McLaren Vale system water security modelling report

Government of South Australia

Department for Environment and Water

Contents

List of figures

List of tables

Key abbreviations & definitions

AWO – Australian Water Outlook

CWMS – community wastewater management system

DEW – Department for Environment and Water

ENSO – El Niño–Southern Oscillation

FRA – Fractured Rock aquifer

GIP – government inspection point

MS – Maslin Sands aquifer

GCM – global climate model

GI – geographical indication

NHMM – nonhomogeneous hidden Markov modelling

PET – potential evapotranspiration

PWA – Prescribed Wells Area

PWF – Port Willunga Formation

PWRA – Prescribed Water Resources Area

SA-CR – South Australia Climate Ready

WAP – Water Allocation Plan

WBW – Willunga Basin Water

WMLR – Western Mount Lofty Ranges

WWTP – wastewater treatment plant

Exposure space – a sensitivity contour plot on which information is shown in relation to 2 forcing climate variables

1 Introduction and background

1.1 Study objectives and report outline

This report supported the development of the McLaren Vale Regional Water Security Strategy (the Strategy). The objectives of this report are to:

- describe the process undertaken to develop the McLaren Vale Regional Water Security Strategy
- summarise the past and current water use dynamics in the McLaren Vale region, including sources and availability
- determine the potential future demand for water in the region, with a focus on viticulture, and with consideration of the projected impacts of climate change
- develop and analyse a set of future scenarios to explore uncertainty, and undertake an economic and options analysis of these scenarios
- inform the actions and next steps for water security in the region to be included in the Strategy.

It is important to note that the Strategy excludes analysis of urban water provided by SA Water. Urban water supply and demand will be considered in a long-term water security strategy for Greater Adelaide, which is being developed by SA Water.

This report draws on learnings from the Barossa Water Security Strategy (Department for Environment and Water 2022c, Department for Environment and Water 2022b, Westra et al. 2022). This approach aims to formally stress test the McLaren Vale system using a diverse range of climate projection datasets. A 'business-as-usual' system configuration is considered, as well as 3 alternative system configurations developed through stakeholder workshops and consultation.

The results of the analysis set out in this report have informed the actions and recommendations included in the Strategy and assist with determining the investment needed to meet future demand scenarios based on existing and potential water supply options. The resultant actions aim to further assist with planning for resilient water supplies to support a thriving McLaren Vale region into the future.

1.2 Approach to developing the Strategy

The need for long-term water security planning in the McLaren Vale region was identified by community members and industry representatives concerned about the expected impacts of climate change on the availability of water in the region, and the need to maintain local industries and businesses, as well as a healthy environment. Concerns were also raised regarding the price of water and volumes available to enable the future economic development of the region. A water security planning process was seen as an opportunity to look at all water sources, to consider the potential impacts of climate change on these sources, and to identify potential water security solutions for the region.

The Hills and Fleurieu Landscape Board held workshops in December 2020 and October 2021 to better understand water security concerns and to decide with the community what steps to take next. A working group was formed to further discuss and explore how best to progress the short-term water security issues as well as the development of a regional water security plan. The Department for Environment and Water (DEW) took on the lead role in coordinating the development of a water security strategy in October 2022.

The purpose of developing the Strategy was to:

- ensure there is an acceptable quantity and quality of water for communities, industry and the environment that is affordable now and into the future
- complement 'traditional' water allocation planning undertaken by government and deliver solutions to water management challenges
- ensure infrastructure, on-ground or policy solutions are aligned and will contribute to regionally beneficial outcomes
- support informed investment in enhanced water security options in a changing climate
- build resilience for an uncertain future.

The Strategy has been developed in partnership between the community, the McLaren Vale Grape, Wine and Tourism Association, City of Onkaparinga, McLaren Vale Community Sustainability Company, SA Water, Hills and Fleurieu Landscape Board, Willunga Basin Water, community interest groups, Department of Primary Industries and Regions South Australia and the Department for Environment and Water. Representatives from these organisations formed a steering committee, which provided oversight and guidance throughout the Strategy development process. In addition, the working group, consisting of partner representatives and community members, continued to meet and provided advice and support to progress workshops, communications materials and final content of the Strategy.

A strategic foresight and resilience-based planning approach was used with community workshops, which were held to:

- develop a shared vision for the McLaren Vale region, as well as water security goals (Workshop 1)
- create plausible future scenarios based on the key global, regional and local variables that may impact the future water security of the region (Workshop 2)
- identify options and actions to achieve the shared vision under the range of plausible future scenarios (Workshops 1 & 2)
- share outcomes of analysis and agree on final options and actions to include in the Strategy (Workshop 3).

Future scenarios based on uncertainties and challenges faced by the region were used to help build future resilience and prepare for uncertain futures. Actions to achieve the shared vision and water security goals were developed and refined by testing the actions across these future scenarios. In this way, the plans take into account the key uncertainties that the McLaren Vale region may encounter in the future.

In addition to the workshops, technical analysis was undertaken to support the Strategy development, particularly around potential impacts of climate change on water resources in the McLaren Vale region and analysis of future demand (see Section 6). An economic and options analysis of water security options identified through the workshops was undertaken to determine which ones would be most effective in contributing to water security. Marsden Jacob Associates was engaged to assist with this analysis and results have been included in Sections 6 and 7. The analysis highlighted a portfolio of water security options that could be implemented to achieve the future vision for the region (see Section 7).

The information gathered through the workshop and analysis phases informed the actions and next steps set out in the Strategy. A process description and timeline is provided in Figure 1.

Figure 1. Process description and timeline

Other water-related investigations were undertaken during the development of the Strategy. Where possible, information was shared across projects to ensure consistency in assumptions and use of data so that the outcomes of the Strategy can inform future policy and infrastructure development. Projects included:

- amendment of the McLaren Vale Water Allocation Plan, which manages the sustainable take and use of groundwater in McLaren Vale
- investigation of salinity hot spots to better understand increasing groundwater salinity in areas of McLaren Vale and potential management options
- commencement of the McLaren Vale Irrigation Water Security Project, which involves investigating the case for a new recycled water storage to deliver additional volumes of recycled water to businesses in the McLaren Vale region.
- development of the long-term water security strategy for Greater Adelaide, SA Water's long-term plan for resilient water supplies for the Greater Adelaide area, which includes the McLaren Vale region.

1.3 Study area

The study area comprises the McLaren Vale Geographical Indication (GI), with an area of 42,800 ha, extending from Flagstaff Hill in the north to Sellicks Beach in the south (Figure 2). The McLaren Vale region is a premium wine grape growing area, with a focus on sustainable growing and irrigation practices. The region also supports other irrigated agriculture, grazing and residential areas. The extent of the McLaren Vale GI is similar to the City of Onkaparinga local government area boundaries.

