Facilitating Long-Term Outback Water Solutions (G-FLOWS) - Stage 3

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CSIRO

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GEOLOGICAL SURVEY OF South Australia

to support communities in the region and develop opportunities for water-dependent industries and enterprises. This research program has discovered new outback water sources that can support regional communities and economic development in the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands. The project also developed a new methodology that can be used to identify water sources in other remote areas of Australia and internationally, potentially facilitating mining and other economic opportunities.

KEY RESULTS

Previous projects in the G-FLOWS research program developed and applied new and innovative geophysical techniques to investigate groundwater resources in different parts of South Australia, including the APY Lands. The third stage of the program built on previous research and identified and mapped several groundwater resources, including a large buried palaeovalley system that could be a significant potential groundwater resource for communities and enterprises in the APY Lands. A range of tools and techniques were also developed that can be used to assess potential groundwater resources in any remote, arid and data-poor region.

IMPACT

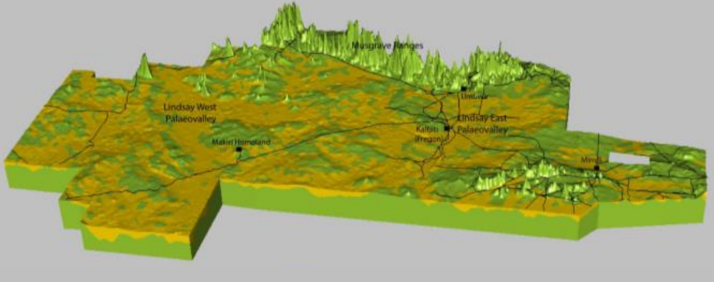
This research has reduced the risks associated with water development proposals in remote areas and allows for more informed decision-making to secure water supplies. It will also reduce project assessment times and make sure that economically viable mining developments are not impeded by a lack of information on suitable water sources. The G-FLOWS project has already made a substantial contribution to South Australia's economy, with the tools developed being applied to other regions.

Data from the project has also been used in various workshops and teachings, including Australian groundwater schools and NExUS, teaching groundwater fundamentals to tomorrow's leading mineral explorers, enhancing knowledge and increasing capability.

PALAEOVALLEY LOCATION AND ARCHITECTURE

Palaeovalleys are ancient, buried river valleys formed when climatic conditions were different (wetter) than they are today. They can form relatively accessible aquifers with capacity to store large quantities of groundwater. The project focussed on a section of the Lindsay East Palaeovalley in a remote part of the APY Lands, located in north western South Australia. This water-bearing formation was found buried under tens of metres of ancient sediments by using a geophysical model of the area developed from airborne electromagnetic (AEM) survey data. Drill and borehole data were used to confirm the AEM data and wells drilled in the targeted palaeovalley showed relatively high yields and low salinity groundwater (<1000 mg/L).

The AEM and drill hole data were then used to develop a 3D geological model of the Musgrave Province in the APY Lands.

