CAVES: OBSERVATORIES OF RAINFALL RECHARGE

Andy Baker, Martin Andersen, Pauline Treble*, Monika Markowska*, Katie Coleborn, Ingrid Flemons and KSS#

Connected Waters Initiative Research Centre, UNSW Australia. www.connectedwaters.unsw.edu.au
***Australian Nuclear Science and Technology Organisation, Lucas Heights, Australia**
 # the Kempsey Speleological Society

Objectives

Groundwater can be recharged from rivers (river recharge) or from rainfall (rainfall recharge, also known as diffuse recharge).

Rainfall recharge occurs when water moves through the soil and reaches the groundwater. Quantifying rainfall recharge is difficult, as it is hard to measure directly, and also hard to determine how much water is used by the vegetation. Some of our best understanding comes from modelling studies (Barron et al., 2012).

Our novel approach is to use caves as natural observatories of the recharge. The water dripping into the cave has come from rainfall recharge, and we can measure it directly.

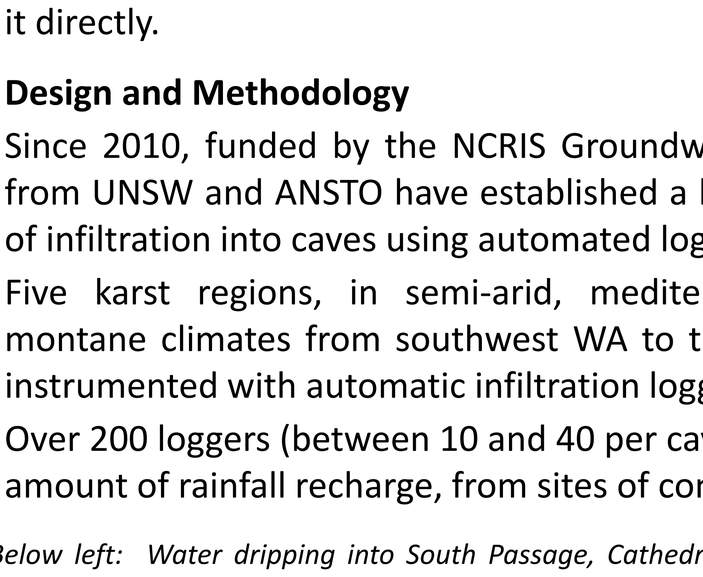
Design and Methodology

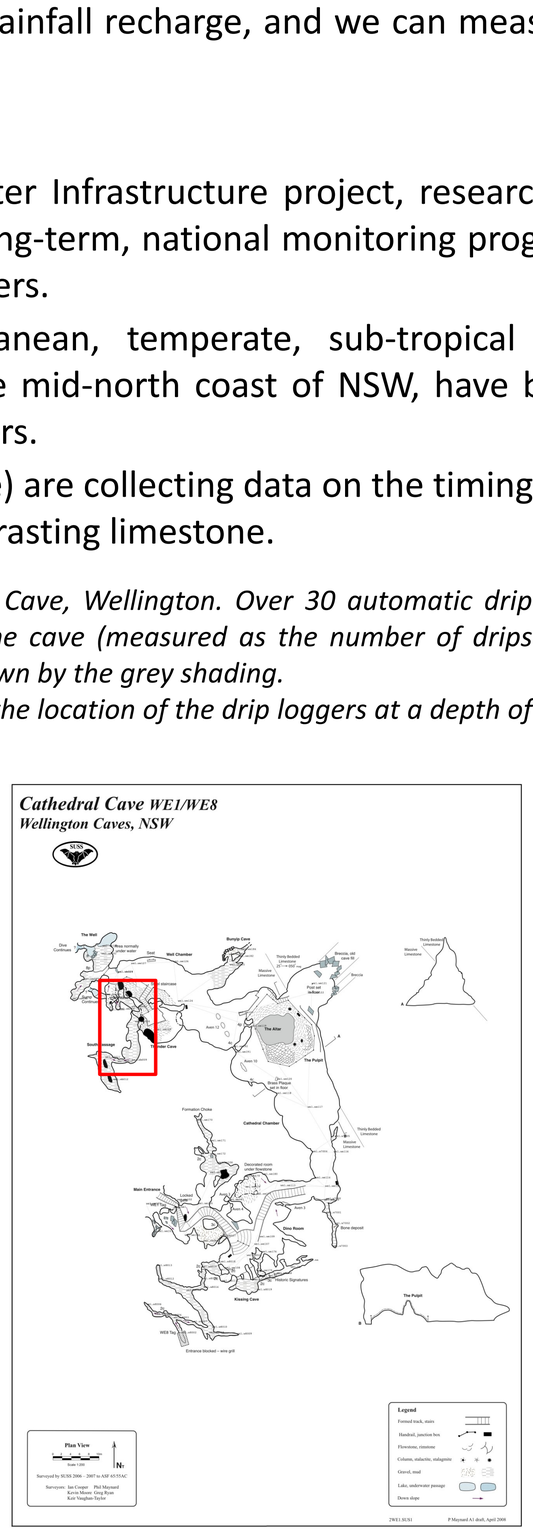
Since 2010, funded by the NCRIS Groundwater Infrastructure project, researchers from UNSW and ANSTO have established a long-term, national monitoring program of infiltration into caves using automated loggers.

