
- a representative from the Australian Council of Learned Academies' expert working group on shale gas
- state government representatives.

In addition, we also ran two short courses focused on water and unconventional gas in Sydney and Perth, which provided more in-depth understanding of the technical aspects of unconventional gas; both of these courses sold out.

We also collaborated on training with the US National Ground Water Association (NGWA). In 2013, this included running two specialty courses on fractured rock in Brisbane and Perth.

Fractured rock aquifers underlie approximately 40% of the Australian continent, including the Murray–Darling Basin, and many of Australia's mining and coal seam gas regions, including the Pilbara and the Surat Basin. The methods taught at universities apply mainly to porous media aquifers, and many people do not realise that they need to use different methods when investigating fractured rock systems. This course covered the best methods for investigating groundwater flow

and contaminant transport in fractured rocks. Partnering with the NGWA allowed the NCGRT to provide this training not only to our researchers but also to the broader Australian groundwater community for the first time since 2003.

In addition to these short courses, the NCGRT hosted the NGWA Darcy and McEllhiney lecturers in Australia and had staff and researchers attend both the NGWA Groundwater Summit in Texas and the NGWA Groundwater Expo in Nashville.

In partnership with SKM and CSIRO, the NCGRT ran a series of workshops in all major capital cities to help clarify the new aspects of the Australian Groundwater Modelling Guidelines. The guidelines were published in June 2012 by the National Water Commission and have rapidly been adopted throughout the groundwater industry as a benchmark for best industry practice. The guidelines are almost uniformly referenced by environmental regulators, model developers and groundwater modellers.

Groundwater Governance – A Global Framework for Action (2011–2014) is a project supported by the Global Environment Facility and implemented by the Food and Agriculture Organization of the United Nations, in conjunction with UNESCO's International Hydrological Programme, the International Association of Hydrologists and the World Bank. The NCGRT continues to contribute to this important project. NCGRT Director Craig Simmons, Chief Investigator Tony Jakeman and Strategic Development Manager Laki Kondylas are all members of the permanent consultation mechanism and recently Dr Andrew Ross, a postdoctoral fellow from Program 5 at the Australian National University, was appointed by UNESCO as a senior groundwater specialist to work on this and other UNESCO groundwater projects.

## International visitors

| NAME                           | ORGANISATION   | COUNTRY     |
|--------------------------------|--|-------------|
| Dr Christian Anibas            | Free University Brussels                                 | Belgium     |
| Ms Ine Beyen                   | Free University Brussels                                 | Belgium     |
| Dr Chris Bradley               | Birmingham University                                    | UK          |
| Mr Miguel Cambron              | VU Brussels  | Netherlands |
| Dr Mark Cuthbert               | Birmingham University                                    | UK          |
| Professor Marco Dentz*         | Institute of Environmental Assessment and Water Research | Spain       |
| Dr Ian Duncan                  | University of Texas at Austin                            | USA         |
| Dr Tatiana Filatova            | University of Twente                                     | Netherlands |
| Professor Jean Freid           | UNESCO   | USA         |
| Dr Janek Greskowiak            | University of Oldenberg                                  | Germany     |
| Dr Dongmei Han                 | China Academy of Sciences                                | China       |
| Ms Sam Hawken                  | University of Southampton                                | UK          |
| Professor Jim Hendry           | University of Saskatchewan                               | Canada      |
| Professor Guangcai Hou         | China Geological Survey                                  | China       |
| Dr Karsten Jensen              | University of Copenhagen                                 | Netherlands |
| Professor Rolf Kipfer          | Eawag  | Switzerland |
| Dr Stefano Lo Russo            | Polytechnique University of Turin                        | Italy       |
| Professor Jodi Mead            | Boise State University                                   | USA         |
| Dr Denis O'Carroll             | University of Western Ontario                            | Canada      |
| Professor Tomasz Okruszko      | Warsaw University of Life Sciences                       | Poland      |
| Professor Yves Parlange        | Cornell University                                       | USA         |
| Mr Mathias Possemiers          | KU Leuven  | Belgium     |
| Ms Coralie Ranchoux            | University Montpellier 2                                 | France      |
| Professor John M (Jack) Sharpe | University of Texas at Austin                            | USA         |
| Professor William Woessner     | University of Montana                                    | USA         |
| Professor Warren Wood          | Michigan State University                                | USA         |
| Dr Lihe Yin                    | China Geological Survey                                  | China       |
| Professor Peter Young          | Lancaster University                                     | England     |
| Professor Xinping Zhang        | Hunan Normal University                                  | China       |
| Professor Chunmiao Zheng       | Peking University  | China       |
| Professor Xun Zhou             | China University of Geosciences                          | China       |

 $<sup>^{\</sup>star}$ Please note that Professor Dentz visited the NCGRT on two separate occasions in 2013.

#### 2013 NCGRT awards

The recipients of the 2013 NCGRT awards were:

NCGRT Industry Award for excellence in industry engagement and training

Sarah Bourke (a Flinders University Program 3 PhD researcher student), in recognition of her research collaboration with Rio Tinto and for her contribution to the delivery of the NCGRT's industry training program

**Dr Wendy Timms** (a University of New South Wales Program 1 chief investigator), for the research partnership that she has forged with the NSW Department of Primary Industries on a number of projects, her work with the International Association of Hydrogeologists, and her contribution to the NCGRT's industry training program

NCGRT Service Award for diligence and service above and beyond the call of duty

**Dr Andrew Ross** (an Australian National University Program 5 postdoctoral fellow), for his significant contribution to the preparation of NCGRT's report for the UNESCO Asia–Pacific Groundwater Governance program and active participation in the NCGRT's media outreach

Joshua Dean (a La Trobe Program 4 PhD student), for his contribution to the delivery of the NCGRT's marketing and communications activities (such as media releases and fact sheets), plus his regular contribution to the industry training program

NCGRT Research Award for excellence in science and research

**Dr Chunhui Lu** (a Flinders University Program 2 postdoctoral fellow), and **Dr Adrien Guyot** (a University of Queensland Program 4 postdoctoral fellow), for their sustained commitment to the pursuit of research excellence, and being inspirational examples to students and researchers based in their programs and across the wider NCGRT

NCGRT Director's Award for outstanding leadership, research and service

**Dr Vincent Post** (a Flinders University Program 2 chief investigator), in recognition of his exceptional science work, including his recent paper in the prestigious *Nature* journal on the discovery of vast new freshwater resources under the sea. In addition to his research work, Vincent has been involved in numerous training and outreach activities, including designing a course on solute and reactive transport modelling, participating in the NCGRT's roadshow promoting the national modelling guidelines, and delivering a public lecture that provided long-term perspective on coastal groundwater systems.



## Outreach

The focus of the NCGRT's outreach strategy in 2013 was on strengthened technology transfer and adoption activities.

The NCGRT had a target of 12 media releases during 2013, with a goal of 500 positive news items.

Instead of broad groundwater topics and issues, we explored more of our research projects and results. This resulted in some strong positive feedback from industry but also a reduced interest from the media

As many of our research stories focused on specific geographical areas, we expected a targeted audience compared to previous media releases which covered the broader groundwater issues. In response, we produced 17 media releases to ensure that our goal could be met.

These stories generated nearly 600 positive news items broadcast across a mix of print, radio and online media. In particular, ABC Radio has taken significant interest in the work of the NCGRT.

In addition, the NCGRT developed six targeted feature articles for industry publications, including SA Mines & Energy Journal, Australian Resources and Investment, Water Management Review, Australian Grain Magazine and UNESCO's Free Flow. These articles provided in-depth discussion around groundwater issues or research impacts specific to certain industries and sectors.

Free Flow featured over 100 authors from more than 50 international institutions who shared their work in water management and cooperation at international, regional, national, municipal and local levels of activity. Their articles draw upon experiences from around the world and reflect how people are cooperating and changing their interaction with water to improve the sustainability of their development.

A joint contribution from NCGRT Director Craig Simmons and Neil Power (Director, State Research Coordination, Goyder Institute for Water Research) outlined the complex challenges and approaches used to secure Australia's groundwater future. Once again, the NCGRT delivered a very successful seminar and lecture program in 2013, bringing world-leading groundwater experts to locations across Australia.

During April, we delivered our most successful NCGRT Distinguished Lecturer series yet, which was attended by over 400 participants across six cities. Professor Andrew Boulton, an Adjunct Professor at the University of New England who has worked on river and groundwater ecology for over 25 years, delivered an engaging talk on integrating river ecology and groundwater. A recording of his talk has also been viewed over 140 times on our website.

The NCGRT has again helped to bring the US National Ground Water Association's Darcy and McEllhiney lecturers to Australia in 2013. Dr David L Rudolph's 2013 Darcy Lecture gave insight into how groundwater quality is affected by agricultural land-use practices, at both local and regional scales. Dr John Jansen's 2013 McEllhiney Lecture covered aquifer sustainability, including approaches to aquifer management, regulatory approaches and meaningful ways to provide information and build consensus.

Other visiting speakers included Dr Badin Gibbes (the University of Queensland), Professor Jack Sharpe (the University of Texas at Austin), Dr Russell Crosbie (CSIRO), Dr Scott Tyler (the University of Nevada), Dr Ian Duncan (the University of Texas at Austin), and Professor Warren Wood (Michigan State University). Where possible, their talks were recorded and made available on our website.

A second major upgrade to the NCGRT website included enhancements to design and functionality, along with the addition of several new features.

The website is now mobile device friendly, and a new groundwater jobs board and notification service have been introduced to support the groundwater industry and to help NCGRT students to find future employment.

Video seminars and information sheets are now better presented, and a new searchable journal database was also added to aid knowledge transfer. The NCGRT has also increased its electronic communication in 2013 and revamped its stakeholder database to improve delivery of quarterly newsletters, monthly industry training updates, and event promotions. This includes the use of social media, which has seen slow but steady growth across each of our LinkedIn, Twitter and Facebook channels.

The NCGRT had a major presence at the International Association of Hydrogeologists' Congress in Perth in September. This event has not been held in Australia since 1994, so the NCGRT was particularly pleased to have the opportunity to play a key role in proceedings.

