IRRIGATION RESEARCH

MAKING CONNECTIONS ABOUT CONNECTIVITY

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Managing groundwater is a complex business; we can't see what is happening with the water so models have been developed to help us manage it. But how good are these models, and can they be improved?

In an attempt to improve our knowledge of aquifer systems, Ken Crawford and his team in the northwest of NSW have developed the concept of an aquifer recharge blueprint for groundwater zones. Their work underscores the fact that because groundwater isn't stored in one giant, geological underground "bucket", assessing sustainable yield, which is based on aquifer recharge, must be approached in a systematic way supported by field investigations. Sustainable yield is important because it is the key tool for determining how water is allocated in groundwater sharing plans.

Sunlight on the Gap: The view is from the top of Gins Leap looking north towards the Gap (photo: K. Crawford, 2006).

The connectivity between surface water and groundwater, which depends on soil type, geology and drainage, is another factor that needs to be considered in estimating sustainable yield.

Our investigations have shown that it is important to understand how the complex recharge processes work. Below the surface, the underground strata can be like an underground landscape where faults, volcanic events, bedrock highs or changes in rock types can give rise to hydrogeological boundaries. This means that connectivity is site specific. It also means that there is a real risk that numerical models used for estimating sustainable yield are too simplistic and do not take into account the geological changes which give rise to the hydrogeological boundaries and therefore different groundwater regimes.

The Argo amphibious vehicle, owned and operated by Groundwater Imaging Pty Ltd, entering the Namoi River north of the Gap. Six driving wheels and a fifteen HP outboard motor allowed the vehicle to progress upstream dragging the 100 m array of electrode senders and receivers. Geo-electric data was recorded continuously and observed on a monitor (photo: K. Crawford, 2008).

Since sustainable yield estimates are based on understanding the unique aquifer recharge sources of each groundwater zone, a best management practice (BMP) system of assessment is essential if Water Sharing Plans (WSP) are to be fair. The absence of a basin-wide system to assess and compare aquifer recharge in separate hydrogeological zones is a threat to the sustainability of groundwater use as it will lead to poor management of the groundwater resource.

To determine smaller groundwater regimes or hydrogeological zones within the larger regional districts, more field investigations and data collection, including subsurface imaging and strategic drilling are, necessary. Understanding surface-to-groundwater connectivity in unique hydrogeological zones is integral to the blueprint approach developed by us. At present we don't really know enough about where underground water comes from, how quickly it is recharged or potential storage in the highly variable underlying formations.

Connectivity case study

In September last year we conducted a geo-electric survey along a 10.8 km stretch of the Namoi River near Gins Leap, north of Boggabri in NSW (see photo). This stretch of the river includes a feature called the Gap, which is a constriction between two volcanic ridges. This constriction extends to the underground landscape where Permian volcanic rhyolite is also the bedrock. All surface water and groundwater associated with the uplands catchment of the Namoi River and its tributaries passes through the Gap. The major tributaries include Cox's Creek and the Mooki, Peel, Cockburn, Manilla and McDonald rivers.

Figure 1. White dotted line indicates the 1 km wide Gap (photo source: Google Earth Professional, 2008).The geo-electric survey depth slice 20 m below the Namoi River, near Gins Leap and the Gap. The blue indicates impervious basement beneath the river; red to green indicates alluvial sediment; redder parts are more saturated and/or more clayey; and the greener parts are less saturated and/or more gravelly. (The unbroken line is the direction of photograph from Gins Leap Boggabri NSW).

As part of the geo-electric survey we continuously sampled water depth, pH, electrical conductivity (EC) and temperature. Geo-electric data was located using GPS via a shifting algorithm that accounts for the antenna displacement from the array centre. The data was processed by finding the best layered EC model that fits the field data at each location. The geo-electric data was then compared with lithologies in borehole data for correlation and presented in three dimensions.

Other depth slices were generated at various depths and compared with borehole data. Figure 2 shows a 3D composite presentation.

Making connections

From this work we can see that we can't assume uniform connectivity between surface and groundwater.

