Australian Cotton Water Story Groundwater Resource Condition

Presented by

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UNSW Connected Waters Initiative

Based upon work by the UNSW CWI team

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The story begins.....

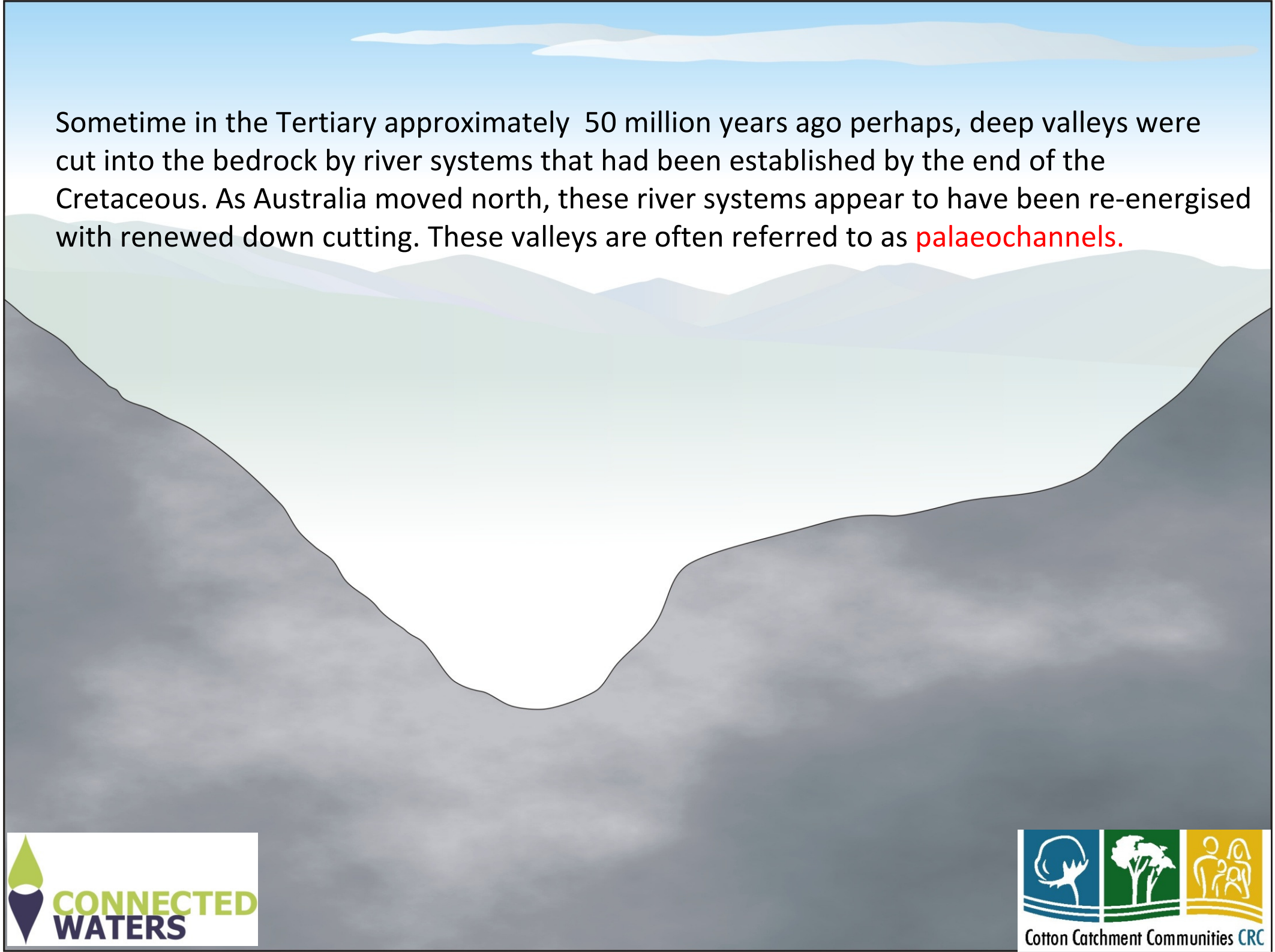
Once upon a time in our land, which was then far far away, things began to move!

About 60 million years ago, Narrabri was approximately 6000kms further south – not that far from the South Pole. It had been part of a supercontinent that began to split up.

The Mesozoic Era (Triassic, Jurassic and Cretaceous) had finished about 85 million years ago. The coal deposits had been laid down even earlier at about 400 million years ago, towards the end of the Palaeozoic Era (Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian).

Dinosaurs roamed the land at the end of the Cretaceous, but it must have been dark and cold for much of the time, given the latitude close to the south pole!

We build a simple conceptual model of water resources now available based upon our understanding of how geomorphological processes have developed in the past!


Sometime in the Tertiary approximately 50 million years ago perhaps, deep valleys were cut into the bedrock by river systems that had been established by the end of the Cretaceous. As Australia moved north, these river systems appear to have been re-energised with renewed down cutting. These valleys are often referred to as palaeochannels.
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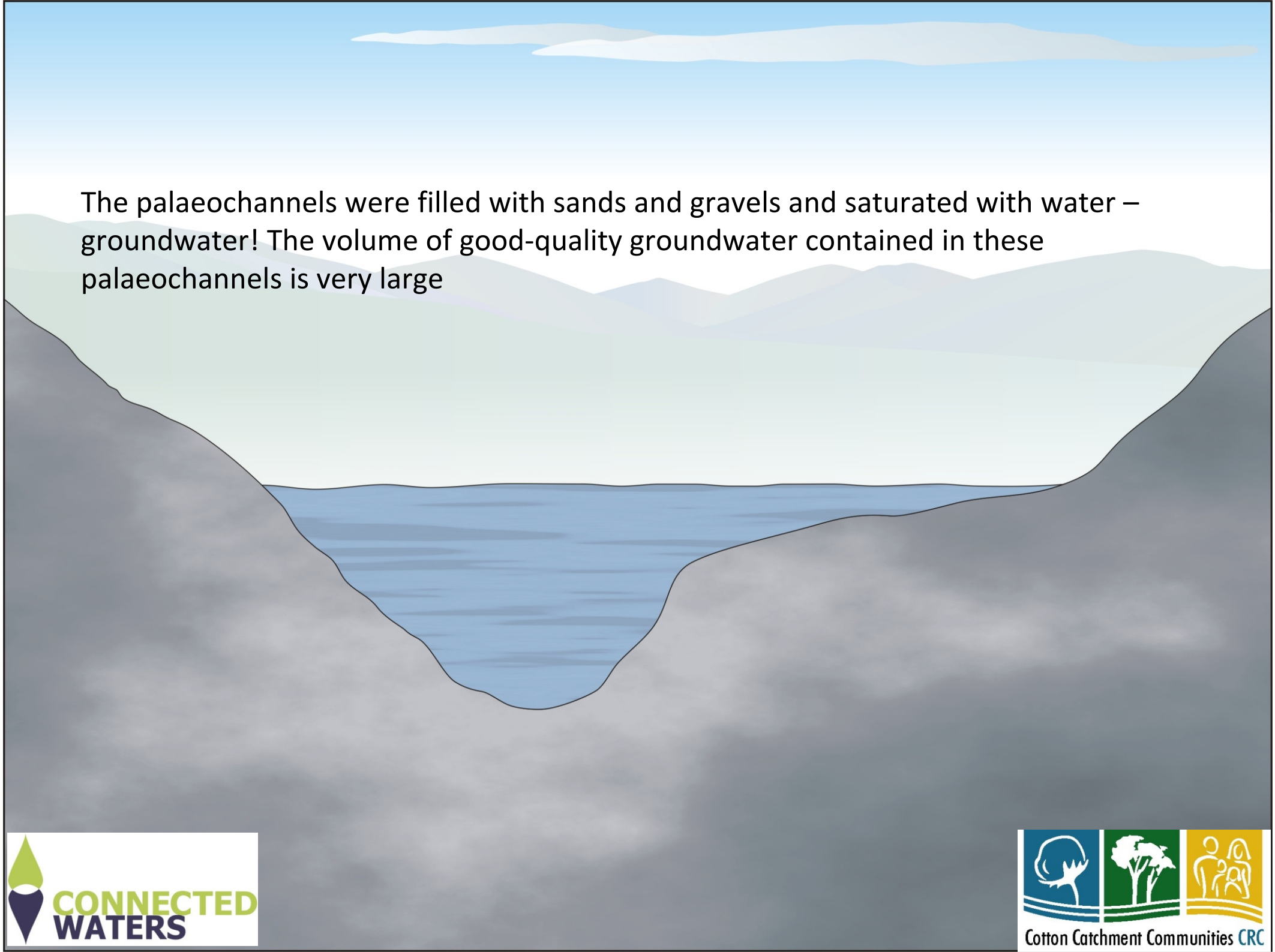
The palaeochannels were filled with sands and gravels and saturated with water – groundwater! The volume of good-quality groundwater contained in these palaeochannels is very large
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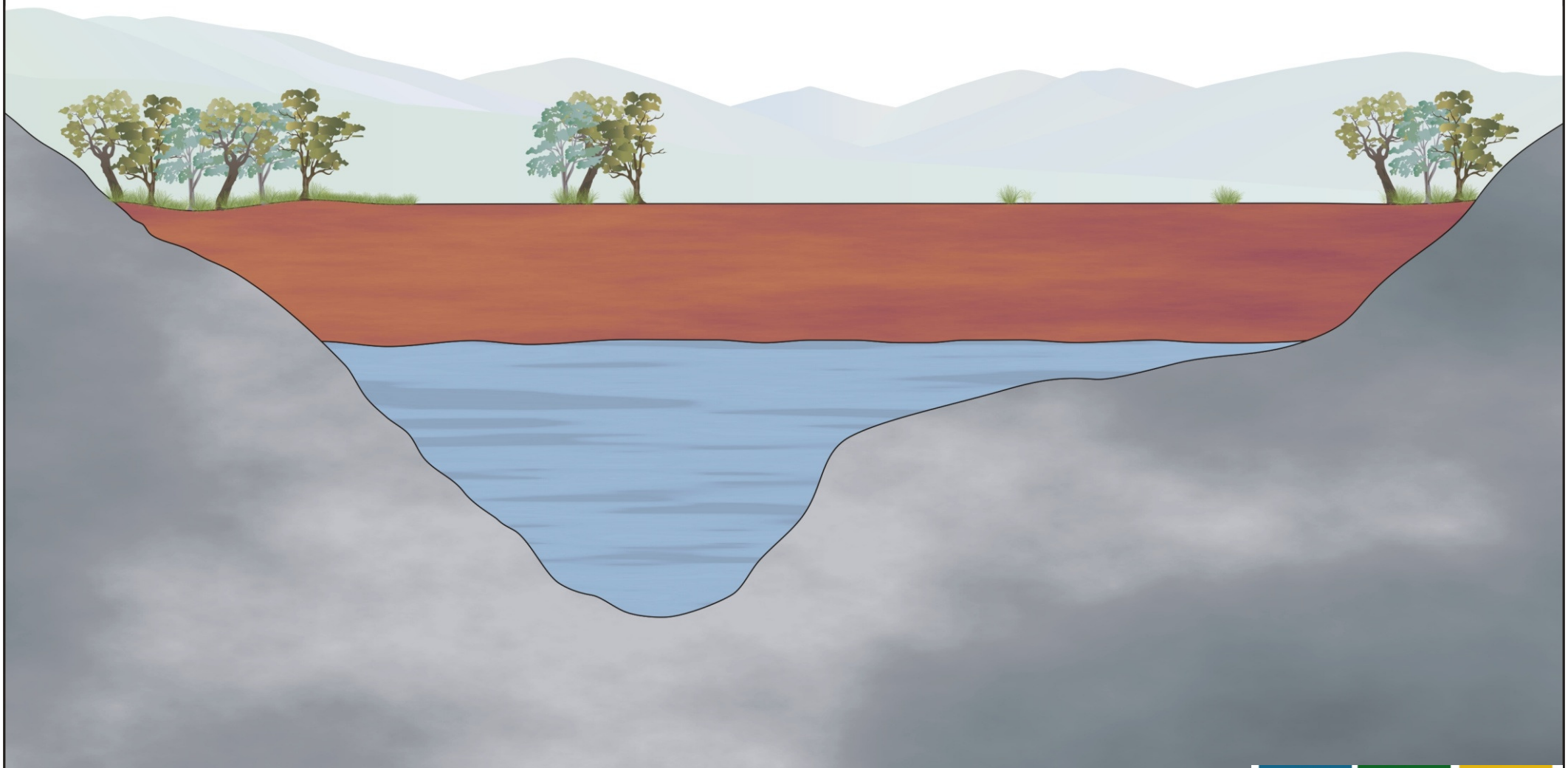
Some time later, silts and clays were laid down on top of the sands and gravels. Possibly some of the silts and clays came from the Nandewar Volcano that erupted about 17 million years ago ….



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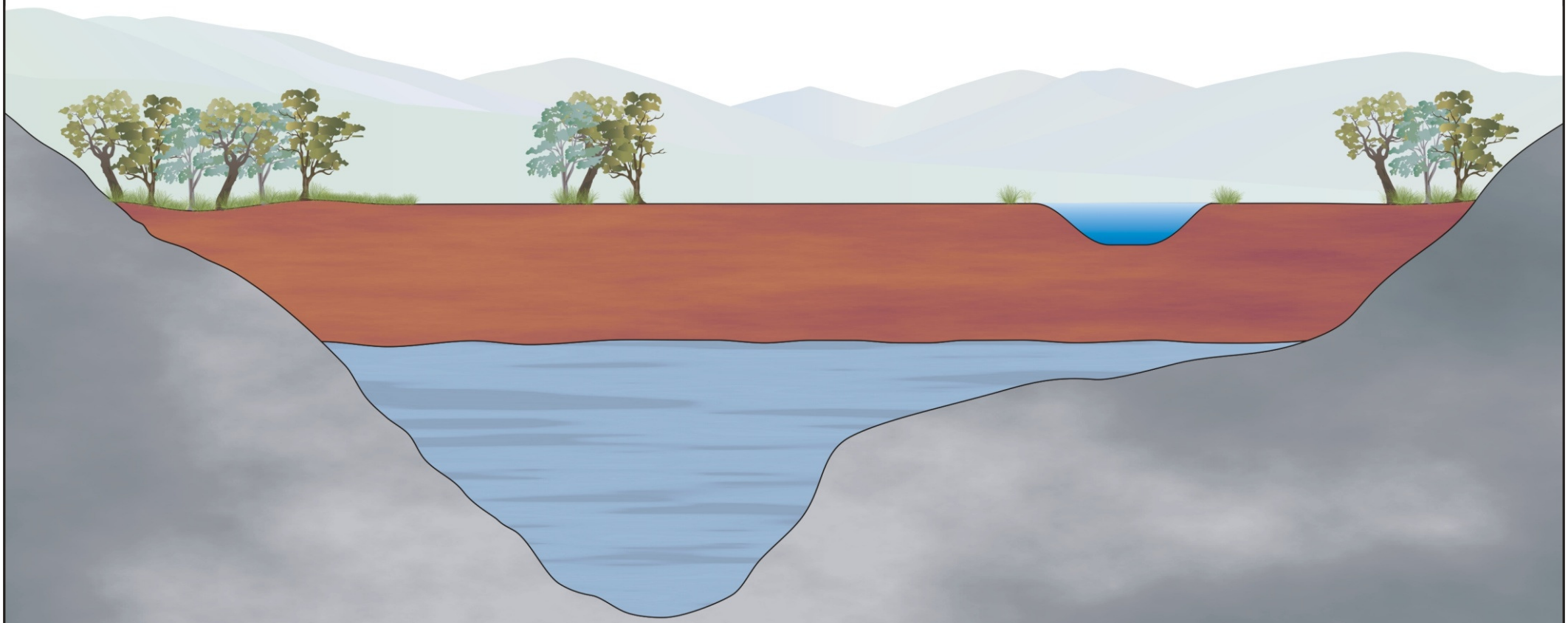
The River Namoi sits mostly on top of the silts and clays – often at a location not above the palaeochannel.