As well as being congress partner, the NCGRT sent a large number of staff and students, with over 70 giving presentations, including three plenary addresses and several keynotes.

During the congress, the NCGRT held our annual NCGRT dinner, which was attended by over 140 researchers and stakeholders. This was a great opportunity for researchers from across the country to come together under the NCGRT banner, along with a 'who's who' of groundwater both nationally and internationally.

Besides the International Association of Hydrogeologists' Congress, the NCGRT had a strong presence at a number of other important conferences and events in 2013, including the Australian Water Association Water Skills conference, the US National Ground Water Association Summit, the OzWater conference, the Australia and New Zealand FEFLOW User Group Meeting, the Geological Society of America Annual Meeting and Exposition, and the American Geophysical Union annual fall meeting.

| KEY F | PERFORMANCE INDICATORS  | 2013 TARGET  | 2013 RESULT   | CUMULATIVE<br>TARGET | CUMULATIVE<br>RESULT |
|-------|---|--|---|----------------------|----------------------|
| OUT   | REACH   |  |   |                      |                      |
| 01    | Number of unique and positive media articles and segments that mention the Centre           | 500  | 597   | 560                  | 1,764                |
| 02    | Number of significant public talks delivered by Centre staff                                | 30   | 78  | 68                   | 223                  |
| О3    | Conduct stakeholder survey  | Undertake<br>1 survey  | 1 survey  | N/A                  | N/A                  |
| O4    | Number of publications produced by the NCGRT promoting our research and training activities | 1 public<br>annual report<br>4 quarterly<br>newsletters<br>12 info sheets<br>4 targeted<br>feature<br>articles | 1 public<br>annual report<br>4 quarterly<br>newsletters<br>12 info<br>sheets<br>6 targeted<br>feature<br>articles | N/A                  | N/A                  |
| O5    | Number of web-based outreach tools  | 5 videos<br>12 media<br>releases   | 6 videos<br>17 media<br>releases  | N/A                  | N/A                  |

The American Geophysical Union is the largest worldwide conference in the geophysical sciences, attracting more than 22,000 attendees annually. The NCGRT supported several researchers to attend, with many presenting, including program leaders Tony Jakeman and Andy Baker.

The NCGRT continued its support for and contribution to the Australian Curriculum Project. Led by the Australian Water Association, the Australian Curriculum Project represents a collective group of industry, research and government bodies who are working together to ensure existing water education materials are updated, new materials are developed, and all resources are integrated into the Australian curriculum and produced in a new and useable digital format. Working together is helping to reduce duplication, share effort, and save cost.

The NCGRT also continued to more directly engage schools through the Kids Teaching Kids program. By sponsoring the Kids Teaching Kids national conference, the NCGRT was able to secure a groundwater workshop during the event, and introduced a groundwater short video competition that received nine entries. Travel grants were provided to five schools. The conference had an 'Urban Water Cycle' theme this year, and a total of 467 students and teachers from 49 schools participated. The conference sold out in the first week of registrations in February.

In addition to supporting the conference, the NCGRT hosted a visit from a group of students from Christies Beach High School. The group was given a tour of the environmental labs at Flinders University and spoke to several researchers about the earth sciences as a career. The visit was filmed and broadcast by the channel Network Ten TV show *Totally Wild*.

Another 12 fact sheets were developed during the year, creating an impressive collection of 24 information resources explaining fundamental groundwater issues, concepts and NCGRT research.

Fact sheets have been developed in three main categories: background factsheets that explain major groundwater concepts and issues, project briefs that describe NCGRT research, and technical fact sheets that aim to share new or advanced methods to aid knowledge transfer from academic research to industry and government.

New fact sheets covered topics such as:

- approaches to integrated assessment models
- longitudinal stream chemical sampling
- using vegetation to minimise groundwater contamination
- using chemistry to measure river bank storage
- using fibre optic cable to measure groundwater temperature
- seawater intrusion.

# Media release: Scientists find sources under



#### VINCENT POST

Scientists have discovered huge reserves of freshwater kilometres out to sea, providing new opportunities to stave off a looming global water crisis.

A new study, published in the international scientific journal Nature today, reveals that an estimated half a million cubic kilometres of low-salinity water are buried beneath the seabed on continental shelves around the world

The water, which could perhaps be used to eke out supplies to the world's burgeoning coastal cities, has been located off Australia, China, North America and South Africa.

"The volume of this water resource is a hundred times greater than the amount we've extracted from the Earth's sub-surface in the past century since 1900,"

says lead author Dr Vincent Post of the National Centre for Groundwater Research and Training (NCGRT) and the School of the Environment at Flinders University. "Knowing about these reserves is great news because this volume of water could sustain some regions for decades."

Dr Post says that groundwater scientists knew of freshwater under the seafloor, but thought it only occurred under rare and special conditions. "Our research shows that fresh and brackish aquifers below the seabed are actually quite a common phenomenon," he says.

These reserves were formed over the past hundreds of thousands of years when on average the sea level was much lower than it is today, and when the coastline was further out, Dr Post explains. "So when it rained, the water would infiltrate into the ground and fill up the water table in areas that are nowadays under the sea.

"It happened all around the world, and when the sea level rose when ice caps started melting some 20,000 years ago, these areas were covered by the ocean. Many aquifers were - and are still - protected from seawater by layers of clay and sediment that sit on top of them."

The aquifers are similar to the ones below land, which much of the world relies on for drinking water, and their salinity is low enough for them to be turned into potable water, Dr Post says.

## vast freshwater the sea

this water - build a platform out at sea and drill into the seabed, or drill from the mainland or islands close to the aquifers."

While offshore drilling can be very costly, Dr Post says this source of freshwater should be assessed and considered in terms of cost, sustainability and environmental impact against other water sources such as desalination, or even building large new dams on land.

is much less salty than seawa- Person, Shemin Ge and W Mike Edter," Dr Post says. "This means munds is published in the Decemit can be converted to drinking ber issue of Nature. water with less energy than seawater desalination, and it would also leave us with a lot less hyper-saline water.

"Freshwater on our planet is increasingly under stress and strain so the discovery of significant new stores off the coast is very exciting. It means that more options can be considered to help reduce the impact of droughts and continental water shortages."

But while nations may now have new reserves of freshwater off-shore, Dr Post says they will need to take care in how they manage the seabed: "For example, where low-salinity groundwater below the sea is likely to exist, we should take care to not contaminate it.

"Sometimes boreholes are drilled into the aquifers for oil and gas exploration or pro-

"There are two ways to access duction, or aquifers are targeted for carbon dioxide disposal. These activities can threaten the quality of the water."

> Dr Post also warns that these water reserves are non-renewable: "We should use them carefully - once gone, they won't be replenished until the sea level drops again, which is not likely to happen for a very long time.

The study "Offshore fresh groundwater reserves as a global phenomenon" by Vincent EA Post, "Freshwater under the seabed Jacobus Groen, Henk Kooi, Mark



## Management and governance

Our focus in 2013 was on maintaining high standards of corporate governance and providing the data and analytical advice necessary to support high-quality decision making across all areas of the NCGRT's operations.

We also completed the development of a comprehensive plan to fully acquit the Centre's foundation funding grant from the Australian Research Council (ARC) and National Water Commission (NWC).

The NCGRT's Research Management Committee has continued meeting on a monthly basis to review research performance, particularly the progress of our postdoctoral and PhD researchers, and to identify new collaboration opportunities. This work is producing good results as evidenced by our low attrition rate and the increased number of co-supervisory arrangements that have been put in place.

We have also continued with our quarterly financial reporting processes. These processes enable us to closely monitor activity levels across our collaborating organisations, and help maintain the integrity of our reporting systems. Expenditure for 2013 was on track with our forecasts and the net ARC/NWC surplus as at the end of 2013 has marginally reduced compared to 2012. The current ARC net surplus of \$4.84 million combined with the final scheduled ARC payment for 2014 (of \$626,875) will be sufficient to support the NCGRT in discharging its research obligations and implementing a range of initiatives that will safeguard its research legacy.

The NCGRT has also undertaken quarterly reviews of its risk profile in order to ensure that organisational risks are addressed in a systematic and strategic manner. Consequently, as noted in our mid-year report, we have focused significant management attention on identifying new markets and delivery mechanisms for our industry training team.

This work has progressed extremely well and the team's 2014 program offers genuine opportunities to safeguard its financial sustainability and cement its reputation as Australia's leading groundwater training provider.

Monitoring progress towards addressing the recommendations of the ARC's 2012 Mid-Term Review has continued. We are pleased to report that Director Craig Simmons successfully completed the Australian Institute of Directors' program in September. Completing this course was the final item on our Mid-Term Review response plan and we are obviously pleased that all of the panel's recommendations have now been addressed.

Our Advisory Board has continued to be closely involved with all aspects of the NCGRT's operations. Although attendance rates at face-to-face meetings were a fraction below target, the level and quality of board engagement increased in 2013 with members providing significant input (by email and telephone conference) on the development of the National Groundwater Strategy, Centre of Excellence proposal as well as our 2013 mid-year report and 2014 business plan. We would therefore like to extend our thanks to the board for the valuable advice and support that they have provided to the NCGRT's management team. We are looking forward to working with the board on new opportunities to transform the NCGRT into an enduring national institution in 2014.

