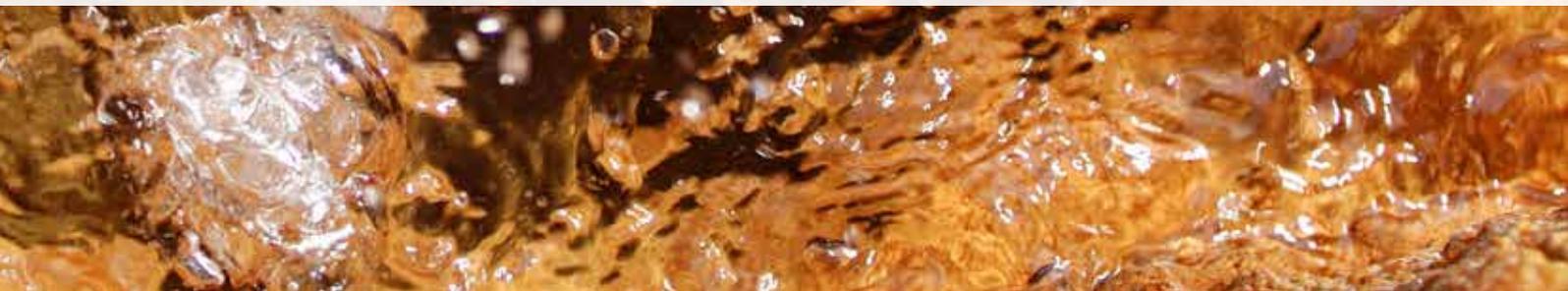




National Centre for  
**Groundwater Research and Training**  
Annual report 2012





**The National Centre for Groundwater Research and Training 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.**

**This report summarises the NCGRT's performance between 1 January 2012 and 31 December 2012. It outlines progress towards achieving our strategic plan objectives.**

The NCGRT's mission is to be an institution of national and international standing with the capacity, through the development of people, knowledge and technologies, to support the sustainable management of Australia's groundwater resources.

Administered by Flinders University, with 21 Australian partner organisations, and formal linkages with some of the world's leading groundwater research organisations, the NCGRT enables nearly 200 Australian and international 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.



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# Our VISION

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

# Our mission

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

**A research centre should be more than the sum of its parts. It should generate linkages that enable research beyond the capacity of individual scientists, it should give students training and mentoring opportunities beyond 'science in a test tube', and it should share its expertise with industry, such that its cutting edge scientific advances can make a real difference.**

I believe that in 2012, the National Centre for Groundwater Research and Training has achieved these things.

The NCGRT continues to undertake world-leading research work within its five programs – this is evidenced by the number and quality of journal papers produced in 2012 – a key finding of our International Scientific Advisory Committee meeting early this year. We continue to expand our research capabilities, and today we have 21 partner organisations across the country, and in 2012 formalised a number of significant international relationships, including with the University of Texas at Austin and the University of Neuchâtel. These relationships allow us to attract the highest calibre of experts, researchers and students to the NCGRT and to provide opportunities for our own staff and students.

Currently we have some 48 postdoctoral fellows, 57 PhD candidates and 21 honours students, who are either completing, or have completed working with us. 2012 has marked the first PhD graduates from the NCGRT, and I am very pleased to see them move on to successful careers with a strong grounding in research. Importantly we have already reached our five-year goal for PhD and postdoctoral recruitment; we achieved this milestone in less than three years, although we won't rest on our laurels.

A highlight of 2012 was the NCGRT's Summer School, which brought together NCGRT researchers and students from across the country for three days of presentations, workshops and networking. The 2012 Summer School was held at the Australian Academy of Science's home, the Shine Dome, in Canberra, and included a series of industry presentations, and a workshop on 'how to sell groundwater', run by members of ABC TV's 'The Gruen Transfer'.

The NCGRT Distinguished Lecturer program continued successfully this year with Professor Robert Glennon from the University of Arizona, who presented on America's water crisis. For 2013 we have secured Professor Andrew Boulton, who will give a lecture on 'hydroecology and stygofauna'. Andrew is an exceptional scientist and his lecture promises to be both informative and engaging.

The NCGRT had a strong presence at a number of high-profile scientific conferences this year, including, importantly, the US National Ground Water Association summit in California. We are already planning for the International Association of Hydrogeologists congress in 2013, which will be held in Perth, and at which a number of our scientists have already been invited to give plenary addresses.

We are continuing to forge strong new links with industry, including with the US Geological Survey, the Australian Nuclear Science and Technology Organisation and Rio Tinto. As we advance as a centre, we are increasing our emphasis on sharing our knowledge with industry and having it adopted for everyday use.

Our industry training program is an important part of this effort, and in 2012, we attracted more than 600 attendees to our training activities, and provided in-house training to Geoscience Australia and the Australian Government's Office of Water Science. Moreover we have this year formalised strong relationships with the Australian Water Association and the US National Ground Water Association and we continue to work closely with the International Association of Hydrogeologists to deliver the highest quality training.

Beyond connecting with industry, the NCGRT is also involved in groundwater governance policy. In December, for example, we served as general rapporteur for the Beijing meeting of the UNESCO International Groundwater Governance project, and Program 5 leader Tony Jakeman and I are serving as international experts on the permanent consultation mechanism for the project.

Raising the visibility and profile of our work is a key goal for the NCGRT, and we take a proactive approach to our media engagement. In 2012 one of our key strategies was to engage Julian Cribb, one of Australia's premier science writers, to develop frequent media releases for us.



This has been a great success with over 1000 media mentions this year. We now have visibility with most major Australian media outlets. This is important for ensuring that industry, government and the general community understands both the importance of groundwater and the work of the NCGRT.

And, finally, a major milestone in 2012 was the completion of our formal Australian Research Council mid-term review. The review panel concluded that the NCGRT has made 'excellent progress to date', and that it has 'fostered the development of a critical mass in groundwater research and management capability for Australia and provided a supportive and stimulating environment for the next generation of researchers'.

I am extremely pleased with this result, as I feel it truly reflects the tremendous contributions of so many excellent researchers, students and staff members who have worked so hard – and continue to work so hard – to make the NCGRT a leading groundwater institution on both the national and international stage. I am very grateful to them all.

I would also like to acknowledge and thank the Australian Research Council and the National Water Commission for their ongoing support. I have particularly appreciated the constructive approach that they have taken in relation to the management of the underspend in our research operations budget, and the in-principle agreement enabling the NCGRT to make an application to carry any unspent funds through to our second funding term. This is an important vote of confidence in the NCGRT which will enable us to commence this new term with significant research momentum.

A handwritten signature in black ink that reads 'Craig T. Simmons'.

Professor Craig T. Simmons  
Director, NCGRT

# Research program leaders

## Program 1 Innovative Characterisation of Aquifers and Aquitards



**Professor Andy Baker**  
*The 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.

## Program 2 Hydrodynamics and Modelling of Complex Groundwater Systems



**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 variable-density 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.

## Program 3 Surface Water –Groundwater Interactions



**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.

#### Program 4 Groundwater-Vegetation- Atmosphere Interactions



**Professor David Lockington**  
*The 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.

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.

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



**Professor Tony Jakeman**  
*The 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 *Environmental Modelling and Software*.



**Monika Markowska**  
**Program 1 honours student**

In the Yarrangobilly Caves of the Snowy Mountains, the highest altitude cave region in Australia, Monika Markowska checks the drip counter she placed under a stalactite.

These drips of water can speak volumes about past climate via surface water to groundwater interactions: 'By looking at cave formations like stalagmites we can work out what past [paleo] climates were like... stalagmites are a good record of continental climate, allowing seasonal-scale reconstructions.'

By measuring the frequency of the drips and comparing the data with information from weather stations outside, Monika can, for example, relate how the drips change over time in response to aboveground influences like rainfall.

And, with the innovative use of a temperature tracer more commonly inserted under the skin of fish, she can track changes in the temperature of the drip water, and use the heat signal as a passive tracer.

Studying at the University of New South Wales and working for the Institute for Environmental Research at the Australian Nuclear Science and Technology Organisation, Monika joined the National Centre for Groundwater Research and Training in 2011.

Her work using drip hydrogeology to understand paleo climate earned first class honours, and is the subject of her PhD, which she begins this year.

'We want to understand or better resolve paleo climate records so we can anticipate future climate change, and of course we want to gather more information about surface water and groundwater interactions.'

And where better to gather this information than in a cave, a natural laboratory for groundwater.



Research

# Research

**The NCGRT has completed an impressive program of research operations work in 2012; this has included the successful completion of reviews by our International Scientific Advisory Committee and the ARC's mid-term review panel. Both teams of reviewers were impressed with the coherence of the NCGRT's research strategy, and our commitment to delivering high-impact research that is aligned with the needs of end users.**

They also reinforced the need to maintain a strong focus on ensuring that we have effective research integration; we have responded to this challenge by:

- pursuing more joint program appointments, and co-supervisory arrangements for PhD candidates
- initiating a survey into the level of demand for more social networking tools to be added to our website
- conducting cross-program workshops on topics of mutual interest, such as managing uncertainty and heat tracers
- planning 2013 cross-program workshops on groundwater age indicators, and integrating research at the Ti Tree research site
- developing the content for an NCGRT-wide workshop on achieving effective cross-program collaboration and integration.

The NCGRT's five flagship programs are continuing to produce significant results which are outlined in more detail in the individual program reports that follow this section. In addition to focusing on research, our chief investigators have continued to invest a significant amount of time and effort in supervising our PhD candidates and honours students. Their efforts have culminated in the successful submission of 4 PhD theses and 20 honours projects in 2012.

The NCGRT would also like to acknowledge the contributions of the eight postdoctoral fellows whose contracts with us finished during 2012. Many have taken up full-time positions at universities across Australia, and indeed internationally. This is an excellent result and another important step towards our goal of building a vibrant and sustainable groundwater research community. Our newly launched

alumni network will enable us to maintain regular contact with these students and researchers over the years to come.

## Awards

The quality and relevance of our science continues to be recognised nationally and internationally. We are particularly pleased that several PhD candidates and postdoctoral fellows have received external awards for their research endeavours including:

- Josh Dean (a Program 4 PhD candidate) who received the 2011 Farrer Memorial Trust scholarship from the NSW Department of Primary Industries which enabled him to attend the 2012 Goldschmidt Geochemistry Conference in Montréal
- Rose Deng (also a Program 4 PhD candidate) who received the 2012 Farvolden Award for best student paper at the US National Ground Water Association Summit
- Dylan Irvine (a Program 2 PhD candidate) who was awarded an industrial traineeship with CSIRO in connection with his work on geothermal energy
- Program 2's Dr Yueqing Xie who was awarded the 2012 Australian Water Association South Australian Postgraduate Prize for his contributions to groundwater research and free convection processes.

## Director's Award

The NCGRT has launched its own 'Director's Award'. The inaugural winners were Joseph Guillaume (a Program 5 PhD candidate) and Dr Margaret Shanafield (a Program 3 postdoctoral fellow) in recognition of their research excellence, publication records, and positive contribution to NCGRT life. Celebrating these successes plays an important part in building a high-performance research culture.

## Publications

Researchers from the NCGRT have had another highly productive year. As noted in the key performance table overleaf, our researchers have produced over 200 publications this year. The citation rate is equally impressive, exceeding both our annual and cumulative targets. This is a positive reflection on the impact, importance and quality of NCGRT research.



JOSEPH GUILLAUME

## Joseph Guillaume Program 5 PhD candidate

PhD candidate Joseph Guillaume loves 'wicked problems' that have no clear definitions and no established methods for solutions. 'You need to be creative to be the person with the answers, or the person able to get them.'

Switzerland-born Joseph grew up in Melbourne, and did a Bachelor of Philosophy at the Australian National University in Canberra. For his honours he worked on decision-support modelling to help cyclists figure out their best route. One of his examiners told him about a PhD scholarship with the National Centre for Groundwater Research and Training on the topic of uncertainty in modelling. He joined the NCGRT three years ago.

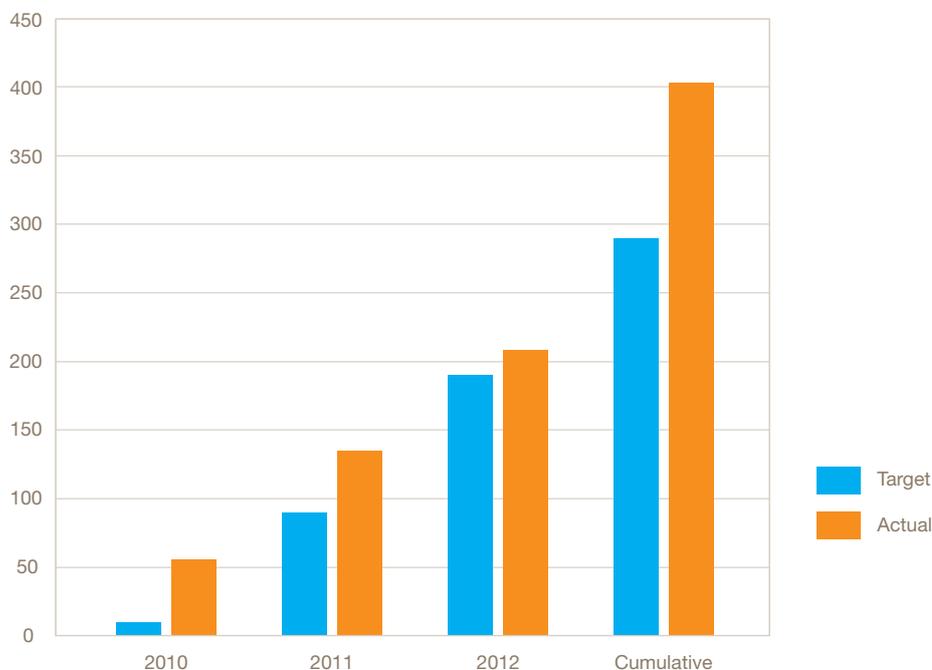
Joseph is exploring the idea of helping water managers decide on a plan for their region by managing uncertainty in their models. These models are very complex as they integrate data on surface water, groundwater, alternate water resources (like recycled water), and wider impacts (such as economic factors).

An insight from policy makers on this 'wicked problem' sparked his approach: what they need to know is 'could we be wrong?' Joseph realised that to have confidence in predictions from complex models, it is useful to ask a series of closed questions with the criteria 'possible or impossible'.

'If you use the model to "stress test" a policy for gaps — to learn about policy rather than predict the future — you get a better policy and a better grasp of uncertainty.'

Joseph is one of two winners of the 2012 NCGRT Director's Award.

## NUMBER OF PUBLICATIONS APPEARING IN QUALITY JOURNALS, AND BOOK CHAPTERS



In addition to journal articles, students and researchers have contributed to the publication of 12 science fact sheets on a broad range of topics, including parameter estimation and uncertainty, 3D geological modelling, chemical sampling, and connected and disconnected streams. These fact sheets are an important component of our knowledge transfer and adoption strategy.

### Industry links

The NCGRT has deepened its connections with several research institutions by entering into arrangements with CSIRO for the co-supervision of PhD candidates, and with the SA Department of Environment, Water and Natural Resources. These arrangements have enabled us to pool our research talent on a major regional water balance project. We have also partnered with SKM and CSIRO on critical reviews of the science underpinning coal seam gas and mining in Australia, commissioned by the Department of Sustainability, Environment,

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>RESEARCH</b>					
R1	Total number of publications appearing in journals, and book chapters	180	213	280	405
R2	Percentage of publications appearing in A or A* quality journals	50% (90 articles)	50% (108 articles)	N/A	57%
R3	Number of citations	1250	2894	2050	4373
R4	Number of invitations to present talks, papers and keynote lectures at major national and international meetings	90	177	170	357

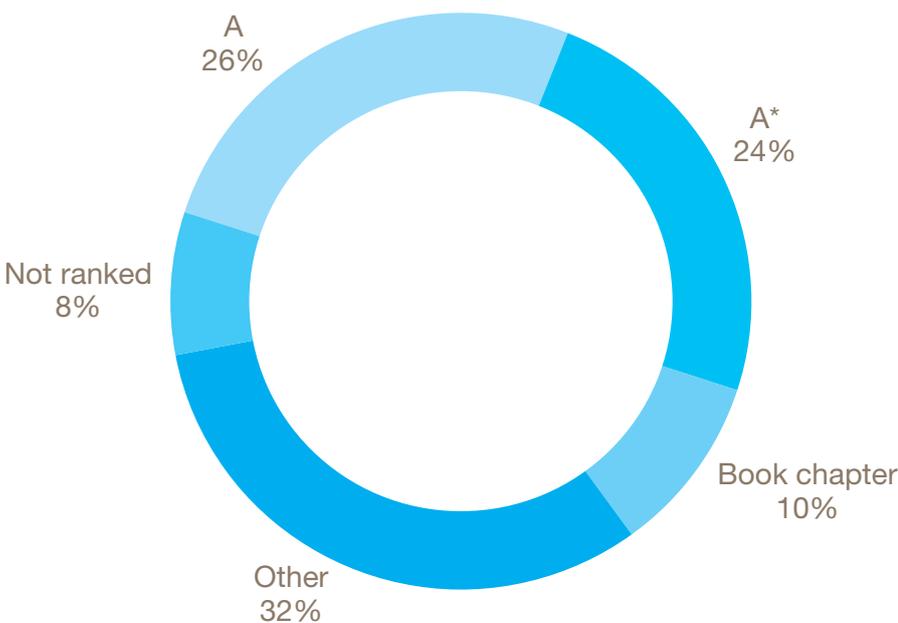
Water, Population and Communities. These partnerships provide important opportunities for our researchers to extend their technical skill sets, and to establish the networks necessary to undertake interdisciplinary research work now and into the future.