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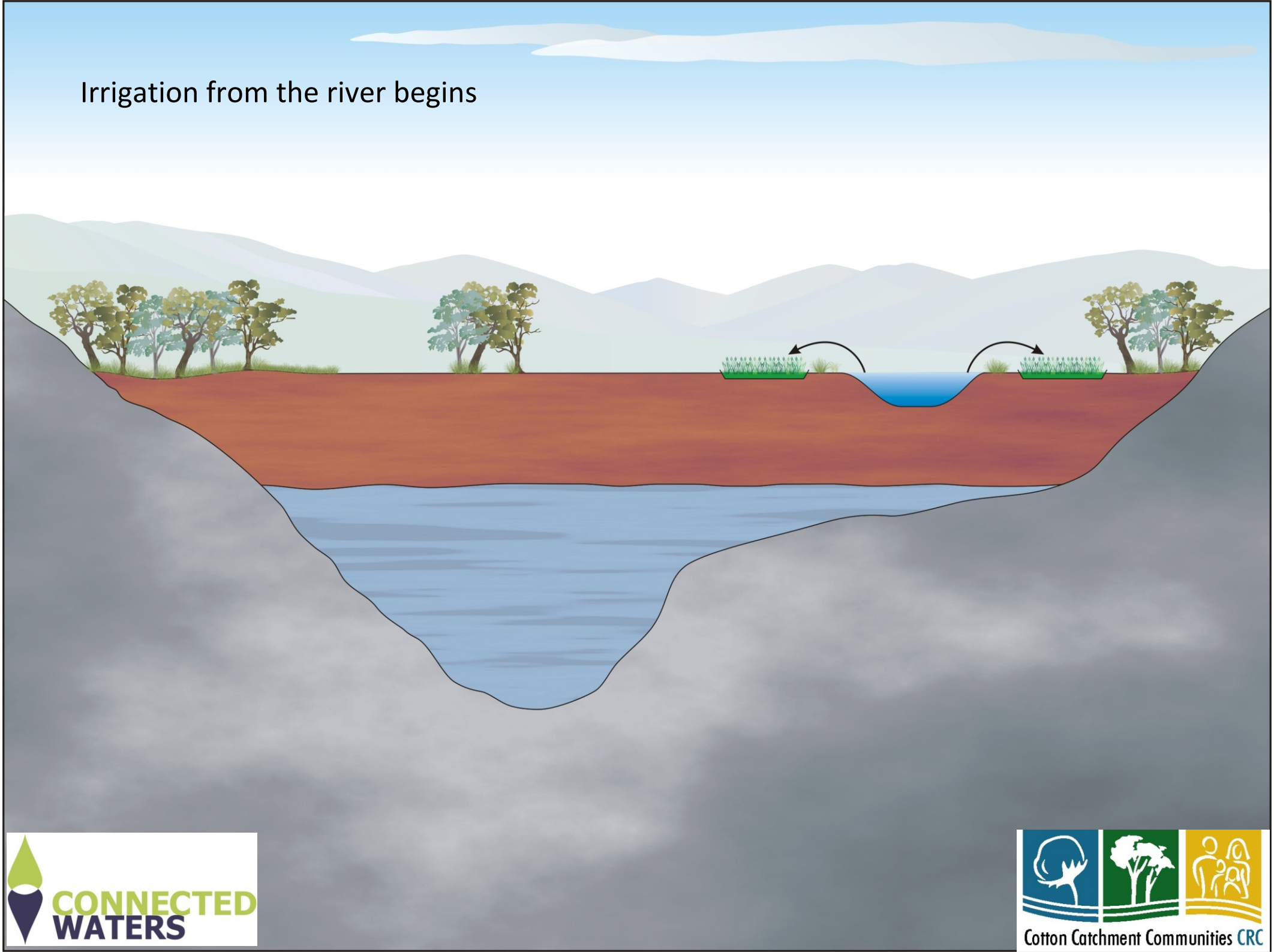
Irrigation from the river begins



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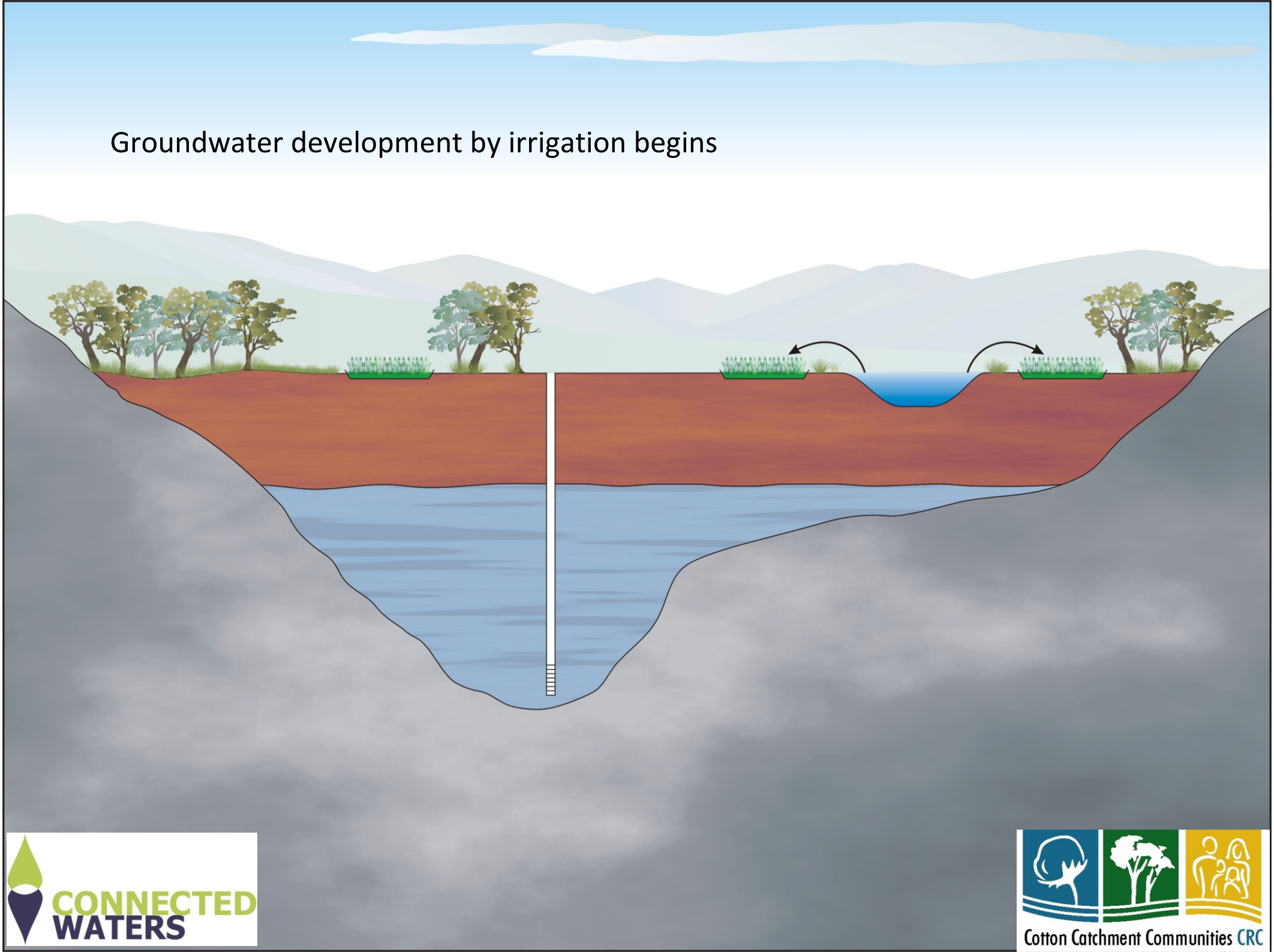
Groundwater development by irrigation begins



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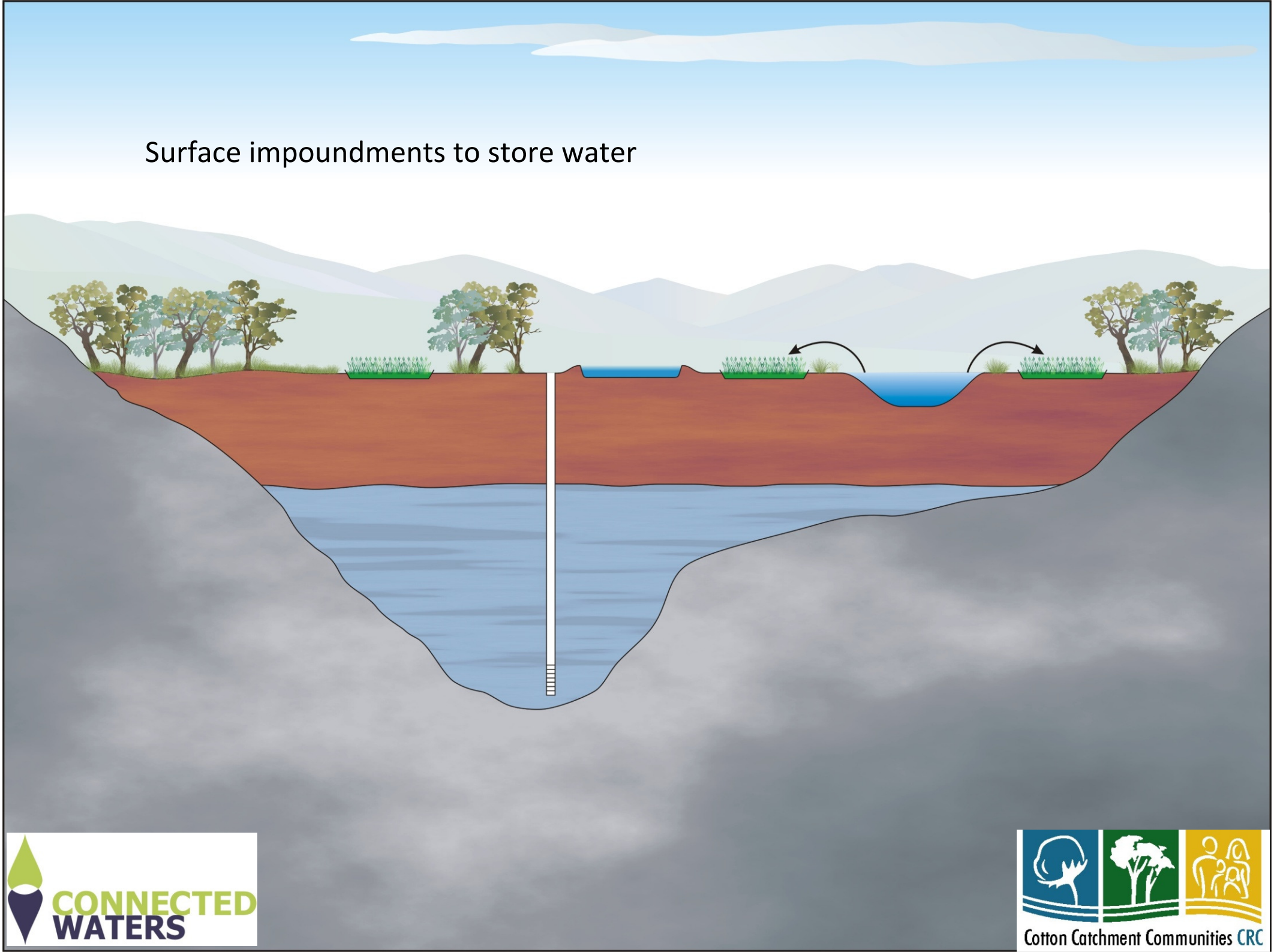
Surface impoundments to store water



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But --- Is the story correct?

The development of surface and groundwater resources proceeded at a rapid rate in the 1980's and 1990's.

Groundwater levels began falling quite quickly and the general story began to be questioned, particularly in view of the nauties drought that started to have a significant impact early in the life of the Cotton Catchment Communities CRC.

QUESTIONS

1.How sustainable is groundwater use?

2.Does irrigation practice lead to deep drainage?

3.Is the conceptual model of an impermeable surface layer overlying a high yield aquifer correct?

4.Is surface water linked to groundwater?

5.What about water quality?

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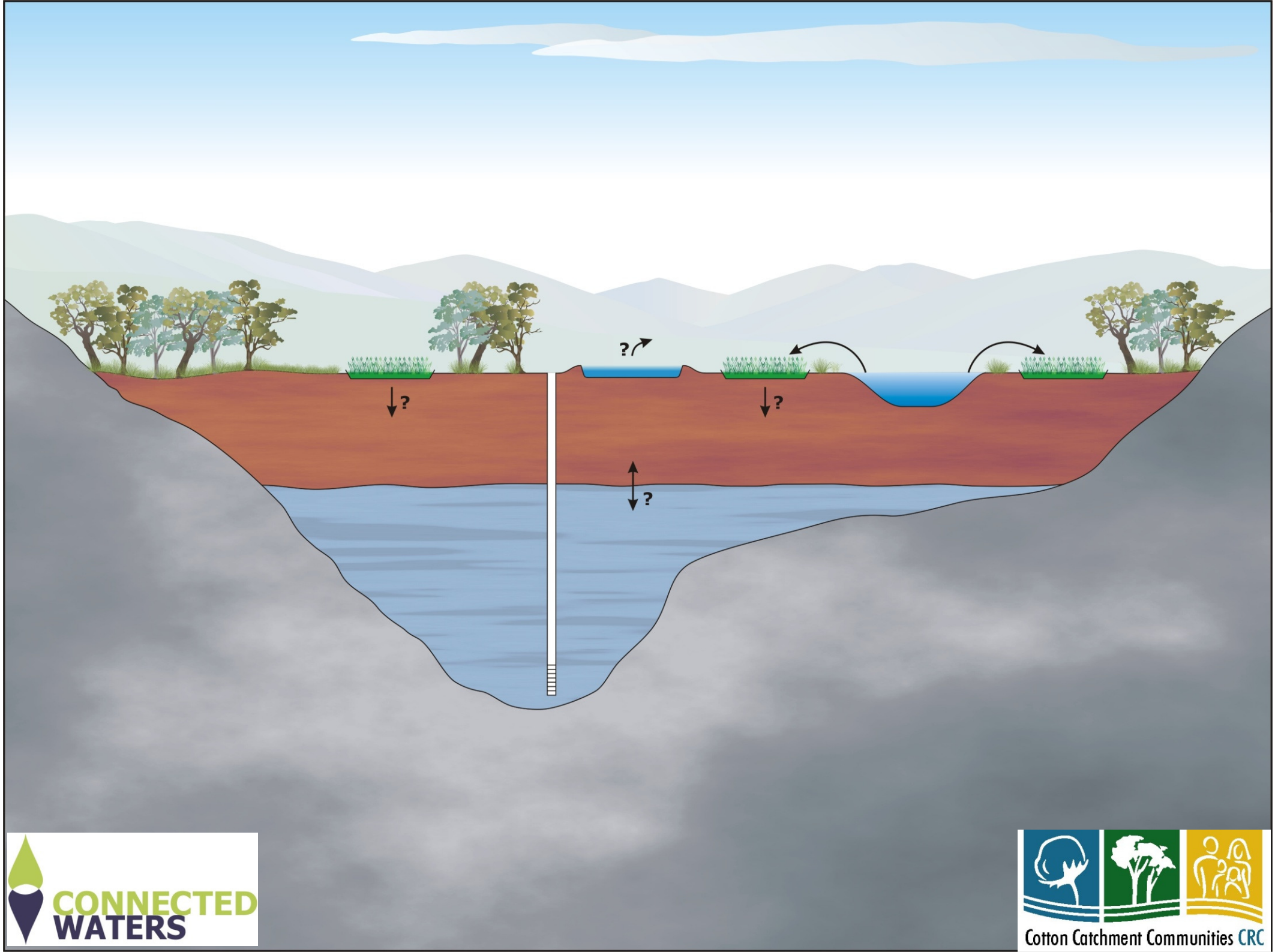
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Water levels and sustainability?

How sustainable is groundwater abstraction?

What has been the impact of abstraction over the past 20 years?

Is there evidence of over-abstraction?

Do groundwater levels recover – indicating active recharge?

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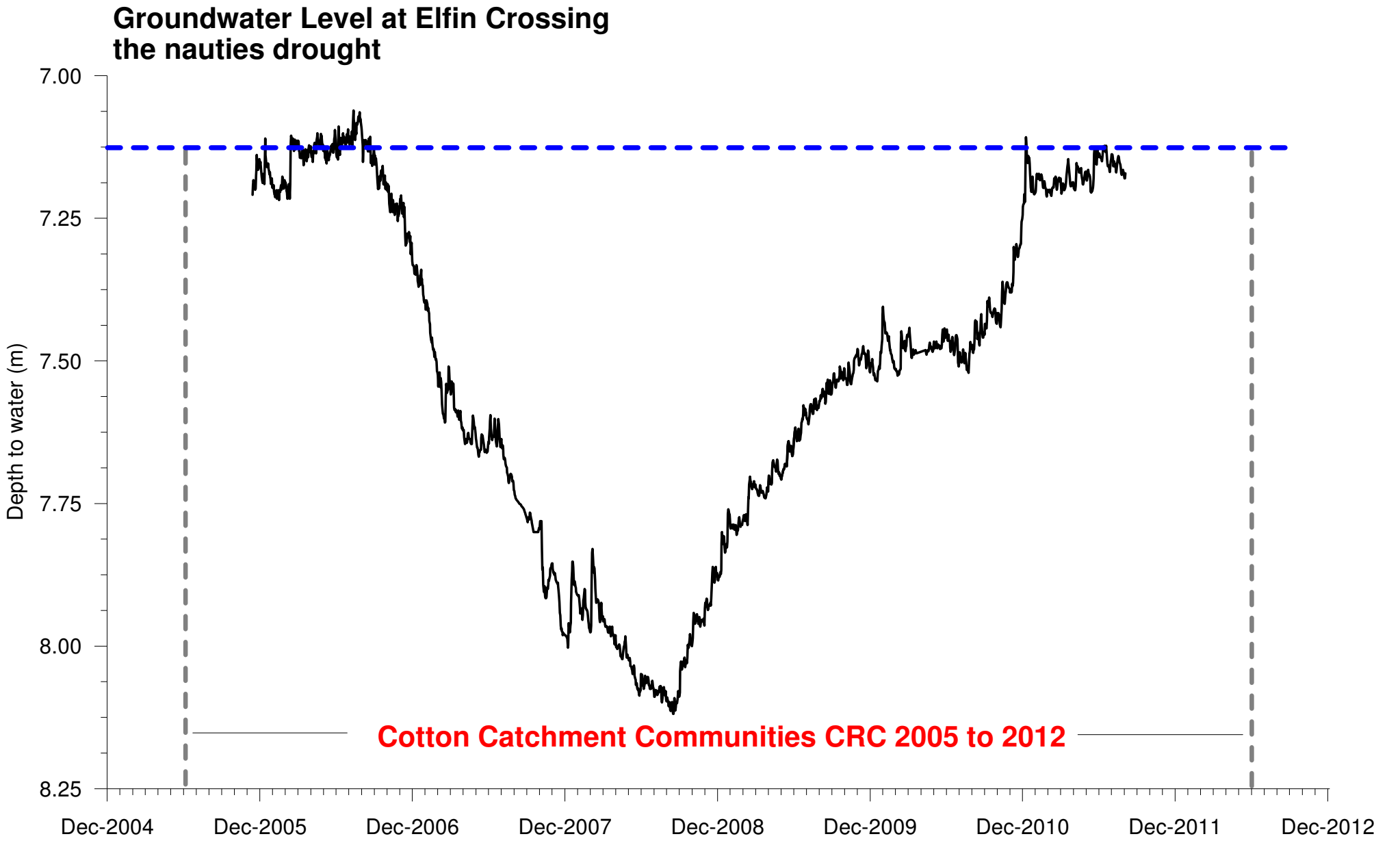