More detail on our management and governance operations in 2013 may be found on the following page, in the form of an income statement and table showing performance against our key performance indicators.

| INCOME STATEMENT                     | 2013<br>\$ | CUMULATIVE<br>JUN 2009 – DEC 2013<br>\$ |
|--------------------------------------|------------|---|
| REVENUE                              |            |   |
| Commonwealth ARC/NWC                 | 6,637,500  | 28,873,125                              |
| Collaborator & partner organisations | 1,651,937  | 10,197,357                              |
| Industry training                    | 460,179    | 2,779,841                               |
| Other non-core                       | 3,265,811  | 6,920,278                               |
|                                      | 12,015,427 | 48,770,601                              |
| EXPENSE                              |            |   |
| Research operations                  | 6,669,545  | 24,881,569                              |
| Centre management                    | 2,024,724  | 7,649,864                               |
| Industry training                    | 449,860    | 2,642,922                               |
| Other non-core                       | 1,625,843  | 5,975,356                               |
|                                      | 10,769,972 | 41,149,711                              |
| NET SURPLUS / (DEFICIT)              | 1,245,455  | 7,620,890                               |
| IN-KIND CONTRIBUTIONS                | 5,570,822  | 21,409,343                              |

| KEY P | PERFORMANCE INDICATORS  | 2013 TARGET                               | 2013 RESULT                         | CUMULATIVE<br>TARGET                             | CUMULATIVE<br>RESULT           |
|-------|---|---|-------------------------------------|--|--------------------------------|
| MAN   | AGEMENT AND GOVERNANCE  |   |                                     |  |                                |
| MG1   | Attendance rates of members at NCGRT Advisory Board meetings  | 80%                                       | 71%                                 | N/A  | N/A                            |
| MG2   | Timely submission of reports and plans to project executive   | 100%                                      | 100%                                | N/A  | N/A                            |
| MG3   | Annual cash contributions from non-ARC/NWC sources  | \$1.65 million                            | \$5.38 million                      | \$10.2 million                                   | \$19.9 million                 |
| MG4   | Annual in-kind contributions from non-ARC/NWC sources   | \$3.91 million                            | \$5.57 million                      | \$18.84 million                                  | \$21.41<br>million             |
| MG5   | NCGRT's ability to achieve and maintain its annual expenditure operations budget within forecast levels | Annual expenditure within 10% of forecast | Achieved<br>9% below<br>target      | Annual<br>expenditure<br>within 10%<br>of target | Achieved<br>3% below<br>target |
| MG6   | Unqualified audit report  | Achieved                                  | Draft report  — audit not finalised | N/A  | N/A                            |

Note: MG3, MG4, MG5 and MG6 are unaudited figures and are subject to change.



## Appendix 1: Peformance indicators and funding targets

| KEY F | PERFORMANCE INDICATORS  | 2013 TARGET | 2013 RESULT           | CUMULATIVE<br>TARGET | CUMULATIVE<br>RESULT |
|-------|---|-------------|-----------------------|----------------------|----------------------|
| RESE  | EARCH   |             |                       |                      |                      |
| R1    | Total number of publications appearing in quality journals (including book chapters)                              | 180         | 204                   | 460                  | 608                  |
| R2    | Research quality (% of category A or A* journal papers)   | 50%         | 54%<br>(110 articles) | 37%                  | 56%                  |
| R3    | Number of citations   | 1,250       | 8,744                 | 3,300                | 13,117               |
| R4    | Number of inivitations to present talks, papers and keynote lectures at major national and international meetings | 90          | 229                   | 260                  | 586                  |
| CAPA  | ACITY BUILDING  |             |                       |                      |                      |
| C1    | PhD completion rate   | 95%         | 88%                   | 95%                  | 92%                  |
| C2    | Number of new honours students  | 6           | 13                    | 49                   | 70                   |
| СЗ    | Honours student completion rate   | 100%        | 92%                   | 100%                 | 96%                  |
| C4a   | Number of professional training courses run by the Centre for non-NCGRT staff and students                        | 15          | 21                    | 50                   | 72                   |
| C4b   | Number of people attending professional training courses run by the Centre for non-NCGRT staff and students       | 500         | 582                   | 1,950                | 2,194                |
| LINK  | AGES  |             |                       |                      |                      |
| L1    | Number of international visitors and exchanges (of at least one week)   | 30          | 32                    | 78                   | 133                  |
| L2    | Number of national and international workshops organised and managed by the Centre                                | 20          | 24                    | 42                   | 61                   |
| L3    | Number of visits to overseas laboratories and research facilities   | 50          | 65                    | 135                  | 223                  |
| L4    | Number of joint grant and/or scientific applications with national and international collaborators                | 20          | 24                    | 46                   | 69                   |
| L5    | Number of industry engagement meetings per year   | 125         | 189                   | 277                  | 534                  |
| L6    | Participation on significant national and international bodies (including editorial boards)                       | 60          | 120                   | 105                  | 337                  |

| KEY PERFORMANCE INDICATORS |   | 2013 TARGET  | 2013 RESULT  | CUMULATIVE<br>TARGET                             | CUMULATIVE<br>RESULT     |  |
|----------------------------|---|--|--|--|--------------------------|--|
| OUTREACH                   |   |  |  |  |                          |  |
| O1                         | Number of unique and positive media articles and segments that mention the Centre                       | 500  | 597  | 560  | 1,764                    |  |
| O2                         | Number of significant public talks delivered by Centre staff  | 30   | 78   | 68   | 223                      |  |
| О3                         | Conduct stakeholder survey  | Undertake<br>1 survey  | 1 survey   | N/A  | N/A                      |  |
| O4                         | Number of publications produced by the Centre promoting research and training activities                | 1 public<br>annual report<br>4 quarterly<br>newsletters<br>12 info sheets<br>4 targeted<br>feature<br>articles | 1 public<br>annual report<br>4 quarterly<br>newsletters<br>12 info sheets<br>6 targeted<br>feature<br>articles | N/A  | N/A                      |  |
| O5                         | Number of web-based outreach tools  | 5 videos<br>12 media<br>releases   | 6 videos<br>17 media<br>releases   | N/A  | N/A                      |  |
| MAN                        | AGEMENT AND GOVERNANCE  |  |  |  |                          |  |
| MG1                        | Attendance rates of members at NCGRT Advisory Board meetings  | 80%  | 71%  | N/A  | N/A                      |  |
| MG2                        | Timely submission of reports and plans to project executive   | 100%   | 100%   | N/A  | N/A                      |  |
| MG3                        | Annual cash contributions from non-ARC/NWC sources  | \$1.65 million   | \$5.38 million   | \$10.2 million                                   | \$19.9 million           |  |
| MG4                        | Annual in-kind contributions from non-ARC/NWC sources   | \$3.91 million   | \$5.57 million   | \$18.84 million                                  | \$21.41 million          |  |
| MG5                        | NCGRT's ability to achieve and maintain its annual expenditure operations budget within forecast levels | Annual expenditure within 10% of forecast  | Achieved 9% below target   | Annual<br>expenditure<br>within 10%<br>of target | Achieved 3% below target |  |
| MG6                        | Unqualified audit report  | Achieved   | Draft report  — audit not finalised  | N/A  | N/A                      |  |

Note: MG3, MG4, MG5 and MG6 are unaudited figures and are subject to change.

#### Supplementary and base funding targets

The funding that the Centre receives from the Australian Government has two components:

- 75% base funding
- 25% supplementary funding.

Payment is contingent on the NCGRT's ability to achieve the relevant performance targets. The following table outlines the performance indicators, targets and results that the NCGRT must achieve in order to secure its base and supplementary funding.

| KEY PERFORMANCE INDICATORS  | 2013 TARGET                                   | 2013 RESULT                                    |              |
|---|---|--|--------------|
| RESEARCH  |   |  |              |
| Number of publications appearing in journals, and book chapters                           | Base funding target Supplementary Total       | 135<br>45<br><b>180</b>                        | 204          |
| CAPACITY  | ·   |  |              |
| Number of new honours students  | Base funding target<br>Supplementary<br>Total | 4<br>2<br><b>6</b>                             | 13           |
| Number of professional training courses run by the NCGRT for non-NCGRT staff and students | Base funding target<br>Supplementary<br>Total | 11<br>4<br><b>15</b>                           | 21           |
| Number of participants in professional training courses                                   | Base funding target<br>Supplementary<br>Total | 375<br>125<br><b>500</b>                       | 582          |
| LINKAGES  |   | ·  |              |
| Number of international visitors and exchanges  | Base funding target<br>Supplementary<br>Total | 22<br>8<br><b>30</b>                           | 32           |
| Number of national and international workshops organised and managed by the NCGRT         | Base funding target<br>Supplementary<br>Total | 15<br>5<br><b>20</b>                           | 24           |
| OUTREACH  |   |  |              |
| Number of significant public talks  | Base funding target<br>Supplementary<br>Total | 22<br>8<br><b>30</b>                           | 78           |
| FINANCE   |   |  |              |
| Annual cash contributions from all non-ARC and NWC sources                                | Base funding target<br>Supplementary<br>Total | \$1,238,952<br>\$412,984<br><b>\$1,651,936</b> | \$5,377,927* |
| Annual in-kind contributions from all sources other than ARC and NWC                      | Base funding target<br>Supplementary<br>Total | \$2,935,232<br>\$978,411<br><b>\$3,913,642</b> | \$5,570,822* |

<sup>\*</sup>Figures are unaudited and are subject to change.

### Appendix 2: List of researchers and technical staff

| NAME                    | UNIVERSITY | PROJECT TITLE/ACTIVITY  | SUPERVISOR/S   |
|-------------------------|------------|---|--|
| HONOURS STUE            | DENTS      |   |  |
| Program 1               |            |   |  |
| Ms Bronwyn<br>Cameron   | UNSW       | Optimising engineering design of seepage barriers to improve the quality of mine water discharges                             | Dr Ander Guinea Maysounave (UNSW)<br>Prof. lan Acworth (UNSW)<br>Dr Wendy Timms (UNSW) |
| Mr Andrew Chong         | UNSW       | Dissolved gases and geochemical traces in low permeability strata   | Dr Steve Bouzalakos (UNSW)<br>Dr Wendy Timms (UNSW)                                    |
| Mr Nicholas Grbich      | UNSW       | Groundwater dissolved organic carbon as a tracer  | Prof. Andy Baker (UNSW)  |
| Mr Chris Lui            | UNSW       | Design of a low permeability barrier (LPB) to limit seepage between an open pit mine and a river                              | Dr Wendy Timms (UNSW)<br>Dr Richard Crane (UNSW)                                       |
| Mr David Zhao           | UNSW       | The effect of process water seepage on the hydraulic integrity of low permeability clay liners in tailings storage facilities | Dr Steve Bouzalakos (UNSW)<br>Dr Wendy Timms (UNSW)                                    |
| Ms Yolanda Zhong        | UNSW       | Geotechnical and geochemical<br>stability of clayey rocks interacting<br>with groundwater seepage to mines                    | Dr Wendy Timms (UNSW)  |
| Program 2               |            |   |  |
| Mr Andrew Boyd          | Flinders   | An investigation of the effects of historical land cover change on groundwater recharge processes in the Willunga Basin, SA   | Dr Vincent Post (Flinders)   |
| Ms Erin McIntosh        | Flinders   | Investigation of groundwater flow conditions for an aquifer storage and recovery scheme on South Goulburn Island.             | Prof. Okke Batelaan (Flinders)<br>Prof. Peter Cook (Flinders/CSIRO)                    |
| Mr Thomas Neill         | Flinders   | Transient modelling of coastal groundwater age near Aldinga Beach, South Australia  | Dr Vincent Post (Flinders)   |
| Program 3               |            |   |  |
| Ms Lauren<br>Houthuysen | Flinders   | Groundwater recharge and seawater intrusion on Milingimbi Island  | Prof. Peter Cook (Flinders/CSIRO)<br>Prof. Okke Batelaan (Flinders)                    |
| Mr Ry Klose             | Monash     | Groundwater – surface water interaction in Deep Creek   | Prof. Ian Cartwright (Flinders) Dr Ben Gilfedder (Flinders)                            |
| Mr Avish Kumar          | UQ         | Submarine groundwater discharge at<br>the western foreshore of North<br>Stradbroke Island, Southeast<br>Queensland, Australia | Dr Massimo Gasparon (UQ)<br>Dr Nina Welti (UQ)   |
| Program 5               |            |   |  |
| Mr Zachariah<br>Doherty | UWA        | Pricing of groundwater  | Assoc. Prof. Alex Gardner (UWA)  |
| Ms Jessica Lee          | UWA        | Adaptive management and groundwater   | Assoc. Prof. Alex Gardner (UWA)  |