Preparations for the delivery of the 2013 South Australian Department of Environment, Water and Natural Resources Aboriginal scholarship have been completed. We are looking forward to continuing with this innovative program next year.

The NCGRT has delivered on its commitment to undertake more industry-led research projects, and in 2012 completed independent studies of the Arrow and Santos coal seam gas proposals. We have consolidated our new international research relationships with the UNESCO International Hydrological Programme and the World Bank. A particular highlight was the recent Asia-Pacific Groundwater

Governance Consultation (held in Beijing in December) to which the NCGRT contributed significantly. This three-day meeting process explored opportunities to improve groundwater management throughout the Asia-Pacific region through the development of more effective governance systems. The meeting provided an important opportunity for the NCGRT to share its expertise with a global audience and a platform for more research and training collaborations in the future.

## PUBLICATION QUALITY



ASHTON CLARIDGE

### Lauren Houthuysen Undergraduate scholarship recipient

Growing up in Craigmore in South Australia, NCGRT Indigenous scholarship holder Lauren Houthuysen spent her holidays with her mother's family in the Riverland. 'During those trips, visiting my uncle's fruit block and going to the river, we were always conscious of water as a big issue.'

When it came to attending university, Lauren followed her interest in science. From the options available, she didn't like the idea of studying policy or management, so she chose environmental science at Flinders University. Her preference for earth science, geology and groundwater subjects led her to apply for a scholarship with the NCGRT.

In conjunction with winning the NCGRT scholarship, Lauren was awarded 12 weeks of full-time work placement with the South Australian Department of Environment, Water and Natural Resources for each year of her scholarship. Her work at the department includes validating data, GIS mapping, and shadowing the process behind getting water allocation plans out to the public.

'It has been so helpful to see how what I learn at university is applied, and since many people in the department have done my degree, I've been getting good advice on picking subjects, doing honours and working with supervisors.'

Now that Lauren has completed her environmental science degree, she has been offered an honours year. She is joining a project on Milingimbi Island in the Northern Territory, testing aquifers that supply the coastal community.

'I feel like this scholarship gave some direction to my interest in hydrogeology. Without it I wouldn't have considered doing an honours year.'

# Program 1

## Innovative Characterisation of Aquifers and Aquitards

### Program leader:

Professor Andy Baker, UNSW

### 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 2012 we remained at full postdoctoral staffing capacity, saying farewell to Anna Greve and welcoming her replacement Ander Guinea. Together with program partners Geoscience Australia and the NSW Department of Primary Industries, our researchers, PhD candidates 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 2012, four papers on heat tracing were published in *Water Resources Research*. Also in 2012 a new constant temperature room has been built and equipped (from both NCGRT and UNSW funding) for a new and improved experimental heat tracing facility.

In November we organised a successful workshop in Sydney on using heat as a tracer. The meeting had 34 attendees with researchers from programs 1, 2 and 3 presenting 10 talks. International collaborators from Denmark and the UK also gave presentations, and representatives from the NSW Office of Water, CSIRO and the Australian Nuclear Science and Technology Organisation were in attendance.

The 3D geological modelling group has focused on developing new international

linkages. Chief Investigator Bryce Kelly has established a new collaboration with Royal Holloway, University of London, and is developing the first 3D palaeo-environmental model of the Surat Basin. Postdoctoral fellow Sanjeev Jha, in conjunction with Program 5's Cameron Holley, has established a new collaboration with University of Illinois (USA), the National Institute of Hydrology (India), the University of São Paulo, (Brazil), and Delft University of Technology (the Netherlands). This team is developing a new analytic element environment. Chief Investigator Grégoire Mariethoz, in association with Jef Caers and Alex Boucher from Stanford University, has signed a contract with Wiley to author a new book on multiple point statistics.

Within the aquitards group, large diameter clay sediment cores were successfully completed at a site in the Upper Namoi with long-term monitoring of hydrological conditions continuing in this area. A field open day was held in October in collaboration with our partners the NSW Department of Primary Industries, attracting many local farmers and mining company representatives.

Program 1 was well represented at the 34th International Geological Congress with many oral presentations and posters of our latest research. In particular, Chief Investigator Mal Cox was co-convenor of the groundwater session. The NCGRT and the Queensland University of Technology hosted a reception for the German Ambassador, Dr Muller, a high-profile event at the congress. This event included addresses by the Chair of the German Committee of the International Union of Geological Sciences (IUGS), and Professor Oberhansli, who was the successful candidate for the new president of IUGS.

Postdoctoral fellow Adam Hartland published the first application of a new method for analysing carbon isotope ratios in dissolved organic carbon in fresh waters. Dissolved organic carbon is a major component of the global carbon cycle; this includes the movement of carbon from soil to groundwater. This research included the optimisation of a system for analysing dissolved organic

carbon in rivers, aquifers and aquitards. This high-precision, low-cost and high-throughput technique is suitable for long-term field deployment and laboratory experiments.

Program 1 researchers continue to inform the coal seam gas debate. Chief Investigator Bryce Kelly published a commentary in the March/April edition of *Australian Geographic*, entitled 'What's the hurry with CSG fracking?' Dr Wendy Timms presented the first findings of her aquitard permeability and field studies at several conferences and workshops around Australia and at the International Association of Hydrogeologists congress. A paper 'Leading practices for assessing the integrity of confining strata: application to mining and coal-seam gas extraction' is available for download, outlining a number of new and integrated approaches for extraction projects.

The centrifuge permeameter has completed three industry contracts to characterise aquitard materials, including permeability. For example, it is not possible to test the very low permeability of deep shales in the Great Artesian Basin using any other technique. Testing to date has demonstrated the sensitivity of permeability to moisture content and jointing.

In 2013, the new experimental heat tracing facility will be taken into use with a series of exciting experiments. Field experiments on heat tracing are planned for Wellington Caves, Maules Creek and Fowlers Gap.

The 3D geological modelling team aims to publish an invited commentary on the impact of groundwater use in the Murray–Darling Basin, a case study on stochastic process-based modelling in the lower Namoi, and a case study on multiple point statistics using transform-invariant distances data from Maules Creek, a Murray–Darling Basin site.

The aquitard team will focus on publishing research completed to date, and on further developing instrumentation for the geocentrifuge. Other projects in progress include studies on nanoparticle and dissolved gas transport in low permeability strata, and the integrity of low permeability caprocks that overlie coal seams and potential sites for carbon sequestration.



WENDY PEEL

**Adam Hartland**  
**Program 1 postdoctoral fellow**

Dr Adam Hartland, from Birmingham in the United Kingdom, calls chemistry the 'central science', because it gives the most insight into all natural sciences: 'It's exciting to work in a chemistry department, getting to apply chemical approaches to a range of environmental problems. And getting to use lots of new toys!'

Adam's interest in hydrogeochemistry (the chemical processes between water and solid substances like sediment and rock) began during a professional placement at New Zealand's National Institute of Water and Atmospheric Research. Nine months later, on his return to the United Kingdom, Adam began a PhD on karst aquifers with the University of Birmingham.

Adam then moved to Sydney, taking a postdoctoral fellowship with the NCGRT at the University of New South Wales' Water Research Laboratory. His work looked at the role of aquitards (lower permeability groundwater systems) in controlling groundwater recharge to aquifers and the impacts on water quality.

'We still have plenty of data to analyse, but preliminary results confirm that groundwater aquitards are important for the quality of water ending up in aquifers. Aquitards seem to shield underlying groundwater from pollutants.'

In November 2012, Adam accepted a position as lecturer in environmental chemistry at the University of Waikato in New Zealand: 'I'm mostly in lecture halls or my office but I'm planning for a regular timeslot in the lab.'

Adam credits his time at the NCGRT and University of New South Wales with developing him as an independent scientist and academic, and retains his affiliation with the NCGRT.

# Program 2

## Hydrodynamics and Modelling of Complex Groundwater Systems

### Program leader:

Professor Craig Simmons, Flinders

### Chief and partner investigators:

Professor Ling Li, UQ

Dr Vincent Post, Flinders

Professor Henning Prommer, UWA

Assoc. Prof. Adrian Werner, Flinders

### Research associates:

Professor Okke Batelaan, Flinders

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 developing modelling practices and tools that can be applied across a range of issues and applications.**

Our work addresses some of the most pressing challenges currently facing hydrogeology, such as geologic heterogeneity, hydraulic and tracer applications, surface water – groundwater interaction, and understanding of and prediction in regional-scale systems. We also specifically tackle current issues which face groundwater modelling, including – but not limited to – model simplicity and complexity, model reliability, and uncertainty. We aim to develop state-of-the-art modelling exemplars to systematically and quantitatively demonstrate how modelling and hydrogeologic prediction can be improved using innovative tools and approaches.

Program 2 has 11 postdoctoral fellows and 12 PhD candidates who are working on a number of major projects, including heterogeneity in groundwater fluids and geologic structures, heterogeneity of streambed sediments and impact for connection to groundwater, modelling groundwater interaction with ephemeral lakes and streams, improving calibration of surface water – groundwater interaction models, simplicity versus complexity in groundwater modelling, and using environmental tracers to constrain hydraulic models.

In addition to a major node in Adelaide, Program 2 has grown to include a node at the University of Western Australia with the appointment of Chief Investigator Henning Prommer. We continue our work at the University of Queensland with Chief Investigator Ling Li's team.

Our relationship with Dr Randy Hunt from the United States Geological Survey (USGS) continued in 2012 spearheaded by the release of two papers published by Randy and Craig Simmons. 'Using every tool in the toolbox' – co-authored by Program 3 leader Peter Cook – was published in the journal *Ground Water* and is an analysis of why not all tools currently available to hydrogeologists are used in every day hydrogeology; 'Updating the debate on model complexity' was published in *GSA Today* and gives an overview of the session run on the topic to the Geological Society of America in 2011.

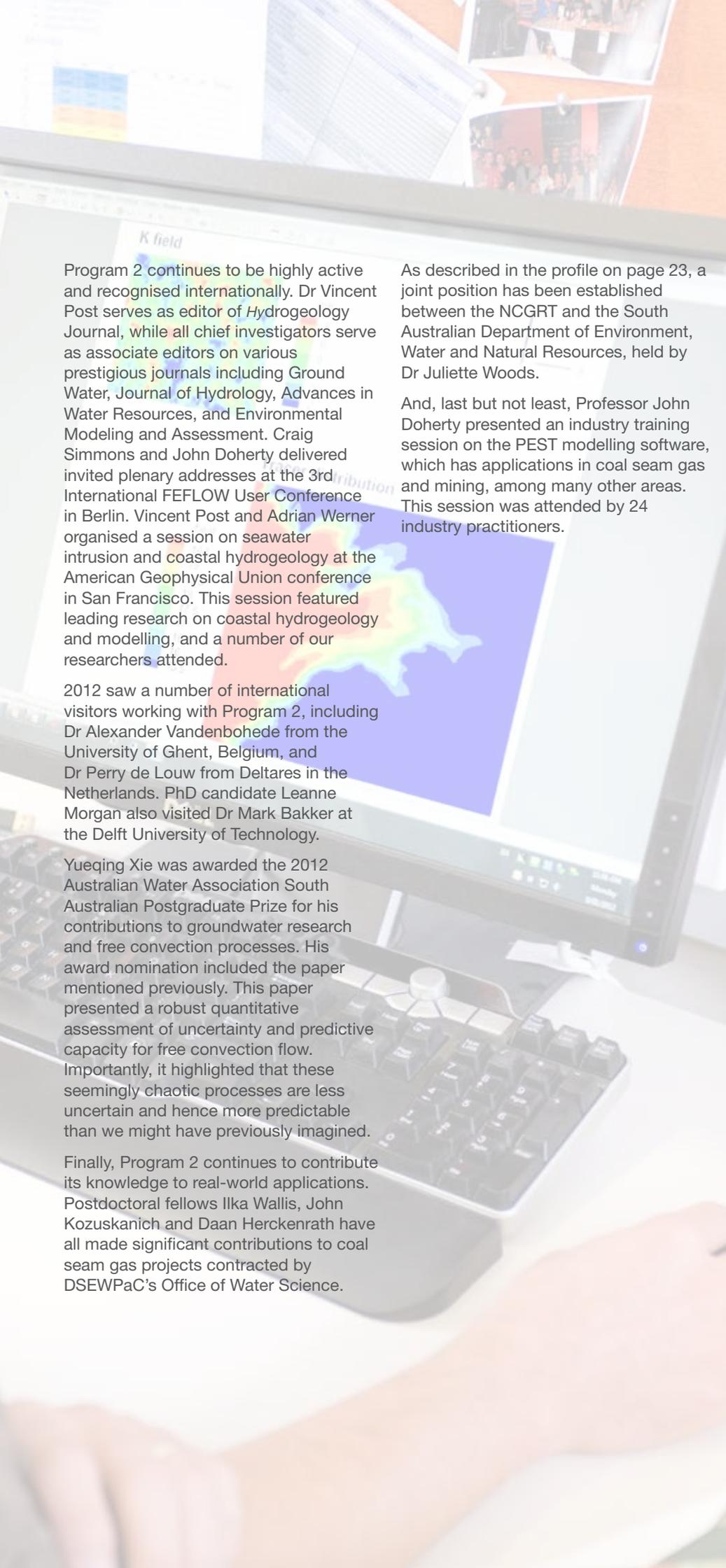
Our relationship with Professor Philip Brunner from the University of Neuchâtel continued with the publication of a paper in the journal *Ground Water*: 'HydroGeoSphere: A Fully Integrated, Physically Based Hydrological Model'. Chief Investigator Adrian Werner's invited paper 'Seawater intrusion processes, investigation and management: recent advances and future challenges', was accepted for publication by *Advances in Water Resources*. These papers demonstrate that Program 2 is providing thought leadership in critical hydrogeology and groundwater modelling topics at an international level.

A number of other research papers appeared in prominent journals in 2012, but only a few are highlighted in this report, as follows:

- Yueqing Xie completed his PhD with the final publication, 'Prediction and uncertainty of free convection phenomena in porous media', in *Water Resources Research*.
- PhD candidate Carlos Ordens published 'Groundwater recharge to a sedimentary aquifer in the topographically closed Uley South Basin, South Australia', in *Hydrogeology Journal*.

- PhD candidate Danica Jakovovic published 'Tracer adsorption in sand-tank experiments of saltwater up-coning', in the *Journal of Hydrology*.
- Adrian Werner and PhD candidate Leanne Morgan published 'Vulnerability indicators of sea water intrusion' in *Ground Water*.
- PhD candidate Jessica Liggett published 'Influence of the first-order exchange coefficient on simulation of coupled surface-subsurface flow' in the *Journal of Hydrology*.
- Craig Simmons contributed to a paper in collaboration with Program 3, which was led by Program 3 postdoctoral fellow Margaret Shanafield: 'Aquifer response to surface water transience in disconnected streams' in *Water Resources Research*.
- Henning Prommer published a number of papers including 'In situ recovery of gold: column leaching experiments and reactive transport modeling' in *Hydrometallurgy*, and 'Elucidating temperature effects on seasonal variations of biogeochemical turnover rates during riverbank filtration', in the *Journal of Hydrology*.
- John Doherty, Craig Simmons and Philip Brunner published 'Uncertainty assessment and implications for data acquisition in support of integrated hydrologic models' in *Water Resources Research*.

In conjunction with SKM, NTEC Environmental Technology and CSIRO, Program 2 ran a short course on the national groundwater modelling guidelines in May. This course was designed to present an overview of the key ideas presented in the recently released Australian Groundwater Modelling Guidelines. The guidelines themselves were developed by the NCGRT and SKM and published by the National Water Commission in mid-2012; from Program 2, Vincent Post and Adrian Werner authored a chapter, while Craig Simmons and postdoctoral fellow Juliette Woods acted as reviewers.



Program 2 continues to be highly active and recognised internationally. Dr Vincent Post serves as editor of *Hydrogeology Journal*, while all chief investigators serve as associate editors on various prestigious journals including *Ground Water*, *Journal of Hydrology*, *Advances in Water Resources*, and *Environmental Modeling and Assessment*. Craig Simmons and John Doherty delivered invited plenary addresses at the 3rd International FEFLOW User Conference in Berlin. Vincent Post and Adrian Werner organised a session on seawater intrusion and coastal hydrogeology at the American Geophysical Union conference in San Francisco. This session featured leading research on coastal hydrogeology and modelling, and a number of our researchers attended.

2012 saw a number of international visitors working with Program 2, including Dr Alexander Vandenbohede from the University of Ghent, Belgium, and Dr Perry de Louw from Deltares in the Netherlands. PhD candidate Leanne Morgan also visited Dr Mark Bakker at the Delft University of Technology.

