Government of Western Australia
Department of Water and Environmental Regulation

Australian Government
Bureau of Meteorology

National Hydrological Projections demonstration case – Myalup groundwater system

Changing climate

Western Australia's South West region has experienced a drying trend since the 1970s. It is one of the few places in the world where global climate models consistently show that the future will be hotter and drier. To adapt to this drying trend, water resource managers seek to balance the increasing demand on water as a resource with the need to protect water quantity and quality for users and the environment.

Working together

In this study, completed in 2024, scientists from the Bureau of Meteorology (the Bureau) and the Department of Water and Environmental Regulation (the department) worked closely together to demonstrate how the Bureau's National Hydrological Projections (NHP) can be applied to local-scale water resource assessment and management decisions. Our co-designed demonstration case of the Myalup groundwater system sought to:

- inform the department's guidance on the use of the Bureau's NHP dataset in water management
- investigate how the NHP can be practically applied to assess the impacts of climate change for water resource management
- assess and communicate projected changes in the Myalup superficial groundwater resource because of changing climate

Myalup groundwater system

Myalup is located on the sandy calcareous soils of the Swan Coastal Plain, about 150 km south of Perth in the state's South West. Our study region stretches from the southern end of Noorook Yalgorup (Lake Clifton) to the northern tip of the Derbal Elaap (Leschenault Inlet) and inland to Korijekup (Harvey) (Figure 1). The region is home to a network of wetlands with high ecological value, including the Ramsar-listed Lake Preston and Lake Clifton. The region's superficial groundwater system supports these wetlands and provides 80 per cent of the water used to irrigate the Myalup Irrigated Agricultural Precinct. Demand for water is increasing: with 25 GL used in 2019, up from 16 GL in 2006.

Managing groundwater

The department's water management objectives for the Myalup study area include:

- sustainable use of groundwater resources for urban water supply, industry and irrigated agriculture, including maintaining water quality and preventing intrusion of saline water from the ocean and the hypersaline lakes
- protection of groundwater-dependent ecosystems (GDEs) and Aboriginal cultural values associated with water in the landscape.