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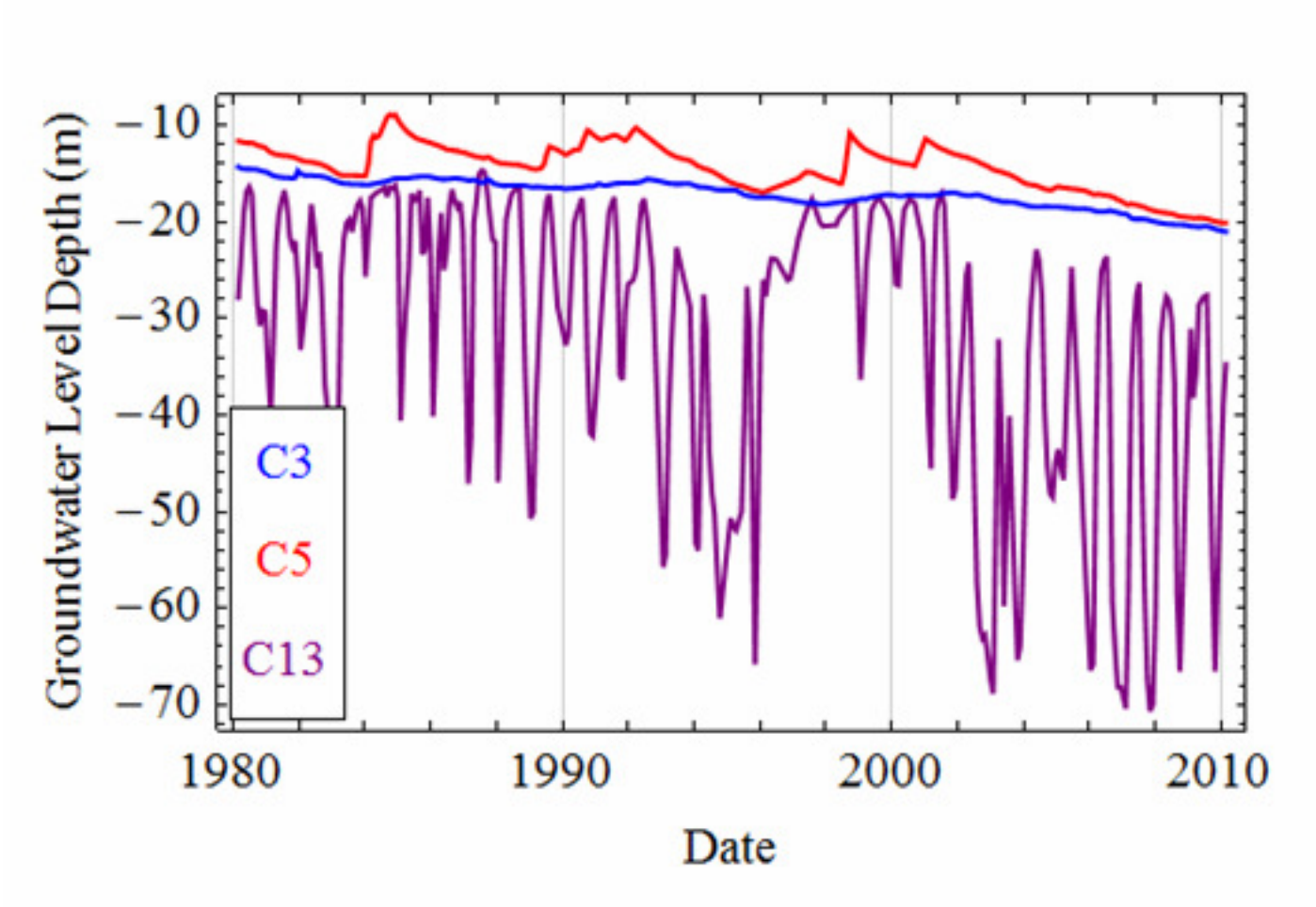
Groundwater levels falling in response to abstraction



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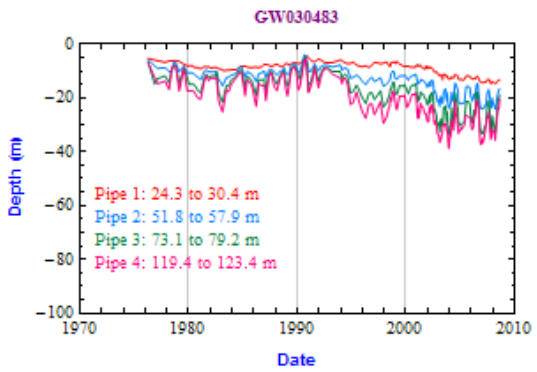
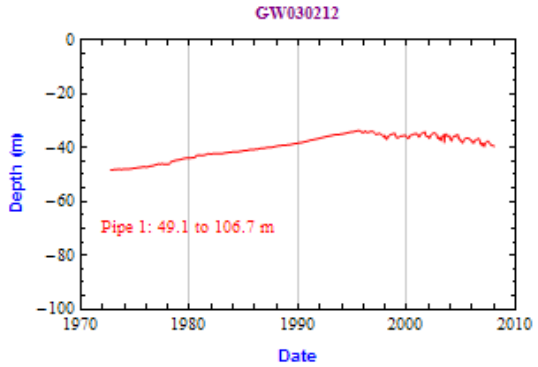
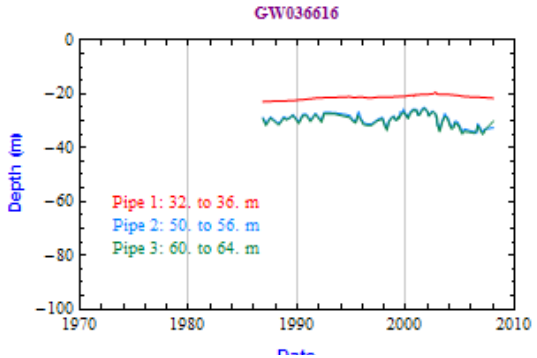
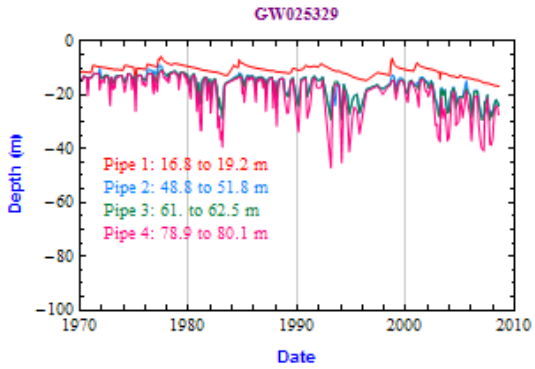
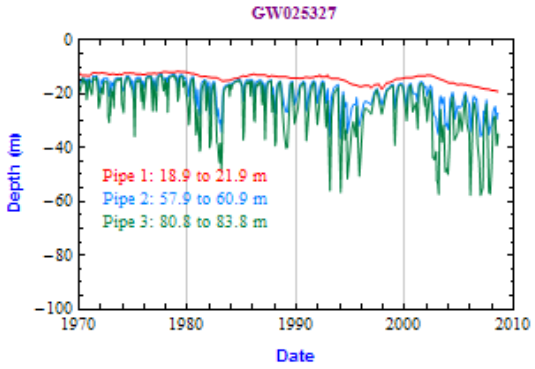
In a National Water Commission funded project, every groundwater hydrograph in the Namoi, Gwydir, Macquarie and Lachlan Catchments has been examined. The groundwater level response over the past 40 years has indicated significant variation:

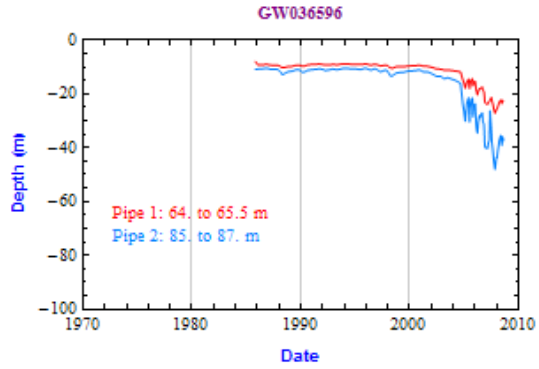












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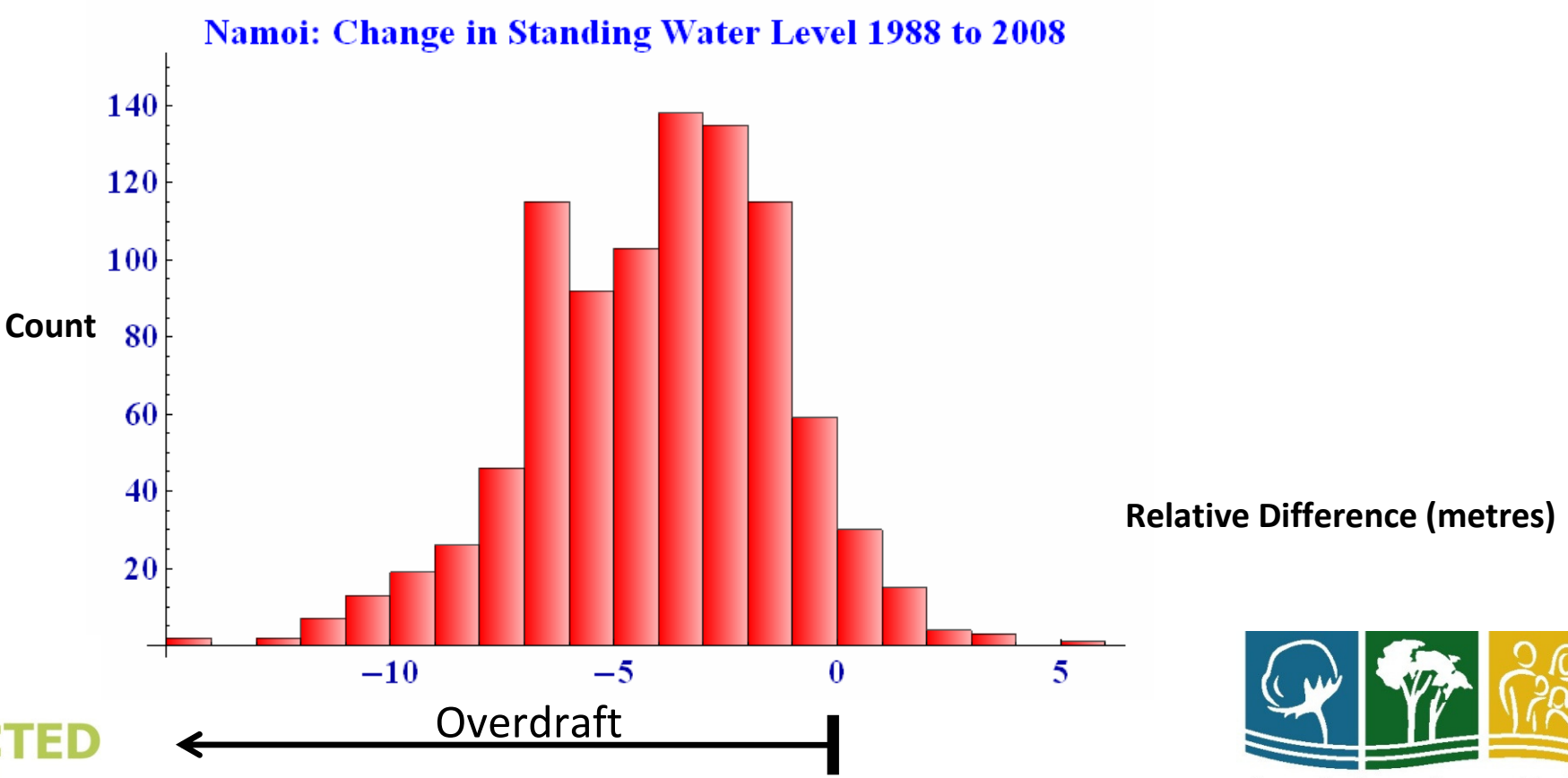
Namoi

- 458 monitoring locations with records for both 1988 and 2008
- 925 pipes
- Largest fall in level 14.47 m
- Largest rise in level 5.54 m
- For most the water level has declined between 1 to 7 metres



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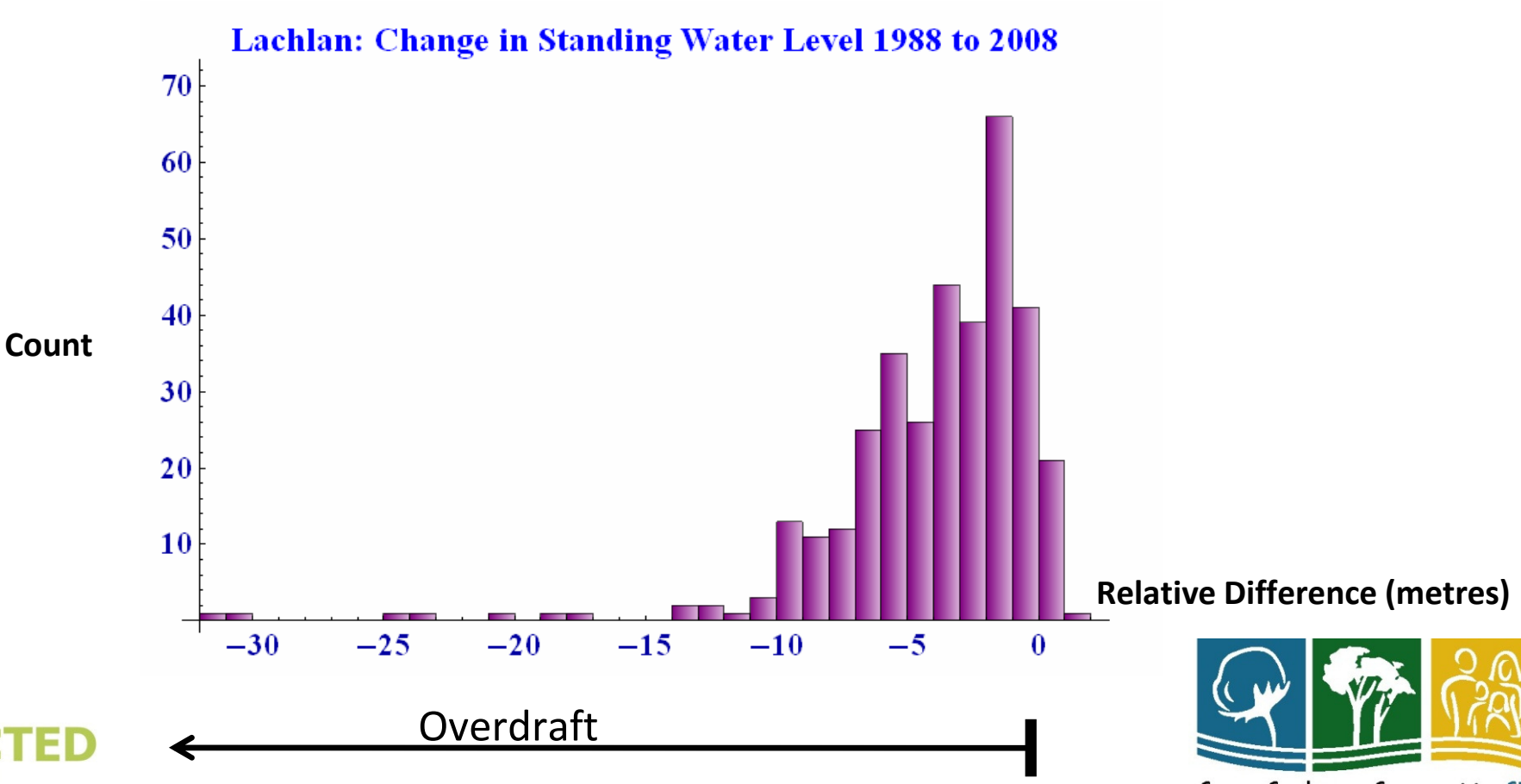
Lachlan Catchment

- 181 monitoring locations with records both in1988 and 2008
- 349 monitoring pipes
- Largest decline in the standing water level 31.75 metres
- For most the water level has declined between 1 to 10 metres