Yueqing Xie was awarded the 2012 Australian Water Association South Australian Postgraduate Prize for his contributions to groundwater research and free convection processes. His award nomination included the paper mentioned previously. This paper presented a robust quantitative assessment of uncertainty and predictive capacity for free convection flow. Importantly, it highlighted that these seemingly chaotic processes are less uncertain and hence more predictable than we might have previously imagined.

Finally, Program 2 continues to contribute its knowledge to real-world applications. Postdoctoral fellows Ilka Wallis, John Kozuskanich and Daan Herckenrath have all made significant contributions to coal seam gas projects contracted by DSEWPaC's Office of Water Science.

As described in the profile on page 23, a joint position has been established between the NCGRT and the South Australian Department of Environment, Water and Natural Resources, held by Dr Juliette Woods.

And, last but not least, Professor John Doherty presented an industry training session on the PEST modelling software, which has applications in coal seam gas and mining, among many other areas. This session was attended by 24 industry practitioners.

HEIDLINEHAN

### **Ilka Wallis Program 2 postdoctoral fellow**

After completing her masters in hydrogeology at the University of Kiel in her home country of Germany, Dr Ilka Wallis worked for more than 10 years as a hydrogeologist and numerical modeller in South Africa, the United Kingdom, India and Australia.

'Most of my work over those years was about improving our understanding of hydrological systems through analytical and numerical models, to help water managers plan and predict outcomes. What interests me most is using numerical modelling to translate how physical flow and transport processes integrate with geochemical reactions in complex groundwater systems.'

Ilka finally settled in Australia for a PhD at Flinders University. Her PhD looked at reactive transport modelling, and particularly the transport of arsenic underground, trying to predict the flow of groundwater together with the distribution of heavy metals and other changes in geochemistry.

Ilka's postdoctoral study at the NCGRT, in collaboration with CSIRO, is exploring the possibility of injecting coal seam gas water into drinking water aquifers for disposal, from a geochemical point of view.

'With a numerical model, that is, a quantitative framework, I try to replicate what I see in the field data, and create a mathematical description of the processes between rock and water underground. If you can replicate the process, then you can predict what will happen if you disturb it in some way.'

During her time in South Africa, Ilka contributed to lecturing at Rhodes University and the University of Pretoria, a role she is happy to be reprising by lecturing for Flinders University's School of the Environment.

# Program 3

## Surface Water – Groundwater Interactions

### Program leader:

Professor Peter Cook, Flinders and CSIRO

### Chief investigators:

Dr Martin Andersen, UNSW

Professor Ian Cartwright, Monash

Dr Massimo Gasparon, UQ

Dr Marc LeBlanc, James Cook

Professor David Lockington, UQ

### Partner investigators:

Dr Glenn Harrington, CSIRO

Dr Sébastien Lamontagne, 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.**

Program 3 is active at a large number of field sites, spanning all mainland states and the Northern Territory. We currently have 8 postdoctoral fellows and 12 PhD candidates and the program also trained 12 honours students in 2012.

Most PhD and postdoctoral projects are now well underway and producing significant results. Communication of research results has become a focus, and the program is having a significant impact on the international stage. Program 3 sent strong contingents to the US National Ground Water Association (NGWA) summit in California in May, and also to the Geological Society of America (GSA) annual congress in North Carolina in November.

The program presented four papers at the NGWA summit, and three papers at the GSA congress. Of particular note, postdoctoral fellow Dr Jordi Batlle-Aguilar gave an invited talk at the GSA congress on his study of surface water – groundwater

interaction in the Mitchell River in north Queensland. This project has been a collaboration between NCGRT researchers at James Cook University, Flinders University and CSIRO, and has been using water chemistry in the stream to identify the aquifers that are contributing baseflow to the river. It is a great achievement for the NCGRT's young researchers to be reaching the level where they are being specifically invited to attend such important international conferences.

The communication push will continue in 2013, and postdoctoral fellow Harald Hofmann and Chief Investigator Ian Cartwright are organising a special session at the 2013 European Geosciences Union general assembly on measuring and modelling surface water – groundwater interactions.

Program 3 continues to work on methods for assessing surface water – groundwater connectivity. Postdoctoral fellow Margaret Shanafield has completed an analysis on the relationship between surface water – groundwater connection status, and the response of piezometers near rivers to changes in river level. The work has shown that, in some circumstances, it is possible to determine that a river is disconnected from the groundwater by comparing water level changes in the river with those measured in an adjacent piezometer. A paper on this work has now been accepted by *Water Resources Research* – one of the most prestigious journals in this field. This work is continuing through an exchange program between Flinders University and the University of Neuchâtel. As part of this ongoing work, Margaret travelled to Switzerland in July, and Flinders University hosted a student from the University of Neuchâtel between October and December.

Postdoctoral fellows Ben Gilfedder and Harald Hofmann published a paper in the high-impact journal *Environmental Science and Technology* detailing novel methods of continuously measuring radon at low concentrations. This work was also presented at the American

Geophysical Union in San Francisco in December. A paper that uses this technology to study short-term groundwater fluxes to wetlands has also been submitted to *Ground Water*. It shows that groundwater fluxes to wetlands respond over a few days to external processes such as hydraulic loading on the floodplain and river levels.

The Ti Tree Basin in the Northern Territory is providing a focal point for collaboration between programs 3 and 4. A new postdoctoral fellow, Chao Chen, commenced with the NCGRT in June 2012. Chao is a joint appointment between Flinders University and the University of Technology, Sydney, and is a split position between these programs. She will share her time between the two universities, and will become the link for increased collaboration between other Program 3 and Program 4 students working at this field site.

2012 saw the completion of field installations at the Ti Tree research site. One of the emphases at this site is understanding groundwater recharge from ephemeral streams. Thirty piezometers have been installed in the bed of the river, and sapflow loggers have been installed in riparian vegetation to assess how they respond to river flow events. A detailed aerial survey of the site also took place in November, in collaboration with Airborne Research Australia. The team are now hoping for some large rainfall this summer to trigger a river flow event.



HEIDLINEHAN

**Margaret Shanafield**  
**Program 3 postdoctoral fellow**

Sometimes Lake Tahoe is so clear you can see 40 metres down. Chicago native Dr Margaret Shanafield did her masters in surface-water hydrology there, but has since changed focus to something far less transparent: how surface water and groundwater interact.

‘Shifting to groundwater was like going over to the dark side,’ she jokes.

Joining the National Centre for Groundwater Research and Training two years ago for her postdoctoral study, Margaret is exploring how measuring the temperature at different streambed depths can be used to track how water moves between rivers and aquifers.

Margaret led a state-of-the-art project using fibre optic cable as a giant thermometer to track water seeping into drainage channels in the southeast of South Australia. Using a laser to bounce light down the cable, a measurement can be taken at every metre and every 30 seconds.

This data is helping the South Australian Department for Environment, Water, and Natural Resources to better manage the channels and the aquifers below to meet both environmental and agricultural demands.

Margaret is also helping Flinders University PhD candidates to apply temperature tracing in their projects. One such candidate is tracing water for Rio Tinto, seeing whether water discharged from a specific mine is seeping back in again.

Margaret’s recent paper in *Water Resources Research* highlights her latest work: a new way to discover whether a stream is connected to an aquifer by how quickly the nearby water table is recharged during high stream flows.

Margaret is one of two winners of the 2012 NCGRT Director’s Award.

# Program 4

## Groundwater–Vegetation– Atmosphere Interactions

### Program leader:

Professor David Lockington, UQ

### Chief investigators:

Professor Ian Cartwright, Monash

Dr Edoardo Daly, Monash

Professor Derek Eamus, UTS

Dr Huade Guan, Flinders

Professor Catherine Lovelock, UQ

Dr Matthew McCabe, UNSW

Assoc. Prof. John Webb, La Trobe

### Research associate:

Dr John Hutson, Flinders

**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.**

This research is becoming increasingly focused around a core set of field sites, typically involving researchers from other programs, as well as a number of researchers external to the NCGRT.

These sites are:

- **south-east Queensland**

Several sites in coastal south-east Queensland are being developed to capture eco-hydrological fluxes associated with groundwater-driven wetlands. Typical instrument stations monitor groundwater, soil moisture profiles, evapotranspiration and climate. Primary sites are being established on Bribie and North Stradbroke islands. Six PhD candidates and three postdoctoral fellows are working at the sites.

- **Kangaloon, New South Wales**

This site 110 km south-west of Sydney is a focus for researchers based at the University of Technology, Sydney. Researchers at this site are trying to gain a better understanding of the relationship between groundwater availability and plant traits.

- **Baldry, New South Wales**

The Baldry site is located in the Goobang National Park, near the town of Parkes, and is equipped for surface collection. Matthew McCabe and UNSW postdoctoral fellow Hoori Ajami are focusing on surface water – groundwater interactions at this site.

- **south-west Victorian forests**

This set of six paired sites is a focus for postdoctoral fellow Dr Samantha Grover and other researchers, John Webb, Edoardo Daly and La Trobe PhD candidate Josh Dean. Program 4 researchers from the University of Queensland have helped set up evapotranspiration instruments at this site.

- **Ti Tree, Northern Territory**

The Ti Tree Super Science site is a major focus for researchers from both programs 3 and 4, where we are investigating groundwater use by vegetation in arid zones.

We expect instrumentation of these key sites for long-term groundwater–vegetation–atmosphere interaction research to be finalised in 2013.

Program 4 has 8 postdoctoral fellows and 15 PhD candidates. Nadia Santini was awarded a PhD this year for her work on the growth response of mangroves to variation in groundwater sources; she is the first Program 4 PhD student to complete.

Support from the Department of Innovation, Industry, Science and Research's Groundwater Education Investment Fund has enabled us to establish well-instrumented sites on Queensland's North Stradbroke and Bribie islands for long-term studies of these complex systems. A key aspect to our research is the assessment of different local-scale monitoring tools, especially the application of sap-flow meters. Program 4 at the University of Queensland hosted a collaborating research team from the University of Ghent for a two-month intensive investigation of groundwater–vegetation interaction at these sites in 2012. In addition, the results from a comprehensive experiment designed to

establish the potential of two new approaches (and the limitations of current standards) for estimating the sapwood area was accepted for publication in *Tree Physiology*. It was co-authored by postdoctoral fellow Dr Adrien Guyot, PhD candidate Junliang Fan and David Lockington.

Program 4 research topics are of significance to water and environment agencies across the country, and our interaction with a number of organisations continued in 2012. Collaboration with the south-east Queensland water agency, Seqwater, continues to enable doctoral and postdoctoral research into coastal groundwater–vegetation interaction on North Stradbroke and Bribie islands; Seqwater manages the aquifers here. Researchers are quantifying the local meteorology, evapotranspiration from key land uses, and the groundwater sensitivity of groundwater-dependent tree and wetland species. A study of water sources used by estuarine trees by David Lockington, Program 3 Chief Investigator Dr Massimo Gasparon and Catherine Lovelock among others was accepted in 2012 for publication in *Oecologia*, and revealed a high level of complexity of vegetation water use in estuarine settings.

At the Kangaloon site, PhD candidate Sepideh Zolfaghar, together with Derek Eamus and postdoctoral fellow Randol Villalobos, has managed to identify the key measurable functional characteristics of eucalypt response to variation in depth to groundwater. The research gives us important insight into effective assessment approaches for groundwater-dependent ecosystems. The group also collaborates with Program 3 researchers at the arid zone Ti Tree site, especially as riparian zone tree hydraulic functional behaviour is also important to establish groundwater-dependent ecosystem assessment guidelines.

In south-west Victoria, PhD candidate Josh Dean, in collaboration with the Victorian Department of Primary Industries, has continued his research on

blue gum forestry in south-west Victoria and its impact on regional groundwater resources. Program 4 personnel at both Monash and La Trobe universities are involved in the project.

At Monash University, PhD candidate Parikshit Verma is concluding his assessment of the significance of root distribution on hydraulic lift, evapotranspiration and recharge dynamics (and how we should measure them in the field). In 2012, he along with Edoardo Daly and others published a review of groundwater–vegetation–atmosphere interaction models in *Reviews of Geophysics*.

Large scale climate–vegetation hydrological modelling and monitoring strategies are being explored by Program 4 researchers from the University of New South Wales, along with government agencies at Baldry. In 2012, postdoctoral fellow Hoori Ajami developed PARFLOW and MIKE-SHE models of the region using remotely sensed and local hydrological data. This follows previous comparison tests of these two models. The monitoring–modelling framework for this site is being developed to support long-term research into large scale hydro-climate processes.

Program 4 researchers at Flinders University are pursuing related research topics. The Flinders team wants to improve understanding of topographic and vegetation controls on groundwater–vegetation–atmosphere interactions and the implications for groundwater recharge and discharge. A particular focus in 2012 was the development of sites and experiments for assessing several larger scale methodologies for groundwater recharge estimation and soil–plant–atmosphere partitioning of sub-surface water. One of these researchers, Flinders PhD candidate Rose Deng, won the Farvolden Award for best student paper at the 2012 US National Ground Water Association Summit.

2013 will see a significant number of our PhD candidates complete their research and submit their theses. Postdoctoral projects will also mature. The International Association of Hydrogeologists congress in Perth in September will provide a significant opportunity for communicating the outcomes from Program 4 (and, more broadly, NCGRT) research.



### **Joshua Dean Program 4 PhD candidate**

The world's southernmost capital city, New Zealand's Wellington, sits on a natural harbour, surrounded by green hills. This is where PhD candidate Joshua Dean grew up, and where he gets his avid interest in water as a vital resource and how the Earth works and regulates itself.

While studying his honours in surface water geomorphology, Joshua saw a notice offering groundwater scholarships in Australia, and has been at the National Centre for Groundwater Research and Training for three years, studying at La Trobe University.

The Victorian Department of Primary Industries funds his project, which focuses on the impact of tree plantations on surface water and groundwater quality and quantity: 'There's a lot of anecdotal evidence about using trees to lower the water table and reduce salinity, but during the drought people began to say that the trees used too much water. My research is trying to quantify the effects of biomass water use more accurately.'

Using bores he has sunk at two neighbouring sites in Victoria's Grampians, Joshua is measuring the groundwater table to a high level of accuracy and directly measuring water use by the vegetation. His aim is to find ways to minimise the impact of plantations on groundwater resources, but still usefully combat dryland salinity.

'One of the most important discoveries so far is that, in this region, groundwater recharge occurs mostly further down the slopes, and so to avoid excess water use by a plantation, we can plant on the upper areas of the catchments.'

# Program 5

## Integrating Socioeconomics, Policy and Decision Support

### Program leader:

Professor Tony Jakeman, ANU

### Chief investigators:

Dr Barry Croke, ANU

Professor Allan Curtis, Charles Sturt

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

Dr Jennifer Ticehurst, 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.**

The unique interdisciplinary character of our research recognises that the sheer complexity of groundwater systems calls for innovative methods and tools to assess socioeconomic and environmental outcomes of policy options across time and space, cater for the diversity of stakeholder knowledge and views, and to account for different sources and types of uncertainty.

Our research aims to integrate hydrology, hydrogeology, ecology and the social sciences including economic, legal and policy dimensions. This involves engaging with stakeholders in management agencies as well as landholders and scientific experts to frame the issues of concern, develop conceptual models and approaches and discuss their subsequent implementation and findings. Emphasis is placed on the process of engagement to produce and share knowledge and to establish trust and ownership, as much as on the outcomes of options and the outputs of new tools and knowledge.

Projects in the Willunga, Lachlan and Namoi catchments are now well established and in 2011 we began a

three-year project in the Campaspe catchment. We regard place-based research of these integrative projects as essential to learn how to build the interdisciplinary knowledge base and scientific tools to address similar groundwater problems across Australia.

Progress on the Willunga project in 2012 has included the development of an integrated model. Sondoss El Sawah along with PhD candidate Joseph Guillaume and Allan Curtis's team ran a set of interviews with key stakeholder groups, including catchment managers, policy makers, non-government organisations and landholders, on each group's perspective on managing the groundwater system. As a result, we constructed a set of profiles describing each group's objectives and the decisions available to them, along with relevant questions and issues of concern. We have completed the conceptual design of the integrated model components, including the ecological model and an agent-based model for landholder decisions. The conceptual design was informed by outcomes from the stakeholder engagement process along with expert input. For example, we ran a workshop in March 2012 to bring together experts in hydro-ecological modelling to contribute to the conceptual design of the ecological model. The next phase of the project will focus on building numerical models, sharing results with stakeholders, and assessing the learning outcomes of the modelling experience.

The Lachlan project, under the leadership of Wendy Merritt and Allan Curtis along with postdoctoral fellow Baihua Fu, is focused around developing hydro-ecological models and tools for the Lachlan catchment that incorporate groundwater-ecosystem interactions as appropriate. A component of the project is building on the IBIS catchment-scale model framework, with work in 2012 commencing on the development of a simple surface water – groundwater model which will be used as input to ecological response models of the nationally and locally significant wetlands in the catchment.

However, the main focus of the Lachlan project in 2012 was the development of a framework for a data management system and modelling tool tailored to short-term planning around environmental water. There is strong interest from the Lachlan Catchment Management Authority, in particular, in this work. The development of this data management system will be a major task of the coming 12 months.