Five karst regions, in semi-arid, mediterranean, temperate, sub-tropical and montane climates from southwest WA to the mid-north coast of NSW, have been instrumented with automatic infiltration loggers.

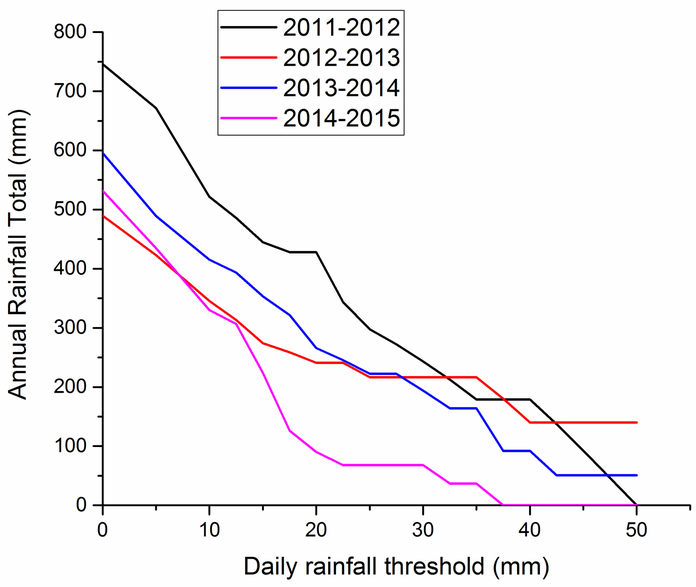
Over 200 loggers (between 10 and 40 per cave) are collecting data on the timing and amount of rainfall recharge, from sites of contrasting limestone.

Below left: Water dripping into South Passage, Cathedral Cave, Wellington. Over 30 automatic drip loggers record the amount of rainfall recharge reaching the cave (measured as the number of drips recorded every 15 minutes). Rainfall recharge events are shown by the grey shading.
Below right: Cathedral Cave, Wellington. The red box shows the location of the drip loggers at a depth of 25 m below the surface.

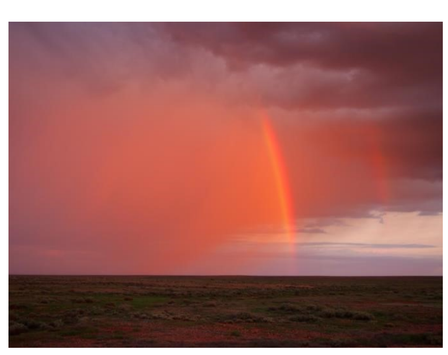




Daily Rainfall Threshold (mm)	Northern drips	Southern drips
50	0.60	-0.05
45	**0.66**	0.66
42.5	0.57	**0.88**
40	0.57	**0.90**
37.5	0.63	0.85
35	**0.77**	0.58
32.5	**0.70**	0.74
30	**0.66**	0.77
27.5	0.61	0.72
25	0.55	0.78
22.5	0.53	0.80
20	0.38	0.82
17.5	0.41	0.72
15	0.24	0.65
12.5	0.10	0.61
10	0.12	0.66
5	-0.01	0.70
0	-0.06	0.59