| NAME                          | UNIVERSITY | PROJECT TITLE/ACTIVITY  | SUPERVISOR/S   |
|-------------------------------|------------|---|--|
| MASTERS BY RE                 | SEARCH     |   |  |
| Program 1                     |            |   |  |
| Yulong Zhu                    | Flinders   | Sources of water for groundwater pumping in connected stream–aquifer–vegetation systems   | Assoc. Prof. Adrian Werner (Flinders)<br>Craig Simmons (Flinders)                            |
| PHD CANDIDATI                 | ES         |   |  |
| Program 1                     |            |   |  |
| Mr Juan Carlos<br>Castilla    | UNSW       | Assessing the effects of climate change on groundwater: multiple sources of uncertainty   | Dr Grégoire Mariethoz (UNSW)<br>Dr Martin Andersen (UNSW)<br>Assoc. Prof. Bryce Kelly (UNSW) |
| Mrs Katarina David            | UNSW       | Characterisation of low permeability strata in the Sydney Basin   | Dr Wendy Timms (UNSW)<br>Prof. Andy Baker (UNSW)   |
| Mr Landon Halloran            | UNSW       | Heat as a tracer for flow in ephemeral stream beds  | Dr Martin Andersen (UNSW)<br>Prof. Ian Acworth (UNSW)  |
| Mr Mark Hocking               | UNSW       | Quantifying water balance uncertainty associated with predicting coal seam gas impacts in the Condamine Catchment   | Assoc. Prof. Bryce Kelly (UNSW)<br>Prof. Andy Baker (UNSW)                                   |
| Mr Mohammedreza<br>Keshavarzi | UNSW       | Using novel hydrochemical and geophysical techniques to characterise near-surface fractured rock aquifer systems  | Prof. Andy Baker (UNSW)<br>Assoc. Prof. Bryce Kelly (UNSW)                                   |
| Mr Adam King                  | QUT        | The Cressbrook Creek alluvial aquifer system, southeast Queensland: conceptual hydrogeological model, hydrological processes and response to flood events | Assoc. Prof. Malcolm Cox (UQ)  |
| Mr Kasif Mahmud               | UNSW       | Developing the potential of texture generation methods for applications in geostatistics  | Dr Grégoire Mariethoz (UNSW)   |
| Ms Monika<br>Markowska        | UNSW       | Hydrochemical proxies of past hydroclimates from stalagmites  | Prof. Andy Baker (UNSW)<br>Dr Pauline Treble (ANSTO)#  |
| Mr Mark Peterson              | UNSW       | Apparent groundwater age and matrix diffusion of radionuclides in fractured rocks   | Dr Martin Andersen (UNSW)  |
| Program 2                     |            |   |  |
| Mr Wesley Burrows             | Flinders   | Predictive uncertainty analysis using a complex and simple model pairing  | Prof. John Doherty (Flinders)<br>Prof. Craig Simmons (Flinders)                              |
| Mr Jackson Carr               | Flinders   | Quantifying arsenic cycling in sulphidic groundwater systems  | Prof. Henning Prommer (UWA)<br>Dr Ryan Vogwill (UWA)#  |
| Mr Dylan Irvine               | Flinders   | Quantification and comparison of solute and heat tracers  | Prof. Craig Simmons (Flinders)<br>Assoc. Prof. Adrian Werner (Flinders)                      |
| Miss Danica<br>Jakovovic      | Flinders   | Upconing in coastal environments: modelling and laboratory approaches   | Assoc. Prof. Adrian Werner (Flinders)<br>Dr Vincent Post (Flinders)                          |
| Mr Matthew<br>Knowling        | Flinders   | Effects of climate change and alternative management strategies on the Uley South Basin, South Australia  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |
| Mr Tariq Laattoe              | Flinders   | Reactive transport modelling of hyporheic zone transient stream conditions  | Dr Vincent Post (Flinders)<br>Assoc. Prof. Adrian Werner (Flinders)                          |
| Ms Jessica Liggett            | Flinders   | An analysis of surface—subsurface<br>exchange and solute transport<br>processes in a fully integrated code  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |

| NAME                         | UNIVERSITY | PROJECT TITLE/ACTIVITY   | SUPERVISOR/S   |
|------------------------------|------------|--|--|
| Mr James<br>McCallum*        | Flinders   | Investigating environmental tracer age distributions in hydrogeology   | Prof. Craig Simmons (Flinders)<br>Prof. Peter Cook (Flinders/CSIRO)                          |
| //r Carlos Miraldo<br>Ordens | Flinders   | Recharge processes in the heterogeneous closed Uley South Basin: combining modelling and field-based approaches  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |
| /Is Leanne Morgan            | Flinders   | National scale vulnerability assessment of seawater intrusion project  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |
| Joseph Rawson                | UWA        | Understanding and quantifying reactive transport processes controlling sustainable abstraction of arsenic-safe drinking water                                  | Prof. Henning Prommer (UWA)  |
| lr David Schafer             | UWA        | Use of surrogate models for effective reactive transport model calibration and predictive uncertainty  | Prof. Henning Prommer (UWA)<br>Dr Adam Siade (UWA)   |
| iss Megan<br>ebben           | Flinders   | Groundwater-dependent vegetation in arid and semi-arid zones   | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |
| Sugiarto                     | Flinders   | The influence of stratified aquifer heterogeneity and aquifer bottom steepness on geometric pattern of fresh seawater inferface in unconfined coastal aquifers | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                      |
| Ty Watson                    | Flinders   | Effects of model simplification on parameter estimation and predictive uncertainty   | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. John Doherty (Flinders)                       |
| gram 3                       |            |  |  |
| Alexander<br>nson            | Monash     | Quantifying sources and fluxes of water in upland catchments   | Prof. Ian Cartwright (Monash)  |
| Sarah Bourke                 | Flinders   | Infiltration from losing streams in sub-tropical arid environments   | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Glenn Harrington (CSIRO)                             |
| Roger<br>nswick              | Flinders   | The importance of the hyporheic zone for quantifying groundwater discharge to rivers   | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Sébastien Lamontagne (CSIRO)                         |
| Michelle Irvine              | Flinders   | Identifying sources of recharge and groundwater flow processes using hydrochemistry  | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Glenn Harrington (CSIRO)<br>Prof. Ian Acworth (UNSW) |
| ss Saskia<br>orduijn         | Flinders   | Quantifying surface water –<br>groundwater interaction in a<br>heterogeneous environment   | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Glenn Harrington (CSIRO)                             |
| Seng Chee Poh                | UQ         | Groundwater connectivity in estuarine wetlands: evidence from 222-radon and rare earth elements fractionation  | Assoc. Prof. Massimo Gasparon (UQ)<br>Prof. David Lockington (UQ)                            |
| Nicholas<br>ckett            | JCU        | Streamflow generation in tropical catchments constrained using continuous isotopic measurements  | Dr Marc Le Blanc (JCU)<br>Dr Sarah Tweed (JCU)<br>Dr Glenn Harrington (CSIRO)                |
| Salini<br>sidharan           | Flinders   | Reactive transport modelling   | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Saeed Torkzaban (CSIRO)#                             |
| Nicolaas Unland              | Monash     | Interaction of groundwater and surface water in the coastal setting of East Gippsland, Victoria  | Prof. Ian Cartwright (Monash)<br>Dr Edoardo Daly (Monash)                                    |
| Chani Welch                  | Flinders   | Temporal variability of the chemistry of groundwater discharge to rivers as a function of bank storage   | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Glenn Harrington (CSIRO)                             |
|                              | Flinders   | Arid zone groundwater recharge and the role of ephemeral surface water   | Prof. Peter Cook (Flinders/CSIRO) Dr Glenn Harrington (CSIRO)                                |