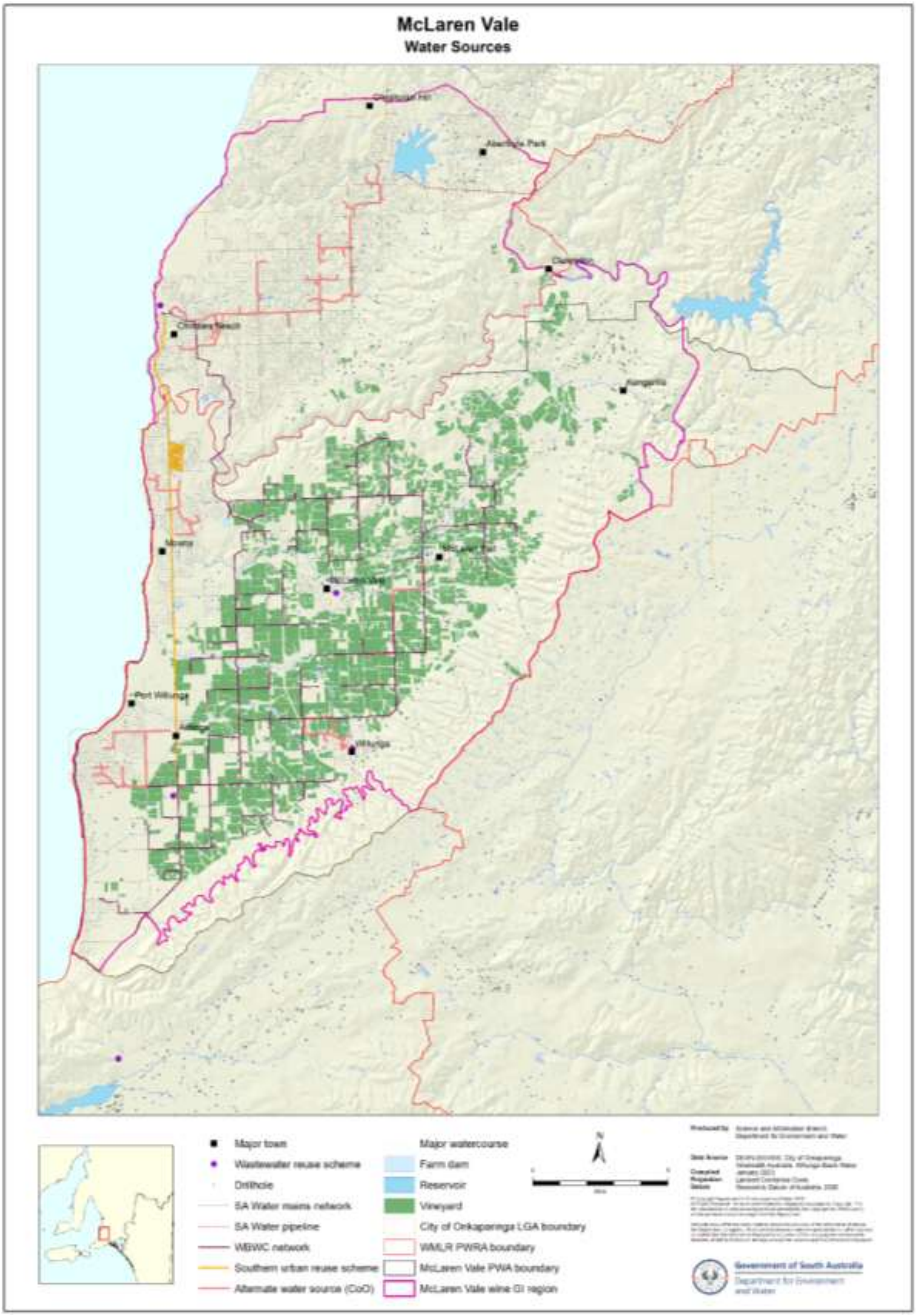

Figure 2. McLaren Vale Geographical Indication, including prescribed resource boundaries, vineyards, pipelines, water reuse schemes and major towns

1.4 Historical and current land use

Figure 3 (left) shows the primary land use in the region, from the Australian Land Use and Management (ALUM) Classification version 8 (ABARES 2018), with omitted land use (mainly the north-western 'Intensive uses' area – see section 1.4.2 below) taken from the 2018 Catchment Scale Land Use of Australia (CLUM) update (ABARES 2019). Figure 3 (right) shows the area breakdown attributed to each of these primary land use categories.