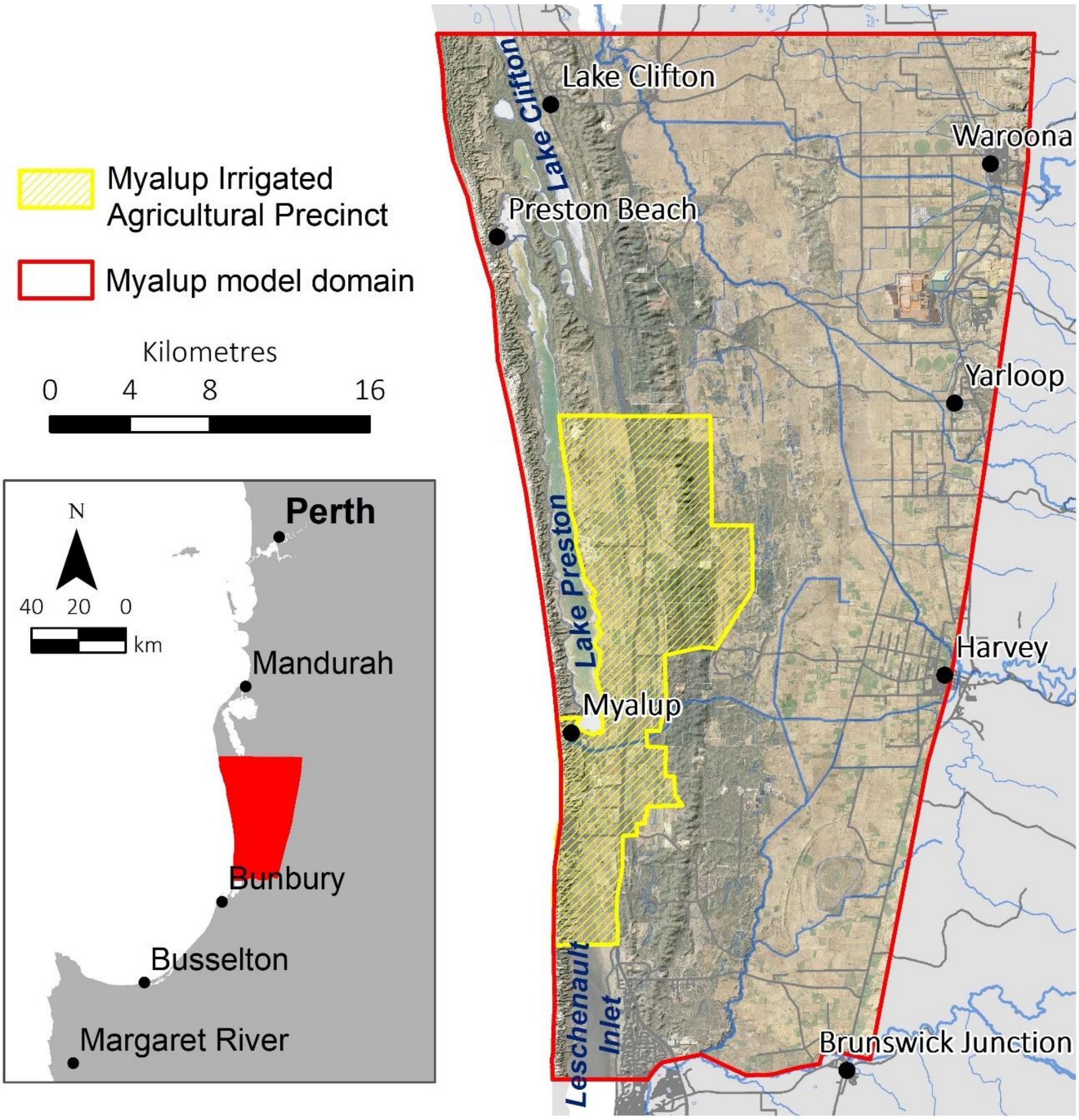


Figure 1 Myalup study area

Modelling superficial groundwater

To simulate the dynamics of groundwater levels across the Myalup study area, the department developed the Myalup numerical groundwater model (Giannoulopoulos, 2022) using the FEFLOW finite element modelling code (Diersch, 2013). The model is based on the department's conceptual understanding of the area's hydrogeology and uses high-resolution data on groundwater abstraction from metered farm production bores, mainly within the Myalup Irrigated Agricultural Precinct. Model results are presented as time series of water levels at 133 observation points (Figure 2).

The model enables the department to estimate the groundwater system response to existing abstraction and future water management scenarios, such as increased pumping, managed aquifer recharge and changes in irrigation practices. It also allows estimation of the relative change in groundwater levels under a range of future climate projections and possible climate change adaptation measures.