The Namoi and Willunga projects continue to be used as vehicles to extend our framework and tools for managing uncertainty in groundwater management by creating a 'closed question modelling' methodology. The methodology potentially provides a new perspective for addressing uncertainty in a simple, practical, yet comprehensive way. The Namoi project resulted in a publication on 'Directions for social research to underpin improved groundwater management' authored by postdoctoral fellow Emily Sharp and Allan Curtis.

In 2012 we continued work on assessing the opportunities for managed aquifer recharge at large catchment scales and held the first national workshop on this issue in April 2012.

This has led firstly to an interdisciplinary NCGRT paper, 'Managed aquifer recharge in farming landscapes using large floods: an opportunity to improve outcomes for the Murray-Darling Basin', led by PhD candidate Andrea Rawluk, and co-authored by PhD candidates Andrew Ross and Muhammed Arshad, postdoctoral fellow Emily Sharp, along with Program 1 Chief Investigator Bryce Kelly, and Partner Investigator Ross Brodie, and Tony Jakeman, Alan Curtis, and Barry Croke.

Secondly, we are organising a research forum in March 2013, co-convened by Charles Sturt University, the Australian National University and the University of New South Wales, to develop the agenda for research to underpin conjunctive use around greenfield agriculture in the Ovens Valley. This is being led by Allan Curtis and Tony Jakeman.

In 2012, Program 5 presented the Groundwater for Decision Makers industry training course for the second time. NCGRT nodes at Charles Sturt University and the Australian National University also joined with the University of Canberra in a three-year Commonwealth-funded collaborative futures network on Murray–Darling futures.

The ANU Australian Centre for Environmental Law's Water Law and Policy 2012 conference, held on 7 December, included three presentations sponsored by the NCGRT. Dr Anita Foerster from the University of Melbourne Law School, presented 'An environmental law assessment of the Murray–Darling Basin Plan, with a focus on the sustainable diversion limits for groundwater', PhD candidate Rachel Blakers and Tony Jakeman presented 'Water allocation planning and management: the role of integrated modelling and assessment', and Alex Gardner and PhD candidate Madeleine Hartley presented 'Legal scenarios for integrated modelling'.

Upon returning from a year of external study at the Sturm College of Law, Denver University, Colorado, University of Western Australia PhD candidate Madeleine Hartley has begun work on applying the Colorado learning on water use efficiency to Gngalara. Additionally, the legal scenarios for the Namoi integrated model were further refined.

Research on groundwater governance is progressing on several fronts. This includes work by postdoctoral fellow Darren Sinclair, research affiliate Cameron Holley and Neil Gunningham on innovative approaches to groundwater governance, including assessing the efficacy of existing approaches to groundwater resource management, particularly compliance and enforcement; exploring alternative policy and regulatory approaches; and examining the potential for collaborative governance in groundwater. Their major activity in 2012 was completion of a comprehensive survey of approximately 4000 water

licence holders in New South Wales, covering their knowledge and perceptions of, and experiences with, compliance and enforcement. This was part of a research partnership with the NSW Office of Water. Although the statistical results will not be available until early 2013, some preliminary findings were presented at the Water Law and Policy conference. During 2012, Darren and Cameron also conducted field work on collaborative groundwater governance in California, and gave two presentations at the US National Ground Water Association summit, as well as presenting to the Delta Science Program in Sacramento. Overall, Darren and Cameron published five journal articles and gave eight presentations during 2012.

Jennifer McKay and colleagues continue to explore macro issues in water planning and governance for groundwater and conjunctive uses of water in two main data collections. The first is with water planners in all parts of Australia with an emphasis on the Murray–Darling Basin and the second is based around the business model of Salisbury Council in South Australia for managed aquifer recharge water.



HEIDLINEHAN

### **Madeleine Hartley Program 5 PhD candidate**

PhD candidate Madeleine Hartley remembers the drought finally breaking in her hometown in New South Wales, and how quickly people's actions changed: 'It seemed strange. Why not always use water wisely?'

Perhaps this impression prompted Madeleine to specialise in environmental law; to complete an honours in achieving sustainable groundwater management in New South Wales; and, in an unusual move for a law graduate, to undertake a PhD.

Madeleine joined the National Centre for Groundwater Research and Training three years ago for a PhD at the University of Western Australia in groundwater law. She is exploring if and how to legislate for groundwater-use efficiency as a method of ensuring the sustainable development of groundwater resources.

Madeleine is using three case studies: the groundwater systems underlying Perth, the Namoi (close to home), and, for an international flavour, the Denver Basin aquifer system in Colorado. Her year-long exchange there introduced her to a whole new landscape for water law with some potentially useful insights on the possible costs and benefits of water regulation in Australia.

'In Colorado, water law is not a component of environmental law as in Australia – it's like a subset of property law. They have dedicated water lawyers and water courts; here, water law is restricted to a few notable academics and a few notable cases.

'Scientists seem hesitant for the law to be involved in regulating water-use efficiency, but it has a role in removing administrative barriers and ensuring transparency. And climate change projections suggesting water shortages in Perth and Colorado are justification for legislating groundwater use efficiency, especially since slow recharge means demand could outstrip supply.'



Capacitw

# Capacity building

**The NCGRT's capacity-building activities have two dimensions. The first is internal, and is focused on attracting and developing the potential of our students and researchers. The second is external and focused on promoting the transfer and adoption of our knowledge across the scientific, policy and groundwater management communities.**

## Recruitment

The NCGRT's recruitment activities have continued to deliver strong results – we have achieved our cumulative recruitment targets nearly a year ahead of schedule. Our 2012 national call for PhD candidates produced 78 applications. It is pleasing to see that interest in PhD opportunities remains so high after three years of intensive recruitment activity. Our recruitment success reflects positively on the NCGRT's growing reputation as one of the world's leading groundwater science organisations. Our search for the best domestic and international research talent will continue in 2013 as part of our ongoing commitment to developing Australia's groundwater capacity. These recruitment activities will ensure that the NCGRT maintains research momentum, and is in the strongest possible position to mount successful future funding applications.

## Professional development

The NCGRT has continued to deliver a range of professional development activities as part of its ongoing efforts to create a research environment in which its researchers and students can thrive. One of the key highlights was the delivery of a nationwide program of professional development workshops for our postdoctoral fellows and PhD candidates.

This year's workshops focused on communication and science writing skills and were delivered by Professor Andrew Boulton, of the University of New England and CSIRO Publishing, and Mr Julian Cribb, of Julian Cribb and Associates. The workshops explored the role that knowledge brokers, such as journalists, policy and industry professionals, can play in promoting the transfer and adoption of scientific research. The NCGRT is reinforcing this message by updating its 2013 key performance indicators to include the production of an expanded range of information resources.

The workshops also included a media release writing competition, which was won by Dr Juliette Woods, a Program 2 postdoctoral fellow, based at Flinders University; her piece was entitled 'Efficient irrigators improve Murray health'. The NCGRT is now working with Juliette to finalise this piece for release.

## NCGRT Summer School

The 2012 Summer School was held in Canberra at the Australian Academy of Science 'Shine Dome' in late November. The event was attended by 130 members of the NCGRT's research community. The key theme of this year's program was examining the role that policy plays in influencing changes in groundwater management practice. Our invited speakers provided insights on the powerful role that academic research can play in catalysing change, provided the research is aligned with policy priority needs and communicated in an engaging and accessible way. The speakers also emphasised the importance of producing credible and verifiable research data, as well as demonstrating a willingness to objectively analyse the strengths and weaknesses of research findings.

Members of the ABC television program 'The Gruen Transfer' continued the communication theme with a workshop on how to 'sell' groundwater to policy makers, industry practitioners and the public. The workshop was a major hit, with the Gruen team providing new perspectives on how we can ignite interest in the NCGRT's research.

In addition to the extensive line-up of external speakers, this year's Summer School program also created opportunities for five of our leading postdoctoral fellows to present research papers to their peers. Delivering papers is an essential skill and an important part of research life. The inclusion of our home-grown talent in this year's event was extremely well received.

## Training survey

Another major accomplishment in 2012 was the completion of a survey into the training experiences and future professional development needs of our PhD candidates. The survey was initiated following our mid-term review and the results were very positive. The majority of respondents indicated that they were



## Juliette Woods Program 2 postdoctoral fellow

A recent addition to the National Centre for Groundwater Research and Training, Dr Juliette Woods comes with a decade of consulting experience and plenty of ideas: 'As a consultant you answer a specific question for the client and location, so I have a backlog of local solutions I would like to apply more widely.'

An applied mathematician, Juliette ended up in the groundwater field because the work of the student next to her looked more interesting than her own honours in population biology. She saw that groundwater modelling would use all her studies in applied maths, computing, physics, and geology.

Juliette has since specialised in groundwater and salinity: modelling the Willunga Basin for the South Australian government; completing a PhD at the University of Adelaide in applied maths, simulating River Murray salt interception disposal basins; testing an all-purpose fluid flow computation on groundwater simulations of Australian salt lakes at the University of Texas' Institute for Computational Engineering and Sciences; and, back in Adelaide, working as a consultant for government, the Murray-Darling Basin Authority and natural resource management boards.

Having worked in the private, public and academic fields, Juliette is a strong advocate for cross-sector exchanges; she now splits her time between the NCGRT and work for the state government on climate change and salinity.

'More communication between academia and government is a win win: universities can know what government needs for environmental management and can access government data; the government, as a result, gets better methods tailored to their needs and better ways of managing their data.'

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>CAPACITY BUILDING</b>					
C1	Number of new postdoctoral fellows recruited each year	10	16	41	55
C2	Number of new PhD candidates recruited each year	6	9	54	60
C3	PhD completion rate	95%	80%*	N/A	N/A
C4	Number of new honours students recruited each year	10	21	43	57
C5	Honours student completion rate	100%	95% <sup>^</sup>	100%	95%
C6a	Number of professional training courses run by the NCGRT for non-NCGRT staff and students	10 courses	24 courses	35 courses	51 courses
C6b	Number of people attending professional training courses run by the NCGRT for non-NCGRT staff and students	400 attendees	664 attendees	1450 attendees	1612 attendees

\* Of the five PhD candidates who were expected to complete their studies in 2012, four successfully submitted their theses and one candidate withdrew at the beginning of 2012 to take a position in the South Australian Government.

<sup>^</sup> Of the 21 students who commenced in 2012, one elected to extend their project by an additional 12 months.

COURSE	LOCATION	ATTENDEES	NOTES
<b>NCGRT 2012 INDUSTRY TRAINING COURSES</b>			
Getting to Know Groundwater	Nelson, NZ	31	
Australian Groundwater School	Perth	37	
	Sydney	42	
	Adelaide	32	
Australian Groundwater School	Canberra	31	In-house training at Geoscience Australia
Coal Seam Gas: The Science	Canberra	40	In-house training for the Office of Water Science
Coal Seam Gas: The Science	Sydney	36	
	Brisbane	35	
Coal Seam Gas Workshop	Brisbane Melbourne Sydney	48 49 50	Held in conjunction with the Australian Water Association
Soil & Groundwater Pollution	Sydney Perth	22 12	Held in conjunction with the Australian Water Association
Groundwater Essentials	Mount Lofty Ranges	26	
	Elliston	12	
	Port Lincoln	30	
Groundwater in Mining	Brisbane	24	
	Perth	30	
PEST Modelling	Brisbane	24	
Groundwater use by Vegetation	Sydney	8	
Groundwater in the Murray–Darling Basin	Melbourne	11	
Groundwater Modelling Guidelines	Melbourne	12	
Groundwater for Decision Makers	Canberra	12	
Groundwater Resource Management in Agriculture	Brisbane	10	Training for a delegation from the Thai government
<b>TOTAL</b>		<b>24</b>	<b>664</b>

either 'satisfied' or 'very satisfied' with all aspects of the PhD training experience, including the level and quality of their contact time with supervisors, fellow NCGRT researchers and students; and their ability to access experimental research materials and equipment. Students are also regularly accessing the technical and professional development programs that are offered by their home universities and the NCGRT. The survey also indicated strong interest for courses on numerical modelling, grant writing and the management of interdisciplinary research projects. We will be looking to include all of these topics in next year's professional development program.

### Industry training

The NCGRT's groundwater industry training program had its origins over 20 years ago. It is recognised as the industry leader in groundwater professional education, offering short courses, technology transfer, technical training and workshops across Australia.

In 2011, the training team met its target of delivering 16 training courses; however, total attendee numbers were slightly below our target of 550. This was due to a number of factors, including poor economic conditions leading to reduced training budgets in our traditional markets and new competitors in the groundwater training space.

In response we initiated a comprehensive review of our training program, using feedback from our annual NCGRT stakeholder survey to help focus and refine our thinking. This process has resulted in a number of key changes to the way in which we will approach industry training in future including:

- an adoption of technology to help manage and communicate our training program and also to provide a platform for delivery
- an increased focus on quality, ensuring that our training offerings are regularly reviewed and that we use only the best presenters from academia, industry and government
- a refresh of our branding and messaging that clearly positions us as the national leader in groundwater training
- the linking and communication (where appropriate) of our research through our training courses
- the incorporation of 'thought leadership' workshops on groundwater issues of national significance
- the development of courses in growth areas like mining and coal seam gas
- a focus on delivering in-house training tailored to key stakeholder organisations
- a deliberate strategy of fostering and formalising relationships with key industry associations and key international organisations.

Although 2012 started slowly in terms of training numbers, much of this reflected the focus on getting the fundamentals of the operation right and implementing the appropriate changes from which the program could grow. The second half of 2012 was exceptionally busy and confirmed NCGRT as the premier provider of groundwater training activities in Australia. In 2012 the industry training team delivered 24 training activities to 664 attendees.

The industry training team also led the establishment of partnerships for NCGRT with the Australian Water Association, the US National Ground Water Association and the International Association of Hydrogeologists.

We have embraced a culture of continuous improvement and at the end of 2012 commenced an independent external review of our training operations to identify where we might be able to gain efficiencies in the business unit.

See the previous page for capacity building key performance indicators and a full list of training courses run in 2012.



HEIDLINEHAN

### Nina Welti Program 4 postdoctoral fellow

Trudging through ankle-deep muck in North Stradbroke Island's pristine mangroves is all in a day's work for Dr Nina Welti, who began her career in wetland restoration at 15 years old.

Nina checks one of the 45 wells she has installed here for monitoring purposes: 'This entire island is very low in the basic nutrients of carbon, nitrogen and phosphorus, so it is a tight balance to maintain the ecosystem functions – using North Stradbroke's pristine 'baseline condition' coastal wetlands, we want to quantify the role groundwater plays in moving nutrients around in the ecosystem.'

Once she has this baseline data, so difficult to attain in a world where pristine coastal ecosystems are rapidly disappearing, Nina aims to predict how the island's balance may respond to predicted climate change stresses. This research is sorely needed: coastal wetland systems are very poorly studied in Australia and there is little to no baseline data.

Born in the United Kingdom to Finnish and Swiss parents, raised in the United States, Nina studied wetland and floodplain restoration in the US (Bachelor of Science), Finland (masters), and Austria (PhD) before coming to Australia for her job in Brisbane with the University of Queensland. She joined the NCGRT in February 2012.

'My interest has always been, does restoring these wetlands do anything? How are we changing the nitrogen, carbon and phosphorus that are the building blocks of an ecosystem? It's our duty to measure this and justify the costs to the community.'



Outreach

# Outreach

**The focus of the NCGRT's outreach strategy in 2012 was on delivering a more extensive and ambitious range of activities and publications to raise the profile of the centre among the broader water community in Australia and internationally.**

As the NCGRT continues to mature and more research becomes available, it is becoming critically important to extend our knowledge transfer activities and show the valuable role that the NCGRT is playing in advancing Australia's groundwater expertise and international reputation.

Outreach activities have been continued, improved or introduced based on our understanding of our stakeholders and prospective audiences. Overall, the results have been very positive as demonstrated by the fact that the NCGRT successfully achieved all of its 2012 outreach performance targets.

## Events

The NCGRT participated in a broader range of external events in 2012 for our staff and researchers to connect with end users, share our expertise and verify knowledge gaps.

Some of the major events at which the NCGRT had a presence in 2012 included the OzWater Conference (Sydney, May), the US National Ground Water Association Summit (California, May), the 34th International Geological Congress (Brisbane, August), the 39th International Association of Hydrogeologists Congress (Niagara Falls, September), and the Geological Society of America's Annual Meeting and Exposition (Charlotte, November).

Internally, the NCGRT broadened the format of our annual Summer School to create opportunities for our researchers to engage directly with key stakeholders and present their research.

Several smaller events were also held during the year to highlight research projects or findings to water industry stakeholders or interested community members. For example in October, the NCGRT held a number of talks on the results coming out of our Willunga research site.

## Media

The NCGRT produced 13 media releases during 2012 and achieved good results across print, online and radio as a result.

Feature stories mixing national groundwater issues and NCGRT research resulted in over 1000 positive news items broadcast across a wide mix of national and local news sources. Many of these were radio interviews that achieved national coverage across several ABC programs.

This result was pleasing, particularly when compared against the target of 30 news items, and considering the increased difficulty of getting water stories into the news now that most of the country is no longer in drought.

