Indian Ocean Climate Initiative

Informed Adaptation

GOVERNMENT OF WESTERN AUSTRALIA

How our groundwater has changed

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Climate Note 8/05 (August) in a series outlining observed climate changes or variations over recent decades in south-west Western Australia.

General

Groundwater levels respond to water reaching the watertable, usually recharged from rainfall, hence climate can affect groundwater levels. Some groundwater systems, like the unconfined aquifer on Perth's Gnangara Mound, are quite sensitive to changes in rainfall, whereas confined aquifers are relatively unresponsive to climate change.

Water levels on the Gnangara Mound change over periods of decades in response to long-term changes in annual rainfall (Figure 1), and have declined as much as four metres since 1969 (Figure 2). However the dominant influence on groundwater levels in agricultural areas of the south-west is the clearing of natural vegetation for pasture and cereal crops, which has led to rising levels. Groundwater levels in major aquifers have also declined in response to pumping for water supply and effects of tree plantations. This makes it difficult to discriminate those changes that are specifically due to rainfall and other climatic parameters.

Seasonal groundwater level change

Shallow groundwater levels in the south-west respond to the seasonal rainfall, rising during winter to peak around October and declining during summer to a minimum in April/May. Deeper groundwater levels show a damped response, and may show long-term rising or falling trends without an identifiable seasonal variation.

Groundwater recharge

Recharge to unconfined groundwater systems takes place directly from rainfall when the field capacity of the soil is exceeded, and water can percolate downwards below the root zone under gravity. This generally only takes place when rainfall is intense and prolonged.

The Gnangara Mound

The sandy soils and lack of surface runoff on the Gnangara Mound in the northern Perth area are ideal conditions for groundwater recharge to take place directly from rainfall. The aquifer below the Gnangara Mound has a limited ability to transmit groundwater laterally or vertically by leakage into the underlying confined aquifers. Changes in recharge are therefore reflected in the water levels of the shallow superficial aquifer, and the wetlands expand and contract to vary the amount of groundwater discharge by evaporation.

Over the last century, groundwater levels on the Gnangara Mound have reflected the long-term rainfall trends (Figure 1), rising in response to years of above average rainfall, and falling in response to lower than average rainfall. Recent palaeo-climate studies are unearthing a richer history of these long-term natural variations.

The crest of the Gnangara Mound is most sensitive to changes in rainfall recharge and the maximum decline due to the recent decades of dry climate is about four metres (Figure 2). Elsewhere, water level changes have been much less. Changes close to the river and the coast are relatively small, as these groundwater levels are controlled by sea and river levels.

Groundwater pumping has had local effects in lowering water levels. The pine plantations have also lowered water levels, after an initial rise in response to clearing.

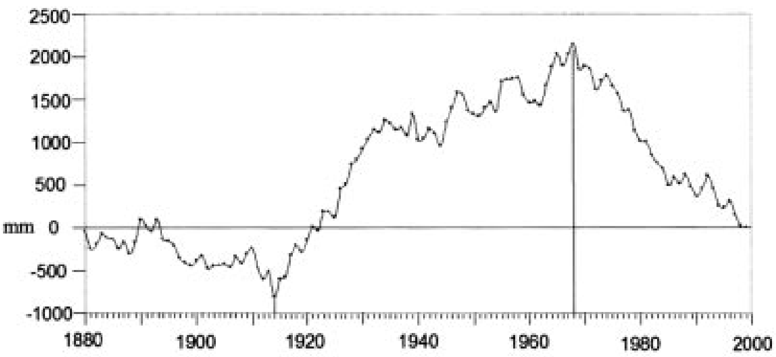

Figure 1: Rainfall in Perth expressed as cumulative departure from mean. Declining values with time indicate lower than long-term average rainfall, while increasing values with time indicate higher than long-term average rainfall. This indicates potential for falling groundwater levels from 1880 to 1914, rising groundwater levels from 1914 to 1969 and falling groundwater levels since 1969.

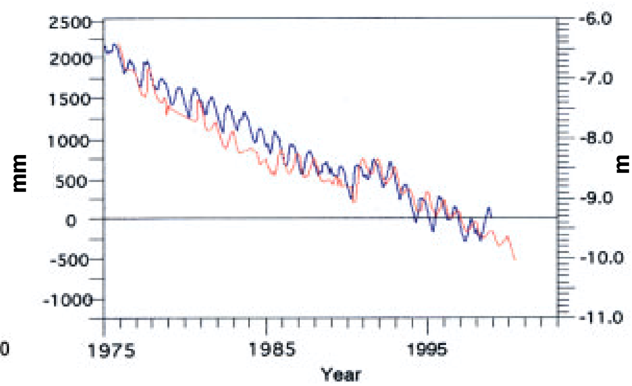

Figure 2: Measured groundwater level (red, right axis) compared with the cumulative departures (decrease) of rainfall from the long-term mean (blue, left axis) for bore PM3 at Lake Pinjar, Gnangara Mound.