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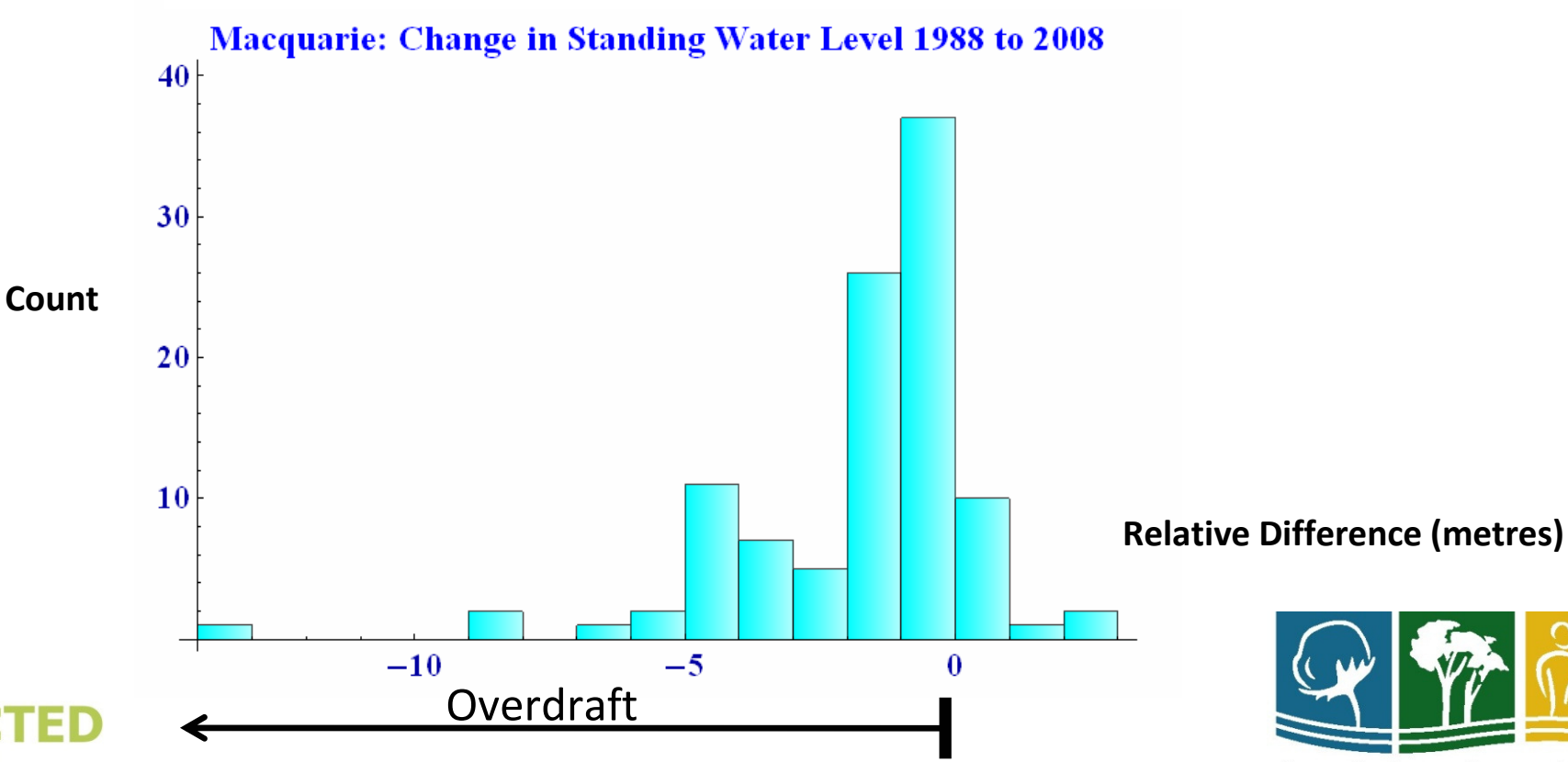
Macquarie

- 79 monitoring locations with records for both 1988 and 2008
- 105 monitoring pipes
- Largest decline in the standing water level 13.57 metres
- For most the water level has declined between 1 to 2 metres



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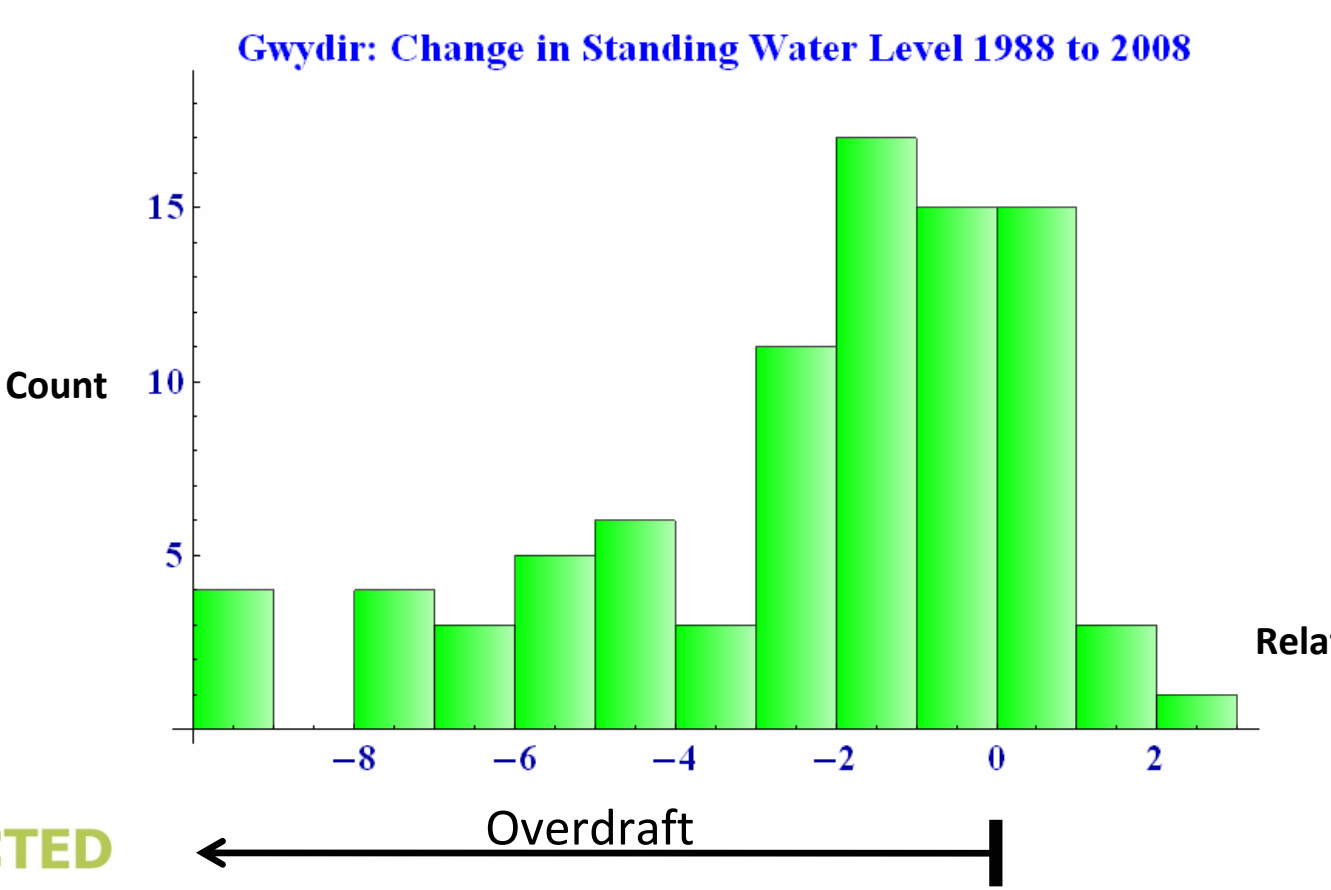
Gwydir

- 41 monitoring locations with records for both 1988 and 2008
- 87 monitoring pipes
- Largest decline in the standing water level 9.95 metres
- For most the water level has declined between 1 to 3 metres



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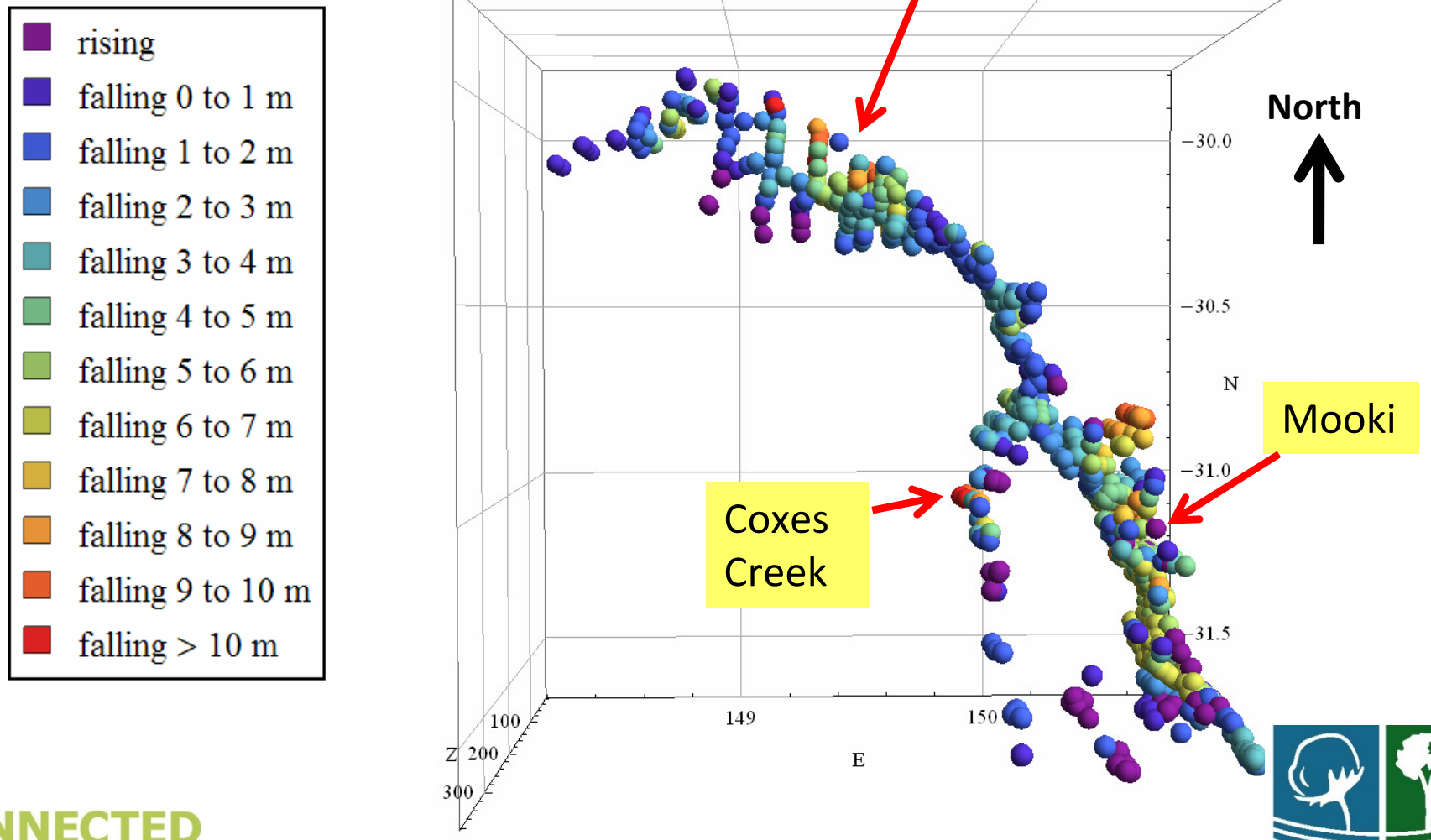

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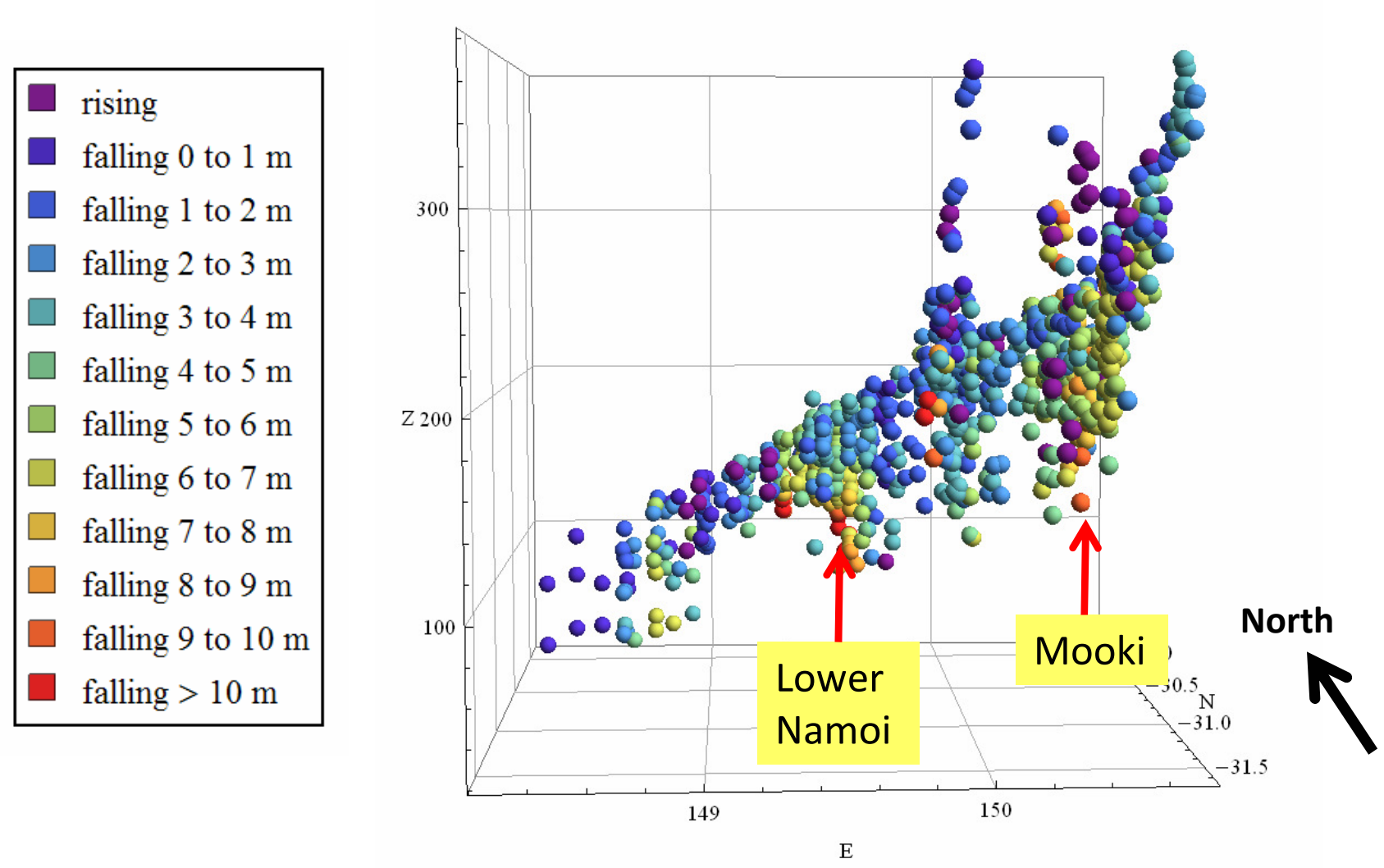
Namoi



Most decline in the lower semi-confined aquifers

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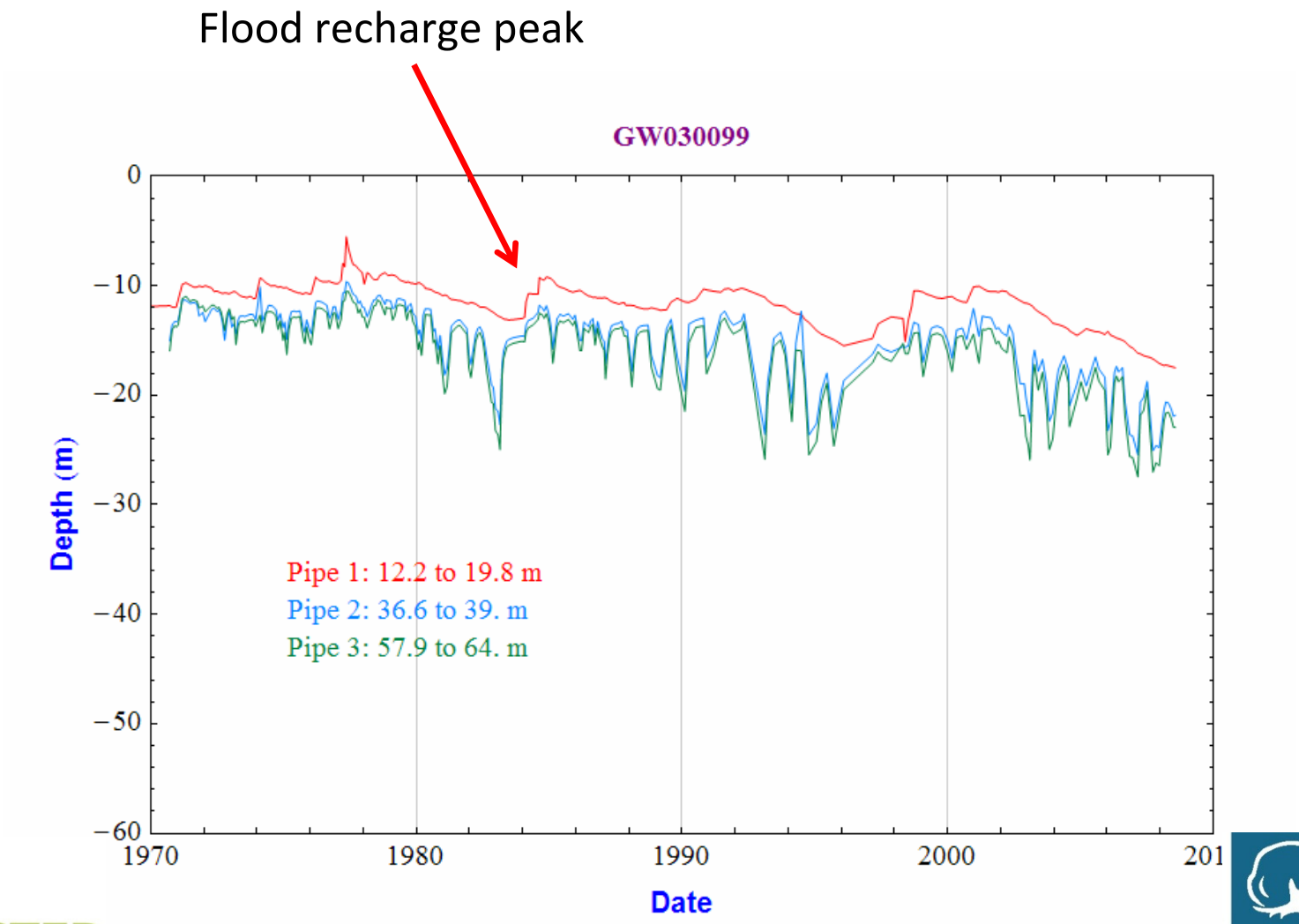
Groundwater Hydrograph showing response to Flood Recharge



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Surface Water – Groundwater Connectivity?