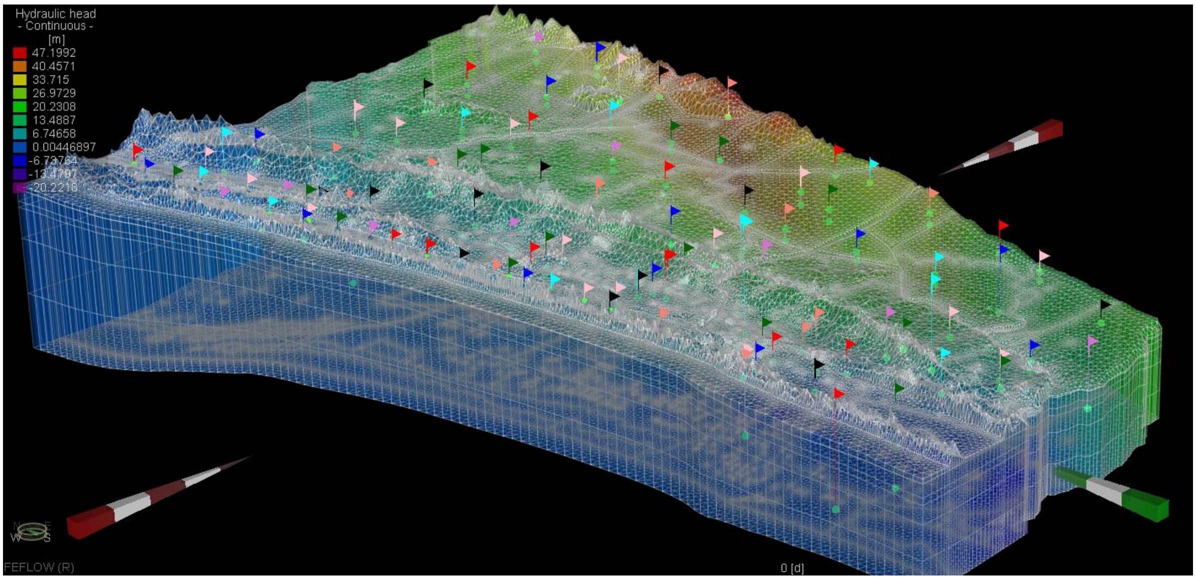


Figure 2 3D view of the Myalup numerical groundwater model (flags represent observations points)

National Hydrological Projections

The Bureau has developed a suite of national climate projections, providing water resource managers with local-scale data to use in water resource investigations (Srikanthan et al., 2022). Development of the NHP data is shown in Figure 3 below.

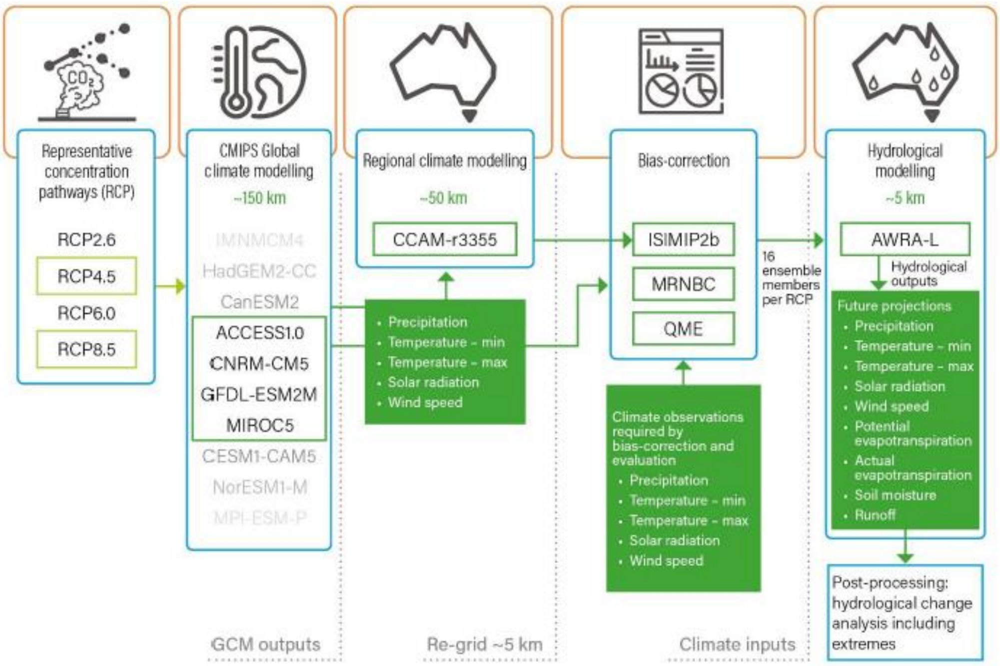


Figure 3 Illustration of climate data processing for the Bureau of Meteorology's National Hydrological Projections (reproduced from *Guide to future climate projections for water management in Western Australia,* 2024)

The NHP were produced using medium and high future greenhouse gas scenarios referred to as representative concentration pathways (RCPs 4.5 and 8.5 respectively), to drive four global climate models (GCMs), from phase five of the Coupled Model Intercomparison Project (Taylor, 2012). These were then downscaled, re-gridded to a 5 km grid scale, and corrected for discrepancies between climate input and observations using three bias correction methods (Srikanthan et al., 2022). In addition, one regional climate model (CCAM; Rafter et al., 2019) was used to dynamically downscale the GCMs (Srikanthan et al., 2022). There are 16 projections for each of the two RCPs, resulting in 32 projections in total, which are considered equally plausible.

Access to the NHP and related information is available through the [Australian Water Outlook service](#).

Myalup climate

Myalup is located within the Southern and South-Western Flatlands Natural Resource Management region. Western Australia's South West has high winter rainfall and little summer rainfall. A summary of the climate trend is shown in Figure 4.