In addition to mainstream media, the NCGRT also developed two feature articles for the Australian Water Association's *Water* journal. These articles highlighted issues of national significance, including groundwater policy concerns and coal seam gas mining in Australia and the US.

## Stakeholder survey

In our efforts for continual improvement, the NCGRT undertook a stakeholder survey again in 2012, the results of which assisted us with our planning processes and informed us about how our partners, collaborators, and other stakeholders view us. It also allowed us to determine what steps we need to take to make our interactions with these stakeholders more meaningful.

We conducted a full survey of our stakeholder database that includes past training course attendees, partner organisations, and industry and government representatives.

The results have helped fine tune our outreach and engagement activities, including our workshops and industry training and short course programs.

## Seminars and lectures

The NCGRT delivered a very successful seminar and lecture series that brought world-leading hydrogeologists and groundwater experts to locations across Australia.



## Sondoss El Sawah Program 5 chief investigator

Dr Sondoss El Sawah is practical about her degree in computer science (majoring in decision-support systems) and masters in information systems: 'It was new for Egypt and they were hungry for graduates – I thought, "good, I'll get a job!"'

She did, as a university staff member in Cairo, learning to simplify complex ideas for her students. Sondoss then came to Australia for a PhD in water resource management with the University of New South Wales. Her innovative PhD approach, improving communication between experts and the public about water issues using simulation games, won the 2010 water research prize from the Australian Water Association.

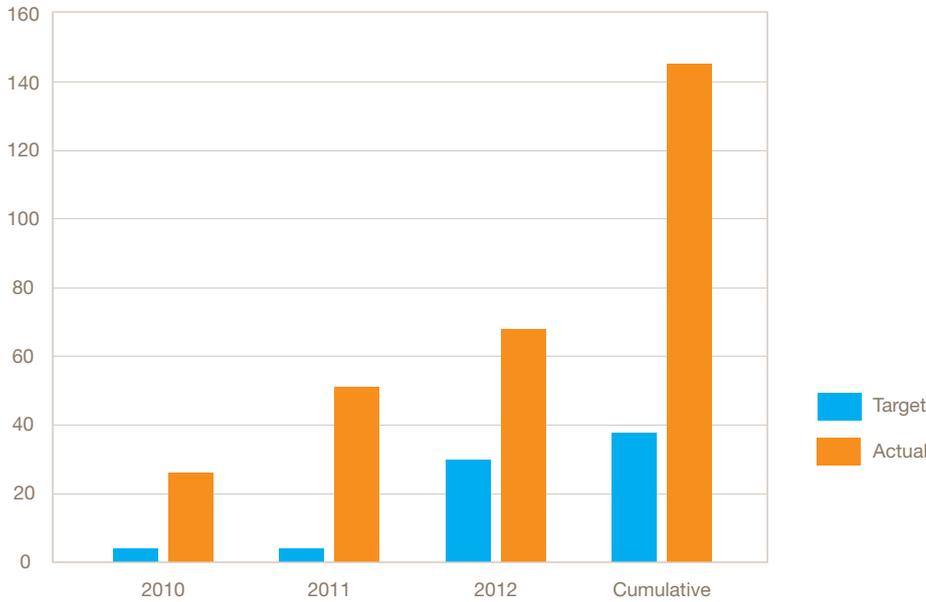
Three years ago, Sondoss joined the NCGRT for postdoctoral research through the Australian National University. A specialist in developing integrated assessments and decision-support systems for water resource management, she uses her combination of 'soft' skills (such as stakeholder consultation and participatory modelling) and 'hard' skills (such as computer modelling) in a broad range of projects.

'I mix methods from different disciplines with the aim of improving learning and communication so that people will start changing how they think about water issues.'

For example, in South Australia's Willunga Basin, where many of the NCGRT programs are undertaking research, Sondoss wears numerous 'hats', developing the way stakeholders get involved and improving how decisions are made.

In November 2011, the NCGRT promoted Sondoss to the level of a chief investigator. A highlight for her has been selling the idea of collaboration during her keynote speech at the NCGRT 2012 Summer School.

**NUMBER OF SIGNIFICANT PUBLIC TALKS DELIVERED BY NCGRT STAFF**



Professor Robert Glennon was our distinguished lecturer in 2012. Professor Glennon is the Morris K. Udall Professor of Law and Public Policy at the Rogers College of Law at the University of Arizona. He presented a series of public lectures to enhance awareness of groundwater issues across the policy, scientific, industry and general public communities.

Other visiting speakers included Dr Majid Hassanizadeh (the US National Ground Water Association’s 2012 Darcy Lecturer), Professor Steve Gorelick, Professor Clifford Voss, and Professor William L. Fisher, all very significant international groundwater scientists.

The NCGRT’s Distinguished Lecturer for 2013 is Australian aquatic ecologist Professor Andrew Boulton, who will speak at all major capital cities in April on hydroecology, with a focus on stygofauna.

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>OUTREACH</b>					
O1	Number of unique and positive media articles and segments that mention the NCGRT	30	1096	60	1167
O2	Number of significant public talks delivered by NCGRT staff	30	68	38	145
O3	Stakeholder survey conducted	1	1	N/A	N/A
O4	Number of publications produced by the NCGRT promoting our research and training activities	1 public annual report 4 quarterly newsletters 2 magazine quality reports	1 public annual report 4 quarterly newsletters 2 magazine quality reports	N/A	N/A
O5	Number of web-based outreach tools	4 online videos 5 podcasts 12 media releases 12 targeted industry publications	5 online videos 5 podcasts 13 media releases 12 targeted industry publications	N/A	N/A

## Kids Teaching Kids

In 2012, the NCGRT embarked on a new educational activity by sponsoring six schools to attend the international Kids Teaching Kids conference in Melbourne in October.

Over 680 students and teachers from 69 schools across Australia participated in the event, where many of the students presented workshops based on the conference theme of 'Catchment to Coast'. The NCGRT mentored a group of students from Christies Beach High School in southern Adelaide to help them explain groundwater and its importance. NCGRT Director Professor Craig Simmons also spoke at an evening dinner function.

Our evaluation of the Kids Teaching Kids program was that it was an excellent way of engaging high school students and raising their awareness of groundwater and earth sciences as an interest and possible career.

## E-news and online communication

The NCGRT completed a major upgrade of its electronic communication tools in 2012, embracing an e-newsletter system and completing an overhaul of its website.

Delivery of internal, external and industry training news is now much simpler and more efficient, with delivery now able to be measured and evaluated with real-time statistics on items such as opens, click-throughs and sharing.

The new website went live in October. The design has been refreshed, content is more dynamic and interactive, and it is now more functional. With the new site developed on a more modern content management system, future upgrades are also being planned such as improved viewing on mobile devices.



HEIDILINEHAN

## Roger Cranswick Program 3 PhD candidate

In Queensland's Hughton River, PhD candidate Roger Cranswick is examining hyporheic exchanges at a level of detail never before attempted.

'There's a lot of research on the changes in the chemistry of water from moving in and out of rivers and the sediments underneath them [hyporheic exchange], but it looks at the exchange on a kilometre scale, as opposed to a few hundred metres.'

Catchment managers across Australia are seeking to improve river health, reintroducing meanders and log snags. This restoration work also increases hyporheic exchange, enhancing the nutrient cycle and promoting a healthier river ecosystem.

'Anecdotally, at least,' Roger agrees. 'My research is about strengthening our methods for quantifying these changes, so if we increase the exchange between a river and the sediment beneath, we can see the improvement in solid data. I am trying to make it easier to see the link between the process of hyporheic exchange and the environmental benefit.'

Roger is studying how long the hyporheic exchange takes in the Hughton River using heat as a tracer to tell how fast water travels into the riverbed sediments. He is combining the heat method with measurements of radon, a naturally occurring gas produced in the sediment, to understand how fast the water cycles underground.

A Flinders University hydrogeology graduate, Roger worked as an environmental consultant in Melbourne after completing his honours. He returned to South Australia in 2011 to join the National Centre for Groundwater Research and Training for a PhD with Flinders University.

# Media release: Australia urged to



**ANDREW ROSS**

AUSTRALIA should prepare now for dry times ahead by 'banking' its water underground when rainfall is plentiful, according to an important new scientific study.

'There is enormous national potential to store surplus water in aquifers, ensuring sufficient water is available for cities, homes, industry, farming and the environment when drought strikes', says researcher Andrew Ross of the National Centre for Groundwater Research and Training (NCGRT).

'We need to start thinking of surface water and groundwater as a single resource - and managing them together, in an integrated way over time,' Mr Ross says.

'We also need to tune water management to our climatic cycles and to harness the power of floods to help us to deal with drought. That means banking surplus water underground during wet periods and bringing it up for use during dry times.

'While it needs national leadership, the concept of water banking can be implemented at grassroots level by landcare and catchment management groups, even by individuals, as well as by larger organisations and agencies. This role can breathe new life into the landcare movement,' he adds.

In his doctoral thesis, Mr Ross proposes that Australia should develop and implement water banking at the national scale, taking advantage of the wet/dry climate cycle and the immensity of our network of underground aquifers.

Based on observations of water management in the Murray Darling Basin (MDB) and the western USA, he argues that 'water banking can provide a big part of the solution to Australia's perpetual boom/bust relationship with water and the climate'.

'Water banking augments the natural processes of water storage in the landscape, avoiding evaporative losses. In the MDB up to 3000 gigalitres (GL or billion litres) of water a year evaporates from surface water storages.'

Water banking helps communities adjust to climate variability and uncertainty, and enables irrigators to receive additional water during droughts. In California one water bank holds up to 800 GL for its members; another has released 750 GL back to its members over a recent 3-year period.

Water banking can assist environmental water managers by allowing them to synchronise supply with specific environmental wa-

tering requirements, Mr Ross says. It helps the development of water markets by bringing diverse sources of water under common rules of use and trade.

'It can also help to increase Australian agricultural exports. Water banking expertise and technology could also be a valuable new export industry in its own right.

'Historically Australians have relied on dams to provide water for agriculture and cities. This strategy is not sufficient to cope with increasing climate variability or droughts as demand for food and water grows.

Water banking can help ensure that there is enough water both for food production and the environment in the MDB - rather than having to close down irrigation when drought hits,' he adds.

Although the volume of storage underground is sometimes unknown, vast networks of aquifers such as those in the Great Artesian Basin and the MDB can probably store more than we require.

'We are already storing about 45 GL of water underground in the Burdekin region of Queensland every year - for use in agriculture and horticulture. In Orange County California they store around 300 GL a year - enough for the annual household use of 2.3 million people. This gives an idea of the potential,' he explains.

'The known capacity of aquifers to store additional water below Perth, Adelaide and Melbourne

# bank its water

could meet the needs of 2.5 million people per year - and may be far larger. Water banking thus offers a way to 'water-proof' Australia's major urban centres for decades to come, ensuring water is available to support predicted population growth,' Ross adds.

'Some people argue that there is no spare surface water to store underground, but this ignores hundreds of gigalitres per year in dam spills and floodwater, recycled storm-water and wastewater, irrigation drainage and water entitlement sales.

'Others object that storing water underground costs more than storing it on the surface - but this fails to account for the high engineering and environmental costs of dams and reservoirs. Also on the surface you can lose a third or more per year due to evaporation, and no-one seems to count this cost.'

He cautions that 'it is important that water banking is consistent with national water management principles and guidelines, and that the broader impacts of water banking arrangements are assessed. Every decision to bank water underground needs to be based on careful analysis of local needs, as well as the suitability of local geology and hydrology. It will be important to ensure the environment is not adversely affected - indeed, it may even benefit from increased groundwater storage.'

Good management of groundwater banks also requires some changes to current water management practices. When Australians deposit

water in an underground water bank they generally do not retain any legal ownership rights, or have any guarantee that they can recover their water. These rights and guarantees need to be established, he points out.

Also, restrictions on how much of their water entitlement they can carry over from one year to another prevent Australians from saving enough water to buffer them against the next drought. Extended carryover could be developed, with rules to prevent excessive aquifer drawdown during droughts.

'We bank money so it is there when we need it. We stockpile many other things, like grain or minerals, so there is always a reliable supply on hand. Why should water be any different?' Ross asks.

'The time to start banking our water is now - before El Nino brings us another drought.'

<b>Water banking media release: media hits at a glance</b>	
<b>Total media hits</b>	<b>140</b>
Radio	120 stories
Radio audience	> 500,000
Press	20 stories
Print circulation:	> 200,000







Linkades

# Linkages

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 2012 we have continued to develop relevant linkages nationally and internationally focusing both on research and training. We have formalised four collaborations over 2012, one domestically with the Australian Water Association and three internationally with the University of Texas, the US National Groundwater Association and the University of Neuchâtel in Switzerland.**

NCGRT staff and researchers have organised 21 workshops including the 'Regulation of groundwater interception by forestry: lessons from Australia and international regimes' forum, organised by Program 5 Chief Investigator Jennifer McKay. In Sydney, Program 1 Chief Investigator Martin Andersen organised a workshop on heat as a tracer. It incorporated 12 presentations from researchers from the University of New South Wales, Flinders, CSIRO, the University of Birmingham and the University of Copenhagen; also present were representatives from the NSW Office of Water, the Australian Nuclear Science and Technology Organisation and UNSW's Water Research Laboratory.

We continue to attract some of the leading international researchers for visits to the NCGRT with 42 visiting in 2011, while our researchers undertook 54 visits to overseas research organisations. In particular we were pleased to invite the following two scientists to visit:

- Professor William Fisher, from the University of Texas at Austin, has chaired and served on numerous state and federal advisory boards, as well as committees and boards of the National Research Council and professional societies, many with a

direct focus on coal seam gas. He has served the White House and the US departments of the interior and energy, is a member of the National Academy of Engineering and the recipient of several awards and medals for his pioneering contributions in the field of geology.

Dr Fisher visited Australia to participate in our thought leadership workshops on coal seam gas which were held in partnership with the Australian Water Association.

- Professor S. Majid Hassanizadeh was the 2012 National Ground Water Association Darcy Lecturer. He is professor of hydrogeology at Utrecht University, and has a background in civil engineering. He has served as editor for a number of the world's most respected hydrology journals. Professor Hassanizadeh's research focuses on flow and transport in porous media, and he visited the NCGRT in his capacity as Darcy Lecturer.

The NCGRT has continued to demonstrate strong industry linkages in 2012. There were over 150 meetings held in 2012, and researchers have participated on significant industry bodies over 100 times. The success of this continued interaction is highlighted by the 26 joint grant and/or scientific applications that were approved; a sample of these is highlighted below:

- Program 5 Chief Investigator Jennifer McKay, along with postdoctoral fellows Ganesh Kerramane and Zhifang Wu, won a \$395,000 grant from the Goyder Institute to look at the optimal water resource mix for Adelaide.
- Program 2 Chief Investigator Ling Li won a \$750,000 ARC Linkage grant to study multi-scale, two-phase flow on complex coal seam systems in conjunction with the Australian Coal Association Research Program.
- Program 4 Chief Investigator Derek Eamus secured \$350,000 from the New Zealand government for a project entitled 'Ready for climate change? The ecophysiology of New Zealand Kauri forests' in conjunction with the universities of Auckland and Edinburgh.



ANNA BLACKKA

## Anna Greve Program 1 postdoctoral fellow

As the only hydrogeologist onsite at the mine, when Dr Anna Greve is there, she works 12 hour days: 'Everyone here wants to know more about water and they want to know immediately. The results of your research are applied immediately too.'

Originally from Germany, Anna first came to Australia as a backpacker, and throughout her study in Germany (science degree) and the Netherlands (masters) she kept coming back. Anna wrote part of her masters thesis at the University of New South Wales, and then studied for her PhD there.

In both her masters and PhD, Anna explored the relationship between water and cracking clay soils. She developed a new technique to monitor cracking depth in the soil: sending electrical currents through the earth and measuring resistivity.

Anna then joined the NCGRT for her postdoctoral study, using geophysical techniques (mainly electrical resistivity and micro gravity) to investigate water storage and water migration in the 'unsaturated zone' – deeper than root zone but not yet in the aquifer.

'Moisture migration and moisture storage in cracking clay soils is very complex. These soils can hold far more water than most people think.'

The water in the unsaturated zone eventually becomes part of the groundwater supply. It is vital, therefore, to understand when and in what quantity and quality the water will arrive in an aquifer, for both current and future irrigation management.

Anna took up her position as hydrogeologist with Xstrata Copper six months ago. Her postdoctoral research is being continued at the NCGRT.