Are surface and groundwater resources connected?

Do we understand the processes?

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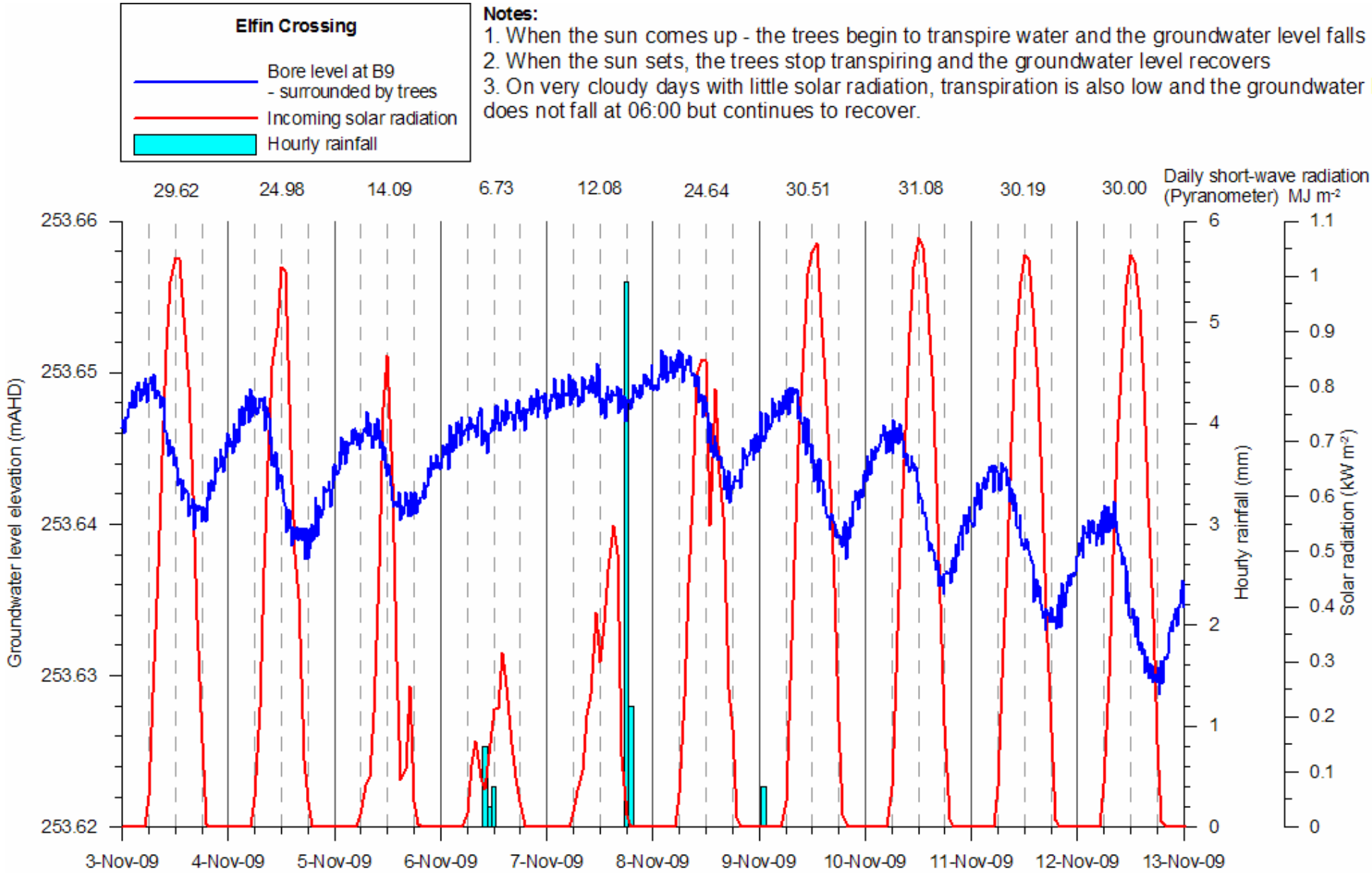

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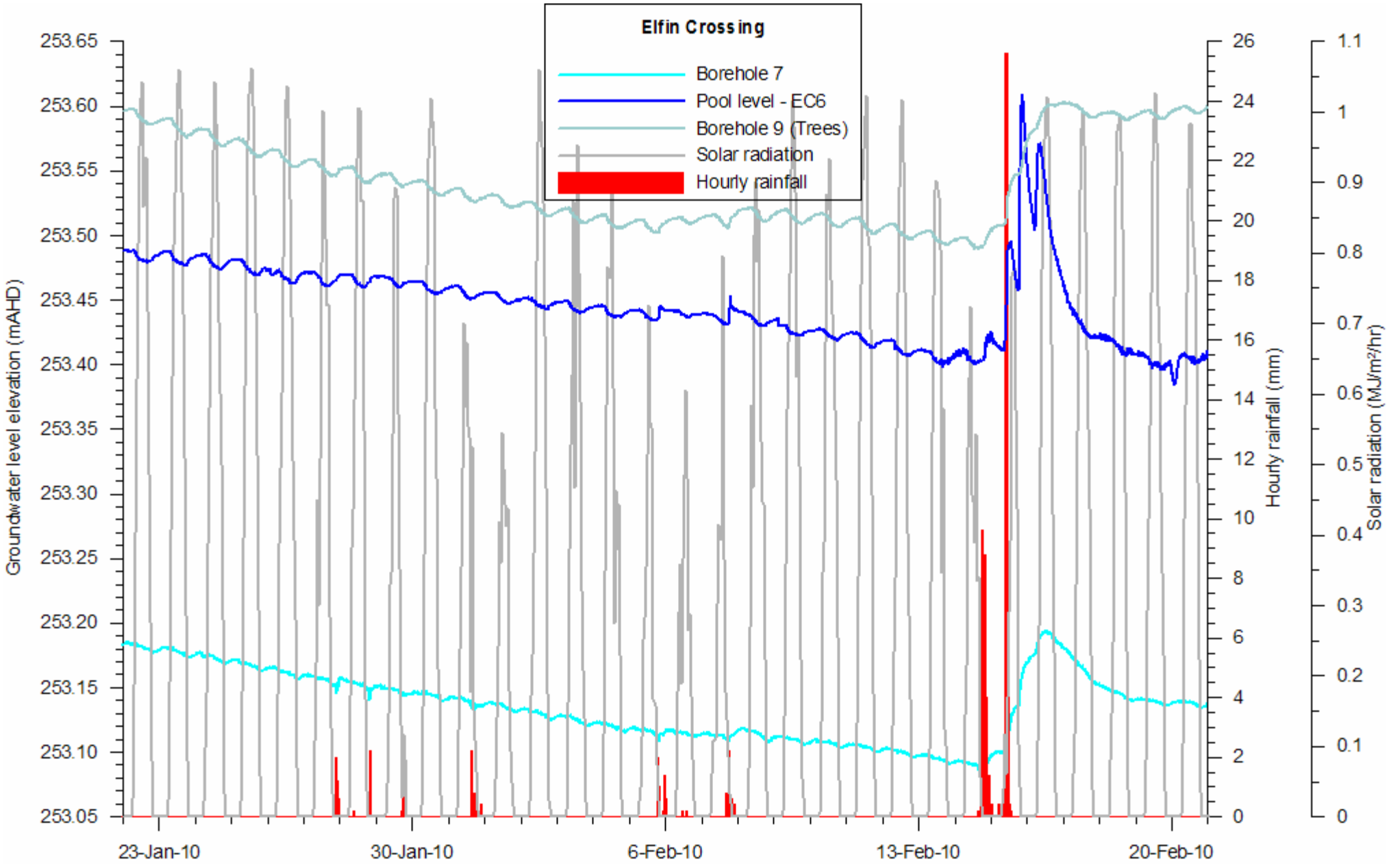

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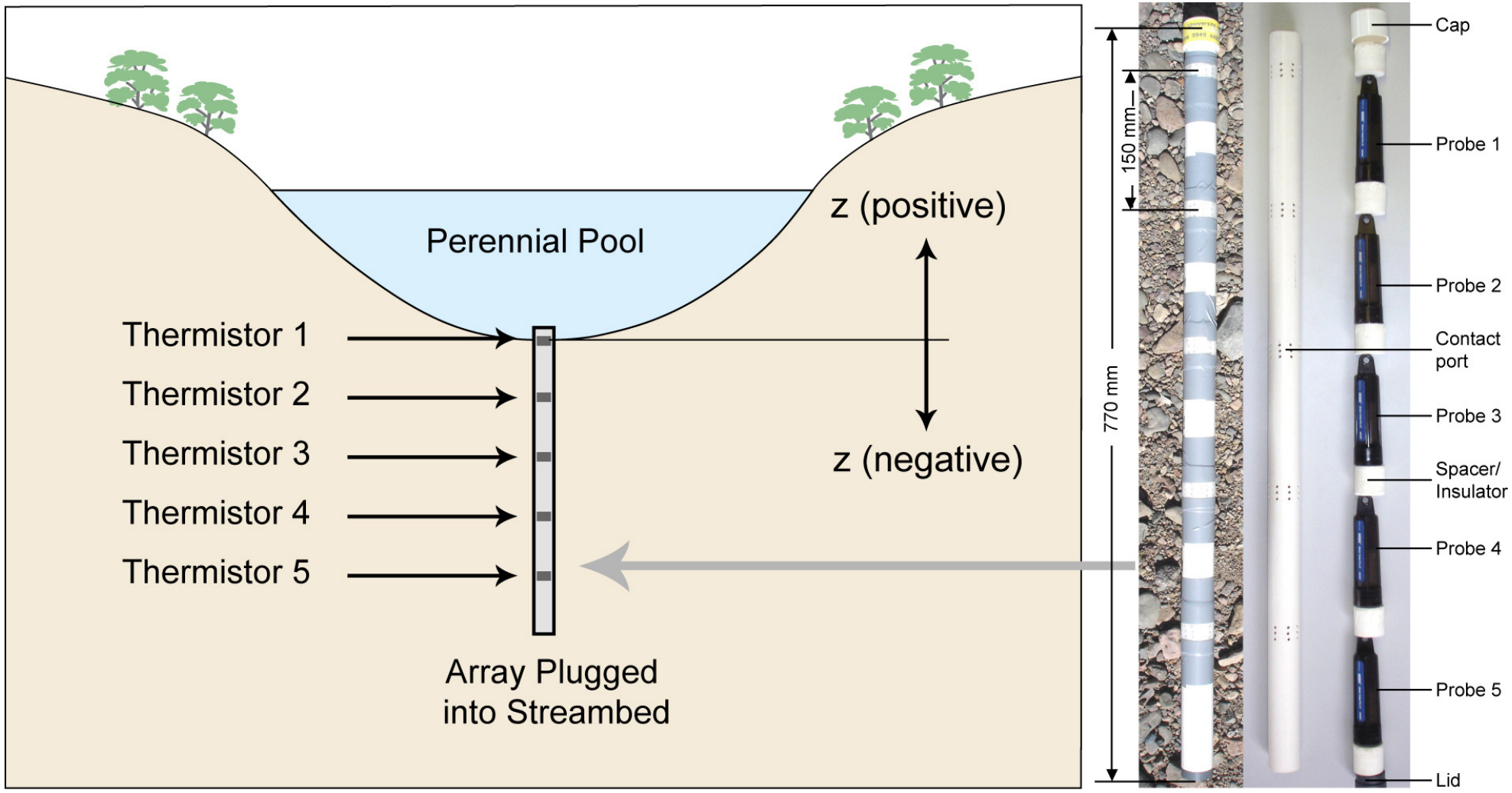

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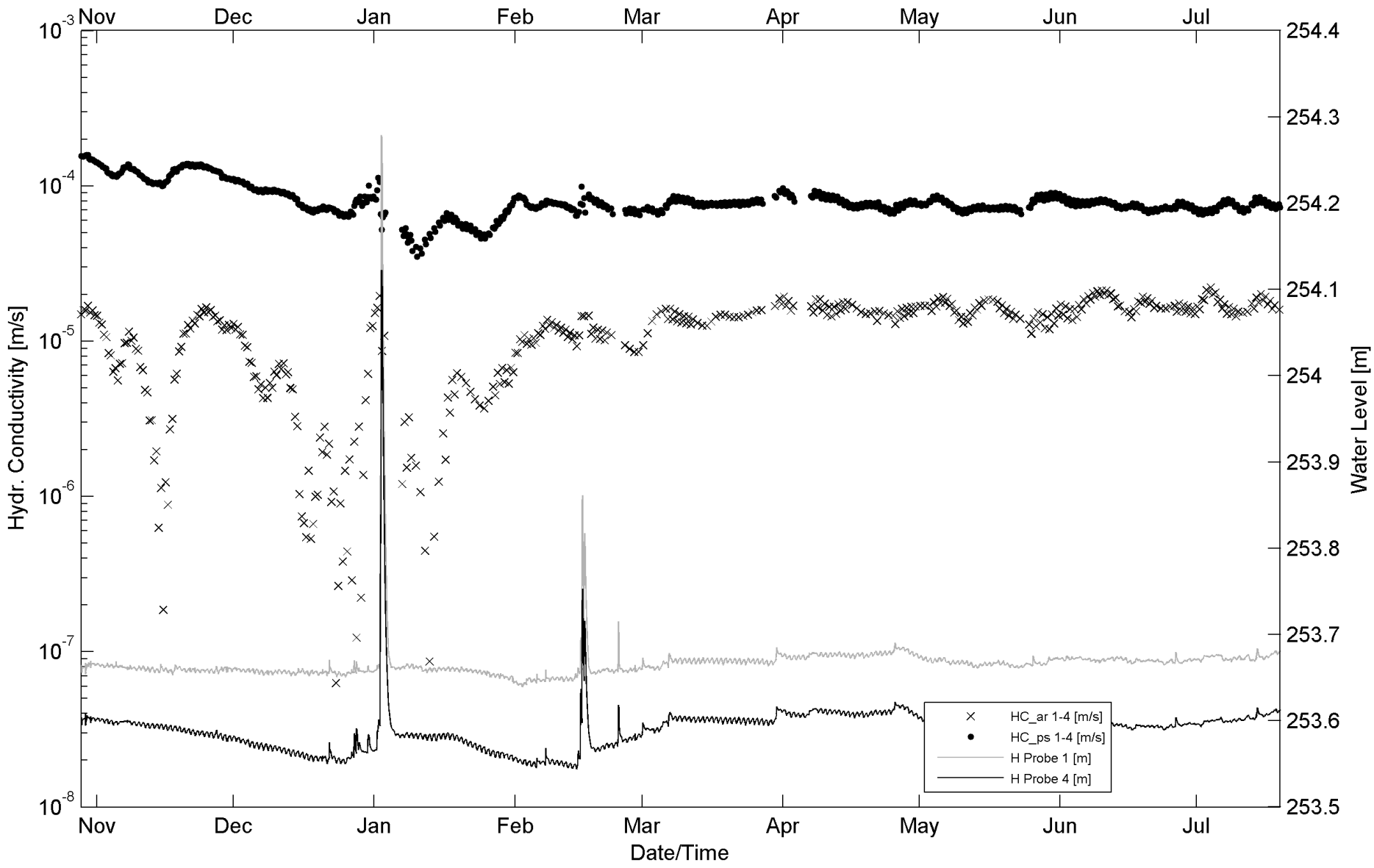

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Deep Drainage?

Does deep drainage occur beneath irrigated fields?

Can we measure it?

Can we quantify it?