| NAME                              | UNIVERSITY | PROJECT TITLE/ACTIVITY   | SUPERVISOR/S  |
|-----------------------------------|------------|--|---|
| Mr Chenming<br>Zhang              | UQ         | Salt transport and distribution in estuarine wetland   | Prof. Ling Li (UQ)<br>Prof. David Lockington (UQ)   |
| Program 4                         |            |  |   |
| Miss Cecilia<br>Azcurra           | UNSW       | The use of stable isotopes to quantify the local water cycle in a semi-arid environment  | Dr Matthew McCabe (UNSW)<br>Prof. Andy Baker (UNSW)<br>Assoc. Prof. Jason Evans (UNSW)#                           |
| Mr Joshua Dean                    | La Trobe   | Catchment-scale water and salinity impacts of changing land use in southwest Victoria  | Assoc. Prof. John Webb (La Trobe)<br>Dr Peter Sale (La Trobe)#  |
| Miss Zijuan (Rose)<br>Deng        | Flinders   | Dependence of canopy temperature on vegetation water status and its implication in groundwater dependent ecosystems and urban environment  | Dr Huade Guan (Flinders)<br>Prof. Craig Simmons (Flinders)  |
| Mr Esmaeilabadi<br>(Ali) Ershadi  | UNSW       | Estimation of evapotranspiration using remote sensing  | Dr Matthew McCabe (UNSW)<br>Assoc. Prof. Jason Evans (UNSW)#  |
| Mr Junliang Fan                   | UQ         | Understanding, monitoring and modelling of groundwater recharge under subtropical coastal forests  | Prof. David Lockington (UQ) Dr Thomas Baumgartl (UQ)# Dr Alexander Scheuermann (UQ)#                              |
| Mr Michael Gray                   | UQ         | The evaporative fluxes of Southeast Queensland sand island vegetation as a contribution to groundwater discharge   | Assoc. Prof. Hamish McGowan (UQ)#<br>Prof. David Lockington (UQ)  |
| Mr Matt Hayes                     | UQ         | Carbon cycling in a groundwater-<br>driven coastal wetland system: North<br>Stradbroke Island  | Prof. Catherine Lovelock (UQ)<br>Prof. David Lockington (UQ)  |
| Mr Sanjeeva<br>(Athula) Manamperi | La Trobe   | Assessing the effect of climate change on episodic recharge in Loddon River catchment, Victoria  | Assoc. Prof. John Webb (La Trobe)<br>Mr Chris McAuley (Vic. Department of<br>Environment and Primary Industries)# |
| Ms Sarah Robbins                  | UQ         | Predicting the impacts of groundwater extraction on phreatophytic plant species of coastal islands: defining environmental response functions of <i>Melaleuca</i> open forests to groundwater fluxes to inform sustainable extraction yields | Prof. David Lockington (UQ)   |
| Mrs Rakhshan<br>Roohi             | La Trobe   | Improving remote sensing evapotranspiration estimates to constrain groundwater contributions to catchment water balances in western Victoria   | Assoc. Prof. John Webb (La Trobe)<br>Dr Peter Sale (La Trobe)#  |
| Ms Rizwana<br>Rumman              | UTS        | Stable isotope analysis of comparative echophysiology of groundwater-dependent ecosystems  | Prof. Derek Eamus (UTS)   |
| Mr Parikshit<br>Verma             | Monash     | Investigation and modelling of groundwater dependent ecosystems  | Dr Edoardo Daly (Monash)<br>Prof. lan Cartwright (Monash)   |
| Mr Hailong Wang                   | Flinders   | Variation of land surface evapotranspiration with vegetation types and groundwater table fluctuations  | Dr Huade Guan (Flinders)<br>Prof. Craig Simmons (Flinders)  |
| Ms Amy White                      | UQ         | Eco-groundwater modelling of a perched lake-aquifer system: Brown Lake on North Stradbroke Island  | Prof. David Lockington (UQ)<br>Dr Badin Gibbes (UQ)#  |
| Ms Tricia Williams                | Flinders   | Investigation of hydrological behaviour in South Australian catchments under changing climatic norms   | Dr John Hutson (Flinders)#<br>Dr Huade Guan (Flinders)  |
| Mrs Yanzi<br>(Chrissie) Xiao      | UQ         | Simulating dynamics between riparian vegetation and groundwater using an eco-groundwater model   | Prof. David Lockington (UQ)<br>Prof. Ling Li (UQ)<br>Dr Sven Arnold (UQ)#   |



|                                 | UNIVERSITY | PROJECT TITLE/ACTIVITY  | SUPERVISOR/S  |
|---------------------------------|------------|---|---|
| Miss Xiang Xu                   | Flinders   | Moisture stable isotope in SPAC: the experiment and modelling   | Dr Huade Guan (Flinders)<br>Dr John Hutson (Flinders)#  |
| ⁄/rs Sepideh<br>Zolfaghar       | UTS        | An ecophysical comparison of woodlands across a depth-to-groundwater gradient   | Prof. Derek Eamus (UTS) Dr James Cleverly (UTS)# Dr Melanie Zeppel (Macquarie University)#  |
| rogram 5                        |            |   |   |
| Mr Muhammad<br>Arshad           | ANU        | Managed aquifer recharge: suitability and economic potential in lower Namoi Valley, NSW   | Prof. Tony Jakeman (ANU)<br>Assoc. Prof. Bryce Kelly (ANU)<br>Dr Barry Croke (ANU)<br>Dr Ejaz Qureshi (CSIRO)#  |
| Ms Emily Barbour                | ANU        | Multi-objective optimisation of environmental flows for regulated river systems   | Prof. Tony Jakeman (ANU) Dr Barry Croke (ANU) Prof. George Kuczera (Uni. of Newcastle)# Dr Carmel Pollino (CSIRO)# Dr Geoff Podger (CSIRO)# Dr Patrick Driver (UNSW)# |
| Ms Rachel<br>Blakers*           | ANU        | Parameterisation of surface water models with groundwater interactions  | Dr Barry Croke (ANU)<br>Prof. Tony Jakeman (ANU)<br>Dr Bob Anderssen (CSIRO)#   |
| Ms Natalie Brown                | UWA        | Iron ore mining and dewatering in the Pilbara with particluar attention to state agreements and cumulative impacts  | Assoc. Prof. Alex Gardner (UWA)   |
| Ms Gabriela<br>Cuadrado Quesada | UNSW       | Sustainable groundwater governance  | Mr Cameron Holley (UNSW)  |
| Ms Theresa Groth                | CSU        | Nature and outcomes of farming as a collective identity   | Prof. Allan Curtis (CSU)<br>Dr Emily Mendham (CSU)  |
| Mr Joseph<br>Guillaume*         | ANU        | Uncertainty and using integrated models to help decision making: the case of acceptable aquifer yield   | Prof. Tony Jakeman (ANU)<br>Dr Sondoss El Sawah (ANU)   |
| Miss Madeleine<br>Hartley       | UWA        | Regulating groundwater under the National Water Initiative: a cross-jurisdictional analysis of consumptive pool requirements and indigenous rights and interests in groundwater | Assoc. Prof. Alex Gardner (UWA)<br>Prof. Simon Young (UWA)#<br>Prof. Tom Romero (University of<br>Denver)#  |
| Ms Saideepa<br>Kumar            | CSU        | Establishing achievable and acceptable environmental condition targets in a complex changing system   | Prof. Allan Curtis (CSU)<br>Dr Emily Mendham (CSU)<br>Assoc. Prof. Wendy Merritt (ANU)  |
| Miss Andrea<br>Rawluk           | CSU        | Socio-institutional aspects of managed aquifer recharge   | Prof. Allan Curtis (CSU)<br>Dr Emily Sharp (CSU)  |
| /Ir Mun-Ju Shin*                | ANU        | Identifiability, sensitivity and uncertainty of hydrological models   | Dr Barry Croke (ANU)<br>Prof. Tony Jakeman (ANU)  |
| Mr James Skurray                | UWA        | Institutions, transaction costs, and groundwater policy: the potential for a cap-and-trade scheme for groundwater in the Gnangara region of Western Australia                   | Prof. David Pannell (UWA)<br>Dr Ram Pandit (UWA)#   |
| Ms Alison Wilson                | UWA        | Tradeoffs between environmental outcomes and agricultural productivity in the context of declining groundwater availability and climate variability                             | Prof. David Pannell (UWA)<br>Prof. Tony Jakeman (ANU)<br>Dr Ejaz Qureshi (CSIRO)#<br>Dr Marit Kragt (UWA)#  |
| Miss Chunfang                   | UniSA      | Incorporating plantation forestry as a water affecting activity into the sustainable water allocation plan  | Prof. Jennifer McKay (UniSA)<br>Dr Ganesh Keremane (UniSA)  |

| NAME                          | UNIVERSITY | PROJECT TITLE/ACTIVITY  | SUPERVISOR/S   |
|-------------------------------|------------|---|--|
| <b>POSTDOCTORA</b>            | L FELLOWS  |   |  |
| Program 1                     |            |   |  |
| Dr Steve<br>Bouzalakos        | UNSW       | Characterisation of hydraulic properties of low permeability aquitards  | Dr Wendy Timms (UNSW)  |
| Dr Alessandro<br>Comunian     | UNSW       | Innovative characterisation of aquifers and aquitards   | Assoc. Prof. Bryce Kelly (UNSW)  |
| Dr Richard Crane              | UNSW       | To quantify the role different aquitards play in groundwater systems: aquitard hydraulic conductivity, contaminant transport, use of physico-chemical tracers                 | Dr Wendy Timms (UNSW)<br>Prof. Andy Baker (UNSW)   |
| Dr Ander Guinea<br>Maysounave | UNSW       | Connected water studies; geophysical techniques in groundwater; field studies and instrumentation   | Prof. lan Acworth (UNSW)   |
| Dr Catherine Jex              | UNSW       | Isotope geochemistry of cave waters and paleoclimate reconstructions from cave stalagmites  | Prof. Andy Baker (UNSW)  |
| Dr Sanjeev Jha                | UNSW       | Aquifer characterisation and hydrological modelling   | Assoc. Prof. Bryce Kelly (UNSW)  |
| Dr Adam Hartland              | UNSW       | Innovative characterisation of aquifers and aquitards using geochemical approaches  | Dr Wendy Timms (UNSW)  |
| Dr Matthias Raiber            | QUT        | Assessment of sedimentary systems in southeast Queensland with multiple aquifers and complex hydrology using integrated 3D hydrogeological and hydrochemical modelling        | Assoc. Prof. Malcolm Cox (UQ)  |
| Dr Gabriel Rau                | UNSW       | Title not available   | Dr Martin Andersen (UNSW)  |
| Dr Hamid Roshan               | UNSW       | Mass and energy transfer modelling of chemically active fractured rocks   | Dr Martin Andersen (UNSW)  |
| Program 2                     |            |   |  |
| Dr Helen Rutlidge             | UNSW       | Novel aquifer and aquitard characterisation   | Prof. Andy Baker (UNSW)  |
| Dr Behzad<br>Ataie-Ashtiani   | Flinders   | Homogenisation of unstable density dependent flow   | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                                |
| Dr Etienne<br>Bresciani       | Flinders   | Impact of vegetation on atmospheric chloride deposition to the land surface (completed 13/11/2013) Assessment of Adelaide Plains groundwater resources (commenced 14/11/2013) | Assoc. Prof. Adrian Werner (Flinders) Prof. Okke Batelaan (Flinders) Prof. Peter Cook (Flinders/CSIRO) |
| Dr Sergio<br>Galindo-Torres   | UQ         | Development of numerical methods<br>based on realistic fluid–solid<br>interactions to solve engineering<br>problems at the pore scale   | Prof. Ling Li (UQ)   |
| Dr Daan<br>Herckenrath        | Flinders   | Next generation modelling of coal seam gas groundwater impacts  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                                |
| Dr John<br>Kozuskanich        | Flinders   | Interpreting environmental tracers in fractured rock environments   | Prof. Craig Simmons (Flinders)<br>Assoc. Prof. Adrian Werner (Flinders)                                |
| Dr Chunhui Lu                 | Flinders   | Seawater intrusion processes and control  | Assoc. Prof. Adrian Werner (Flinders)<br>Prof. Craig Simmons (Flinders)                                |
| Dr Maria Pool                 | Flinders   | Effects of temporal fluctuations on the width of the mixing zone in heterogeneous coastal aquifers  | Dr Vincent Post (Flinders)<br>Prof. Craig Simmons (Flinders)   |