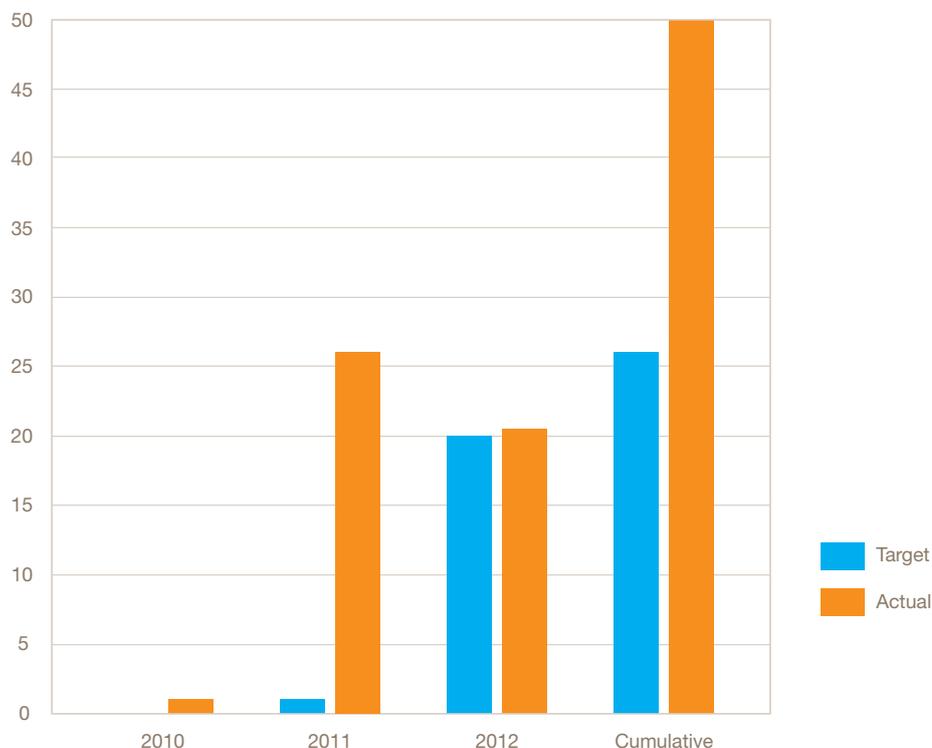
# International visitors, 2012



# NCGRT visits overseas, 2012



## NUMBER OF NATIONAL AND INTERNATIONAL WORKSHOPS ORGANISED BY THE NCGRT



## University of Neuchâtel collaboration

In 2012 the NCGRT formalised its research relationship with the University of Neuchâtel. On 13 September 2012, a memorandum of understanding between the two institutions was signed at a ceremony in Neuchâtel.

An active and extremely productive collaboration between the NCGRT and the Centre for Hydrogeology and Geothermics at Neuchâtel has been maintained since the founding of the NCGRT in 2009. The stimulating atmosphere at the University of Neuchâtel has resulted in many very productive scientific discussions and exchanges.

The common areas of research are reactive transport modelling, mathematical geology and surface water – groundwater interactions. The productivity of the collaboration is reflected by the 16 joint publications accepted in 2012 by some of the world's most prestigious hydrogeology journals. Five additional papers are currently under review.

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>LINKAGES</b>					
L1	Number of new partner or collaborating organisations	2	4	5	7
L2	Number of international visitors and exchanges	30	42	48	101
L3	Number of national and international workshops organised and managed by the NCGRT	20	21	27	50
L4	Number of visits to overseas laboratories and research facilities	50	54	85	158
L5	Number of successful joint grant and/or scientific applications with national and international collaborators	15	26	26	51
L6	Number of industry engagement meetings	100	179	152	345
L7	Participation on significant national and international bodies	40	101	45	217

Currently the NCGRT is a project partner on three Swiss National Science Foundation projects. NCGRT researchers jointly supervise a number of PhD candidates, have organised two successful conference sessions, have given over 20 talks at international conferences, and have organised two technical courses. Numerous scientific exchanges have already taken place and more are planned for the near future.

### US National Groundwater Association summit

The 2012 US National Ground Water Association Summit was held in early May in California, with the theme 'Innovate and integrate: succeeding as a groundwater professional in a water short world'.

A strong contingent of NCGRT researchers participated in the summit, giving presentations, keynote speeches and poster sessions. Program 4 PhD candidate Rose Deng was awarded the Favolden Award for best student paper.

The 2013 summit is to be held in Texas and the NCGRT plans to have a strong presence again. We plan to capitalise on this trip by sending a delegation to the University of Texas at Austin to conduct a research workshop, building on the memorandum of understanding signed with the University of Texas in 2012.

### Australian Water Association

The NCGRT formalised a collaborative relationship with the Australian Water Association (AWA) in 2012. A memorandum of understanding, focused on collaborating on professional groundwater training, was signed at a ceremony at the OzWater conference held in Sydney, May 2012.

The AWA has over 7000 members and is Australia's leading association for water professionals and organisations. This relationship allows the NCGRT to raise the profile of groundwater within the broader water industry and to make available training and activities to a segment of the water industry that traditionally is not heavily exposed to groundwater issues and education.

The NCGRT and AWA collaboration focused in 2012 on a national tour of 'thought leadership' workshops on coal seam gas and groundwater. This was

followed by two more traditional-style training courses on the same topics.

### UNESCO groundwater governance consultation

The NCGRT partnered with UNESCO in delivering its Asia-Pacific groundwater governance consultation which was held in China on 5–7 December. This significant international project (which includes partners such as the World Bank, the International Association of Hydrogeologists and the Global Environment Fund) is titled 'Groundwater governance: A global framework for country action'. It focuses on addressing concerns over the depletion and degradation of groundwater resources. The overall project objective is to increase awareness of the importance of sound management of groundwater resources as a means to preventing and reversing the global water crisis.

The NCGRT acted as the general rapporteur for the Asia-Pacific meeting and contributed a number of presentations, and will be an integral part of the international process in the future.

### Groundwater Futures Forum

The NCGRT convened a 'Groundwater Futures Forum' in Perth on 31 May. The forum was organised by the NCGRT to ensure that our research is (and continues to be) aligned to national groundwater issues. The forum provided an invaluable opportunity to engage a broad cross-section of external stakeholders in discussion about the NCGRT's strategic positioning and long-term objectives.

The NCGRT's Advisory Board played a key role in driving the forum process, and in securing the attendance of some of Australia's leading groundwater scientists, policy makers and industry representatives. Feedback provided at the forum is informing the NCGRT's preparations for future funding applications.



TESS FLYNN

### Sanjeeva Manamperi Program 4 PhD candidate

Groundwater is a valued resource for farmers in the Loddon. Every 10–15 years there are large floods in this region, which are believed to recharge the shallow aquifers. PhD candidate Sanjeeva Manamperi is exploring how these flood events influence recharge.

'Climate change models suggest that floods and droughts will become more frequent, and while there is plenty of data on aquifer recharge under normal conditions, no one has looked at how changes in the drought or flood cycle might influence recharge in the Loddon.'

Sanjeeva came to Australia from Sri Lanka in 2008 with honours in geology, a masters in environmental science, and eight years of experience in hydrogeology. He worked in Queensland as a hydrogeologist before his scholarship from La Trobe University and a grant from the NCGRT enabled him to begin his PhD.

Sanjeeva is studying two major aquifers in the Loddon: the shallower Shepparton Formation and the deep Calivil Formation. Of the two, the Calivil is the main one used for irrigation. 'I've discovered that heavy rainfall and flooding in the catchment hugely recharges the Calivil, and quickly.'

For example, during the drought decade (2001–2010), the water level in the Calivil gradually dropped. After the 2010 floods, the water level almost completely recovered from the decade-long drop within 16–17 months.

The final step for Sanjeeva's PhD will be to make a model, incorporating climate change models, to generate scenarios for managing the Loddon's groundwater resources in the future. His research is supported by the Victorian Department of Sustainability and Environment.



AWA  
australian water association

for  
better  
living

Governance

# Management and governance

**The first half of 2012 was dominated by preparations for the second meeting of the NCGRT's International Scientific Advisory Committee, our mid-term review, and our Groundwater Futures Forum.**

These processes enabled us to reflect on our progress, and to start developing a clear roadmap for future funding applications which we will begin in early 2013.

The mid-term review also helped us identify areas where improvements in our operating approach could deliver important performance dividends. As noted earlier in this report we have already implemented a number of changes to improve cross-program coordination; strengthen the communication links between our stakeholders, researchers and students; and conducted a survey to assess the future training needs of our PhD candidates.

## Intellectual property arrangements

We have completed work on the NCGRT's intellectual property arrangements with Flinders University (in its capacity as the NCGRT's administering organisation), entering into an IP deed with each of the collaborating and partner organisations.

The NCGRT management team has also completed work on the policies and procedures that will underpin the rights and obligations outlined in the deed. A new project on the NCGRT's data management strategy has been commissioned following the mid-term review and is expected to be completed before the end of the first quarter of 2013. These intellectual property projects will enhance our collaboration and data sharing activities.

## Finances

The NCGRT has continued with its programs of quarterly reviews of performance across all areas of its operations. Core research operations expenditure for 2012 was on par with 2011 while NCGRT management expenditure increased following the addition of new centre management positions to assist in the implementation of our knowledge transfer and adoption strategy. The cumulative core underspend has reduced by 12% as reflected on the following pages.

The NCGRT has also completed a further comprehensive round of re-forecasting on the projected underspend in its research operations budget as at 30 June 2014. The new forecast indicates that the underspend will be \$2.3 million (8%) which is a tremendous result and testament to the hard work and leadership of our program leaders. The NCGRT will be applying to the ARC to carry forward any unspent funds into its second funding period.

## Board and committee activities

An external review of the NCGRT's Industry Liaison and Advisory Committee (ILAC) was initiated in the final quarter of 2012 as part of our broader campaign to 'externalise' the NCGRT's activities by increasing opportunities for our full range of stakeholders to contribute to our strategic planning processes. Membership of the current ILAC is confined to a small number of industry stakeholders, and there is no formal process for consultation with many of our industry partners. The review process is examining opportunities to extend ILAC's membership base to include the NCGRT's industry partners and representatives from the Australian public policy community. We are therefore looking forward to working with a re-energised ILAC as soon as the review process is completed at the beginning of 2013.

More broadly, we would like to express our gratitude to the members of our Advisory Board, ILAC, and International Scientific and Advisory Committee (who are listed in appendix 4) for their outstanding contributions during 2012. We are grateful for the significant amount of time which members have invested in our strategic planning processes which means we are entering 2013 confident in our ability gain funding to take us into the future.

## Funding renewal

Work on the NCGRT's future funding position is progressing well. In addition to the Groundwater Futures Forum, the NCGRT convened a strategic planning workshop with key external stakeholders in early December, which was closely followed by a Research Management Committee retreat to explore the NCGRT's future role and structure

HEIDLINER



## Wendy Timms Program 1 chief investigator

On family holidays, Dr Wendy Timms collected rocks everywhere, from the Grand Canyon to volcanoes in Hawaii, so she chose geology and physical science majors at university. 'One day I saw a groundwater summer project advertisement, and found my future path in hydrogeology'.

The summer project led to honours research with CSIRO and a graduate position in the government working on drilling rigs and testing water quality. Wendy boosted her knowledge through groundwater industry training courses run by what was then the Centre for Groundwater Studies, the forerunner of the NCGRT.

An all-rounder, Wendy also did a PhD in environmental engineering, which led her to postdoctoral research in Canada and introduced her to geocentrifuges. She spent years as a consulting water engineer before taking a founding chief investigator role with the National Centre for Groundwater Research and Training in 2009.

Wendy often gets to play with the NCGRT's new geocentrifuge, which can test low permeability geological materials at accelerated gravity. Right now, her team is testing shale that overlies a coal seam.

'We're looking at aquifer connectivity from the other side – how to test naturally disconnected water systems and construct effective seepage barriers. This is important for dealing with mine water and coal seam gas, and for sustainable use of aquifers.'

Recently appointed as senior lecturer in the School of Mining at the University of New South Wales, Wendy's interactive courses are reaching students at four different Australian universities: 'For the first time in Australia, mining students are trained in water quality and wise management of groundwater resources near mine sites'.

beyond June 2014. These processes have confirmed our view that the NCGRT can maximise its research impact by concentrating on a narrower range of national groundwater priority issues.

This approach will have an important bearing on the configuration and management of our research, with the NCGRT adopting a project rather than a program-based approach in future.

2013 will be a historic year for the NCGRT as we work to secure our long-term future and realise our ambition of becoming an enduring national research institution.

## INCOME STATEMENT

	2012 \$	CUMULATIVE JUN 2009 – DEC 2012 \$
<b>REVENUE</b>		
Commonwealth ARC/NWC	6,907,917	22,235,625
Collaborator & partner organisations	2,052,031	8,545,420
Industry training	605,605	2,319,662
Other non-core	1,725,024	3,654,467
	<b>11,290,577</b>	<b>36,755,174</b>
<b>EXPENSE</b>		
Research operations	7,087,090	18,212,024
Centre management	2,827,242	5,625,140
Industry training	724,902	2,193,062
Other non-core	2,716,143	4,349,513
	<b>13,355,377</b>	<b>30,379,739</b>
<b>NET SURPLUS / (DEFICIT)</b>	<b>(2,064,800)</b>	<b>6,375,435</b>
<b>IN-KIND CONTRIBUTIONS</b>	<b>5,645,653</b>	<b>15,388,521</b>

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>MANAGEMENT AND GOVERNANCE</b>					
MG1	Attendance rates of members at NCGRT Advisory Board meetings	80%	87.5%	N/A	N/A
MG2	Timely submission of reports and plans to project executive	100%	100%	N/A	N/A
MG3	Unqualified audit report	Achieved	Achieved	Achieved	Achieved
MG4	Annual cash contributions from non-ARC/NWC sources	\$2.05 million	\$4.38 million	\$8.55 million	\$14.52 million
MG5	Annual in-kind contributions from non-ARC/NWC sources	\$3.90 million	\$5.65 million	\$14.92 million	\$15.84 million
MG6	NCGRT's ability to achieve and maintain its annual expenditure operations budget within forecast levels	Annual expenditure within 10% of target	Achieved 10% below target	Annual expenditure within 10% of target	Achieved 2% below target



Aporendic

# Appendix 1: Performance indicators and funding targets

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>RESEARCH</b>					
R1	Total number of publications appearing in journals, and book chapters	180	213	280	405
R2	Percentage of publications appearing in A or A* quality journals	50% (90 articles)	50% (108 articles)	N/A	57%
R3	Number of citations	1250	2894	2050	4373
R4	Number of invitations to present talks, papers and keynote lectures at major national and international meetings	90	177	170	357
<b>CAPACITY BUILDING</b>					
C1	Number of new postdoctoral fellows recruited each year	10	16	41	55
C2	Number of new PhD candidates recruited each year	6	9	54	60
C3	PhD completion rate	95%	80%*	N/A	N/A
C4	Number of new honours students recruited each year	10	21	43	57
C5	Honours student completion rate	100%	95% <sup>^</sup>	100%	95%
C6a	Number of professional training courses run by the NCGRT for non-NCGRT staff and students	10 courses	24 courses	35 courses	51 courses
C6b	Number of people attending professional training courses run by the NCGRT for non-NCGRT staff and students	400 attendees	664 attendees	1450 attendees	1612 attendees
<b>OUTREACH</b>					
O1	Number of unique and positive media articles and segments that mention the NCGRT	30	1096	60	1167
O2	Number of significant public talks delivered by NCGRT staff	30	68	38	145
O3	Stakeholder survey conducted	1	1	N/A	N/A
O4	Number of publications produced by the NCGRT promoting our research and training activities	1 public annual report 4 quarterly newsletters 2 magazine quality reports	1 public annual report 4 quarterly newsletters 2 magazine quality reports	N/A	N/A
O5	Number of web-based outreach tools	4 online videos 5 podcasts 12 media releases 12 targeted industry publications	5 online videos 5 podcasts 13 media releases 12 targeted industry publications	N/A	N/A

KEY PERFORMANCE INDICATORS		2012 TARGET	2012 RESULT	CUMULATIVE TARGET	CUMULATIVE RESULT
<b>LINKAGES</b>					
L1	Number of new partner or collaborating organisations	2	4	5	7
L2	Number of international visitors and exchanges	30	42	48	101
L3	Number of national and international workshops organised and managed by the NCGRT	20	21	27	50
L4	Number of visits to overseas laboratories and research facilities	50	54	85	158
L5	Number of successful joint grant and/or scientific applications with national and international collaborators	15	26	26	51
L6	Number of industry engagement meetings	100	179	152	345
L7	Participation on significant national and international bodies	40	101	45	217
<b>MANAGEMENT AND GOVERNANCE</b>					
MG1	Attendance rates of members at NCGRT Advisory Board meetings	80%	87.5%	N/A	N/A
MG2	Timely submission of reports and plans to project executive	100%	100%	N/A	N/A
MG3	Unqualified audit report	Achieved	Achieved	Achieved	Achieved
MG4	Annual cash contributions from non-ARC/NWC sources	\$2.05 million	\$4.38 million	\$8.55 million	\$14.52 million
MG5	Annual in-kind contributions from non-ARC/NWC sources	\$3.90 million	\$5.65 million	\$14.92 million	\$15.84 million
MG6	NCGRT's ability to achieve and maintain its annual expenditure operations budget within forecast levels	Annual expenditure within 10% of target	Achieved 10% below target	Annual expenditure within 10% of target	Achieved 2% below target