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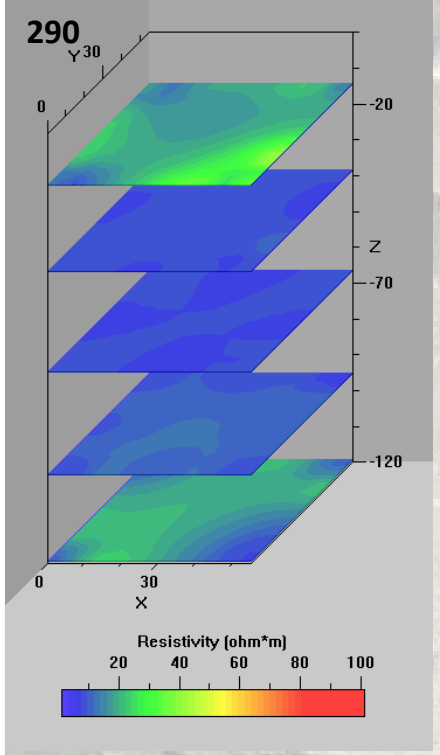

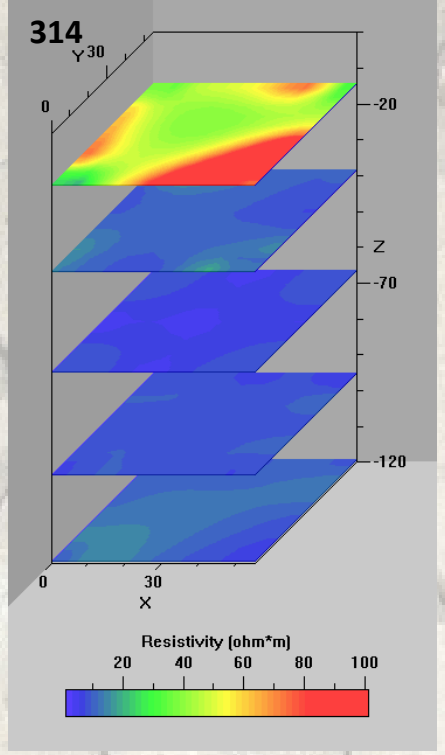

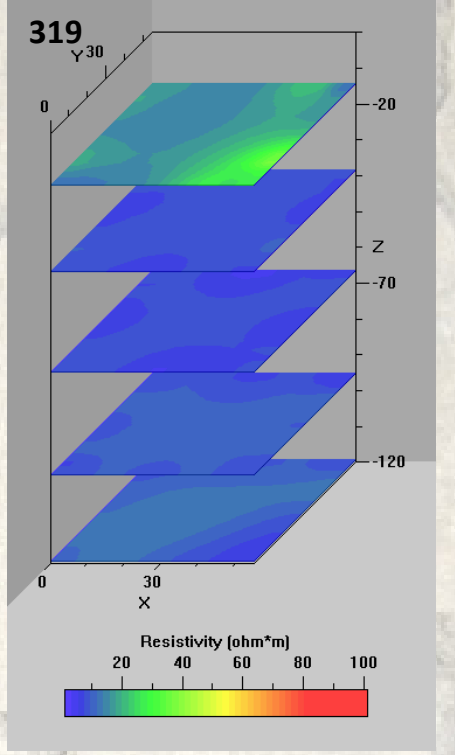

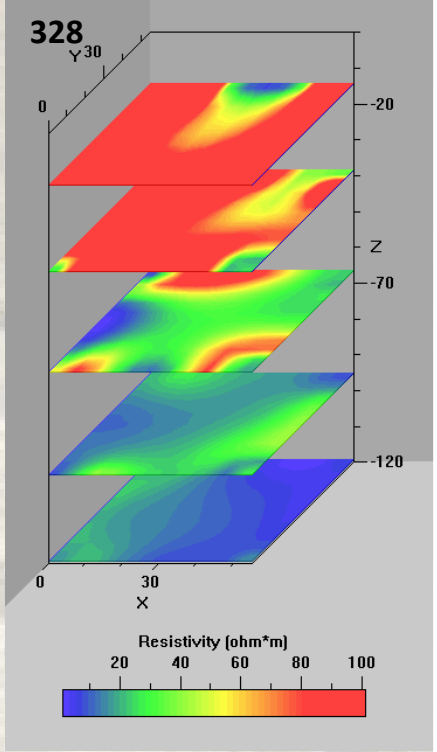

Field trial Nov 2007- Jan 2008

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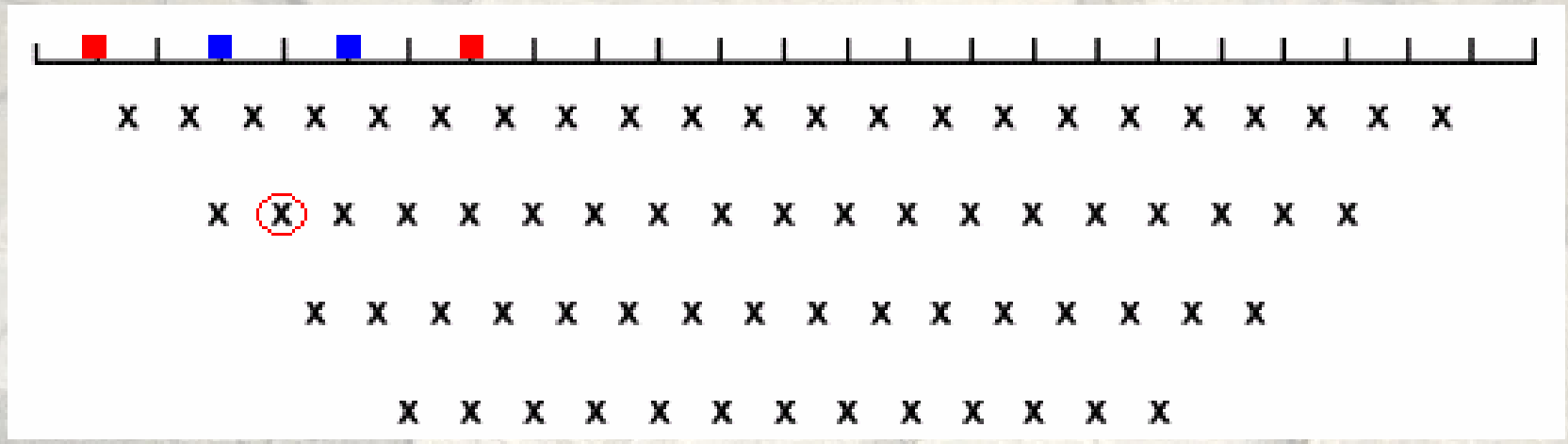
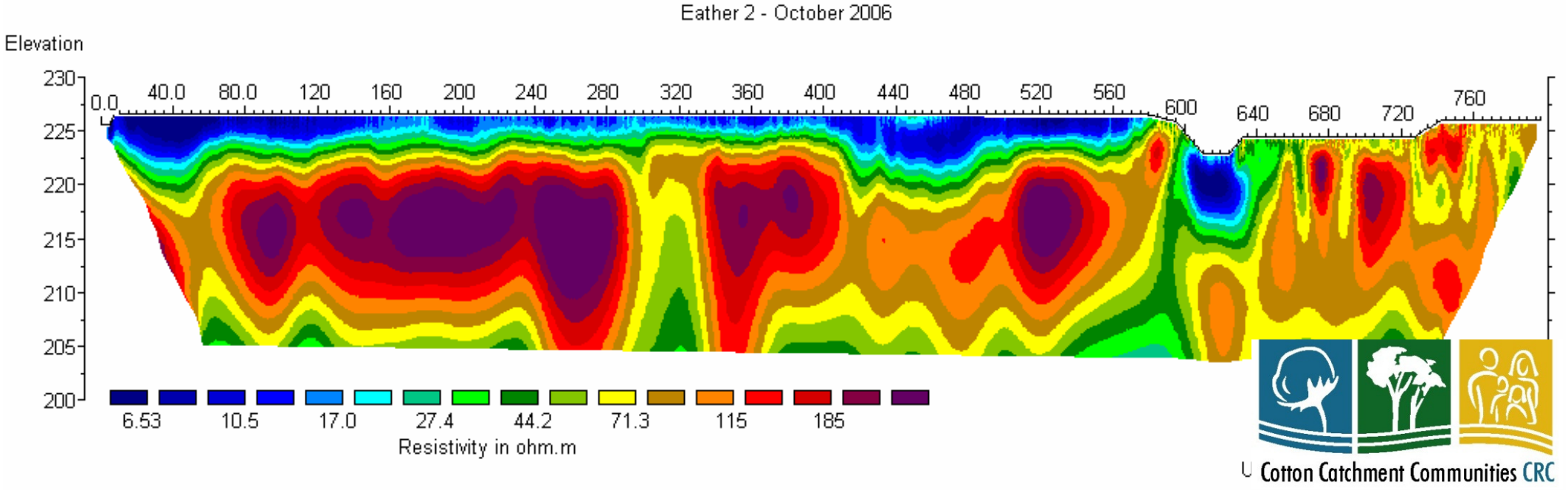
Electrical Resistivity Imaging:

- 4 electrodes, 2 for current flow & 2 for potential measurements ➔ Resistivity





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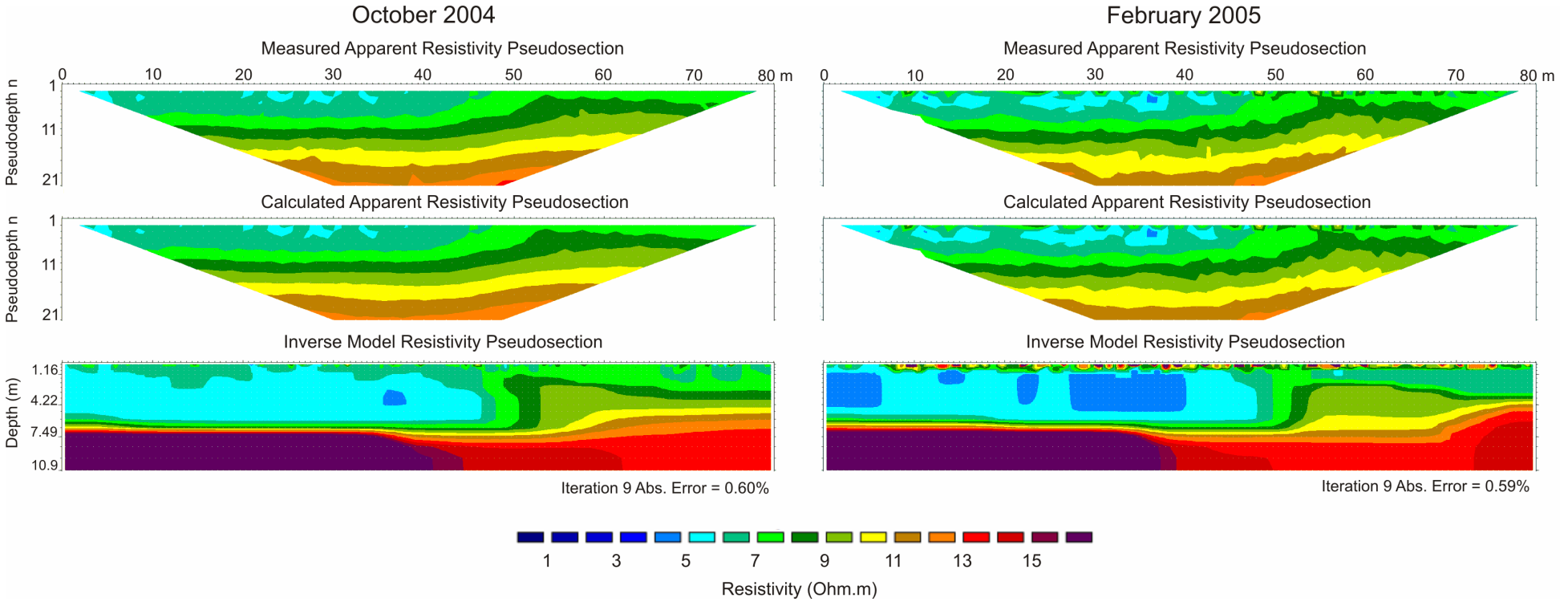

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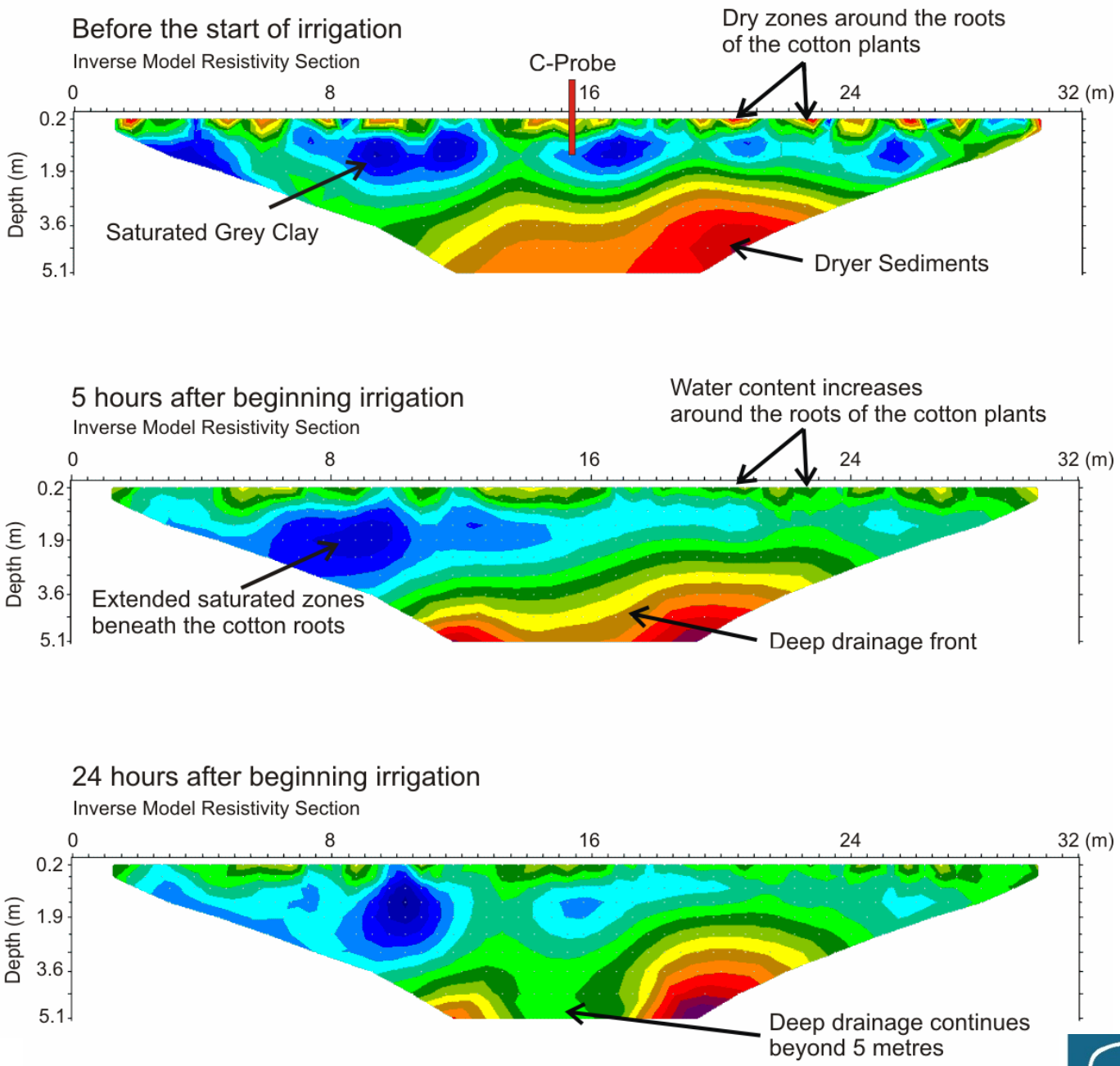
Time-Lapse Furrow Irrigation



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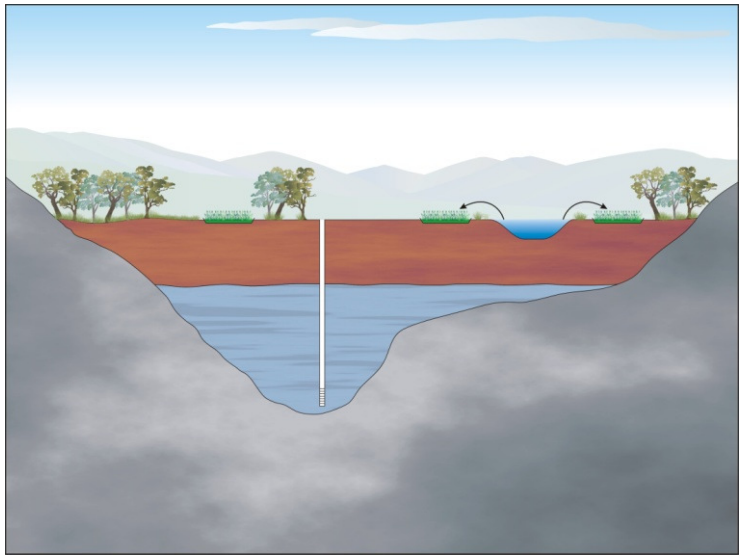
Lithological complexity?

Does the simple ‘layer-cake’ conceptual model sufficiently represent the lithology?