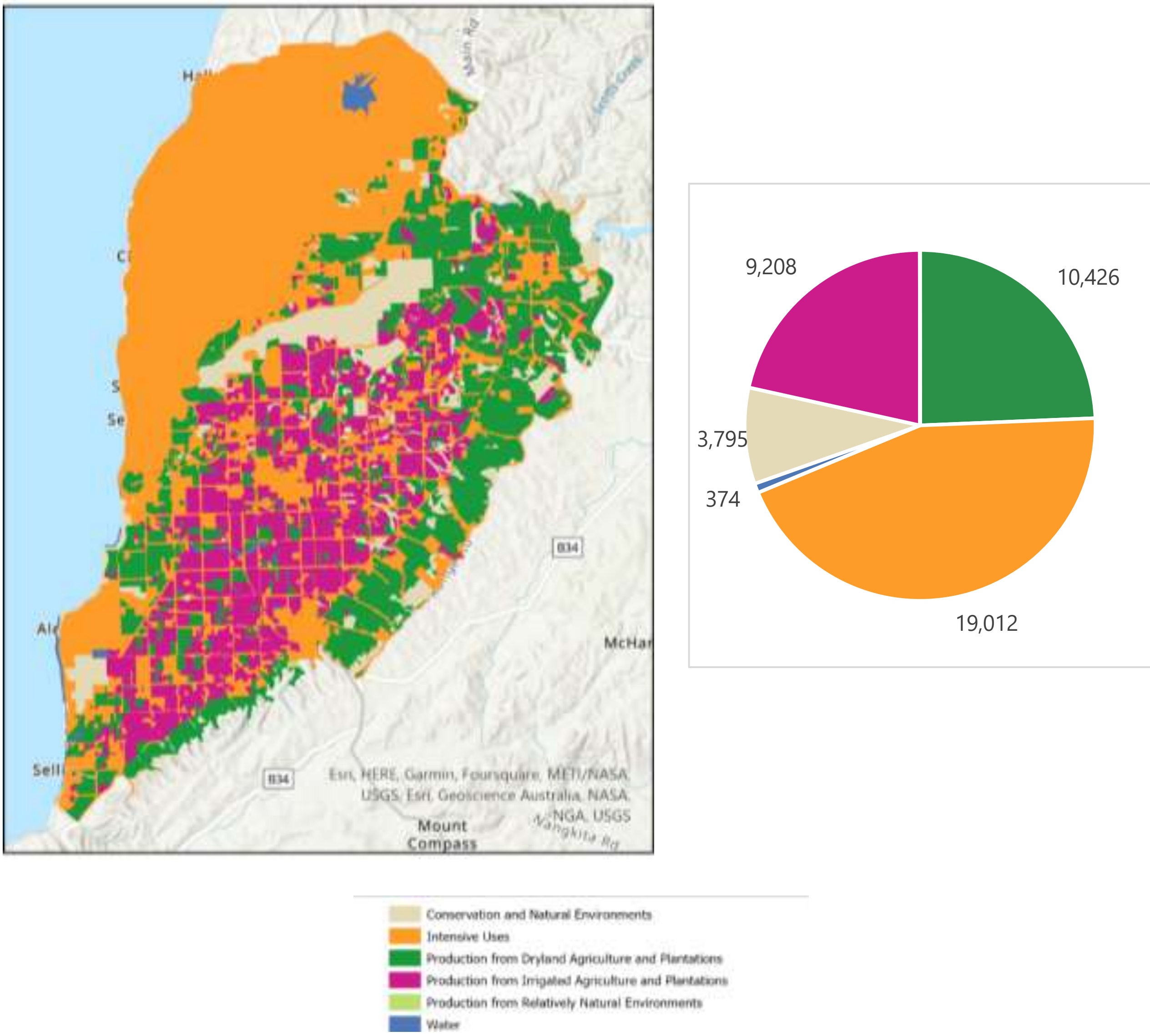

Figure 3. Area breakdown attributed to primary land use categories. Left: primary land use in McLaren Vale GI from the 2016 ALUM database (ABARES, 2016), with missing land use sourced from the lower resolution CLUM 2018 update (ABARES, 2019). Right: pie chart of area attributed to each primary class in hectares.

1.4.1 Viticulture

Grape growing and production for wine is a major use of water in the McLaren Vale region, with vineyards making up an estimated 93% of irrigated agriculture by area[1]. Figure 4 shows historical planted area in the region by variety, with the black line representing total planted area of all varieties. According to crush survey data, the planted area in the region increased between the 2001 vintage (first year of crush survey) and 2007, with total area of plantings steady since 2008. The current planted area in the McLaren Vale GI used in the analysis is 7,377 ha (Wine Australia 2022). The area of white grapes has decreased over this time, with plantings of red varieties increasing. By far the most popular variety in the region is Shiraz (a red varietal), followed by Cabernet Sauvignon (also a red varietal). There has also been an increase in planted area of other red varieties.

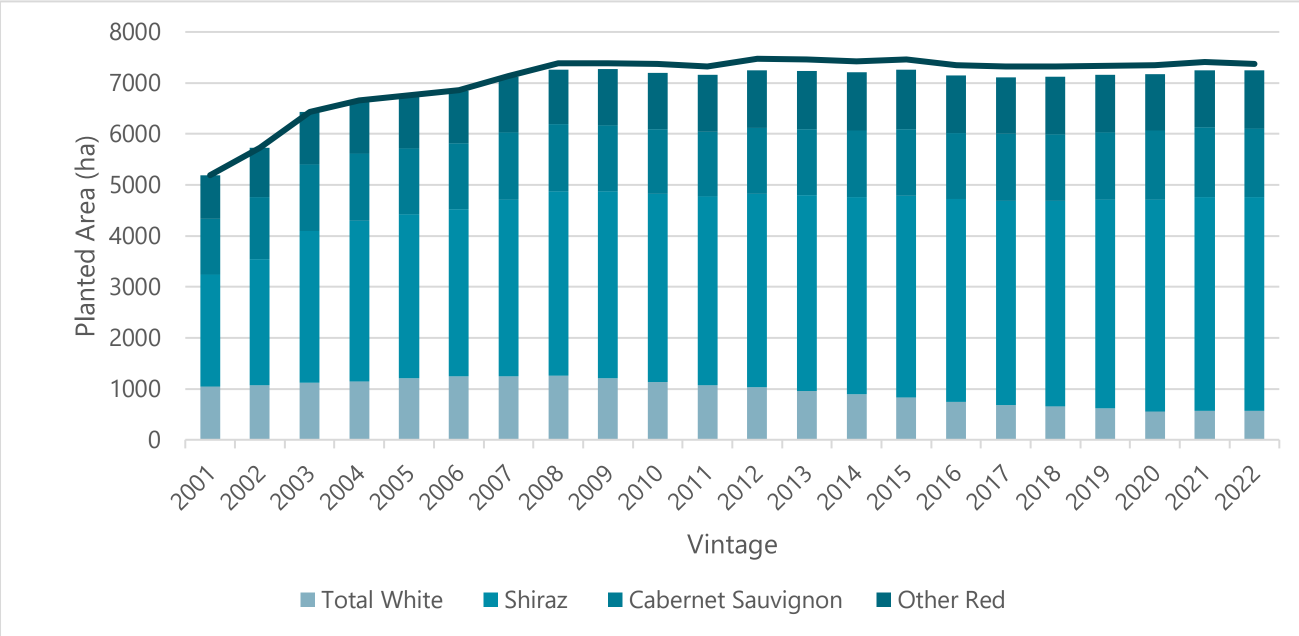

Figure 4. Planted area of vineyards in the McLaren Vale wine region, shown as Total White, Shiraz, Cabernet Sauvignon and other red varieties (stacked columns), and total planted area by year (black line), which includes unspecified varieties and rootstock

Figure 5 shows historical grape yields per hectare (t/ha) in the McLaren Vale GI from the SA Winegrape Crush Survey. There is significant year-to-year variation, ranging from 3.8 t/ha (2015) to 10.8 t/ha (2001), with yield, from visual inspection, showing a decreasing trend over the 2001–2022 vintages.

Water demand is impacted by planted area, variety and yield. The shift towards red varietals is likely in part due to consumer preferences but is also likely influenced by the generally lower irrigation requirements of red varietals compared to white. Reduction in yield may also be due to year-to-year climate variability, availability of water, cost of production, product demand and targeting of higher quality grapes.

[1]From the 2016 land use dataset (ABARES, 2016), of the 9,208 ha of land with a primary classification of 'Production from Irrigated Agriculture and Plantations', 8,577 ha of this land is attributed to the tertiary class of 'Irrigated grapes'. A more accurate estimate of vineyard area is from the Vinehealth Australia crush surveys (Wine Australia, 2022), which estimate that the actual (2022) area of vineyards is 7,377 ha. Discrepancies between the 2 values are attributed to lack of detail in the ALUM dataset (i.e. internal farm dirt tracks being counted as land use for 'Irrigated grapes'). While the 2016 ALUM dataset is a little dated, it still gives a good indication of the proportion of irrigated grapes to other agriculture, suggesting that grapes are 93% of total irrigated agriculture in the region.

