Project brief

Groundwater movement in heterogeneous aquifers

National Centre for Groundwater Research and Training

The NCGRT's team at the University of New South Wales studies the movement of water through aquitards – relatively impermeable underground layers such as clay. Normally, water is expected to flow horizontally through porous substances such as sand, and be limited in its movement downward by aquitards. One new project is showing that substantial amounts of water can, in some cases, move through heterogeneous clayey systems in response to pumping.

WATER MOSTLY MOVES SIDEWAYS

When hydrogeologists study the movement of water underground, they often imagine the ground consisting of horizontal geological layers of permeable and impermeable materials.

In an aquifer where water flows freely, any clay present may act as a flow barrier, isolating flow to sandy and gravelly layers.

Ander Guinea, an NCGRT postdoctoral fellow at the University of New South Wales, has been studying whether there is indeed sometimes significant water movement in a variety of directions due to pumping.

Knowing where water is moving is important because, for example, if you have a contaminant in one particular layer – commonly in Australia this might be salt – you may need to know exactly where it is likely to end up, or how to avoid causing it to move.

THE EXPERIMENT

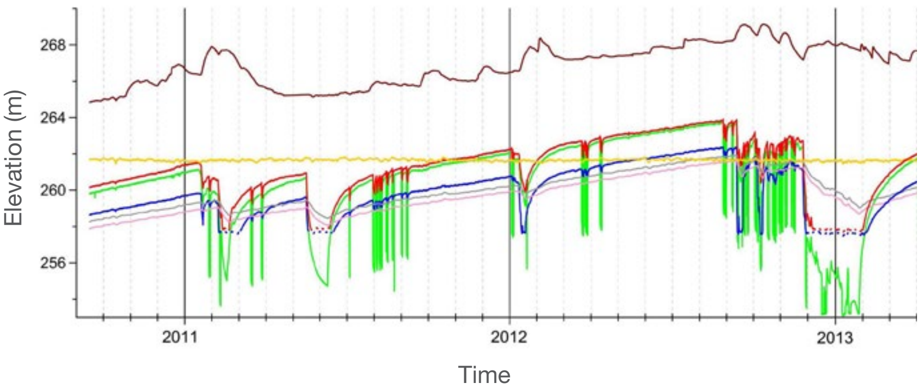
Ander studied two different sites in the Namoi region of New South Wales, both with heavy clay sediments. A site at the Breeza Department of Primary Industries farm was chosen for its heavy but inconsistent (heterogeneous) clay sediments and it's variable shallow salt loads. Groundwater is used in this area for irrigation, and therefore the quality of pumped groundwater is vital. A second site at nearby Cattle Lane was chosen by contrast for the consistency (homogeneity) of its laterally extensive clay sediments.

At both sites, a series of piezometers was used to look at the groundwater at different depths. This gave a window into what was happening in each distinct layer below ground. So, for example, if you found salt in a shallow layer, isolated by clay layers above and below it, traditionally you would not expect to see that salt in any deep piezometers.

Ander measured the water levels in each piezometer in response to pumping from a nearby bore – the results from the Breeza site are shown in the hydrograph to the left.

Each coloured line represents a different piezometer reading, at a different depth. The Breeza hydrograph shows that following steady pumping, the water dropped at all deeper levels, not just the layers with high permeability. This was especially pronounced during extended periods of pumping, for example, over the Summer of 2012/2013. The brown and yellow lines are the two shallowest bores, and were not affected by pumping.

Breeza: Water level record



Want to know more?

The journal paper describing this research is:

Guinea, A, Timms, W, Hartland, A, Acworth, RI, 2013 under review, 'Hydrogeological processes in a clay dominated alluvial deposit, *Hydrogeology Journal*.

By contrast, the data from Cattle Lane hydrograph showed little vulnerability to pumping, due to its more homogenous clay sediments.

Ander also used data from boreholes set up to measure the geophysical properties of the surrounding earth, from a weather station measuring rainfall, and from an electrical resistivity survey. This data all helped to build up a picture of the underground landscape.