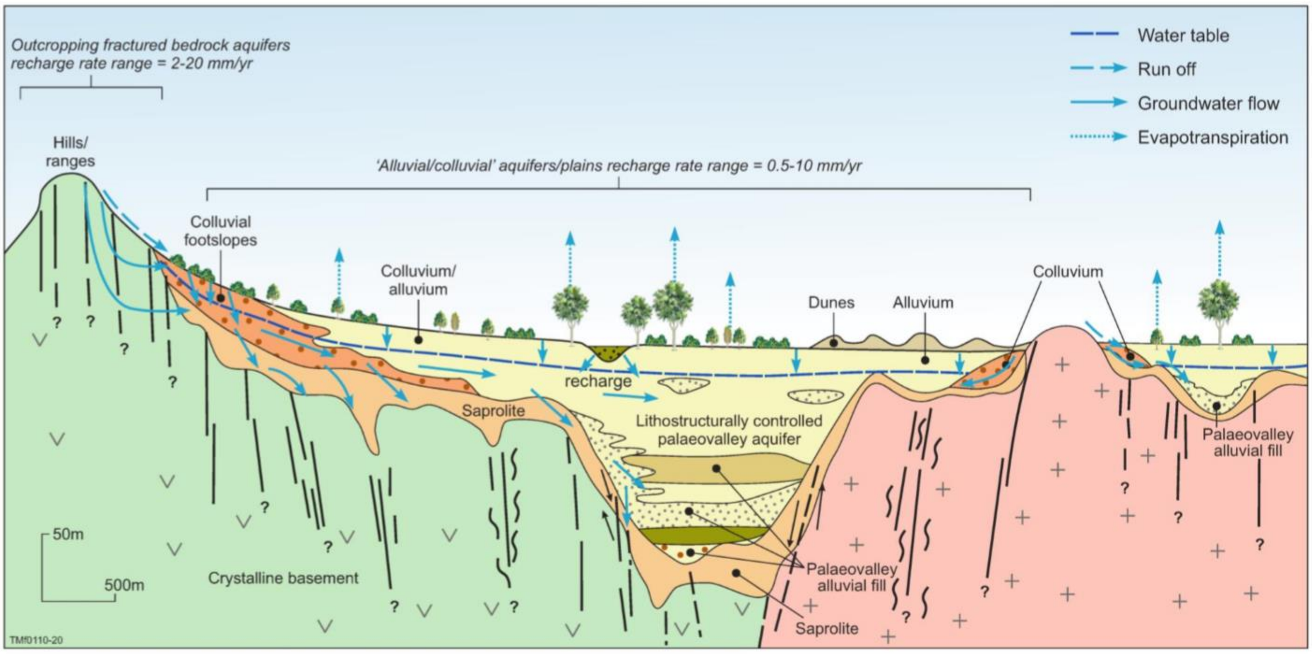


3D geological model of part of the Musgrave Province in the APY lands

GROUNDWATER RECHARGE AND FLOW

Water chemistry, environmental tracer analyses, and groundwater modelling were undertaken to better understand groundwater recharge and water movement through the landscape. Drilling in the palaeovalley identified at least three groundwater aquifers; a shallow water-table aquifer of calcareous mixed sand plain deposits, an interlayered sedimentary aquifer comprising coarse-grained sandstone, clay horizons and a very fine to coarse grained residual sand; and a saprolite/fractured rock aquifer that underlays the palaeovalley sedimentary rocks. While data is preliminary, the coarse-grained sandstones show promise as a productive aquifer, with development yields varying between 5 and 20 L/s and salinities less than 1000 mg/L total dissolved solids (TDS).

Groundwater recharge was estimated to be between 2–20 mm/year on the ranges and between 0.5 and 10 mm/year on the alluvial plains. Groundwater flow and age modelling were undertaken to test different plausible conceptual models of the groundwater regime within the palaeovalley to help us better understand the groundwater resource. Groundwater ages in the upper part of the valley-fill sequences were ~900 years, but over 8500 years in the deeper parts of the palaeovalleys. We developed a schematic hydrogeological conceptual model showing a typical palaeovalley drainage system in the Musgrave Province (below).



Schematic hydrogeological conceptual model showing a typical palaeovalley drainage system in the Musgrave Province (adapted from Munday et al. (2013, 2020) and Gogoll (2016))