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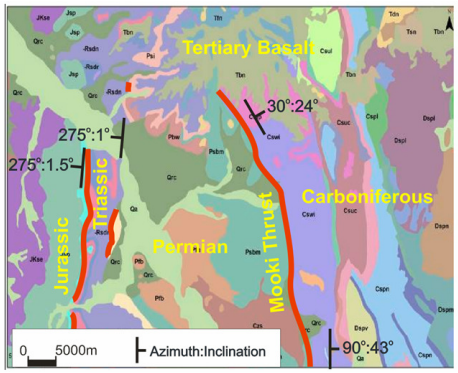
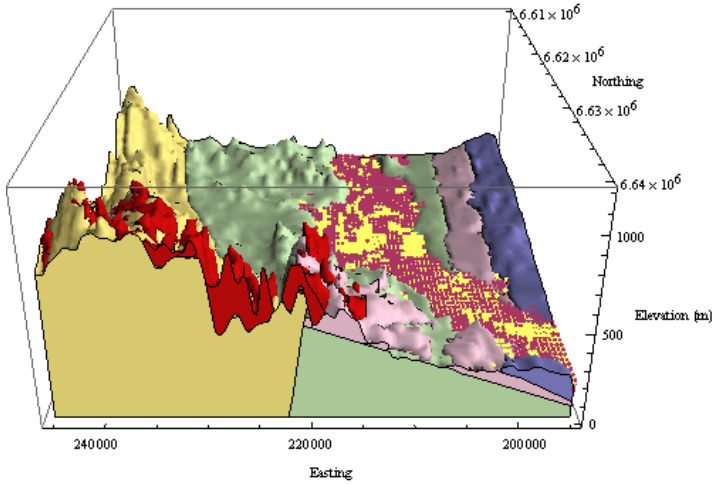
Crystallize: 3D Geological Modelling

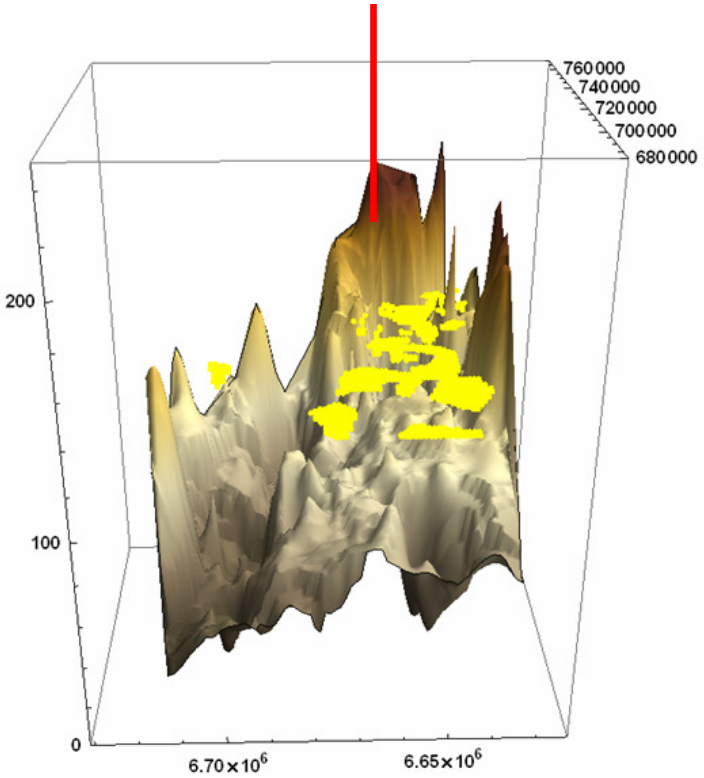
New 3D geological modelling software developed to:



Convert a geological map to a 3D model



We can now map in 3D the location of palaeochannels



Lower Namoi Palaeochannel.

These models can then be used to better position new boreholes.

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New methods have been developed to hydraulically map river and aquifer connectivity

3D Dendrogram Analysis for Mapping Aquifer Connectivity and Flow Model Structure

Rachel S. Blakers[1,3], Bryce F.J. Kelly[2,3], Robert S. Anderssen[4], Gregoire Mariethoz[2,3], Wendy Timms[2,3]

[1]Australian National University, rachel.blakers@anu.edu.au, ACT, Australia. [2]The University of New South Wales, NSW, Australia. [3]National Centre for Groundwater Research and Training, Flinders University, Australia. [4]CSIRO Mathematics, Information and Statistics, Canberra, ACT, Australia

Best student Abstract: MODFLOW and more Conference USA, 2011

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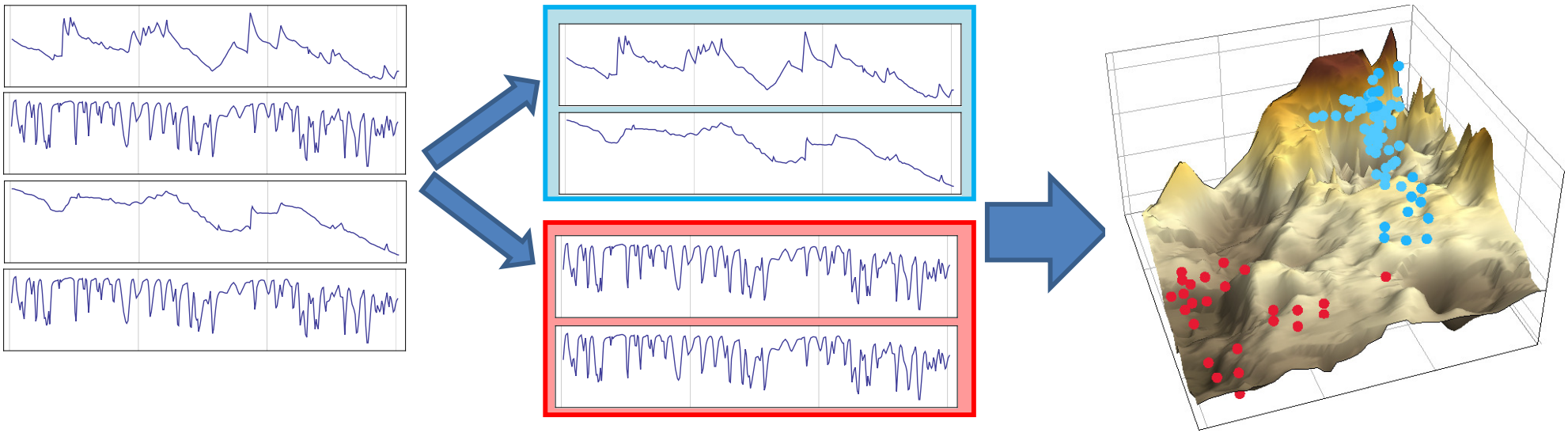
Clustering Methodology

- Cluster boreholes based on the distances between groundwater level time-series and then visualize the spatial locations of the resulting clusters.
- The clustering algorithm was implemented using the *Mathematica* software package.



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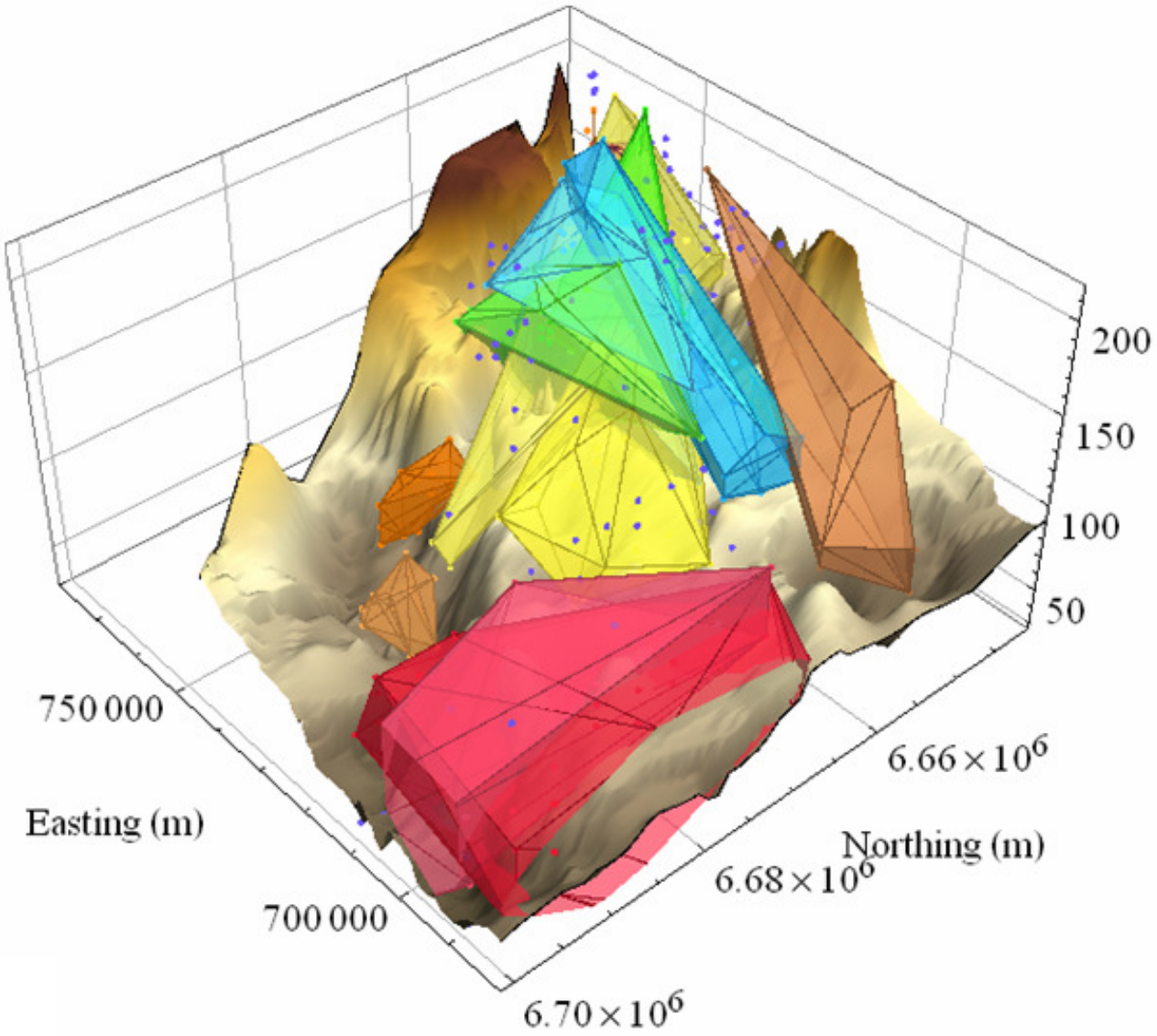
Hydraulic Clusters in the Lower Namoi



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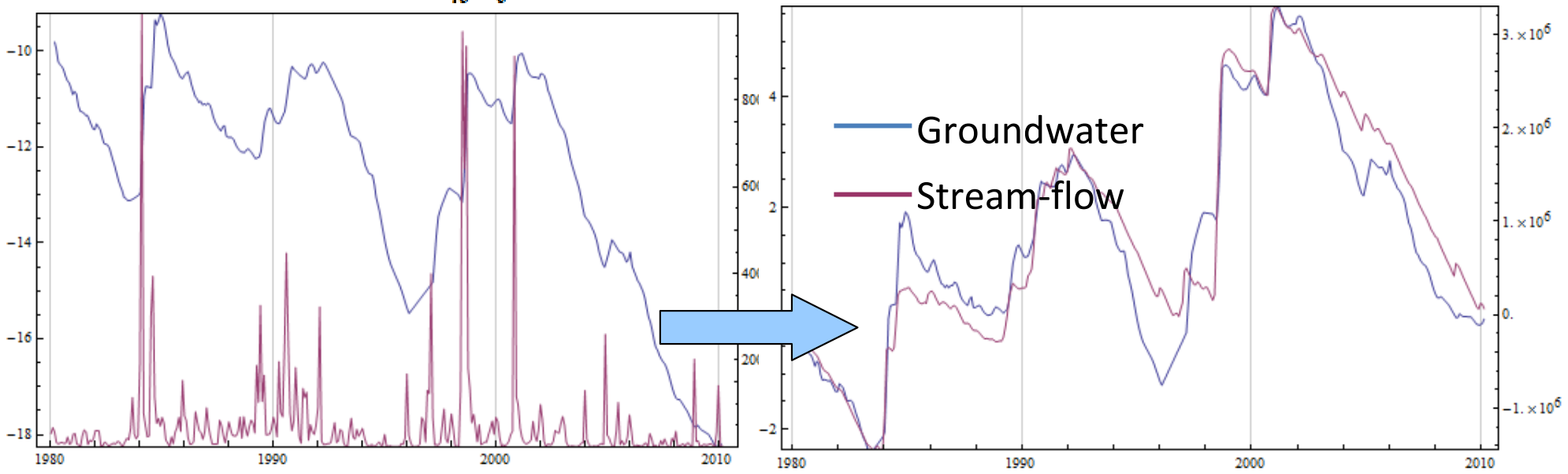
Groundwater – Streamflow Correlation: Methodology

Correlation calculated using cumulative streamflow departure (CFD) and de-trended groundwater data.

$$CFD_i = \sum_{k=i}^{i} (m_k - \bar{M})$$

$\bar{M}$ Mean monthly stream-flow

m_k Total streamflow for month *k*



Raw Data

Transformed Data

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Water Quality?

What is the quality of the groundwater?

Is salinity an issue?

Is the groundwater quality changing over time?

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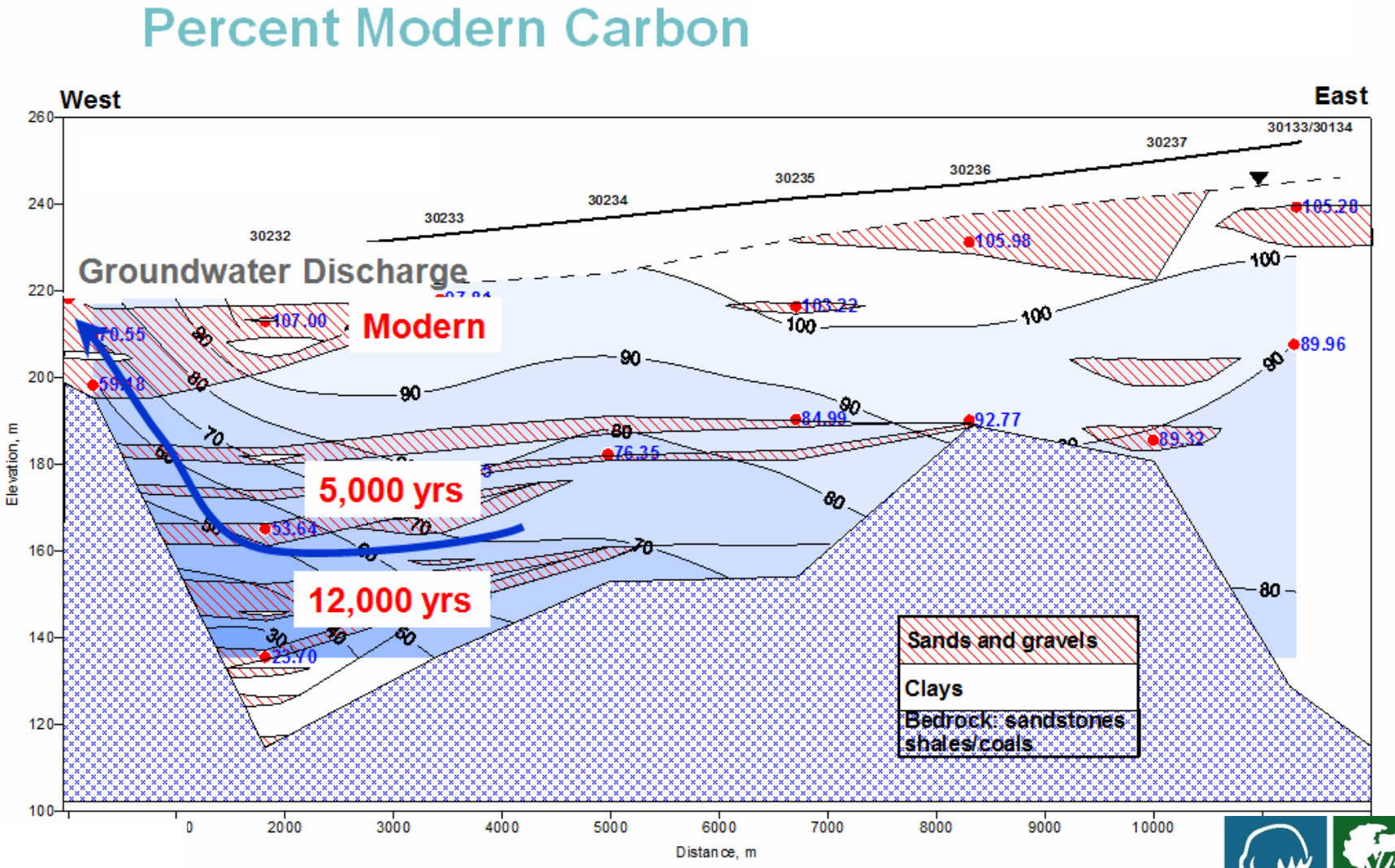
Age of the Groundwater
Northern Transect