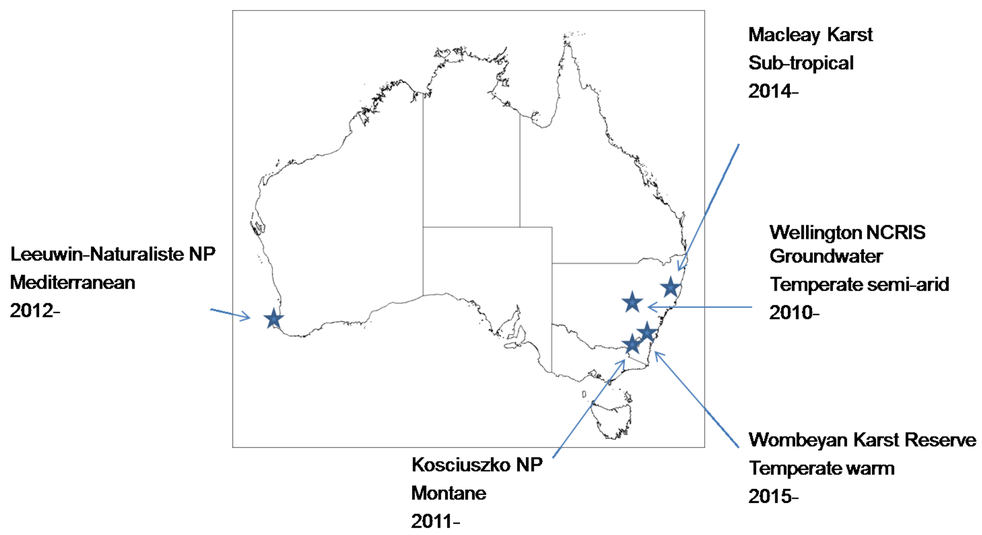


Above left: Correlation between annual cave drip discharge and annual total rainfall amount, for different daily rainfall thresholds. For example, a threshold of '0 mm' includes all rainfall, and a threshold of '30 mm' is the annual rainfall total for days when rainfall >30 mm. All data is calculated for the hydrological year starting 1st July. The total annual recharge for each drip site is normalised to that in 2013-2014. The normalised data is combined for two spatial regions (northern and southern sections of South Passage) as their drip data are similar. Statistically significant Pearson's correlations (at a 99% confidence level) are shown in bold.
Above right: the relationship between rainfall amount and intensity at Wellington, NSW. Note that a wet year does not necessarily have the most high-rainfall days. For example, 2012-2013 was the driest year but had the most rainfall falling above 50 mm per day.



Above: Rainfall. How much is needed to recharge groundwater?
Right: drip counters in Cathedral Cave.
Below: the national monitoring network.

Joint ANSTO – CWI long-term cave monitoring network



Results

Here we present results from Wellington Caves, in the Central-west NSW. This temperate semi-arid region has an average of 619 mm rainfall and 1825 mm evaporation a year. At this site we now have five years of data.

Cave drip water data demonstrate 13 rainfall recharge events have occurred at this location over 5 years.

The amount of rainfall needed to recharge the groundwater varies with location in the cave. In all cases, groundwater recharge only occurs when there is at least 30 mm of rainfall in a day.

Annual rainfall recharge of the groundwater at Wellington does not correlate with total annual rainfall.

Annual rainfall recharge at Wellington correlates with the total annual amount of rainfall for days when rainfall was above 30 mm.

Conclusions

At Wellington, NSW, we observe on average 2.6 rainfall recharge events per year.

The number of rainfall recharge events varies considerably between years. There were more recharge events in the La Niña years of 2010-2012.

Annual groundwater recharge from rainfall correlates with the annual total rainfall for days when rainfall was greater than 30 mm per day. The latter result corroborates the national rainfall recharge modelling study of Barron et al. (2012).

Over time, our drip water time-series get longer, and we will repeat these analyses for the other sites in our long-term monitoring network, and we will extend this analysis.

With anthropogenic global warming, higher temperatures may lead to a greater rainfall intensity (Wasko and Sharma, 2015) and increased evaporation, both of which will affect rainfall recharge but in opposite directions.

Our cave observatory system helps improve our understanding of the rainfall recharge process and provides a baseline monitoring network during this period of climate change.

References

Barron, O.V., Crosbie, R.S., Dawes, W.R., Charles, S.P., Pickett, T. and Donn, M.J. 2012. Climatic controls on diffuse groundwater recharge across Australia. Hydrology and Earth Systems Science, 16, 4557-4570.

Wasko, C. and Sharma, A. 2015. Steeper temporal distribution of rainfall at higher temperatures within Australian storms. Nature Geoscience, 8, 527-529.