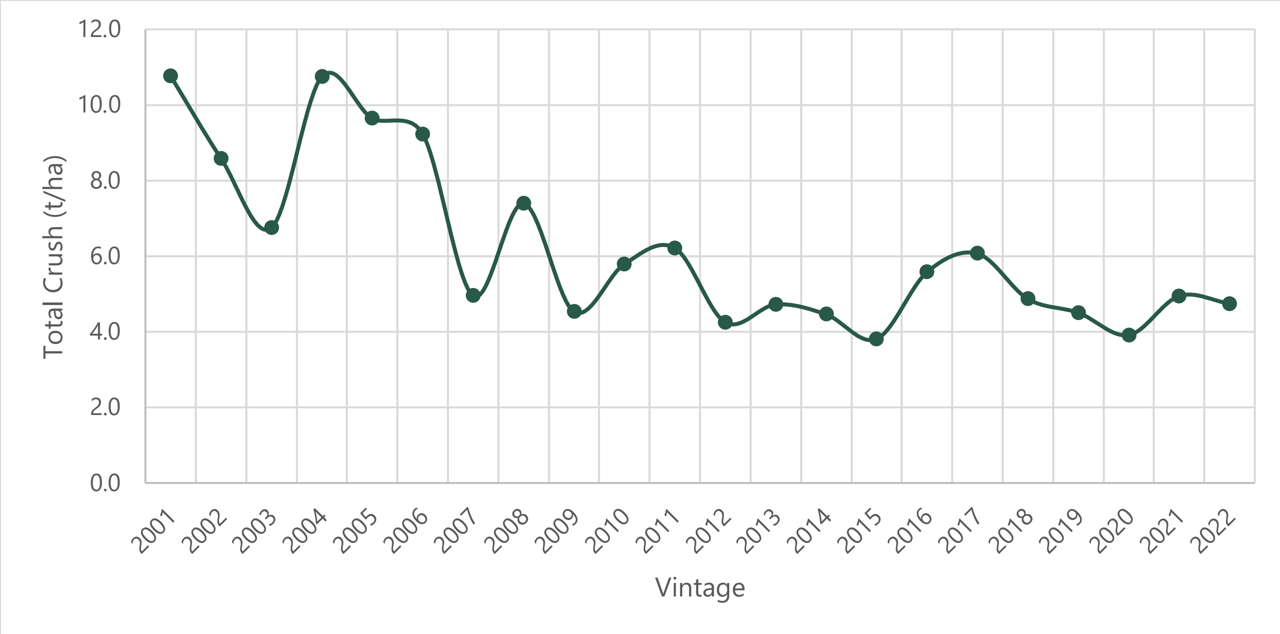

Figure 5. Crush (t/ha) in the McLaren Vale wine region for vintages from 2001 to 2022 from SA Winegrape Crush Survey

1.4.2 Other land use

Other irrigated agriculture in the region includes olives, nuts (including almonds), fruit trees, vegetables, cropping and forestry (Bardsley et al. 2017, ABARES 2018). Other agriculture (dryland) includes pasture (for grazing), cropping, forest plantation and horticulture. A significant area (over 40% of the GI) is classified for 'Intensive uses', comprising residential, recreational, transport, industrial, commercial and mining use. Other land use types in the region are 'Conservation and natural environments' and 'Water', including the Onkaparinga River National Park, Aldinga Conservation Park and Happy Valley Reservoir. Within the residential areas, there are approximately 559 hectares of irrigated green spaces.

2 System representation of McLaren Vale water resources

Developing a quantitative representation of the system is beneficial in determining the effect of climate change on water supply and demand. It can also be used to test other future scenarios or options. In the McLaren Vale region, the main objectives were to determine how demand and supply might change in the future. Demand (for non-potable water) in the McLaren Vale region is largely from viticulture, but demand is also present for other types of agriculture, public green spaces and stock and domestic use. Supply for these purposes comes from 2 main sources, groundwater and recycled water. A conceptual representation of the McLaren Vale system is presented in Figure 6.

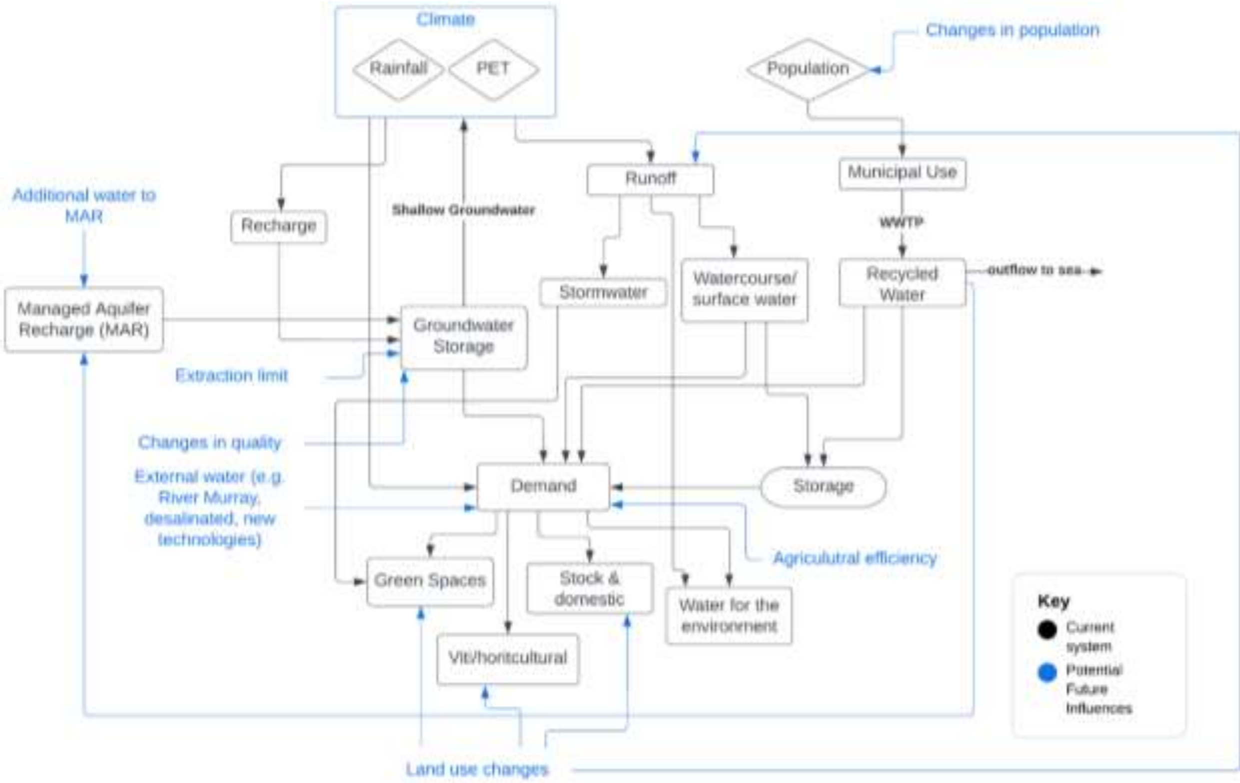

Figure 6. Schematic system model of water fluxes and current and potential future influences on demand in the system