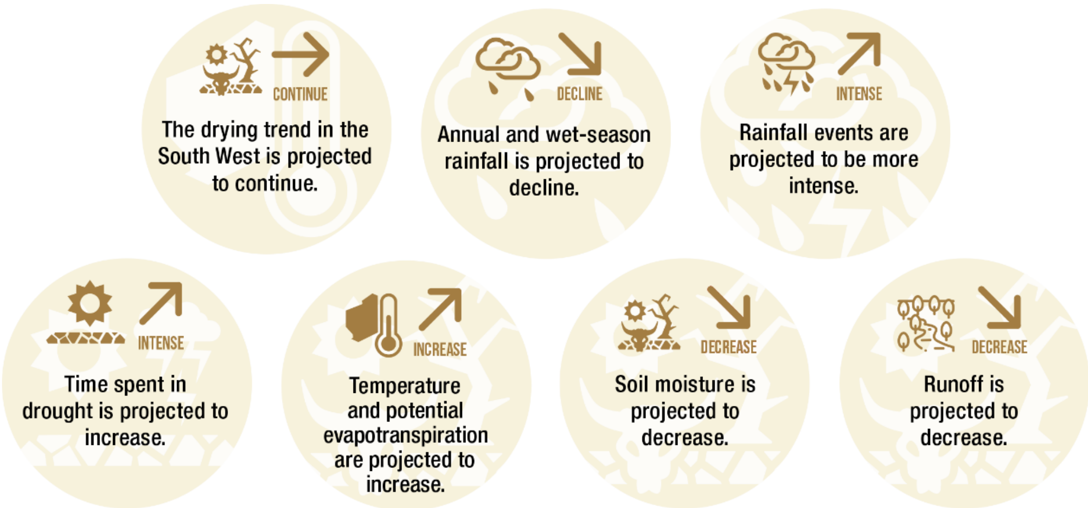


Figure 4 Summary of climate trends for Western Australia's South West (adapted from Turner et al., 2022)

Rainfall in the Myalup study area has been declining, and dry years have become more frequent. The range in projections to 2050 shows the decline will continue. There is a wider variability projected for individual years with very wet and very dry years (Figure 5), reflecting a greater frequency of extreme weather events. Extremely wet years are projected, but they are much less likely than drier years.