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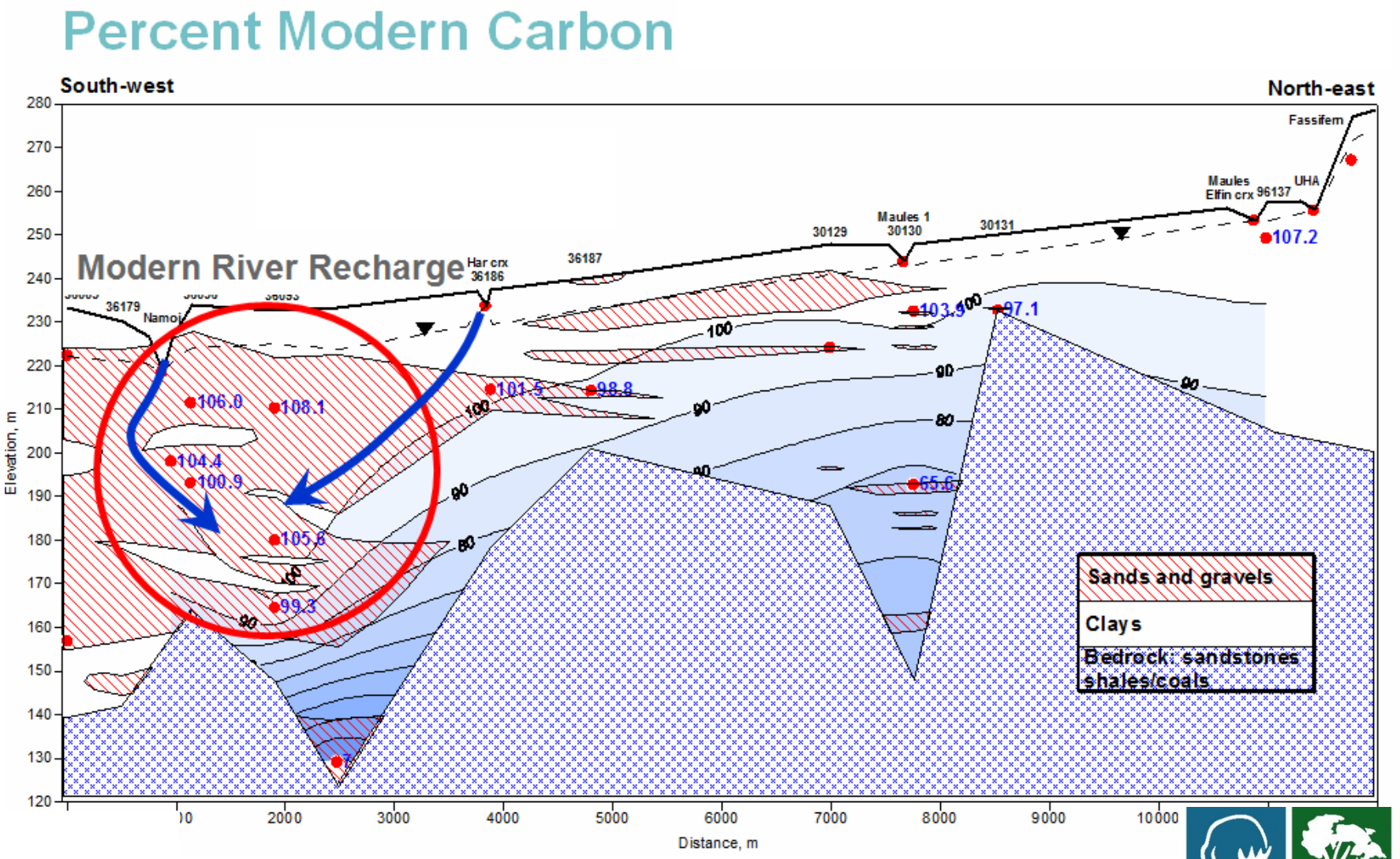
Age of the Groundwater
Maules Creek Transect



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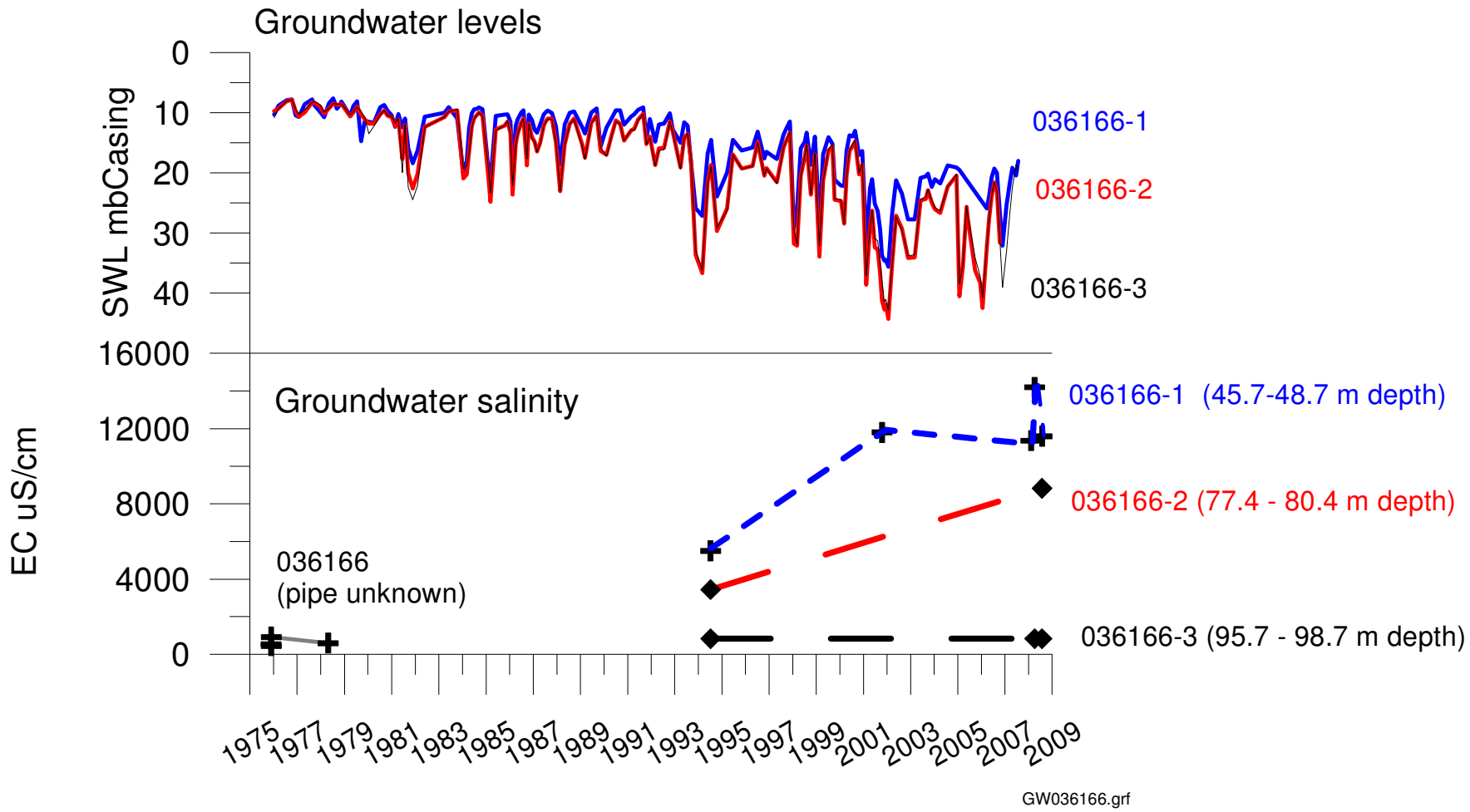
Groundwater Salinity Trends
Namoi Catchment



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Groundwater Salinity Trends
Namoi Catchment

• 105 groundwater monitoring pipes with available electrical conductivity (salinity) data

• 57 stable
• 21 increasing
• 27 freshening

• Salinity change mostly associated with falling groundwater levels?

• At one site in the Namoi, groundwater 80 m below the ground surface has become too saline for irrigating cotton (7,700 µS/cm ANZECC). This site was originally classed as fresh water! Why?

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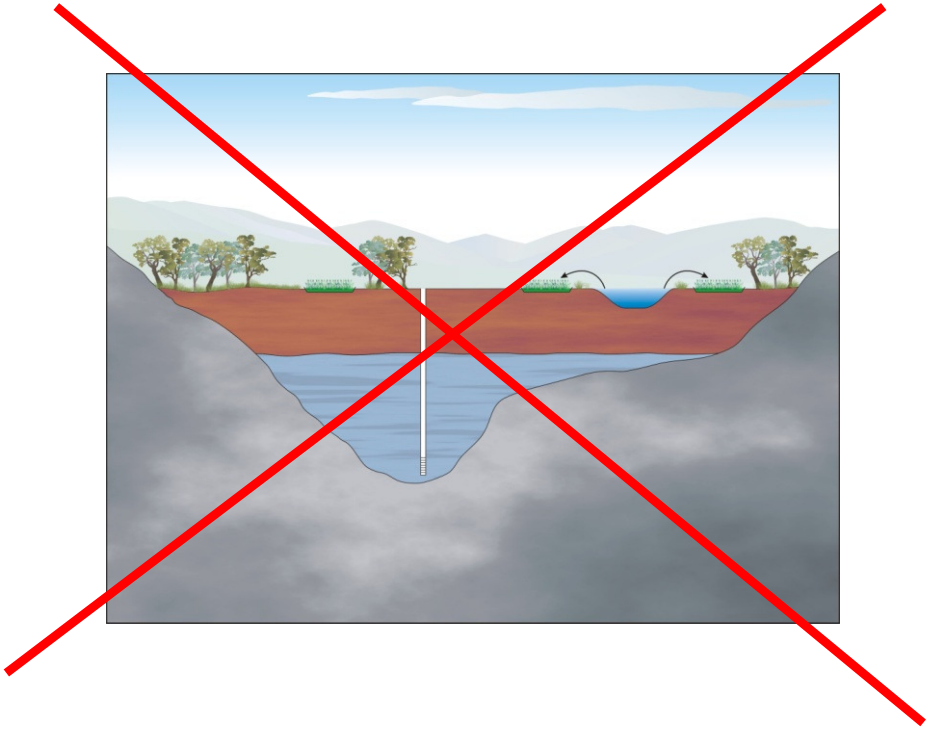
New Conceptual Model?

A more sophisticated conceptual model is clearly warranted based upon the investigations carried out during the Cotton Catchment Communities CRC research program



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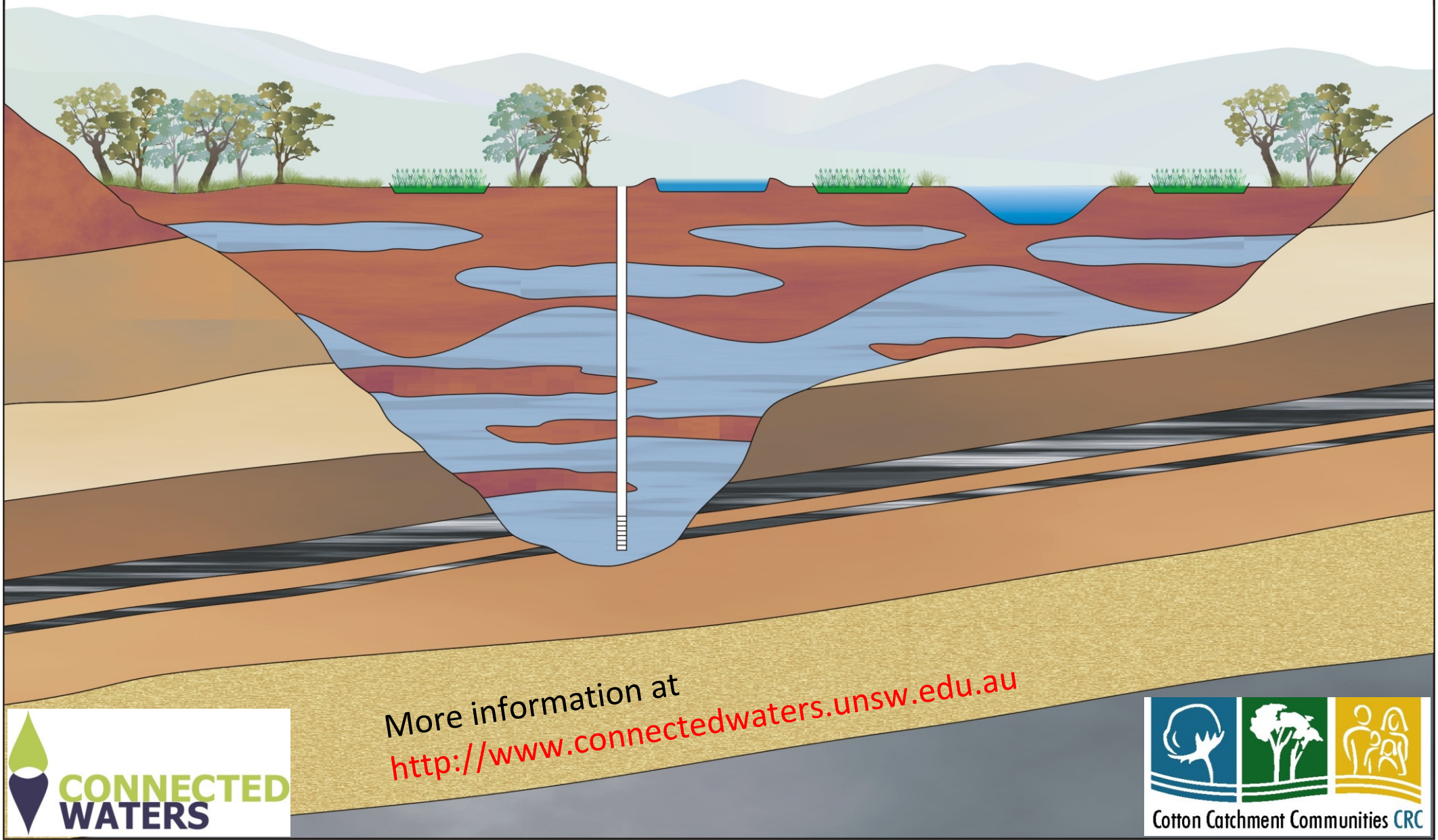
Another layer of complexity is presented by the relationship between the unconsolidated materials and the underlying coal and gas deposits.



More information at
http://www.connectedwaters.unsw.edu.au

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Action Plan

Bryce Kelly has provided the Science Review Panel with a suggested list of objectives which can also serve as a summary:

1.Fund background water quality surveys
2.Record deep drainage at the shallow water table
3.Investigate the viability of managed aquifer recharge
4.Support the development of collective impact modelling
5.Support investigation of the influence of groundwater extraction on river flow
6.Education

Two key take-home messages:

It is a good thing for groundwater extraction points to be well connected to a river, floodway recharge zone or mountain-front recharge zone. If your bore is not well connected to a recharge zone then you do not have sustainable access to water.

Irrigators in areas remote from recharge zones need to be informed that under existing or proposed water sharing plans, groundwater levels will not recover in their lifetime

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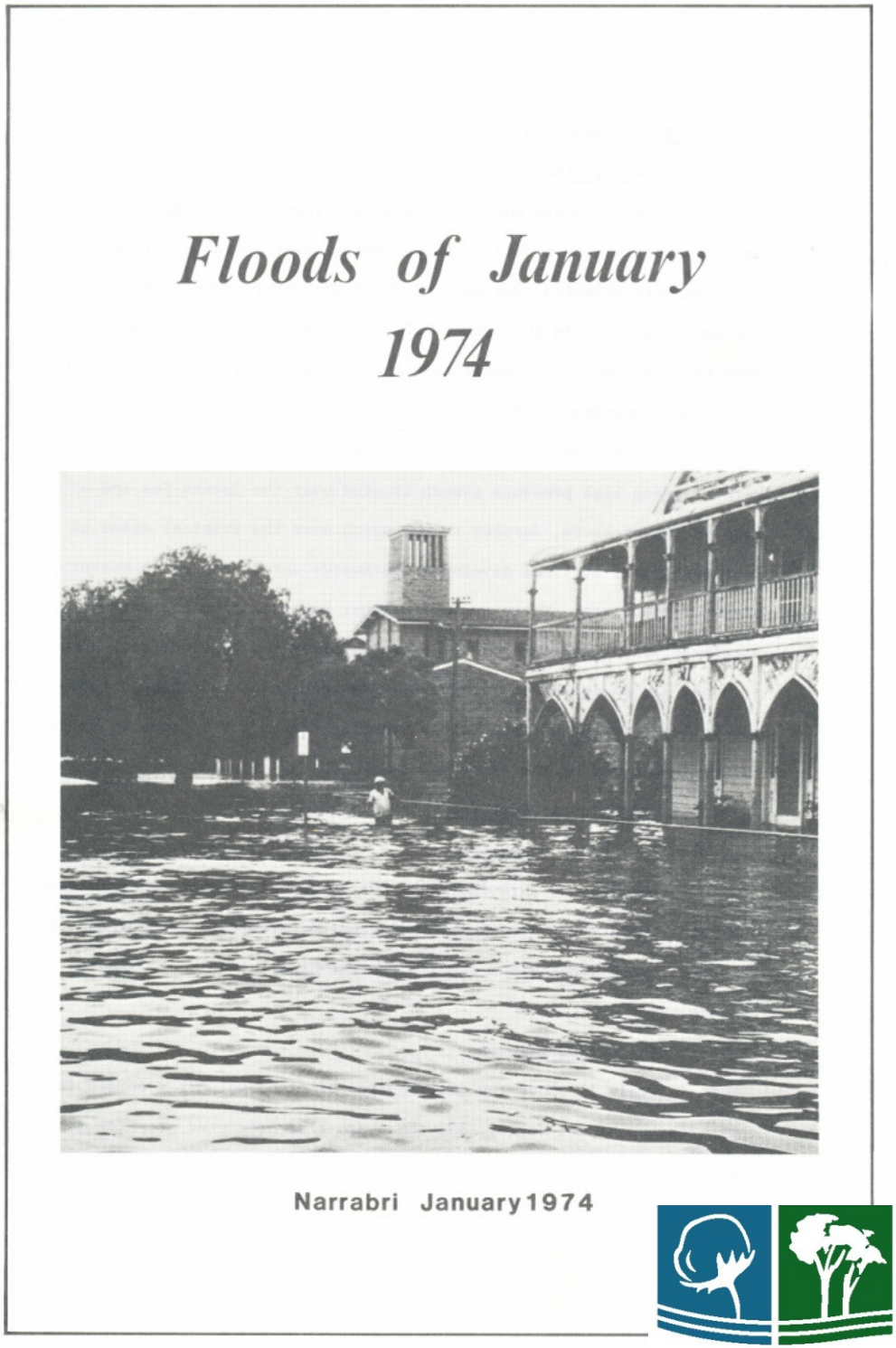
The big floods are our best opportunity to replenish the aquifers.

We are not ready for the next big flood.

We do not have the policy framework for managed aquifer recharge.



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The end of the beginning, of the story!

Thanks for your attention Questions please!

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