3 Historical and current water resources

The following section presents an overview of historical and current water stores and fluxes in the McLaren Vale region. This includes climate processes (e.g. rainfall and evaporation) and extraction.

3.1 Rainfall

Historical rainfall: key points

- An average rainfall of 639 mm/year was recorded at the Willunga gauge for the period from 1900–01 to 2021–22, with rainfall ranging from 411 to 894 mm/year.
- The average rainfall depth corresponds to an average annual rainfall volume of 47 GL over the McLaren Vale GI planted vineyards (7,377 ha).
- The average rainfall over the period from 2012–13 to 2021–22 was 603 mm, showing a minor declining trend compared to the historical record.

Rainfall represents the largest flux of water into the system. The weather station used in this report is Willunga (23753). There are other stations within the McLaren Vale GI but the quality and length of those records is inconsistent. The data for this gauge was downloaded from the SILO LongPaddock dataset (Jeffrey et al. 2001).

Monthly mean rainfall at Willunga Station over the period fom 1900–01 to 2021–22 is provided in Figure 7, with rainfall significantly higher in the winter months (approximately May to September), and January to March having the lowest monthly rainfall. Significant year-to-year variability is apparent in Figure 8, with rainfall ranging from 411 mm (1982–83) to 894 mm (1916–17), and an average over the period of 639 mm/year. A downwards trend in annual rainfall is also observed over this period. Further information on rainfall in the region, including spatial variation and additional trend analysis, can be found in Department for Environment and Water (2022d).

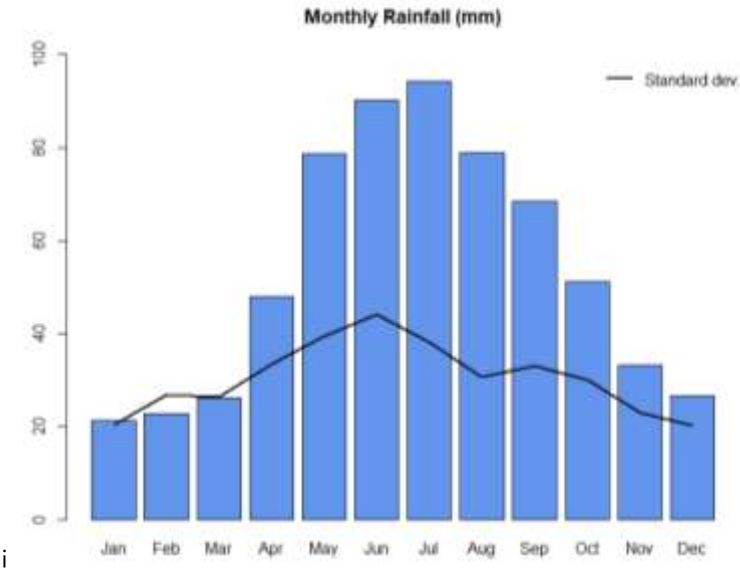

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Figure 7. 1900–01 to 2021–22 mean (bars) and standard deviation (line) of monthly rainfall at Willunga (23753)

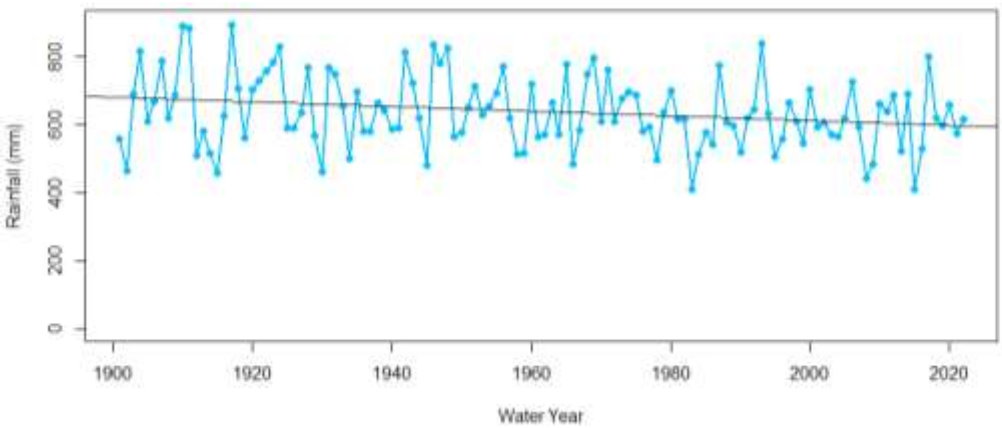


Figure 8 Annual average rainfall (mm) from the Willunga weather station from 1900–01 to 2021–22

3.2 Evaporative demand and potential evapotranspiration (PET)

Historical evapotranspiration: key points

- Annual average PET of 1,232 mm/year was recorded at the Willunga gauge for the period from 1900–01 to 2021–22, with PET ranging from 1,134 to 1,358 mm.
- Over the period from 2012–13 to 2021–22, average PET was 1,291 mm/year, showing an increasing trend compared to the historical record.

Evapotranspiration represents the primary flux of water from the system. Potential evapotranspiration (PET) was calculated using the FAO-56 method (Penman-Monteith equation) for the Willunga (23753) gauge from SILO patched point data, using the R package *Evapotranspiration* (Guo et al. 2016). The FAO-56 approach uses measurements of temperature, relative humidity, solar radiation and wind speed[2], as well

[2]In this case actual wind speed data was not available, so an alternative formulation without windspeed was used (Valiantzas, 2006).

as a reference crop[3]. This measurement is indicative and does not represent actual evapotranspiration conditions in McLaren Vale (as measured actual evapotranspiration data was not available).

PET is also highly seasonal (Figure 9), being highest in the summer months (November to February) and lowest in winter (May to August). Annual average PET over the period from 1900–01 to 2021–22 (Figure 10) was 1,232 mm/year and ranged from 1,134 mm (1948–49) to 1,358 mm (2012–13). An increasing trend in PET over this period can also be observed.