## 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		2012 TARGET	2012 RESULT
<b>RESEARCH</b>			
Number of publications appearing in journals, and book chapters	Base funding target	135	
	Supplementary	45	
	<b>Total</b>	<b>180</b>	<b>194</b>
<b>CAPACITY</b>			
Number of new postdoctoral fellows	Base funding target	7	
	Supplementary	3	
	<b>Total</b>	<b>10</b>	<b>16</b>
Number of new PhD candidates	Base funding target	4	
	Supplementary	2	
	<b>Total</b>	<b>6</b>	<b>9</b>
Number of new honours students	Base funding target	7	
	Supplementary	3	
	<b>Total</b>	<b>10</b>	<b>20</b>
Number of professional training courses run by the NCGRT for non-NCGRT staff and students	Base funding target	7	
	Supplementary	3	
	<b>Total</b>	<b>10</b>	<b>24</b>
Number of participants in professional training courses	Base funding target	300	
	Supplementary	100	
	<b>Total</b>	<b>400</b>	<b>664</b>
<b>OUTREACH</b>			
Number of significant public talks	Base funding target	22	
	Supplementary	8	
	<b>Total</b>	<b>30</b>	<b>68</b>
<b>LINKAGES</b>			
Number of international visitors and exchanges	Base funding target	22	
	Supplementary	8	
	<b>Total</b>	<b>30</b>	<b>42</b>
Number of national and international workshops organised and managed by the NCGRT	Base funding target	15	
	Supplementary	5	
	<b>Total</b>	<b>20</b>	<b>21</b>
<b>FINANCE</b>			
Annual cash contributions from all non-ARC and NWC sources	Base funding target	\$1,539,022	
	Supplementary	\$513,008	
	<b>Total</b>	<b>\$2,052,030</b>	<b>\$4,382,660</b>
Annual in-kind contributions from all sources other than ARC and NWC	Base funding target	\$2,923,164	
	Supplementary	\$974,388	
	<b>Total</b>	<b>\$3,897,552</b>	<b>\$5,645,653</b>

# Appendix 2:

## List of students and staff

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
<b>HONOURS STUDENTS</b>				
Mr Daniel Aramini	1	UNSW	Nanoparticle transport and removal in aquitards	Dr Adam Hartland
Mr Mark Bryan	1	UNSW	The cost of deep drainage	Dr Wendy Timms
Mr Lucas Earl	1	UNSW	Methodological aspects for the setup of a large-scale high-resolution synthetic heterogeneous aquifer	Dr Grégoire Mariethoz
Mr Aaron Fordham	1	UNSW	Structural controls on the hydrogeology of the Wellington Caves	Assoc. Prof. Bryce Kelly
Mr Philip King	1	UNSW	Hydrogeology of Yarramanbah aquitard research site	Dr Wendy Timms
Ms Hui Ling Lim	1	UNSW	The fate of nitrate in low-permeability groundwaters and the role of aquitards	Dr Adam Hartland
Ms Stephanie May	1	UNSW	Hydrogeology of Breeza farm aquitard research site	Dr Wendy Timms
Mr David Watson	1	UNSW	The impact of groundwater pumping on water resources	Dr Martin Andersen
Mr Michael Young	1	UNSW	Heat as a tracer of groundwater flow	Dr Martin Andersen
Ms Monika Markowska	1	UNSW	Heat as a groundwater tracer in highly karstified aquifers	Professor Andy Baker
Mr Joel Bailey	3	James Cook	Spings of the Cape York Peninsula	Dr Marc Le Blanc
Mr Scott Dennett	3	UNSW	Estimating groundwater recharge from ephemeral streams	Dr Martin Andersen
Mr Eamon Lai	3	Monash	Bank flow on the Avon River	Professor Ian Cartwright
Mr Adam Rogan	3	Monash	Sources of nitrate in upland river	Dr Harald Hofmann
Ms Taya Rudolph	3	UNSW	Hyporheic processes in an ephemeral stream	Dr Martin Andersen
Mr Evan Salanoa	3	Monash	Water stores for upland rivers	Dr Harald Hofmann
Ms Susana Simon Mendoza	3	UNSW	Estimating ground-water recharge in ephemeral headwater streams	Dr Martin Andersen
Ms Brittany Smyth	3	Monash	Groundwater – surface water interaction in the King River	Professor Ian Cartwright
Ms Maria Tran	3	UNSW	Stable isotopes as tracers	Dr Martin Andersen
Mr Rex Cover	4	UNSW	MIKE-SHE at Baldry	Dr Matthew McCabe
Ms Rizwana Rumman	4	UTS	Application of stable isotopes to the study of groundwater-dependent ecosystem ecophysiology	Professor Derek Eamus
<b>PHD CANDIDATES</b>				
Mr Juan Carlos Castilla	1	UNSW	Assessing the effects of climate change on groundwater under multiple sources of uncertainty	Dr Gregoire Mariethoz Dr Martin Andersen Assoc. Prof. Bryce Kelly
Mr Landon Halloran	1	UNSW	Heat as a tracer for flow in ephemeral stream beds	Dr Martin Andersen Professor Ian Ackworth
Mr Adam King	1	QUT	The Cressbrook Creek alluvial aquifer system, southeast Queensland: conceptual hydrogeological model, hydrological processes and response to flood events	Assoc. Prof. Malcolm Cox
Mr Kashif Muhammed	1	UNSW	Developing the potential of texture generation methods for applications in geostatistics	Dr Grégoire Mariethoz
Mr Mark Peterson	1	UNSW	Apparent groundwater age and matrix diffusion of radionuclides in fractured rocks	Dr Martin Andersen
Mr Wesley Burrows	2	Flinders	Predictive uncertainty analysis using a complex and simple model pairing	Professor John Doherty
Mr Dylan Irvine	2	Flinders	Quantification and comparison of solute and heat tracers	Professor Craig Simmons

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
Miss Danica Jakovovic	2	Flinders	Upconing in coastal environments: Modelling and laboratory approaches	Assoc. Prof. Adrian Werner
Mr Matthew Knowingling	2	Flinders	Effects of climate change and alternative management strategies on the Uley South Basin, South Australia	Assoc. Prof. Adrian Werner
Mr Tariq Laattoe	2	Flinders	Reactive transport modelling of hyporheic zone transient stream conditions	Dr Vincent Post
Ms Jessica Liggett	2	Flinders	An analysis of surface-subsurface exchange and solute transport processes in a fully integrated code	Assoc. Prof. Adrian Werner
Mr James McCallum	2	Flinders	Investigating environmental tracer age distributions in hydrogeology	Professor Craig Simmons
Mr Carlos Miraldo Ordens	2	Flinders	Recharge processes in the heterogeneous closed Uley South Basin: combining modelling and field-based approaches	Assoc. Prof. Adrian Werner
Miss Megan Sebben	2	Flinders	Groundwater-dependent vegetation in arid and semi-arid zones	Assoc. Prof. Adrian Werner
Mr Yulong (Aaron) Zhu	2	Flinders	Altered patterns of stream – aquifer interactions in response to groundwater development	Assoc. Prof. Adrian Werner
Ms Leanne Morgan	2	Flinders	National-scale vulnerability assessment of seawater intrusion project	Assoc. Prof. Adrian Werner
Mr Ty Watson	2	Flinders	Effects of model simplification on parameter estimation and predictive uncertainty	Assoc. Prof. Adrian Werner
Mr Alexander Atkinson	3	Monash	Quantifying sources and fluxes of water in upland catchments	Professor Ian Cartwright
Miss Sarah Bourke	3	Flinders	Infiltration from losing streams in sub-tropical arid environments	Professor Peter Cook
Mr Roger Cranswick	3	Flinders	The importance of the hyporheic zone for quantifying groundwater discharge to rivers	Professor Peter Cook
Ms Michelle Irvine	3	Flinders	Identifying sources of recharge and groundwater flow processes using hydrochemistry	Professor Peter Cook
Miss Saskia Noorduijn	3	Flinders	Quantifying surface water – groundwater interaction in a heterogeneous environment	Professor Peter Cook
Mr Seng Chee Poh	3	UQ	Groundwater connectivity in estuarine wetlands: evidence from 222-radon and rare earth elements fractionation	Professor David Lockington
Mr Nicholas Rockett	3	James Cook	Streamflow generation in tropical catchments constrained using continuous isotopic measurements	Dr Marc Le Blanc
Mrs Salini Sasidharan	3	Flinders	Reactive transport modelling	Professor Peter Cook
Mr Nicolaas Unland	3	Monash	Interaction of groundwater and surface water in the coastal setting of East Gippsland, Victoria	Professor Ian Cartwright
Ms Chani Welch	3	Flinders	Temporal variability of the chemistry of groundwater discharge to rivers as a function of bank storage	Professor Peter Cook
Mr Cameron Wood	3	Flinders	Arid zone groundwater recharge and the role of ephemeral surface water features	Professor Peter Cook
Mr Chenming Zhang	3	UQ	Salt transport and distribution in estuarine wetland	Professor Ling Li
Mr Junliang Fan	4	UQ	Understanding, monitoring and modelling of groundwater recharge under subtropical coastal forests	Professor David Lockington
Miss Xian Xu	4	Flinders	Moisture stable isotope in SPAC: the experiment and modelling	Dr Huade Guan
Miss Cecilia Azcurra	4	UNSW	The use of stable isotopes to quantify the local water cycle in a semi-arid environment	Dr Matthew McCabe

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
Mr Joshua Dean	4	La Trobe	Catchment-scale water and salinity impacts of changing land use in southwest Victoria	Assoc. Prof. John Webb
Miss Zijuan (Rose) Deng	4	Flinders	Dependence of canopy temperature on vegetation water status and its implication in groundwater-dependent ecosystems and urban environment	Dr Huade Guan
Mr Esmaeilabadi (Ali) Ershadi	4	UNSW	Estimation of evapotranspiration using remote sensing	Dr Matthew McCabe
Ms Amy Gaukroger	4	UQ	Eco-groundwater modelling of a perched lake-aquifer system: Brown Lake on North Stradbroke Island	Professor David Lockington
Mr Michael Gray	4	UQ	The evaporative fluxes of Southeast Queensland sand island vegetation as a contribution to groundwater discharge	Professor David Lockington
Mr Matt Hayes	4	UQ	Carbon cycling in a groundwater-driven coastal wetland system: North Stradbroke Island	Professor Catherine Lovelock
Mr Sanjeeva (Athula) Manamperi	4	La Trobe	Assessing the effect of climate change on episodic recharge in Loddon River catchment, Victoria	Assoc. Prof. John Webb
Mr Parikshit Verma	4	Monash	Investigation and modelling of groundwater-dependent ecosystems	Dr Edoardo Daly
Mr Hailong Wang	4	Flinders	Variation of land surface evapotranspiration with vegetation types and groundwater table fluctuations	Dr Huade Guan
Ms Tricia Williams	4	Flinders	Investigation of hydrological behaviour in South Australian catchments under changing climatic norms	Dr John Hutson
Mrs Yanzi (Chrissie) Xiao	4	UQ	Simulating dynamics between riparian vegetation and groundwater using an eco-groundwater model	Professor David Lockington
Mrs Sepideh Zolfaghar	4	UTS	An ecophysical comparison of woodlands across a depth-to-groundwater gradient	Professor Derek Eamus
Ms Emily Barbour	5	ANU	Multi-objective optimisation of environmental flows for regulated river systems	Professor Tony Jakeman
Ms Rachel Blakers	5	ANU	Parameterisation of surface water models with groundwater interactions	Dr Barry Croke
Ms Theresa Groth	5	CSU	Aspects of the nature and role of occupational identity (farmer/non-farmer)	Dr Emily Mendham
Mr Joseph Guillaume	5	ANU	Uncertainty and using integrated models to help decision making: the case of acceptable aquifer yield	Professor Tony Jakeman
Miss Madeleine Hartley	5	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
Ms Saideepa Kumar	5	CSU	Establishing achievable and acceptable environmental condition targets in a complex changing system	Professor Allan Curtis
Mr Arshad Muhammad	5	ANU	Managed aquifer recharge: suitability and economic potential in lower Namoi Valley, NSW	Professor Tony Jakeman
Ms Gabriela Cuadrado Quesada	5	UNSW	Sustainable groundwater governance	Dr Cameron Holley
Miss Andrea Rawluk	5	CSU	Socio-institutional aspects of managed aquifer recharge	Professor Allan Curtis
Mr Mun-Ju Shin	5	ANU	Identifiability, sensitivity and uncertainty of hydrological models	Dr Barry Croke

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
Mr James Skurray	5	UWA	Institutions, transaction costs, and groundwater policy: the potential for a cap-and-trade scheme for groundwater in the Gnangara region of Western Australia	Professor David Pannell
Ms Alison Wilson	5	UWA	Tradeoffs between environmental outcomes and agricultural productivity in the context of declining groundwater availability and climate variability	Professor David Pannell
Miss Chunfang (Janet) Xu	5	UniSA	Incorporating plantation forestry as water affecting activities into the sustainable water allocation plan	Professor Jennifer McKay

#### POSTDOCTORAL FELLOWS

Dr Steve Bouzalakos	1	UNSW	Characterisation of hydraulic properties of low permeability aquitards	Dr Wendy Timms
Dr Alessandro Comunian	1	UNSW	Innovative characterisation of aquifers and aquitards	Assoc. Prof. Bryce Kelly
Dr Adam Hartland	1	UNSW	Innovative characterisation of aquifers and aquitards using geochemical approaches	Dr Wendy Timms
Dr Catherine Jex	1	UNSW	Isotope geochemistry of cave waters and paleoclimate reconstructions from cave stalagmites	Professor Andy Baker
Dr Sanjeev Jha	1	UNSW	Aquifer characterisation and hydrological modelling	Assoc.Prof. Bryce Kelly
Dr Ander Guinea Maysounave	1	UNSW	Innovative characterisation of aquifers and aquitards	Professor Ian Acworth
Dr Matthias Raiber	1	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
Dr Gabriel Rau	1	UNSW	Heat as a tracer of groundwater	Dr Martin Andersen
Dr Hamid Roshan	1	UNSW	Mass and energy transfer modelling of chemically active fractured rocks	Dr Martin Andersen
Dr Helen Rutledge	1	UNSW	Novel aquifer and aquitard characterisation	Professor Andy Baker
Dr Behzad Ataie-Ashtiani	2	Flinders	Homogenisation of unstable density-dependent flow	Assoc. Prof. Adrian Werner
Dr Etienne Bresciani	2	Flinders	Impact of vegetation on atmospheric chloride deposition to the land surface	Assoc. Prof. Adrian Werner
Dr Sergio Galindo-Torres	2	UQ	Development of numerical methods based on realistic fluid–solid interactions to solve engineering problems at the pore scale	Professor Ling Li
Dr Daan Herckenrath	2	Flinders	Next generation modelling of coal seam gas groundwater impacts	Assoc. Prof. Adrian Werner
Dr John Kozuskanich	2	Flinders	Interpreting environmental tracers in fractured rock environments	Professor Craig Simmons
Dr Chunhui Lu	2	Flinders	Seawater intrusion processes and control	Assoc. Prof. Adrian Werner
Dr Ming Wu	2	UWA	Cowaramup groundwater geochemistry investigation – UZF-PHT3D model development	Professor Henning Prommer
Dr Ursula Salmon	2	UWA	Exploring the use of reactive transport models for an improved understanding of groundwater flow processes	Professor Henning Prommer
Dr Ilka Wallis	2	Flinders	Model-based assessment of reactive transport during re-injection during CSG operations	Dr Vincent Post
Dr Juliette Woods	2	Flinders	Processes impacting the salinity of the lower River Murray and its floodplain	Assoc. Prof. Adrian Werner

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
Dr Yueqing (Steven) Xie	3	Flinders	Solute dynamics due to bank storage in the 3D framework	Professor Peter Cook
Dr Pei Xin	2	UQ	Interaction between the surface and subsurface – surface water – groundwater interactions in coastal wetlands: model development and simulation, laboratory experiment and field observation	Professor Ling Li
Dr Jordi Batlle-Aguilar	3	Flinders	Project 1. Infiltration processes and groundwater recharge estimate in ephemeral losing streams at the transect scale. Project 2. Tropical rivers: surface or groundwater? Study of the Mitchell River, far north Queensland, Australia	Professor Peter Cook
Dr Chao Chen	3	Flinders/UTS	Simulating water use of vegetation within an arid-zone woodland	Professor Peter Cook/ Professor Derek Eamus
Dr Ben Gilfedder	3	Monash	Groundwater interaction with lakes and wetlands: quantification of transient groundwater fluxes in coastal wetlands, estuaries and lakes using radon, stable isotopes and major ions	Professor Ian Cartwright
Dr Harald Hofmann	3	Monash	Spatial and temporal scales of surface water – groundwater interactions in upper catchments	Professor Ian Cartwright
Dr Joshua Larsen	3	UNSW	Hyporheic processes and chemical interactions: groundwater pumping and the impact on surface-groundwater exchange and biogeochemical processes	Dr Martin Andersen
Dr Hamid Roshan	3	UNSW	Mass and energy transfer modelling of chemically active fractured rocks	Dr Martin Andersen
Dr Margaret Shanafield	3	Flinders	Transient infiltration in disconnected streams (modelling)	Professor Peter Cook
Dr Hoori Ajami	4	UNSW	Toward improved estimations of groundwater recharge and evapotranspiration using coupled vs integrated hydrologic models	Dr Matthew McCabe
Dr Maria Chuvochina	4	UQ	Development of a biogeochemical aspect to research	Professor David Lockington
Dr Samantha Grover	4	Monash	Estimation of water balance in groundwater-dependent ecosystems	Dr Edoardo Daly
Dr Hugo Gutierrez Jurado	4	Flinders	Quantification and prediction of climatic-vegetation effects on water fluxes from the unsaturated zone to the groundwater table and vice versa	Dr Huade Guan
Dr Adrien Guyot	4	UQ	Role of the vegetation in the recharge of sandy aquifers in southeast Queensland	Professor David Lockington
Dr Randol Villalobos-Vega	4	UTS	Ecophysiology of groundwater-dependent ecosystems	Professor Derek Eamus
Dr Nina Welti	4	UQ	Characterising biogeochemical hot spots through the catchment	Professor David Lockington
Dr Tomasz Wyczesany	4	UTS	Use of stable isotopes in terrestrial ecohydrology	Professor Derek Eamus
Dr Baihua Fu	5	ANU	Namoi and Lachlan projects	Assoc. Prof. Wendy Merritt
Dr Serena Hamilton	5	ANU	Understanding and modelling groundwater dependent ecosystems (in broad) with Willunga project as an application	Professor Tony Jakeman
Dr Masud Hasan	5	ANU	Lachlan and Campaspe catchment projects	Dr Barry Croke
Dr Ganesh Keremane	5	UniSA	Managed aquifer recharge and statutory water plan	Professor Jennifer McKay
Dr Emily Mendham	5	CSU	The Wimmera social benchmarking project Cotton CRC Integrated Water/Climate Scenario Modelling	Professor Allan Curtis