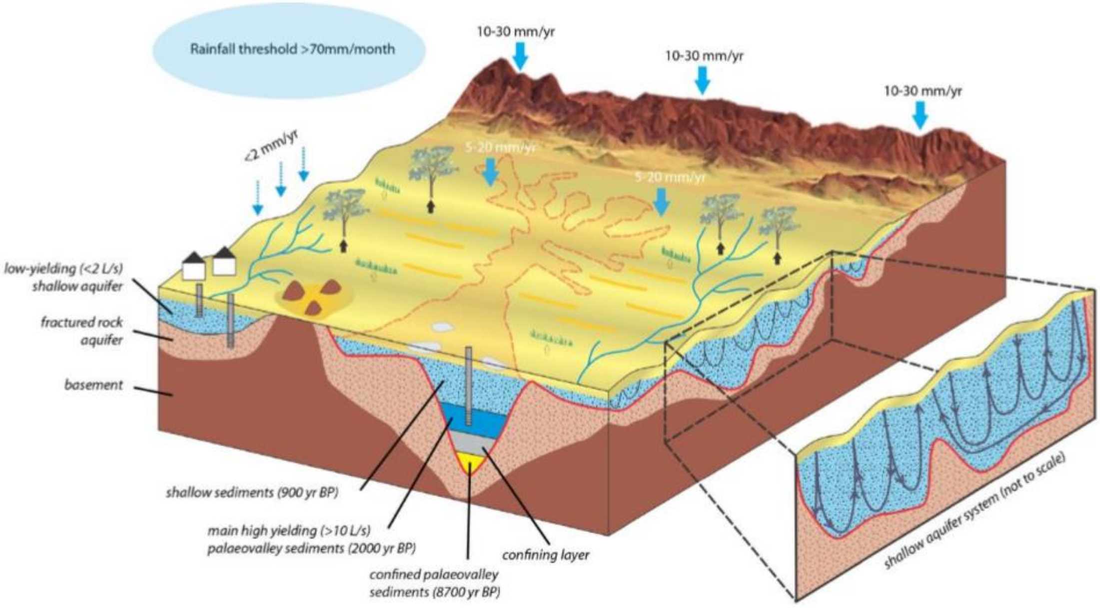
ANANGU PITJANTJATJARA YANKUNYTJATJARA LANDS GROUNDWATER SYSTEM

Conceptualising the hydrogeological processes in a groundwater system is an important step towards developing a numerical model that can simulate the system. Most of the hydrogeological information on the APY Lands has come from basic investigations into water supplies for the communities and road building, and from research projects such as G-FLOWS, and have only covered a small subset of the overall area. A number of different scientific tools and several data sets were used to build up a fuller picture of the APY Lands groundwater system; these included geophysical surveys (such as AEM), well surveys, geochemistry, environmental tracers and aquifer testing.

Groundwater flow systems of the APY region were found to be dominated by local flow systems. There was no evidence of a regional flow system or that groundwater recharge moves from the Musgrave Ranges to the flatter plains of the study area. First pass numerical modelling showed that even small undulations of the water table can drive local groundwater flow systems.

Groundwater recharge to the hydrogeological system occurs when monthly rainfall exceeds 70 mm/month. Rapid recharge to the aquifers occurs when monsoonal activity in the north of the continent deposits intense rainfall events. High rates of groundwater recharge (~10-20 mm/year) occur in the Musgrave Ranges and are associated with fractured rock aquifers, while much lower recharge rates occur (<2 mm/year) in the sedimentary aquifers of plains which are the source of community water supplies.

The discovery of a new fresh groundwater resource (<1000 mg/L TDS) in the APY Lands has enormous potential for the future development of this remote region in outback South Australia.



Schematic conceptual hydrogeological understanding in the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands.

GROUNDWATER KNOWLEDGE INTEGRATION SYSTEM (GKIS)

Regional scale information about groundwater prospectivity is essential for water resources managers to effectively site boreholes for long-term water supply in remote areas of Australia. The existing information and data available are often very limited and any new data may not only change prospectivity but also the conceptualisation of the system. We developed the Groundwater Knowledge Integration System (GKIS) to address these challenges and create a framework for groundwater prospectivity mapping that accounts for the uncertainty due to limited data and can be updated when and where new prospectivity information becomes available.

The GKIS methodology starts with an explicit definition of sustainable groundwater extraction, which is a function of the minimal required pumping rate, minimal period the pumping rate needs to be sustained, the maximum allowed drawdown and groundwater quality requirements (such as maximal salinity levels). Stochastically generated grids of hydraulic properties and salinity are evaluated to obtain probability distributions of maximal pumping rate, available volume and salinity. Groundwater prospectivity is expressed as the joint probability that all requirements for sustainable development are satisfied. The GKIS can be updated as new information becomes available and can be used to extrapolate across data poor areas. Water resource managers now have an effective and resilient tool to improve their decision making and increase their chances of locating sustainable groundwater resources.