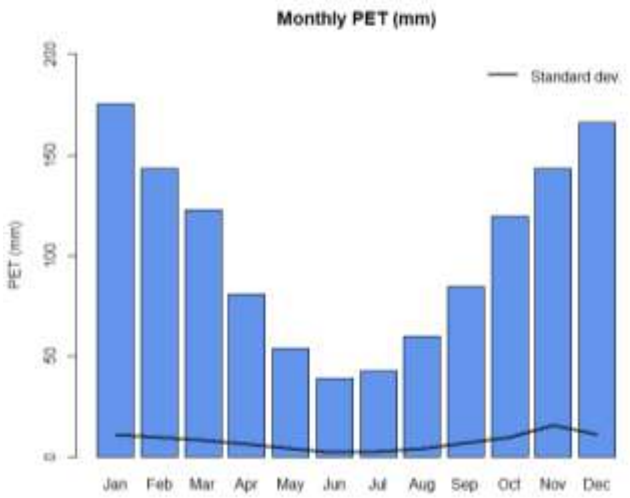


Figure 9. Climatological (1900–01 to 2021–22) mean (bars) and standard deviation (line) of monthly PET (mm) from Willunga (23753)

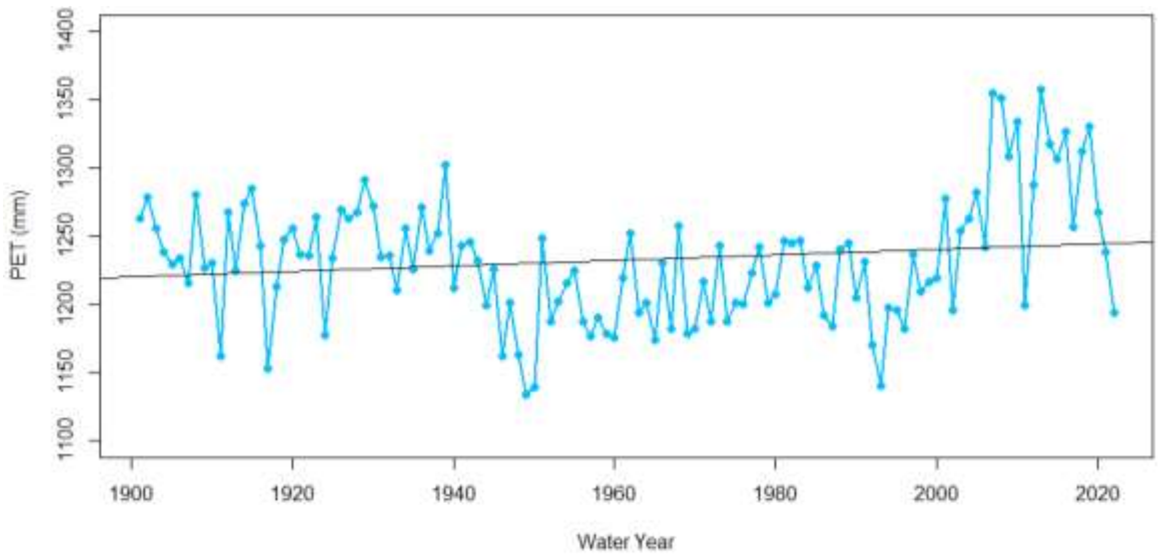


Figure 10. The annual total mean PET (mm) at Willunga (23753) from 1900–01 to 2021–22

[3]Short grass (Allen et al. 1998, Equation 1)

3.3 Groundwater

Groundwater in the McLaren Vale GI is largely managed under the Water Allocation Plan (WAP) for the McLaren Vale Prescribed Wells Area (PWA), but parts of the GI are also within the Adelaide Plains WAP (Central Adelaide PWA) and Western Mount Lofty Ranges WAP (Western Mount Lofty Ranges Prescribed Water Resources Area).

3.3.1 McLaren Vale PWA

Historically, extraction is from 3 main aquifers: Fractured Rock aquifer (FRA), Maslin Sands (MS) aquifer and Port Willunga Formation (PWF, including the Port Willunga Formation Member and Pirramimma Sands Member). There are also 2 other aquifers in the McLaren Vale PWA, the Quaternary and Permian Sands aquifers, which have relatively small extractions. A cross-section of the aquifers can be seen Figure 11.

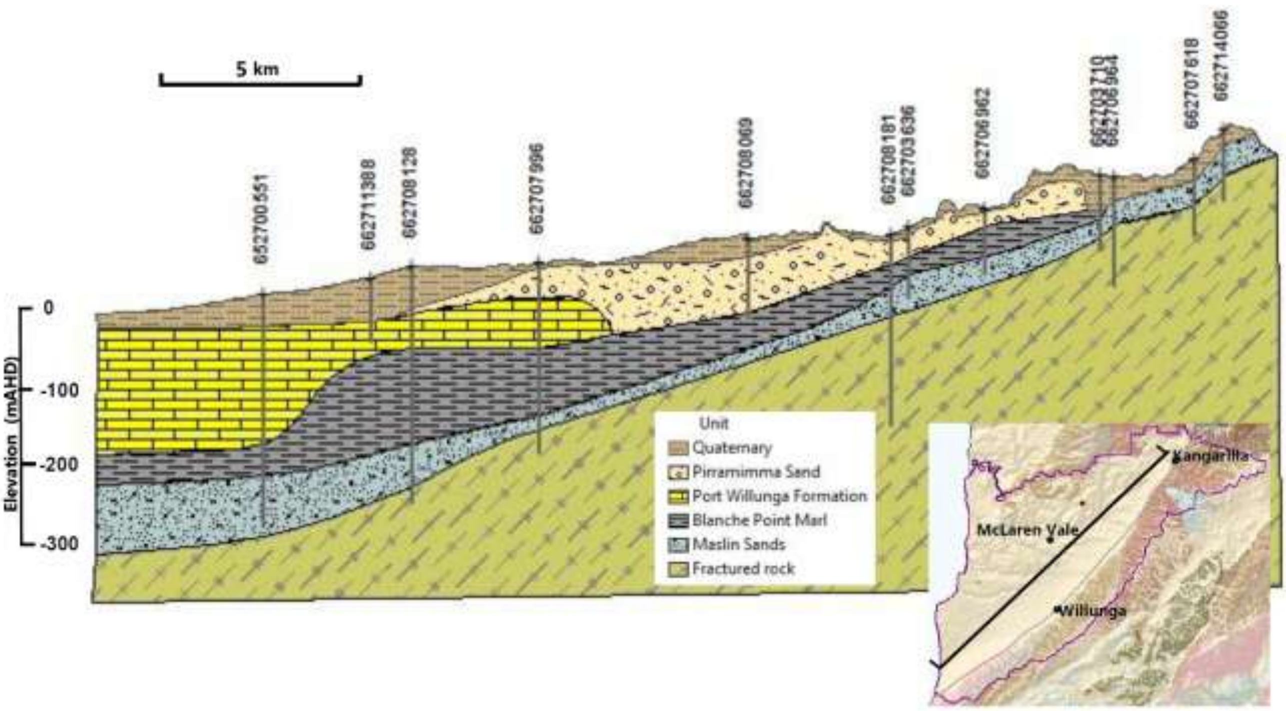


Figure 11. Geological cross-section of the Willunga embayment (Department for Environment and Water 2022d)