THE FINDINGS

Ander's findings at Cattle Lane, a clay-dominated system, fit with the classical layered concept of aquifers and aquitards, where the movement of water is limited. These results show that this traditional model can be applied to some regions.

However, his results from Breeza show that some clayey groundwater systems respond quickly to changes in pressure – both lowering in response to pumping and recovering when pumping ceases. This suggests that water *is* able to move through this system.

At this highly heterogeneous site, the classical model of confining clay aquitards does not work well.

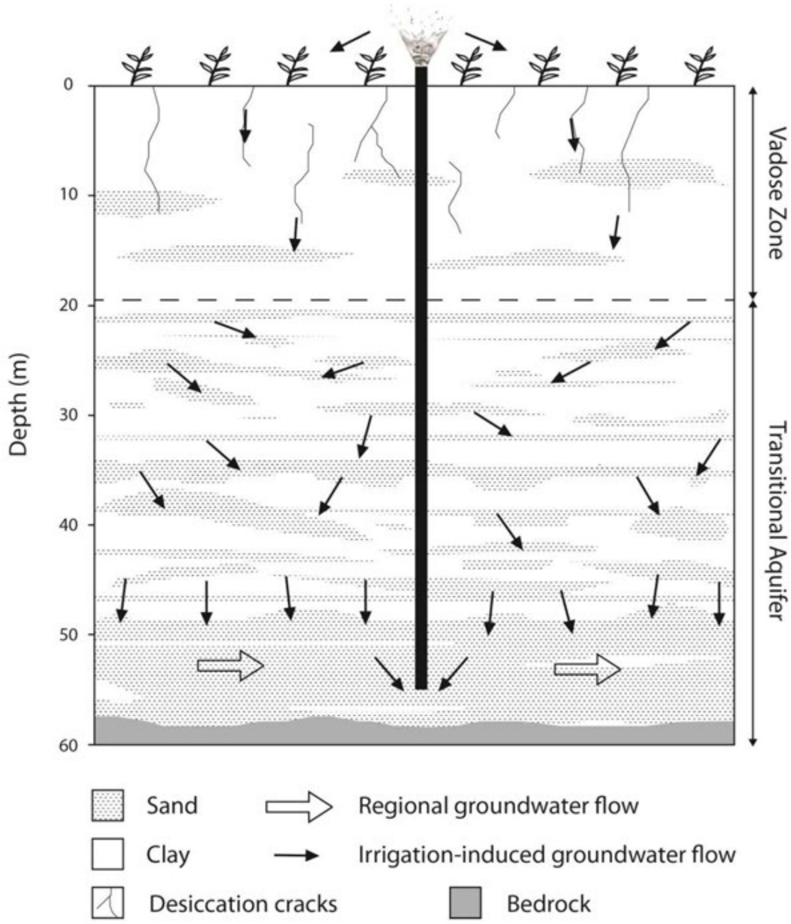
Ander has proposed a new conceptual model for this type of landscape, as seen in the diagram to the right, where water moves in a variety of directions but with a delayed response to groundwater pumping.

THE IMPLICATIONS

This research underscores the importance of understanding the mechanisms at work in any particular location, and that well-established models may not always be appropriate. In particular, this research shows the importance of not assuming that clay sediments are impermeable.

If, for example, a farmer owned a site with heterogenous clay sediments like in the diagram below, and there was salt deposited in some areas, an understanding of pumping and the possibility that the salt could move would be needed. By understanding the characteristics of the aquifer system, the farmer can adjust the irrigation schedule so that watering occurs in a non-continuous way, to give the aquifer time to recover, and preventing significant vertical flow in the least conductive zones.

Equally, if the vulnerability of a terrain needs to be explored, a pumping test should last a minimum of several days. This will give the system enough time to respond to the pumping and provide understanding of potential changes in water quality due to groundwater pumping.



CONTACT US
Call: 08 8201 2193
Fax: 08 8201 7906
Email: enquiries@groundwater.com.au
Web: www.groundwater.com.au
Mail: NCGRT, Flinders University, GPO Box 2100, Adelaide SA 5001

Australian Government
National Water Commission
Australian Research Council