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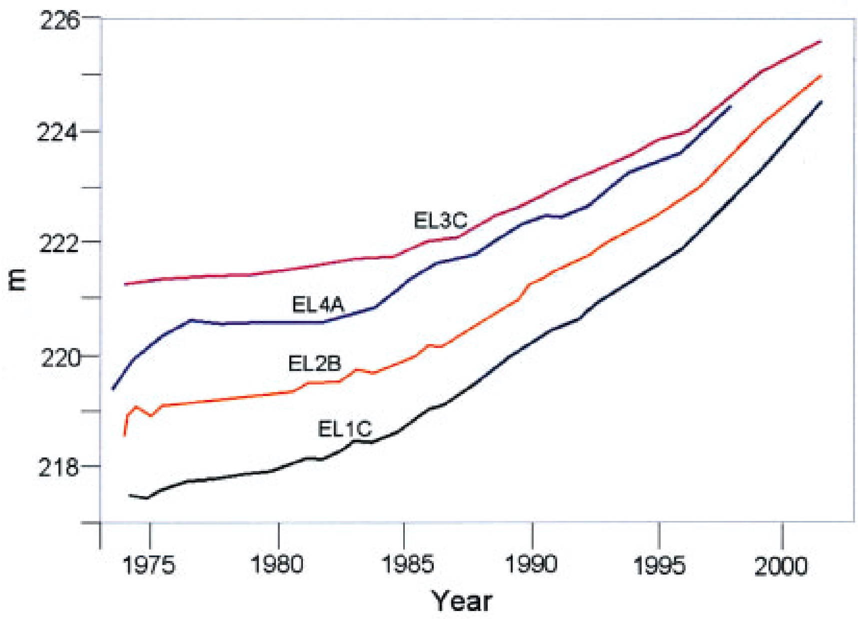

Figure 3: Response of groundwater levels at typical boreholes in the Parmelia aquifer, northern Perth Basin, to replacement of native vegetation by cereals and pasture. The rate of water level rise has accelerated over 30 years.

Coastal lakes and wetlands

In the Perth region, many areas that were swamps in the 1800s became lakes in the 1914-1920 period in response to a rise in average annual rainfall. Hence Butlers Swamp became Lake Claremont, and Perry Swamps became Perry Lakes. Since the change to a lower rainfall average in the 1970s, a number of these lakes have reverted to their former swampy condition.

Agricultural areas

In the agricultural areas of the Wheatbelt, where much of the perennial native vegetation has been replaced by annual pasture and crops, groundwater levels are rising owing to the increased recharge and reduced transpiration caused by clearing. In some areas, the rate of water level rise has lessened in recent years, or even reversed, following lower than average rainfall (see IOCI Climate Note 11/05).

In coastal agricultural areas of the northern Perth Basin, groundwater levels under land cleared for cereal crops and pasture are rising at annual rates of as much as 0.5 metres (Figure 3). These deep water tables show a steady rise without seasonal variation, and show only minor changes in rate of rise in response to high or low rainfall years such as 1974 and 1977 respectively. In these aquifers, groundwater salinity can be expected to be decreasing in response to the greater recharge rate.

Confined aquifers

Potentiometric heads (the level to which water rises in a borehole) in the confined, deeper, aquifers of the coastal plain are not immediately affected by changes in rainfall.

As is characteristic of confined aquifers the dominant influence on potentiometric heads has been pumping. For example, in the Perth region, where the Yarragadee and Leederville aquifers are managed as a strategic drought reserve, pressures have declined significantly since recent pumping for drought contingency (Figure 4).

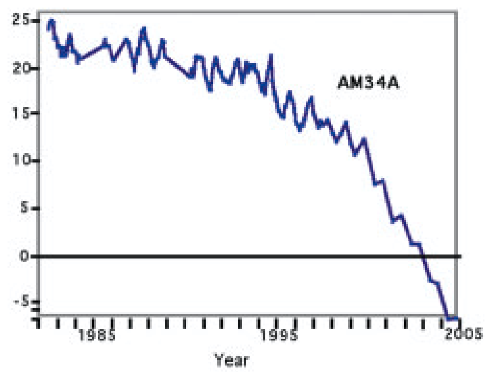

Figure 4: Potentiometric head change in a bore representative of the confined, Yarragadee aquifer, northern Perth area, showing influence of recent drought usage for public water supply.

What can we say about the future?

With a continuation or further decrease of the low average rainfall of 1975-2005 and continuation of established land-use and groundwater extractions, the groundwater levels in some superficial aquifer systems, like the Gnangara Mound, will decline further. Some other superficial systems, such as the Jandakot Mound have already reached a new equilibrium with the current rainfall and development regime, but would be affected by any further rainfall decrease. Sustainable conditions in associated wetlands and in abstractions for water supply, horticulture and industry will be affected by any further changes in rainfall.

In the agricultural areas, outcomes will vary with location. For some areas, particularly in the northern Perth Basin, there will be a further increase of groundwater levels due to past removal of perennial vegetation. However, continued low rainfall, or any further rainfall decrease, will slow the rates of rise in groundwater and in some circumstances, may cause a reversal of trends (see also IOCI Climate Note 11/05).

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