NAME	PROGRAM	UNIVERSITY	PROJECT TITLE/ACTIVITY	SUPERVISOR/S
Dr Marian Patrick	5	ANU	Resilience and resistance of River Red Gums and environmental watering governance: how the concept of scale can help our understanding of environmental watering governance	Assoc. Prof. Wendy Merritt
Mr Andrew Ross	5	ANU	Integrated surface water and groundwater management in the Murray–Darling Basin and western USA	Professor Tony Jakeman
Dr Emily Sharp	5	CSU	An integrated assessment of the socio-economic impacts of climate change, technology and water policy drivers in cotton catchments	Professor Allan Curtis
Dr Darren Sinclair	5	ANU	Regulation and governance	Professor Neil Gunningham
Dr Jennifer Ticehurst	5	ANU	Namoi socio-economic project	Professor Tony Jakeman
Dr Zhifang Wu	5	UniSA	Managed aquifer recharge and statutory water plan	Professor Jennifer McKay

#### RESEARCH FELLOWS

Ms Alice McRorie	1	UNSW	Dissolved gases and organic tracers in groundwater, Breeza aquitard research site	Dr Wendy Timms
Dr Edward Banks	2/3	Flinders	Surface water – groundwater interaction in a fractured rock aquifer system	Professor Peter Cook
Dr Nikki Harrington	2/3	Flinders	Surface water – groundwater interactions in the South East	Professor Peter Cook
Dr Jim Hanan	4	UQ	Development of virtual groundwater-dependent ecosystems	Professor David Lockington

#### RESEARCH ASSISTANTS

Ms Dayna McGeeney	1	UNSW	Centrifuge permeameter manager	Dr Wendy Timms
Mrs Julie McClements	2	Flinders	Technical and Research Support for Program 2	Assoc. Prof. Adrian Werner
Ms Stephanie Villeneuve	2/3	Flinders	Research support in the Willunga Basin and assistance with short course training programs	Professor Peter Cook
Ms Yunhui Guo	4	Flinders	Research support for Program 4	Dr Huade Guan
Ms Lauren Butterly	5	UWA	Mining and groundwater in the Pilbara	Assoc. Prof. Alex Gardner
Ms Clare McKay	5	UWA	Research support for Program 5	Assoc. Prof. Alex Gardner
Ms Natasch Sommer	5	UWA	Research support form Program 5	Professor Tony Jakeman

#### TECHNICAL SUPPORT OFFICERS

Mr Peter Graham	1	UNSW	Technical support officer	Professor Andy Baker
Mr Mark Whelan	1	UNSW	Technical support officer	Professor Andy Baker
Mr Lawrence Burk	3	Flinders	Field and laboratory support	Professor Peter Cook
Mr Nick White	3	Flinders	Field and laboratory support	Professor Peter Cook
Ms Nicole Grant	4	UTS	Technical support officer	Professor Derek Eamus

# Appendix 3: Publications

## Books, book chapters and reports

Baker, A, Fairchild, IJ 2012, 'Drip water hydrology and speleothems' *Nature Education Knowledge*, Vol. 3 (10), pp. 16.

Cook, PG, Lamontagne, S, Stieglitz, S, Cranswick, R 2012, *A re-evaluation of groundwater discharge from the Burdekin floodplain aquifer using geochemical tracers*, NCGRT report.

Ivkovic, KM, Marshall, SK, Morgan, LK, Werner, AD et al. 2012, *National-scale vulnerability assessment of seawater intrusion: summary report*, Waterlines report, National Water Commission, Canberra.

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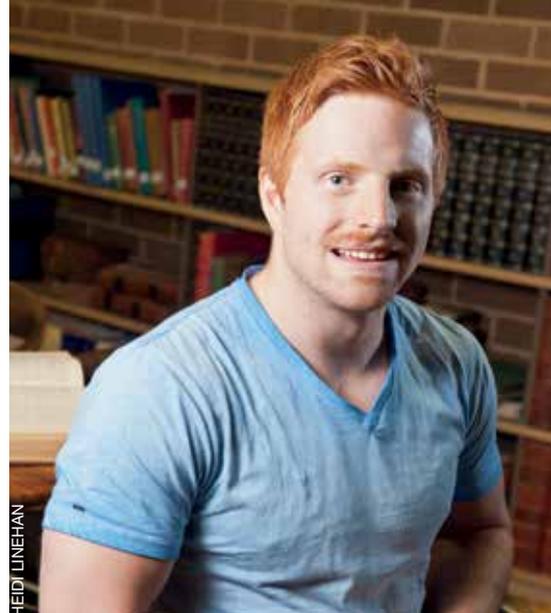
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HEIDI LUNEHAN

## Alex Atkinson Program 3 PhD candidate

The upper catchment of Victoria's Gellibrand River is underlain by impermeable rock, and yet the river runs constantly with clean, fresh water: PhD candidate Alex Atkinson is trying to find out what is supplying water to the river, and how old is the source?

'One day, walking through my field site, I came across pipe-like formations eroded into the top soil – these soil pipes appear to be delivering water to the river.'

Alex, who grew up in the United Kingdom, received a hydrogeology scholarship with the National Centre for Groundwater Research and Training two years ago. With degrees in earth and climate sciences, his background in atmospheric chemistry has translated very well to studying geochemistry in hydrology at Monash University, as shown by his innovative use of tritium.

Tritium is a naturally occurring chemical produced in the atmosphere and incorporated in rain. When rain falls, the tritium in it begins to decay, acting like a clock for the age of the rainfall. Alex used tritium testing, with the first batch funded by the Australian Institute for Nuclear Science and Engineering, to confirm that river water in the upper catchment is 20–30 years old. This supply of 'old water' may be due to the soil piping process, with the soils acting as a water store.

Contributing a piece to the puzzle about surface water and groundwater interactions in the Gellibrand catchment, Alex's research will give managers an increased understanding of the upper catchment's importance for river flow, particularly during drought.

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HEIDI LINEHAN

## Emily Barbour Program 5 PhD candidate

The wetland-rich Lachlan catchment in New South Wales supports a diverse agricultural industry. Here, PhD candidate Emily Barbour is testing her ecological response model incorporating groundwater.

Emily joined the NCGRT three years ago for her PhD in water resource management with the Australian National University. With an environmental engineering and science degree, and experience consulting in Sydney, she followed her interest in water management to CSIRO in Canberra, where she worked in river modelling. Emily noticed the models she worked with did not include the support groundwater gives to ecosystems.

So now Emily is developing an ecological response model that includes both surface water and groundwater, and optimises environmental flows. The model estimates what impact an environmental flow could have on different water users, presents options for how to deliver the water, and measures the trade-offs for each alternative.

For working rivers like those of the Lachlan catchment, this will be a handy tool, giving managers more options and a transparent understanding of how each option may affect different water users.

'The next stage will be talking to landholders and water managers who understand how the system responds, and combining the knowledge from these people on the ground with the conceptual data we already have.'

Emily won an award for her presentation of her work at the International Water Association's WATERMATEX symposium held in Spain during June 2011. She was also recently selected as one of two students to represent ANU during a visit to China.

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### Randol Villalobos-Vega Program 4 postdoctoral fellow

Predictions for a dry 2013 are a source of enthusiasm for Dr Randol Villalobos-Vega, who is studying trees and transpiration in the Kangaloon Borefield of New South Wales: 'A dry year will be great for seeing how much groundwater is exploited by trees, and to see what the stressor will be for trees, for management purposes.'

From a family of farmers and builders, Randol grew up in Costa Rica. After completing a biology degree, a Licenciatura (similar to a masters) in botany, and an 18-month internship at Harvard University, Randol did his PhD at the University of Miami. He studied the effect of groundwater on plant physiology in the tropical savannah of central Brazil.

Randol's postdoctoral study with the NCGRT, through Sydney's University of Technology, is along similar lines: measuring the response of pristine woodland to variations in groundwater depth.

The research site for Randol's work, the Kangaloon Borefield, is in an area designated to protect the quality and supply of water in Sydney's southern catchment. Since the borefield is a potential emergency source of water for human use, Randol's research has theoretical implications for sustainable use of the groundwater resource.

'Our breakthrough research has identified the point where removing groundwater will damage the health of a forest – that is, when the watertable drops below ten metres. The optimal groundwater depth for forest health is between six and nine metres. We think this is also true for most groundwater-dependent ecosystems across Australia, which should be useful for setting sustainable extraction limits.'

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HEIDLINEHAN

### Saskia Noorduijn Program 3 PhD candidate

Cholsey, a village on the River Thames in the United Kingdom, is where novelist Agatha Christie lived and worked. It's also home for PhD candidate Saskia Noorduijn, whose love of the whodunit translates into her profession: 'Research is investigating the unknown, so I'm a bit like a detective.'

Saskia began her studies with a science degree at Aberdeen University, known for its strong hydrology program, which led to a research masters at the University of Western Australia. She spent 18 months as a hydrologist at the Western Australian Department of Environment and Conservation, examining the impact of salinity on a regulated wetland.

Saskia then successfully applied for a scholarship with the NCGRT for a PhD through Flinders University. Her research aims to discover how differences in aquifer properties affect the discharge and recharge of groundwater in streams. She is testing two sites in South Australia: one is a 'losing' stream (streamwater gradually moves into the aquifer); the other is 'gaining' (groundwater moves into the stream).

Saskia is trialling an innovative method to infer characteristics of the aquifers near streams by monitoring the speed with which water from a flood event travels downstream.

'Using multiple measuring points, we can see the impact on the water table in the surrounding aquifer as the flood goes through. The idea is to use this response to estimate groundwater discharge into the stream under natural conditions. If we know how the system works we can adjust management to limit negative environmental and resource impacts.'

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\* appeared in 2011 annual report as 'in press'

# Appendix 4:

## Board and committees

### Advisory Board members

**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 members

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

**Professor Andy Baker**

The University of New South Wales

**Professor Craig Simmons**

Flinders University

**Professor Peter Cook**

Flinders University

**Professor David Lockington**

The University of Queensland

**Professor Tony Jakeman**

The Australian National University

### Industry Liaison Advisory Committee members

**Mr Phillip Commander**

Former President of the International Association of Hydrogeologists

**Mr Kym Good**

Adelaide and Mt Lofty Ranger 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

### International Scientific Advisory Committee members

**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



### Leanne Morgan Program 2 PhD candidate

During her visit to Europe last year, PhD candidate Leanne Morgan and a German colleague painstakingly set up an experiment: raising the 'sea level' in a two-metre-long, sand-filled Perspex box, and recording how the red-dyed seawater interacted with the yellow-dyed freshwater of an aquifer.

This research is part of Leanne's PhD on seawater intrusion in coastal aquifers: 'Seeing how the numerical models line up with the physical process in a simulation like that is very powerful.'

An environmental science and mathematics graduate with an honours in groundwater modelling, Leanne was working for the South Australian government when the NCGRT invited her to join an industry project funded by the National Water Commission, and count it as part of her PhD with Flinders University.

Collaborating with Geoscience Australia, state governments, and other scientists in different disciplines, Leanne helped conduct a national assessment of groundwater vulnerability to seawater intrusion, identifying high-risk aquifers along Australia's coastline in light of predicted climate change pressures.

'It's important to assess the threat because coastal aquifers are a major water resource. We developed mathematical methods for rapidly assessing an aquifer's vulnerability to seawater intrusion resulting from over-extraction, reduced recharge and sea level rise.' A paper on these methods was recently published in the journal *Ground Water*.

Leanne also showed that seawater intrusion influences water levels in coastal aquifers, making water level trends an unsuitable indication of available freshwater. Her paper on this topic, published in the *Journal of Hydrology*, won best student research paper from Flinders University in 2012.

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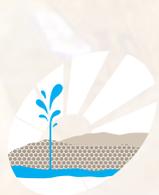
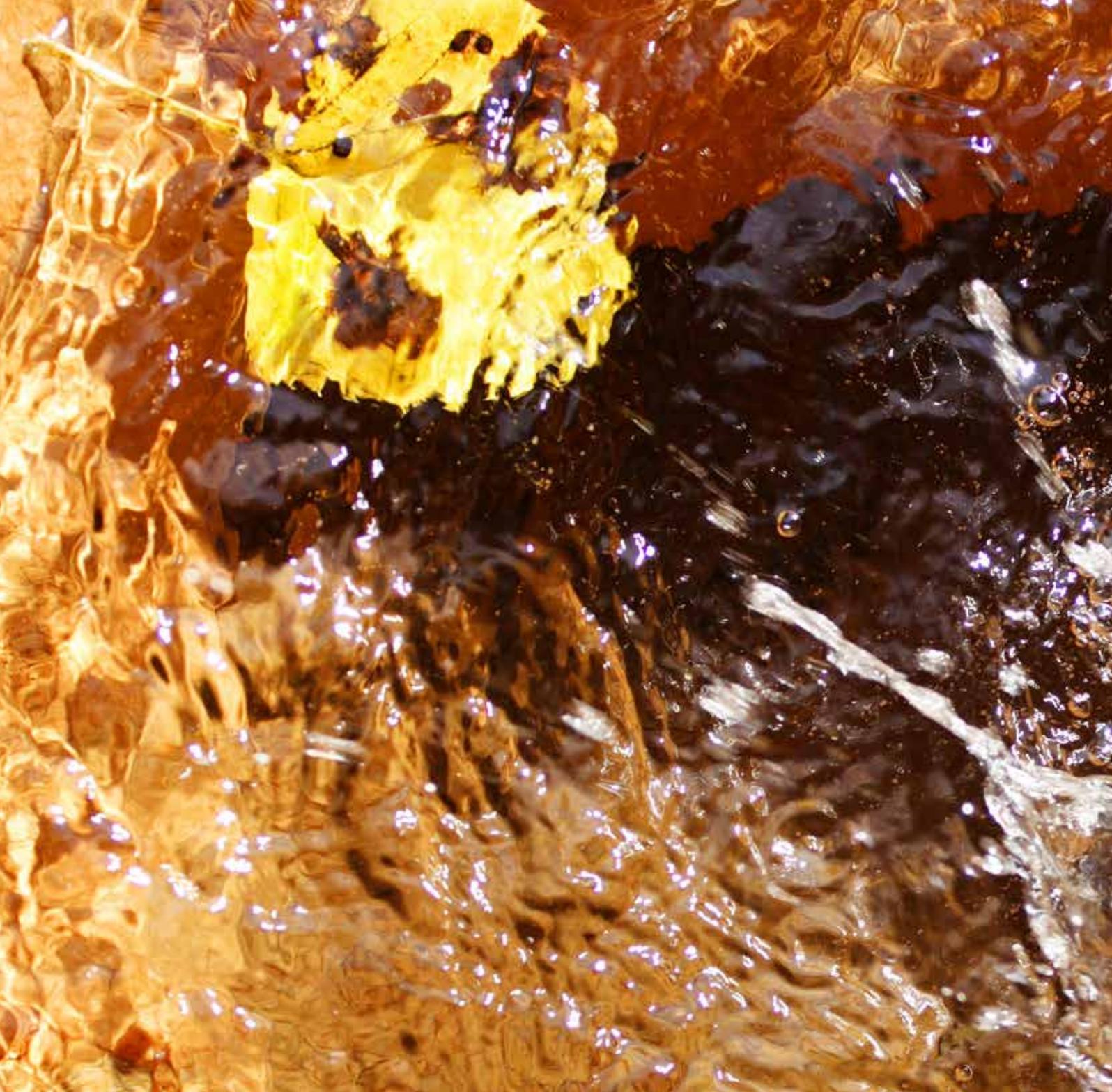
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