Total water use is, on average, below allocation for the McLaren Vale PWA; however, use is spatially restricted by salinity and licensed allocations. Two salinity hotspots have been identified (Department for Environment and Water 2022a); these are located in the Port Willunga Formation (Pirramimma Sands Member) and the Maslin Sands aquifers. In these areas, salinities have been markedly increasing in response to pumping, because of upward leakage from underlying units. Other regions have naturally higher salinity, but those are not changing as significantly over time (S. Barnett, personal communication, 14 November 2022). Subsequent well monitoring across the Willunga basin has highlighted rising salinity levels in 3 areas. The resource limit for the McLaren Vale PWA (all aquifers) is 6,600 ML, and this is fully allocated (Adelaide and Mount Lofty Ranges Natural Resources Management Board 2007). Licensed extraction is fairly close to allocation for the Port Willunga Formation, suggesting possible strain on this aquifer (Department for Environment and Water (2022a).

Figure 12 shows groundwater use by aquifer in the region. 'Allocation licensed for use' is the total licensed allowable extraction, which is the sum of base allocation and rollover allocation from previous years, as defined in the McLaren Vale WAP[4].

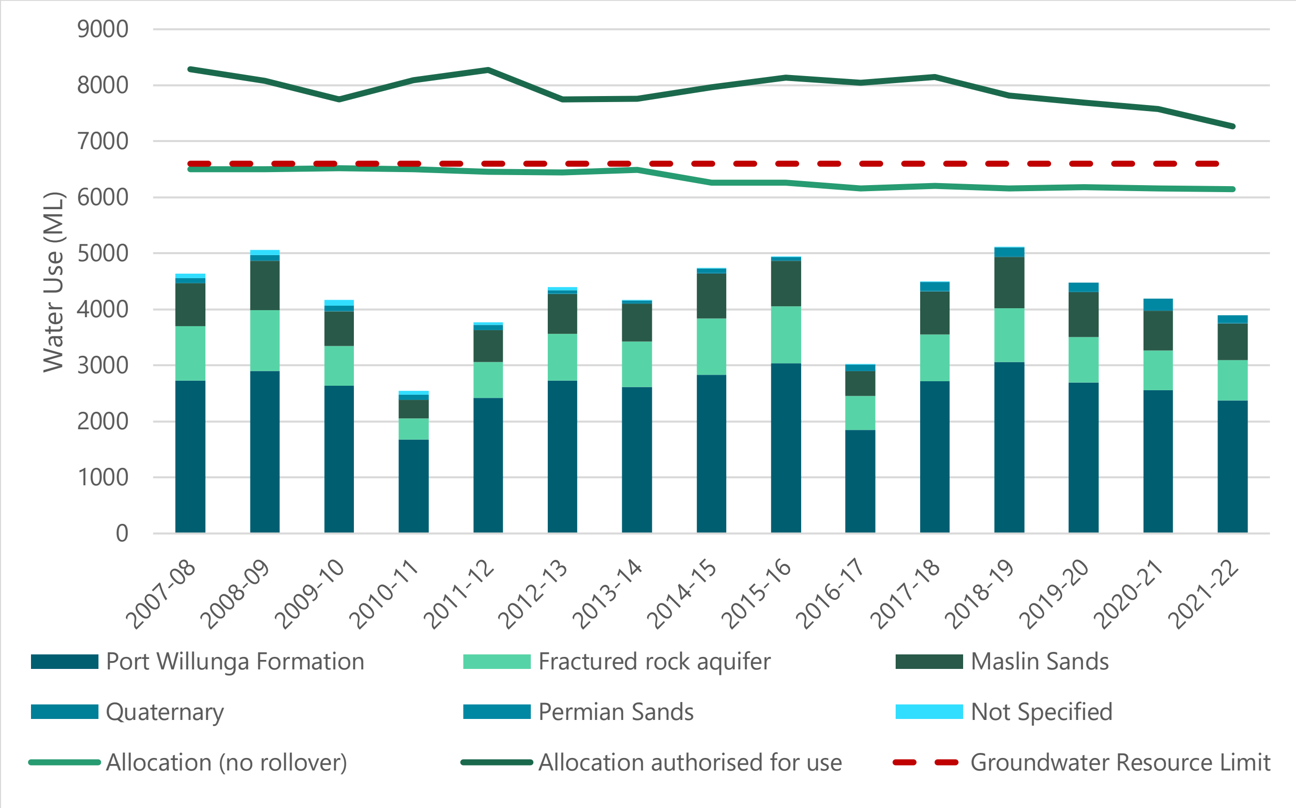


Figure 12. Groundwater use by aquifer in the McLaren Vale PWA over the period from 2007–08 to 2021–22

3.3.2 Total groundwater use in the McLaren Vale GI

A small volume of water use in the region is from 2 other prescribed areas, the Western Mount Lofty Ranges (WMLR) and Central Adelaide prescribed areas. Total groundwater use for the McLaren Vale GI is shown in Figure 13, noting that water use data was not available before 2013–14 in the WMLR, and not before 2019–20 in Central Adelaide.

[4]A rollover credit for the water use year is half the volume of the allocation that was not taken in the previous water use year. A rollover allocation is the sum of the rollover credits from the immediately preceding 3 years, although it cannot exceed 30% of the allocation on licence, and cannot be taken until all the water allocation has been used. A rollover credit expires at the end of the third full water use year after the credit year.