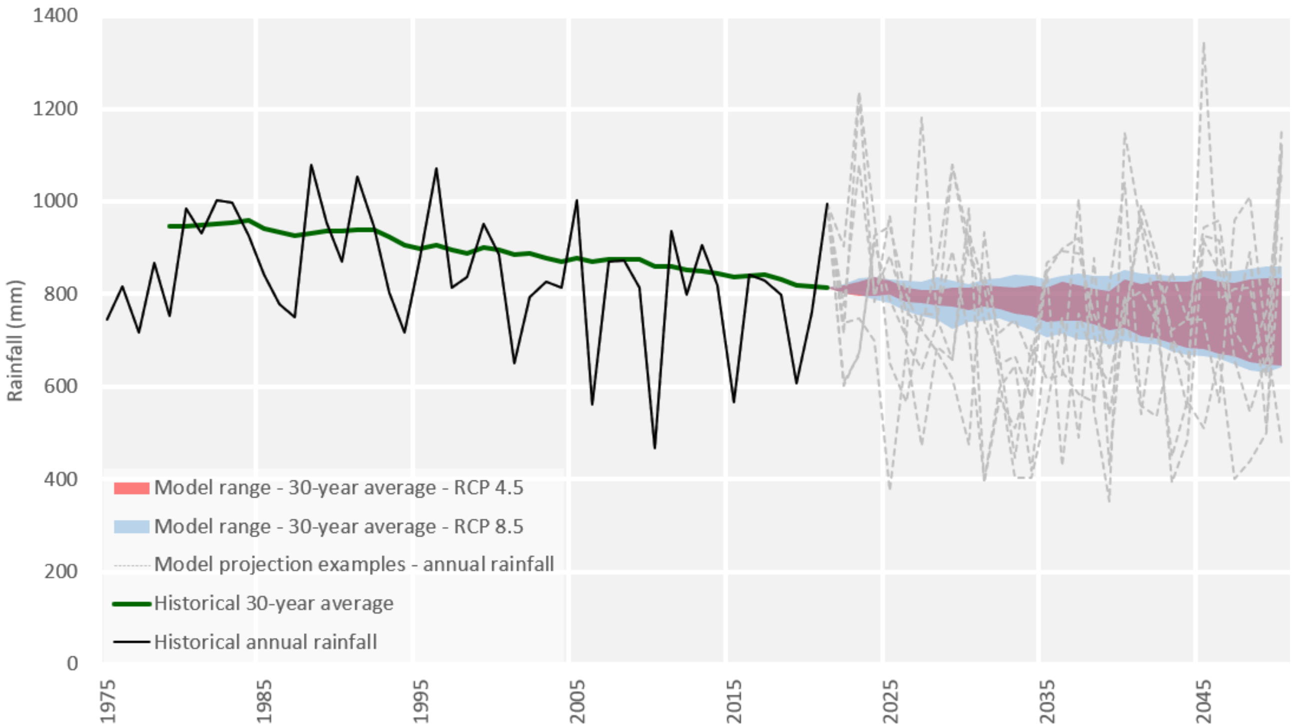


Figure 5 Historical (Australian Water Availability Project) and projected annual rainfall for the Myalup study area.

Investigating groundwater model output

Running the Myalup groundwater model with 32 climate projections and multiple water management scenarios generates a vast amount of output data at the 133 observation points. One challenge of our study was to establish ways to meaningfully display and communicate results so they can inform water management decision making.

As an example, Figure 6 shows the range of modelled groundwater levels in the superficial aquifer at a selected observation point for 30 years from 2020. It shows a general steady-to-declining trend in water levels, consistent with the projected rainfall in Figure 5. There is a large spread in potential water levels by 2050 which reflects the uncertainty in the future climate. Consistent between both RCP 4.5 and RCP 8.5 pathways is an increase in the interannual variability of possible groundwater levels, especially for drier potential future climates. Note that the annual fluctuations in the RCP 4.5 and 8.5 projections time series data mean that the maximum and minimum water levels will vary in any given year, but the trend (or climate change signal) is more apparent in RCP 8.5 over longer time frames.

When compiling results for multiple model scenarios, it is important to ensure that climate change is adequately incorporated into water resource management by using a range of projections to assess the potential impact of a changing climate on the water resource. It is beneficial for water managers to understand the breadth of uncertainty in the climate projections and resulting groundwater levels for a time horizon, and to consider adaptation options for those futures where thresholds are exceeded.

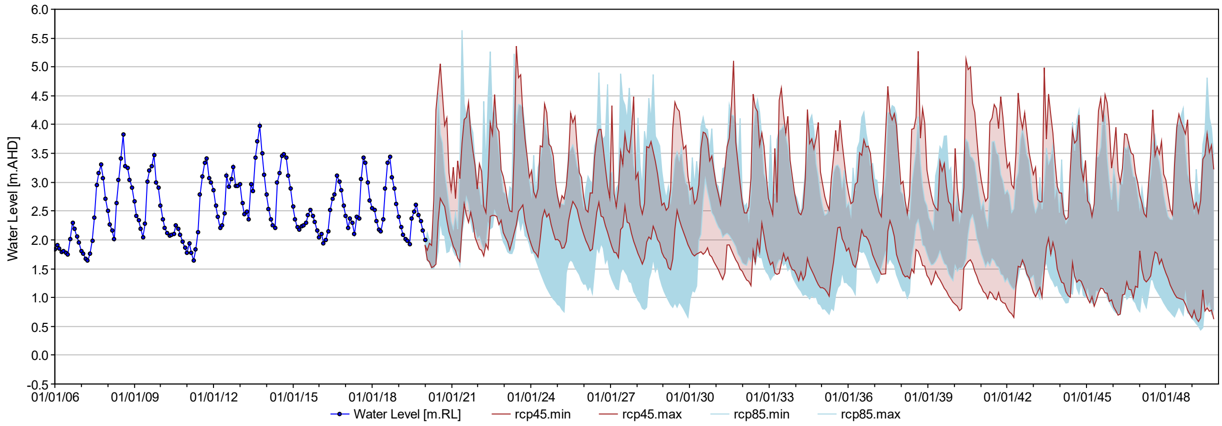


Figure 6 Example of the range of modelled water level output at one Myalup model observation point showing the RCP 4.5 (red) and 8.5 (blue) projections. Future water levels are expected to be somewhere within the blue or red shaded areas. The grey colour represents where the water levels for the RCP 4.5 and RCP 8.5 projections overlap. Historical data is shown in dark blue