|                             | UNIVERSITY   | PROJECT TITLE/ACTIVITY   | SUPERVISOR/S  |
|-----------------------------|--------------|--|---|
| Or Ursula Salmon            | UWA          | Exploring the use of reactive transport models for an improved understanding of groundwater flow processes   | Prof. Henning Prommer (UWA)   |
| Dr Adam Siade               | UWA          | Understanding environmental processes through numerical modelling, calibration and predictive uncertainty analyses   | Prof. Henning Prommer (UWA)   |
| Dr Ilka Wallis              | Flinders     | Model-based assessment of reactive transport during re-injection during coal seam gas operations   | Dr Vincent Post (Flinders)<br>Prof. Craig Simmons (Flinders)        |
| Or Juliette Woods           | Flinders     | Processes impacting the salinity of<br>the lower River Murray and its<br>floodplain  | Assoc. Prof. Adrian Werner (Flinders)                               |
| Or Ming Wu                  | UWA          | Development and application of reactive groundwater models   | Prof. Henning Prommer (UWA)   |
| )r Pei Xin                  | UQ           | Interaction between the surface and subsurface: surface water – groundwater interactions in coastal wetlands: model development and simulation, laboratory experiment and field observation                          | Prof. Ling Li (UQ)  |
| rogram 3                    |              |  |   |
| Dr Eddie Banks              | Flinders     | Surface water – groundwater interactions, use of environmental tracers and hydrogeochemistry to understand exchange processes and sources, and groundwater flow processes in fractured rock aquifers                 | Prof. Peter Cook (Flinders/CSIRO)                                   |
| Dr Jordi Batlle-<br>Aguilar | Flinders     | Infiltration processes and groundwater recharge estimate in ephemeral losing streams at the transect scale and tropical rivers: surface or groundwater? Study of the Mitchell River, far north Queensland, Australia | Prof. Peter Cook (Flinders/CSIRO)<br>Dr Glenn Harrington (CSIRO)    |
| Dr Ben Gilfedder            | Monash       | Groundwater interaction with lakes<br>and wetlands: quantification of<br>transient groundwater fluxes in<br>coastal wetlands, estuaries and<br>lakes using radon, stable isotopes<br>and major ions                  | Prof. lan Cartwright (Monash)                                       |
| Or Joshua Larsen            | UNSW         | Hyporheic processes and chemical interactions: groundwater pumping and the impact on surface water – groundwater exchange and biogeochemical processes   | Dr Martin Andersen (UNSW)   |
| л James<br>лсСаllum*        | Flinders     | Interpreting environmental tracers in heterogeneous aquifer systems – Willunga Basin, SA   | Prof. Peter Cook (Flinders/CSIRO)                                   |
| r Hamid Roshan              | UNSW         | Mass and energy transfer modelling of chemically active fractured rocks  | Dr Martin Andersen (UNSW)   |
| r Margaret<br>hanafield     | Flinders     | Transient infiltration in disconnected streams (modelling)   | Prof. Peter Cook (Flinders/CSIRO)                                   |
| r Yueqing<br>teven) Xie     | Flinders     | Solute dynamics due to bank storage in the 3D framework  | Prof. Peter Cook (Flinders/CSIRO)<br>Prof. Craig Simmons (Flinders) |
| rogram 3/4                  |              |  |   |
|                             | Flinders/UTS | Simulating water use of vegetation within an arid-zone woodland  | Prof. Peter Cook (Flinders/CSIRO)<br>Prof. Derek Eamus (UTS)        |

| NAME                         | UNIVERSITY | PROJECT TITLE/ACTIVITY   | SUPERVISOR/S   |
|------------------------------|------------|--|--|
| Program 4/2                  |            |  |  |
| Dr Yuting Yang               | Flinders   | Groundwater-vegetation-atmosphere interactions   | Dr Huade Guan (Flinders)   |
| Program 4                    |            |  |  |
| Dr Hoori Ajami               | UNSW       | Toward improved estimations of groundwater recharge and evapotranspiration using coupled vs. integrated hydrologic models  | Assoc. Prof. Matthew McCabe (UNSW)<br>Assoc. Prof. Jason Evans (UNSW)# |
| Dr Matteo<br>Camporese       | Monash     | Groundwater-vegetation-<br>atmosphere interactions   | Dr Edoardo Daly (Monash)   |
| Dr Stefania<br>Grimaldi      | Monash     | Modelling surface runoff and soil infiltration in vegetated dry areas  | Dr Edoardo Daly (Monash)   |
| Dr Samantha<br>Grover        | Monash     | Estimation of water balance in groundwater dependent ecosystems  | Dr Edoardo Daly (Monash)<br>Prof. Ian Cartwright (Monash)              |
| Dr Hugo Gutierrez<br>Jurado  | Flinders   | Investigating the influence of climate variability on groundwater-vegetation-atmospheric interactions of water limited areas with a combination of meteorologic, geophysics and remote sensing methods | Dr Huade Guan (Flinders)   |
| Dr Adrien Guyot              | UQ         | Role of the vegetation in the recharge of sandy aquifers in southeast Queensland   | Prof. David Lockington (UQ)  |
| Dr Randol<br>Villalobos-Vega | UTS        | Ecophysiology of groundwater dependent ecosystems  | Prof. Derek Eamus (UTS)  |
| Dr Nina Welti                | UQ         | Characterising biogeochemical hot spots through the catchment  | Prof. David Lockington (UQ)  |
| Dr Tomasz<br>Wyczesany       | UTS        | Use of stable isotopes in terrestrial ecohydrology   | Prof. Derek Eamus (UTS)  |
| Dr Maria<br>Chuvochina       | UQ         | Development of a biogeochemical aspect to research   | Prof. David Lockington (UQ)  |
| Program 5                    |            |  |  |
| Ms Rachel<br>Blakers*        | UWA        | Surface–groundwater model analysis and development   | Prof. Tony Jakeman (ANU)<br>Dr Barry Croke (ANU)                       |
| Dr Baihua Fu                 | ANU        | Namoi and Lachlan projects   | Assoc. Prof. Wendy Merritt (ANU)                                       |
| Mr Joseph<br>Guillaume*      | ANU        | Managing uncertainty in model predictions in NCGRT decision support case studies   | Prof. Tony Jakeman (ANU)   |
| Dr Serena Hamilton           | ANU        | Understanding and modelling<br>groundwater-dependent ecosystems<br>(in broad) with Willunga project as an<br>application   | Prof. Tony Jakeman (ANU)<br>Dr Sondoss El Sawah (ANU)                  |
| Dr Masud Hasan               | ANU        | Lachlan and Campaspe catchment projects  | Dr Barry Croke (ANU)<br>Prof. Tony Jakeman (ANU)                       |
| Dr Ganesh<br>Keremane        | UniSA      | Managed aquifer recharge and statutory water plan  | Prof. Jennifer McKay (UniSA)   |
| Dr Emily Mendham             | CSU        | The Wimmera social benchmarking project Cotton CRC integrated water/climate scenario modelling   | Prof. Allan Curtis (CSU)   |
| Dr Marian Patrick            | ANU        | Resilience and resistance of River<br>Red Gums and environmental<br>watering governance: how the<br>concept of scale can help our<br>understanding of environmental<br>watering governance             | Assoc. Prof. Wendy Merritt (ANU)<br>Prof. Tony Jakeman (ANU)           |