Water is scarce in the low rainfall APY Lands. Local, shallow groundwater resources support Indigenous communities, but little is known about the security of supply or regional water source options. Communities in this region rely on these groundwater systems to supply water for their use (both non-potable and potable) and economic purposes, including road building, pastoral and agriculture and potentially mining or other developments.

NEXT STEPS

New groundwater wells drilled in the G-FLOWS study were a significant and crucial component in gathering groundwater data in the Lindsay East Palaeovalley at the local scale. AEM surveys have provided increased confidence that these findings can potentially be extrapolated to other areas of alluvium/colluvium, and to palaeovalleys such as the Lindsay West Palaeovalley. However, additional hydrogeological investigations are needed to determine the size and sustainability of the groundwater resources in the region, including drilling, aquifer testing and geochemical sampling. This will help to create a more robust model of the system and better understand its sustainability as well as where to target new untapped water resources.

With a full toolkit of proven techniques and the GKIS groundwater prospectivity mapping resource, the G-FLOWS program has benefits far beyond the study site. These technologies have been applied in arid parts of Western Australia and the Northern Territory where knowledge about aquifer systems and groundwater remains limited. In the SA context there is opportunity to further develop an understanding of groundwater resources along the Braemar Corridor and also along the coast west of Ceduna. We anticipate that these tools will also be able to be used to search for deep groundwater resources in other remote landscapes across Australia and internationally.

MORE INFORMATION

The Final Summary Report and other technical reports associated with the research program are located at www.goyderinstitute.org/publications/technical-reports/

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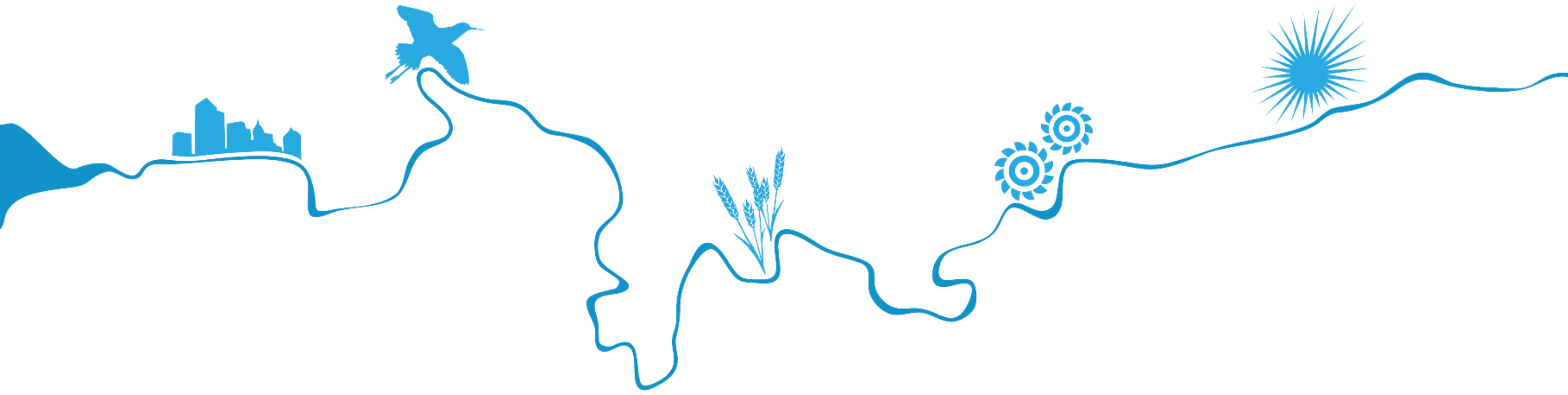

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