Using a storyline approach to choose a subset of projections in water management

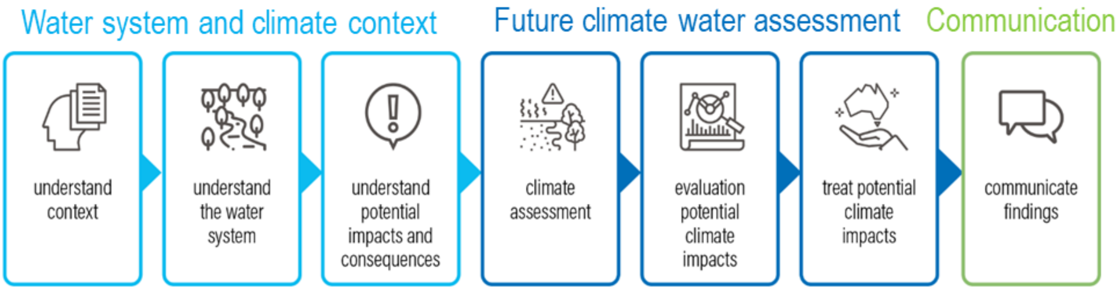
The Myalup groundwater study showed that running model scenarios for the full range of 32 projections is a resource-intensive and data-intensive process. In exercises such as exploring the full range of climate impacts, running all the available scenarios may be justified. However, there will be applications when it may not be instructive or necessary to run the full suite of projections – for instance, in low-risk applications or in situations where there is a lot of scope for adaptation – the investment in time and resources to run multiple projections through large or complex groundwater models may not be beneficial.

The choice of projections to be used in water resource management needs to be carefully considered by water resource managers and will vary depending on the type of assessment (e.g. allocation versus drainage planning), project objectives and the level of acceptable risk associated with decision making. The level of acceptable risk will vary for different water sector assessments and according to the risk appetites and tolerances of decision makers and stakeholders. In any case, climate change needs to be adequately incorporated into water resource decision making by using a range of projections and assessing the climate impact to the water resource, noting that future climate information is just one part of making decisions.

The department has prepared the *Guide to future climate projections for water management in Western Australia* (2024) to aid water managers to:

- develop a storyline and select projections for decision making
- undertake the associated impact assessment
- support the interpretation of future climate results.

The guidance sets out a seven-step framework that identifies key components that will assess the potential impacts of a changing climate, including: system use and climate context, future impacts identified by climate projections, adaptation required to treat the potential impacts and how to communicate the findings.



With a storyline approach (Shepherd et al., 2018), we can use our knowledge of the system to identify and describe links between the water resource response being assessed and the aspects of climate change that drive that response. A storyline approach requires a good understanding of system processes, potential vulnerabilities and sensitivities in the system. Climate processes known to exacerbate system sensitivities can be identified in the projections and, in this way, we can narrow down the projections of particular interest to our system. When developed together with stakeholders, storylines can provide a useful way of communicating and assessing climate-related impacts in a specific decision-making context (Sillmann et al., 2020). The premise of storylines can be used to select a subset of the 32 equally plausible projections for a more detailed analysis of water resource impact and management actions.

What does this mean for the Myalup analysis?

If we have multiple adaptation management options for GDEs at Myalup, we may decide to select a subset of projections for analysis rather than analysing all 32 projections. We know that GDEs are sensitive to declines in superficial groundwater levels when water levels reach their lowest, the strong relationship between projected rainfall and modelled groundwater levels can be seen in the general trend of Figure 5 and Figure 6. Based on our understanding of the system, we expect superficial groundwater levels to be dependent on cumulative rainfall.

Figure 7 shows how we can use a storyline of cumulative rainfall and water level to choose a subset of projections to assess in detail. For instance, to assess the risk of low water levels on GDEs we could choose projections that are known to be hotter and drier with lower cumulative rainfall, such as the CCAM-ISIMIP ensemble members (circled in black in Figure 7). If exploring a low water level scenario, we might also avoid using projections from the CNRM ensemble as they tend to be wetter (circled in green in Figure 7).