The geo-electric survey of the Namoi River just north of Boggabri indicated a likely unsaturated zone extending 2 to 5 m beneath the 10.8 km of the river. This conclusion comes from the comparison of river water EC with lithology and EC beneath the river. This zone appears to be pinched out over the flanks of several bedrock highs. This means that this stretch of the Namoi is disconnected from the aquifer beneath and that infiltration is limited as a result of river-bed silting. The basement highs are very restricted in extent along the river. These observations, together with basement depths as evidenced in boreholes, indicate that the paleovalley sides are very steep, extending about 100 m below the present surface.

River-bed siltation due to dispersive clay deposition appears to be a major process in reducing infiltration and connectivity with the groundwater aquifer in this area of the Namoi. As more field work is carried out this process may prove to be operating in not only other parts of the Upper Namoi, but other tributaries of the Darling River. Therefore, before any assumptions regarding the connectivity of surface and groundwater are made, the extent to which river-bed siltation reduces connectivity should be investigated in the field.

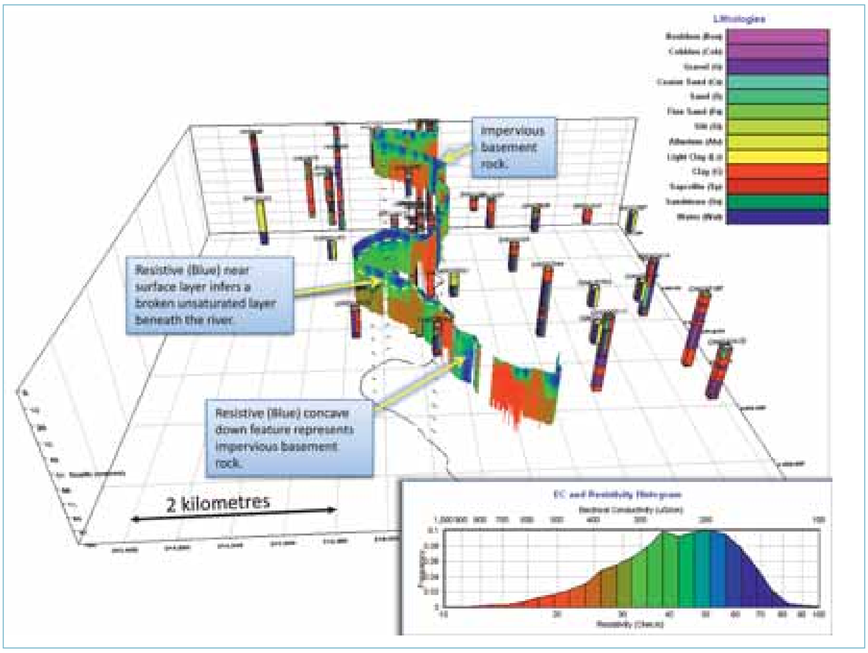

Figure 2. 3D composite graphical presentation of geo-electric data and borehole lithologies (source: D Allen 2008).

More information

Allen, D. (2008). *A geo-electric investigation of groundwater flow beneath the Namoi River in the vicinity of Gins Leap, north of Boggabri*. A report by Groundwater Imaging Pty Ltd for KLC Environmental

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Understanding how river-bed siltation works

In 2003 excavation for a tail-water dam on the property 'Gowrie', Boggabri, uncovered a prior stream at a depth of 4 m. This gravelly layer extended down a further 4 m. The initial excavation at ground level was in a typical black earth soil, which was highly structured. At 3 m deep and immediately above the gravel, a sample was taken of a brown, silty clay. Results from as soil test was carried out at the Gunnedah Resource Centre gave a particle size analysis of 17% clay which was 97% dispersible. The rest of the sample was sand and silt size particles. Even with this relatively low clay content, the dispersive nature of the clay created an almost waterproof seal over the gravel. In other words, the excavation had uncovered an effective paleo-seal.

The same material was so effective as a seal that it was used to seal many of the irrigation channels on 'Gowrie'. The interesting part is that before the gravel could be sealed off in the tail-water dam, rain stopped more work. The dam leaked rapidly for a number of years, however, eventually 'took up' through the natural waterproof seal from erosion and siltation of the layer above the gravel. Today, leakage from the dam is within acceptable limits as the bed was sealed by natural processes over time. Likewise, river-bed siltation through clay deposition is a natural process reducing connectivity with the groundwater aquifer. It is widely known that there are dispersive clay soils in the uplands that erode easily and become up part of the silt-load in the river.