| NAME                           | UNIVERSITY | PROJECT TITLE/ACTIVITY   | SUPERVISOR/S  |
|--------------------------------|------------|--|---|
| Mr Andrew Ross*                | ANU        | Integrated surface water and groundwater management in the Murray–Darling Basin and western USA  | Prof. Tony Jakeman (ANU)                                    |
| Mr Mun-Ju Shin*                | ANU        | Intergrating socioeconomics, policy and decision support   | Prof. Tony Jakeman (ANU)<br>Dr Barry Croke (ANU)            |
| Dr Darren Sinclair             | ANU        | Regulation and governance  | Prof. Neil Gunningham (ANU)                                 |
| Dr Jenifer Ticehurst           | ANU        | Namoi socio-economic project   | Prof. Tony Jakeman (ANU)                                    |
| Dr Zhifang Wu                  | UniSA      | Managed aquifer recharge and statutory water plan  | Prof. Jennifer McKay (UniSA)                                |
| Dr Tingbao Xu                  | ANU        | Rainfall estimation for hydrological modelling   | Prof. Tony Jakeman (ANU)<br>Prof. Michael Hutchinson (ANU)# |
| RESEARCH FEL                   | LOWS       |  |   |
| Program 2/3                    |            |  |   |
| Dr Nikki Harrington            | Flinders   | Surface water – groundwater interactions in the South East of South Australia                    | Prof. Peter Cook (Flinders/CSIRO)                           |
| Dr Edward Banks                | Flinders   | Surface water – groundwater interaction in a fractured rock aquifer system                       | Prof. Peter Cook (Flinders/CSIRO)                           |
| Program 4                      |            |  |   |
| Dr Jim Hanan                   | UQ         | Development of virtual groundwater-<br>dependent ecosystems                                      | Prof. David Lockington (UQ)                                 |
| Program 5                      |            | ,  |   |
| Mr Michael Bennett             | UWA        | A regulatory framework for groundwater management in a drying south-west                         | Assoc. Prof. Alex Gardner (UWA)                             |
| RESEARCH ASS                   | ISTANTS    |  |   |
| Program 1                      |            |  |   |
| Ms Dayna<br>McGeeney           | UNSW       | Centrifuge permeameter research associate  | Dr Wendy Timms (UNSW)                                       |
| Program 2                      |            |  |   |
| Mrs Julie<br>McClements        | Flinders   | Technical and research support for Program 2   | Assoc. Prof. Adrian Werner (Flinders                        |
| Program 2/3                    |            |  |   |
| Ms Stephanie<br>Villeneuve     | Flinders   | Research support in the Willunga<br>Basin and assistance with short<br>course training programs  | Prof. Peter Cook (Flinders/CSIRO)                           |
| Program 2/4                    |            |  |   |
| Ms Lucy Reading                | UQ         | Mike-SHE modelling of<br>groundwater-vegetation interaction<br>on Bribie Island P4 research site | Prof. David Lockington (UQ)                                 |
| Program 4                      |            |  |   |
| Ms Yunhui Guo                  | Flinders   | Research support for Program 4   | Dr Huade Guan (Flinders)                                    |
| Program 5                      |            |  |   |
| Ms Natalie Brown               | UWA        | Research support for Program 5   | Assoc. Prof. Alex Gardner (UWA)                             |
| Ms Isabela Burgher             | ANU        | Research assistance  | Prof. Tony Jakeman (ANU)                                    |
| Mr Benjamin<br>Courtney-Barrer | ANU        | Research assistance  | Prof. Tony Jakeman (ANU)                                    |
| Mr Yang Lui                    | ANU        | Research assistance  | Prof. Tony Jakeman (ANU)                                    |

| NAME                     | UNIVERSITY                 | PROJECT TITLE/ACTIVITY | SUPERVISOR/S                      |  |  |
|--------------------------|----------------------------|------------------------|-----------------------------------|--|--|
| Mr Lachlan<br>McGuinness | ANU                        | Research assistance    | Prof. Tony Jakeman (ANU)          |  |  |
| TECHNICAL SUF            | TECHNICAL SUPPORT OFFICERS |                        |                                   |  |  |
| Program 1                |                            |                        |                                   |  |  |
| Mr Peter Graham          | UNSW                       | Technical support      | Prof. Andy Baker (UNSW)           |  |  |
| Mr Mark Whelan           | UNSW                       | Technical support      | Prof. Andy Baker (UNSW)           |  |  |
| Program 3                |                            |                        |                                   |  |  |
| Mr Lawrence Burk         | Flinders                   | Technical support      | Prof. Peter Cook (Flinders/CSIRO) |  |  |
| Mr Nick White            | Flinders                   | Technical support      | Prof. Peter Cook (Flinders/CSIRO) |  |  |
| Program 4                | Program 4                  |                        |                                   |  |  |
| Ms Nicole Grant          | UTS                        | Technical support      | Prof. Derek Eamus (UTS)           |  |  |
| Program 5                |                            |                        |                                   |  |  |
| Ms Anita Foerster        | UWA                        | Technical support      | Assoc. Prof. Alex Gardner (UWA)   |  |  |
| Mr Takuya<br>Iwanaga     | ANU                        | Software development   | Dr Barry Croke (ANU)              |  |  |
| Mr Andrew Hicks          | ANU                        | Software development   | Assoc. Prof. Wendy Merritt (ANU)  |  |  |

<sup>\*</sup>During 2013 these students completed their PhDs and were appointed as postdoctoral fellows #External supervisors

## Appendix 3: 2013 publications

Books, book chapters, reviews and reports Doherty, J, Herckenrath, D 2013, 'Numerical simulation of two-phase flow using a single-phase model: some experiences', *The development of a new CSG groundwater impact model for the Surat Basin*, OGIA report.

Dyer, F, El Sawah, S, Lucena-Moya, P, Harrison, E, Croke, B, Tschierschke, A, Griffiths, R, Brawata, R, Kath, J, Reynoldson, T, Jakeman, T 2013, *Predicting water quality and ecological responses*, National Climate Change Adaptation Research Facility, Gold Coast.

Eamus, D, Fu, B, Springer, AE, Stevens, L 2014, 'Groundwater-dependent ecosystems', in T Jakeman, O Barreteau, R Hunt, JD Rinaudo and A Ross (eds), Integrated Groundwater Management, Springer, Heidelberg, in press.\*

Guan, H, Bennett, J, Ewenz, C, Benger, S, Vinodkumar, Zhu, SH, Clay, R, Soebarto, V 2013, *Characterisation, interpretation and implications of the Adelaide urban heat island*, Flinders University, South Australia.

Fu, B 2013, A water suitability model for riparian vegetation in the Namoi catchment: Final report, National Centre for Groundwater Research and Training, Canberra, Australia.

Hamel, P, Daly, E, Fletcher, TD 2013, 'Source-control stormwater management for mitigating the impacts of urbanisation on baseflow: A review', *Journal of Hydrology*, vol. 485, pp. 201–11.

Harrington, N, Li, C, Woods, J, Barnett, S, Lawson, J, Plush, B, Skewes, M 2014 'Data review and conceptual model', Framework for a regional water balance model for the South Australian Limestone Coast region, in press.\*

Harrington, N, Woods, J, Turnadge, C, Davies, P, Li, C 2014, 'Overview of the study area', Framework for a regional water balance model for the South Australian Limestone Coast region, in press.\*

Ivkovic, KM, Marshall, SK, Carey, H, Morgan, LK, Sundaram, B, Dixon-Jain, P, Caruana, L, Garlapati, N, Werner, AD 2013, *A national-scale vulnerability assessment of seawater intrusion: Coastal aquifer typology*, Geosciences Australia, Canberra.

Jakeman, T, El Sawah, S, Patrick, M, Asher, M, Guillaume, J 2013, Review of the critical science review of cumulative impacts of coal seam gas mining, Report for the Office of Water Science.

Joseph, S, Graber, ER, Chia, C, Munroe, P, Donne, S, Thomas, T, Nielsen, S, Marjo, C, Rutlidge, H, Pan, GX, Li, L, Taylor, P, Rawal, A, Hook, J 2013, 'Shifting paradigms: Development of high-efficiency biochar fertilizers based on nano-structures and soluble components', *Carbon Management*, vol. 4 (3), pp. 323–43.

Keremane, G, McKay, J, Wu, Z 2013, 'Achieving ecologically sustainable development in multi-level water governance regimes: the case of the Murray–Darling Basin', *Water and the Law: Towards Sustainability*, Edward Elgar.

Keremane, G, McKay, J, Wu, Z 2013, 'Public servants as sustainability policy entrepreneurs in Australia – the issues and outcomes', *The handbook of entrepreneurship and sustainable development research*, Edward Elgar.

Liu, F, Huang, G, Fallowfield, H, Guan, H, Zhu, L, Hu, H 2014, Study on heterotrophic-autotrophic denitrification permeable reactive barriers (HAD PBRs) for in situ groundwater remediation, Springer, Heidelberg.\*

McKay, J 2014, 'Australian water law history – the move from introspective state sovereignty to a national interest approach and the influence of international law', *Sovereignty and the Development of International Water Law*, University of Bergen.\*

Morgan, LK, Werner, AD, Carey, H 2013, *A national-scale vulnerability assessment of seawater intrusion: Seawater intrusion vulnerability indexing – quantitative*, Geosciences Australia, Canberra.

Morgan, LK, Werner, AD, Ivkovic, KM, Carey, H, Sundaram, B 2013, *A national-scale vulnerability assessment of seawater intrusion: First-order assessment of seawater intrusion for Australian case study sites*, Geosciences Australia, Canberra.

Morgan LK, Werner AD, Morris MJ, Teubner M 2013, 'Application of a rapid-assessment method of SWI: Willunga Basin, South Australia', in C Wetzelhuetter (ed.), *Groundwater in the coastal zones of Asia–Pacific*, Coastal Research Library vol. 7, Springer, Heidelberg.

Patrick, MJ, Greco, F, Connell, D, Conrad, J 2014, 'The social-environmental justice of groundwater governance', in T Jakeman, O Barreteau, R Hunt, JD Rinaudo and A Ross (eds), *Integrated Groundwater Management*, Springer, Heidelberg, in press.\*

Post, VEA, von Asmuth, JR 2013, 'Review: Hydraulic head measurements new technologies, classic pitfalls', *Hydrogeology Journal*, vol. 21(4), pp. 737–750.

Robertson, S 2013, 'A regulatory framework for monitoring and enforcement of water access rights in Western Australia', *University of WA Law Review*.

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Taylor, RG, Scanlon, B, Döll, P, Rodell, M, Van Beek, R, Wada, Y, Longuevergne, L, LeBlanc, M, Famiglietti, JS, Edmunds, M, Konikow, L, Green, TR, Chen, J, Taniguchi, M, Bierkens, MFP, MacDonald, A, Fan, Y, Maxwell, RM, Yechieli, Y, Gurdak, JJ, Allen, DM, Shamsudduha, M, Hiscock, K, Yeh, PJF, Holman, I, Treidel, H 2013, 'Ground water and climate change', *Nature Climate Change*, Review, vol. 3 (2), pp. 322–329.

Ticehurst, J, Curtis, A, Sharp, E 2013, A Bayesian network to explore the adoption of various management practices for use in an integrated model of water access by groundwater license holders, technical report, National Centre for Groundwater Research and Training, South Australia.

Ward, C, Kelly, B 2013, Background paper on New South Wales geology with a focus on basins containing coal seam gas resources, a report for the Office of the NSW Chief Scientist & Engineer, UNSW Global, Sydney.