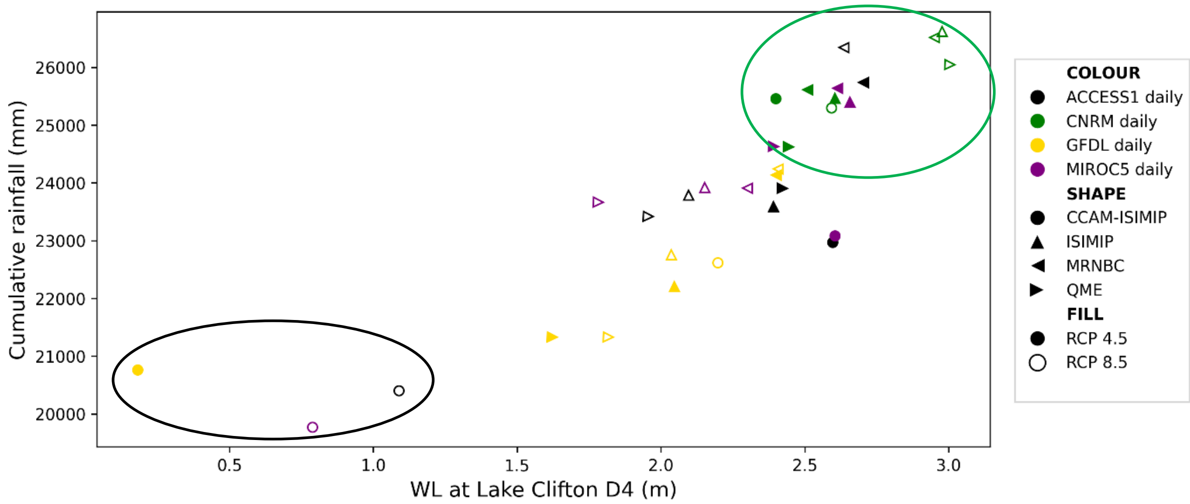


Figure 7 Example storyline of water level (WL) in 2050 at Lake Clifton plotted against cumulative rainfall (2020–2050) for each projection. The green circle highlights wetter GCMs and the black circle highlights low cumulative rainfall from hotter and drier GCMs

Assessing storylines involves assessing the climate metrics for each of the projections based on the selection criteria (other example storylines are shown in Table 1 below). A total of 13 projections fulfil the selection criteria for the first storyline (Table 1), ranging from GDFL-CCAM-ISIMIP-4.5 to ACCESS1-ISIMIP-4.5. The number of projections can be further narrowed down by applying more specific selection criteria. Some of these projections may also be representative of the other two storylines given the overlap in the selection criteria.

Table 1 Example storylines to assess climate impacts on Myalup GDEs based on the main predicted climate trends for the South West region

Storyline	Selection criteria	Potential consequences for GDEs
Future climate with declining average rainfall	Projected average annual rainfall is below the historical baseline value.	• Groundwater recharge will decrease. • Peak groundwater levels will decrease. • Risk of water quality impacts and acidification.
Future climate with decreased wet season rainfall	Projected average cumulative wet season rainfall is below the historical baseline value.	• Amplitude of seasonal groundwater levels will decrease. • Peak groundwater levels will decline.
Future climate with increased number of consecutive dry years	Number of projected consecutive dry years exceeds the number in the historical baseline period. Dry years could be defined as third decile rainfall for the historical baseline period.	• Minimum groundwater levels will decline. • Interannual variability in groundwater levels may change.

The storyline used to choose a subset of projections will be system specific. Depending on the location, aquifer type and management question, other climate metrics may need to be considered – for example, the number of rainfall days above a threshold to produce a recharge, consecutive dry years, or frequency of very wet years.

Next steps

Further investigation into the climate projections and the potential impacts and avenues to treat climate risk will be carried out before a subset of projections is selected for analysis in the Myalup region.

This case study was prepared to inform the department's guidance on the use of the Bureau's NHP dataset in water management. It will provide a pathway for choosing a subset of projections based on system understanding and the management decisions being explored.

The *Guide to future climate projections for water management in Western Australia* (DWER 2024) provides further information on the storyline approach and the application of climate projections to assess the impact of multiple plausible futures.

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