Woods, J, Harrington, N 2014, 'Major challenges in water balance modelling in the South East', Framework for a regional water balance model for the South Australian Limestone Coast region, in press.\*

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Wu, Z, McKay, J, Keremane, G 2014, 'Stormwater reuse for sustainable cities: the South Australian experience', in J Williams and P Martin (eds), *The security of water, food, energy and liveability of cities: Challenges and opportunities for peri-urban futures*, Springer Science, Netherlands, in press.\*

#### Refereed conference proceedings

Batelaan, O, Salvadore, E, Bronders, J, Schmitz, O 2013, 'Urban development and the water balance: coupling land-use dynamics and the hydrological system', *Proceedings of MODSIM 2013*, 20th International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand.

Bouzalakos, S, Timms, W 2013, 'The importance of confining strata integrity in mining, coal seam gas extraction and geological storage of industrial waste (CO<sub>2</sub> and nuclear): towards early detection indicators of potential groundwater contamination', *Proceedings of MODSIM 2013*, 20th International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand.

Bouzalakos, S, Timms, W, Rahman, P, McGeeney, D, Whelan, M 2013, 'Geotechnical centrifuge permeameter for characterising the hydraulic integrity of partially saturated confining strata for CSG operations', *Proceedings of the IMWA 2013 annual conference*, International Mine Water Association.

Cartwright, I 2013, 'Open-system calcite dissolution inferred from multiple isotope tracers: implications for groundwater dating', *Proceedings of 10th Applied Isotope Geochemistry Conference*, International Association of GeoChemistry.

El Sawah, S, Kelly, RA, Beverly, C, Stott, K, Patrick, MJ, Kath, J, Croke, BFW, Qureshi, ME, Courtney-Barrer, B, Asher, MJ, Roberts, A, Jakeman, AJ 2013, 'An integrated model to examine the effects of sustainable diversion limits: a case study in the Lower Campaspe catchment', *Proceedings of MODSIM 2013*, 20th International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand.

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Li, L, Maier, HR, Lambert, MF, Partington, D, Simmons, CT 2013, 'Evaluating and improving simplified hydrologic models for baseflow and rainfall-runoff estimation using distributed physical models', *Proceedings of MODSIM 2013*, 20th International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand.

Partington, DJ, Maier, HR, Brunner, P, Simmons, CT, Werner, AD, Therrien, R, Dandy, GC, Frei, S, Fleckenstein, JH 2013, 'Quantifying in-stream and overland flow generation mechanisms using fully integrated flow models', *Proceedings of MODSIM 2013*, 20th International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand.

Timms, W, Liu, H, Laurence, D 2013, 'Design of a low permeability barrier (LPB) to limit seepage between a mine and a river', *Proceedings of Water in Mining 2013*, Australasian institute of Mining and Metallurgy (The AusIMM).

Timms, W, Whelan, M, Acworth, I, McGeeney, D, Bouzalakos, S, Crane, R, McCartney, J, Hartland, A 2013, 'A novel centrifuge permeameter to characterize flow through low permeability strata', *Proceedings of the 8th International Conference on Physical Modelling in Geotechnics*, the International Society of Soil Mechanics and Geotechnical Engineering.

#### Journal papers

Ahani, H, Kherad, M, Kousari, MR, van Roosmalen, L, Aryanfar, R, Hosseini, SM 2013, 'Non-parametric trend analysis of the aridity index for three large arid and semi-arid basins in Iran', *Theoretical and Applied Climatology*, vol. 112(3–4), pp. 553–64.

Albhaisi, M, Brendonck, L, Batelaan, O 2013, 'Predicted impacts of land use change on groundwater recharge of the upper Berg catchment, South Africa', *Water SA*, vol. 39(2), pp. 211–220.

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Asadi, R, Ataie-Ashtiani, B, Simmons, CT 2014, 'Finite volume coupling strategies for the solution of a Biot consolidation model', *Computers and Geotechnics*, vol. 55, pp. 494–505.\*

Ataie-Ashtiani, B, Rajabi, MM, Ketabchi, H 2013, 'Inverse modelling for freshwater lens in small islands: Kish Island, Persian Gulf', *Hydrological Processes*, vol. 27(19), pp. 2,759–73.

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Atkinson, AP, Cartwright, I, Gilfedder, BS, Hofmann, H, Unland, NP, Cendon, DI, Chisari, R 2013, 'A multi-tracer approach to quantifying groundwater inflows to an upland river', *Hydrological Processes*, online edition: DOI:10.1002/hyp.10122.

Bakhtyar, R, Brovelli, A, Barry, DA, Robinson, C, Li, L 2013, 'Transport of variable-density solute plumes in beach aquifers in response to oceanic forcing', *Advances in Water Resources*, vol. 53, pp. 208–24.

Bass, AM, Munksgaard, NC, Leblanc, M, Tweed, S, Bird, MI 2013, 'Contrasting carbon export dynamics of human impacted and pristine tropical catchments in response to a short-lived discharge event', *Hydrological Processes*, vol. 28 (4), pp. 1835–1843.

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Batelaan, O, Hughes, DA, Swarzenski, PW, Willems, P, Bardossy, A, Charlet, L, Georgakakos, KP, Kitanidis, PK, Syme, G, Corradini, C 2013, 'Editorial: regional studies', *Journal of Hydrology*, vol. 507, pp. A1–A2.

Bennett, ND, Croke, BFW, Guariso, G, Guillaume, JHA, Hamilton, SH, Jakeman, AJ, Marsili-Libelli, S, Andreassian, V 2013, 'Characterising performance of environmental models', *Environmental Modelling and Software*, vol. 40, pp. 1–20.

Bertoncello, A, Sun, T, Li, H, Mariethoz, G, Caers, J 2013, 'Conditioning surface-based geological models to well and thickness data', *Mathematical Geosciences*, vol. 45(7), pp. 873–93.

Bridgeman, J, Baker, A, Carliell-Marquet, C, Carstea, E 2013, 'Hydrological modeling of stalagmite  $\delta^{18}$ O response to glacial-interglacial transitions', *GeoPhysical Research Letters*, vol. 40(12), pp. 3,207–12.

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Cartwright, I, Gifedder, B, Hofmann, I 2013, 'Contrasts between chemical and physical estimates of baseflow help discern multiple sources of water contributing to rivers', *Hydrology and Earth System Sciences*, vol. 18, pp. 15–30.

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Comunian, A, Jha, SK, Giambastiani, BMS, Mariethoz, G, Kelly, BFJ 2013, 'Training images from process-imitating methods – an application to the Lower Namoi Aquifer, Murray–Darling Basin, Australia', *Mathematical Geosciences*, pp. 1–20, in press.

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De Louw, PGB, Vandenbohede, A, Werner, AD, Oude Essink, GHP 2013, 'Natural saltwater upconing by preferential groundwater discharge through boils', *Journal of Hydrology*, vol. 490, pp. 74–87.

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\*These publications were accepted for publication and online in 2013, but will not appear in print until 2014. As such, not all bibliographic details are available.

## Appendix 4: Board and committees

#### Advisory Board

#### Mr Ken Matthews

Former chair and CEO of the National Water Commission

#### Dr John Radcliffe

**CSIRO** 

#### Mr John Ruprecht

Department of Agriculture and Food, Western Australia

#### **Professor Carl Schiesser**

ARC Centre of Excellence for Free Radical Chemistry and Biotechnology

#### **Mr Garry Smith**

DG Consulting

#### **Professor Suzanne O'Reilly**

ARC Centre of Excellence for Core to Crust Fluid Systems

#### **Mr Neil Power**

Goyder Institute; National Groundwater Working Group

#### Mr Gareth Lloyd

Global Carbon Capture and Storage Institute

#### Research Management Committee

The Research Management Committee is composed of the NCGRT's five research program leaders:

#### **Professor Andy Baker**

University of New South Wales

#### **Professor Craig Simmons**

Flinders University

#### **Professor Peter Cook**

Flinders University

#### **Professor David Lockington**

University of Queensland

#### **Professor Tony Jakeman**

Australian National University

#### Industry Liaison Advisory Committee

In June 2013, the committee was reconfigured as an expert panel, consulting on specific issues as required.

We wish to acknowledge the valuable contributions of our committee/panel members during the year.

#### Mr Phillip Commander

Former President of the International Association of Hydrogeologists

#### Mr Kym Good

Adelaide and Mt Lofty Ranges NRM Board

#### Mr Michael Williams

NSW Office of Water

#### Mr Blair Douglas

BHP Billiton

#### Mr Tony McLeod

Murray-Darling Basin Authority

#### Mr Ian Lancaster

Natural Resources, Environment, The Arts and Sport, Northern Territory

#### **Dr John Waterhouse**

Golder Associates

#### Mr Adam Sincock

Department of Sustainability, Environment, Water, Population and Communities

#### **Mr Andrew Moser**

Origin Energy

#### **Ms Sandy Caruthers**

Department of Environment, Water and Natural Resources, South Australia

#### International Scientific Advisory Committee

#### Professor Ghislain de Marsily

University of Paris, VI

#### **Dr Leonard Konikow**

United States Geological Survey

#### **Professor Edward Sudicky**

University of Waterloo

#### **Dr Daniel Peter Loucks**

Cornell University

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As well as Flinders University in South Australia - the lead and administering organisation for the Centre — we are proud to be involved in a range of partnerships that reflect our broad, integrated and innovative approach to research and training, with associations across government, industry and the research community, including:

- Australian National University
- Charles Sturt University
- James Cook University
- La Trobe University
- Monash University
- Queensland University of Technology
- University of New South Wales
- University of Queensland
- University of South Australia
- University of Technology, Sydney University of Western Australia
- University of Neuchâtel
- University of Texas at Austin

## organisations • CSIRO

- Geoscience Australia
- **NSW** Department of Primary Industries
- NSW Office of Water
- SA Department for Water

- Australian Water Association
- DHI Water & **Environment Pty Ltd**
- Innovative Groundwater Solutions
- RPS Aquaterra Consulting Pty Ltd
- SA Water
- Sinclair Knight Merz (SKM) Consulting Pty Ltd
- UŚ National Ground Water Association