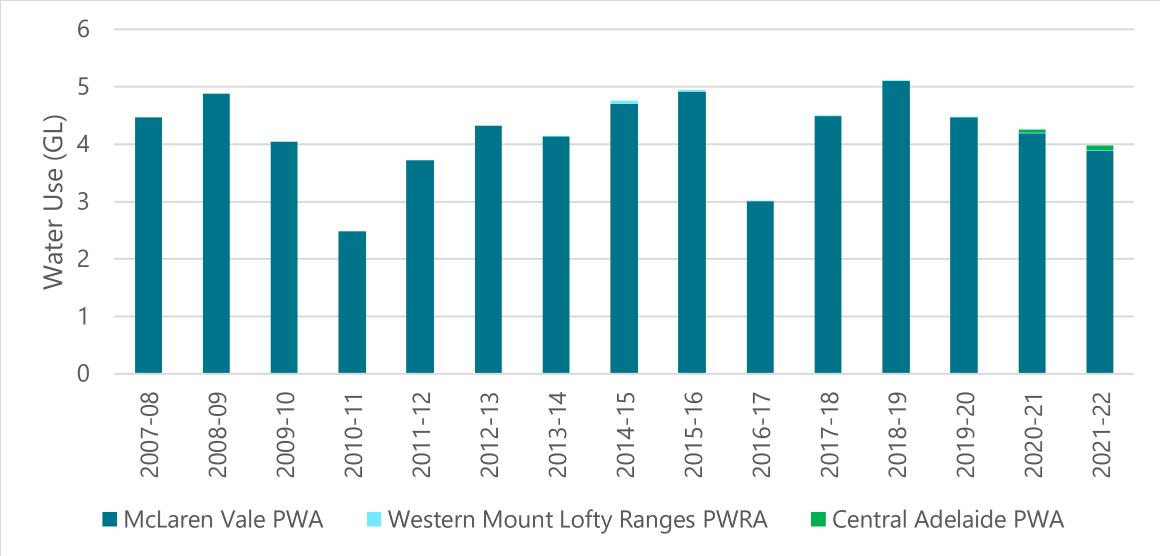


Figure 13. Groundwater use within the McLaren Vale GI, from the McLaren Vale and Central Adelaide PWAs, as well as the Western Mount Lofty PWRA

3.3.3 Stock and domestic use

Approximately 600 bores were identified for stock and domestic use (McLaren Vale PWA WAP, 2007), mostly in the upper part of the PWA where there is no access to mains water. This usage is not licensed and rarely metered. It is estimated in the MV WAP that 500 ML/year of underground water is taken annually for the entire McLaren Vale PWA (0.85 ML/year per borehole) (Adelaide and Mount Lofty Ranges Natural Resources Management Board 2007).

3.4 Recycled water

3.4.1 Willunga Basin Water

Recycled water in the region comes from the Christies Beach and Aldinga wastewater treatment plants (WWTPs) and is provided by Willunga Basin Water (WBW). The scheme began providing water to the region in 1999 and was taken over by CoNEXA in 2014. Figure 14 shows the available recycled water and water use from the period from 2014–15 to 2021–22. Although the current network capacity of the system is approximately 7,200 ML/year, it is important to note that the Christies Beach and Aldinga WWTPs produce approximately 12,400 ML/year. This means that approximately 6,000 ML/year is currently discharged to the gulf.

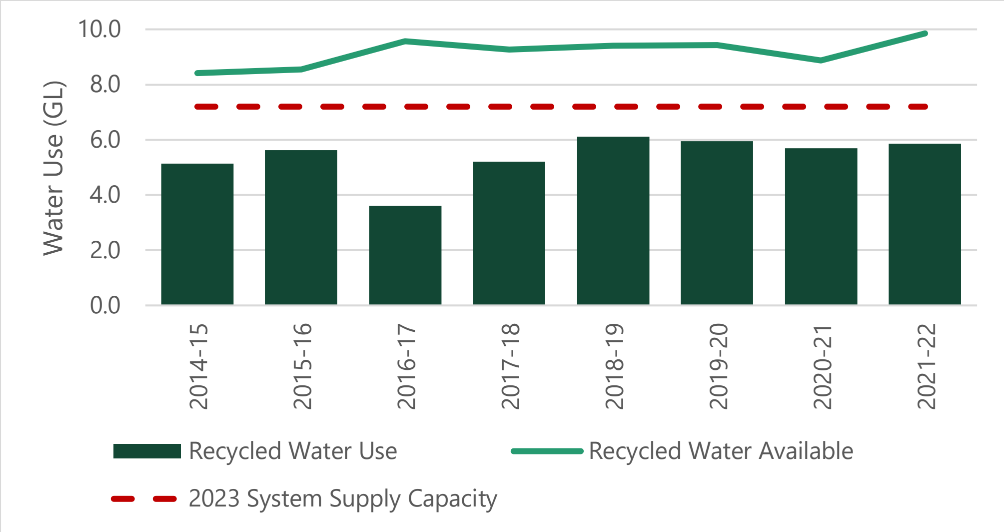


Figure 14. Available recycled water and water use in the McLaren Vale GI over the period from 2014–15 to 2021–22

3.4.2 Community wastewater management systems

The City of Onkaparinga community wastewater management system (CWMS) includes 7 wastewater networks located in Clarendon, Morphett Vale, McLaren Flat, McLaren Vale, Willunga, Maslin Beach and Sellicks Beach. These schemes service 4,500 customers in the council area.

The City of Onkaparinga has a bulk water transfer agreement with WBW to supply local reserves and sporting clubs (Independent Pricing and Regulatory Tribunal of New South Wales 2013). Recycled water is also supplied from Willunga to a golf course, a school, a park and a garden.

3.5 Surface water

Surface water in the McLaren Vale GI is managed under the WAP for the Western Mount Lofty Ranges Prescribed Water Resources Area (PWRA) (Adelaide and Mount Lofty Ranges Natural Resources Management Board 2013). Metered surface water use in the region is negligible compared to other sources and is defined as use from either surface water or watercourses. A watercourse is defined in the *Natural Resources Management Act 2004* as 'a river, creek or other natural watercourse (whether modified or not) in which water is contained or flows whether permanently or from time to time'. This includes dams or reservoirs (that capture water flowing in a watercourse), lakes or channels. Surface water includes all water flowing over land that is not in a watercourse (from rain or hail or rising naturally from underground) or water collected in dams or reservoirs (from the preceding causes). The Hills and Fleurieu Landscape Board also estimates allocated (or 'deemed') usage, as well as unlicensed surface water use for stock and domestic and forestry (Table 1).

Table 1. Surface water use over the past 5 water years (2017–18 to 2021–22)

Water year	Allocated/authorised take (ML)	Stock and domestic use (ML)	Forestry use (ML)	Total allowable take (ML)	Estimated total use (ML)
2017–18	1,202	356	166	1,724	1,191
2018–19	1,203	356	166	1,726	1,202
2019–20	1,176	357	166	1,699	1,132
2020–21	1,183	358	166	1,707	1,156
2021–22	1,183	358	166	1,707	1,127

Source: Hills and Fleurieu Landscape Board

Figure 15 shows the surface water and watercourse use in the region over the period from 2013–14 to 2021–22.

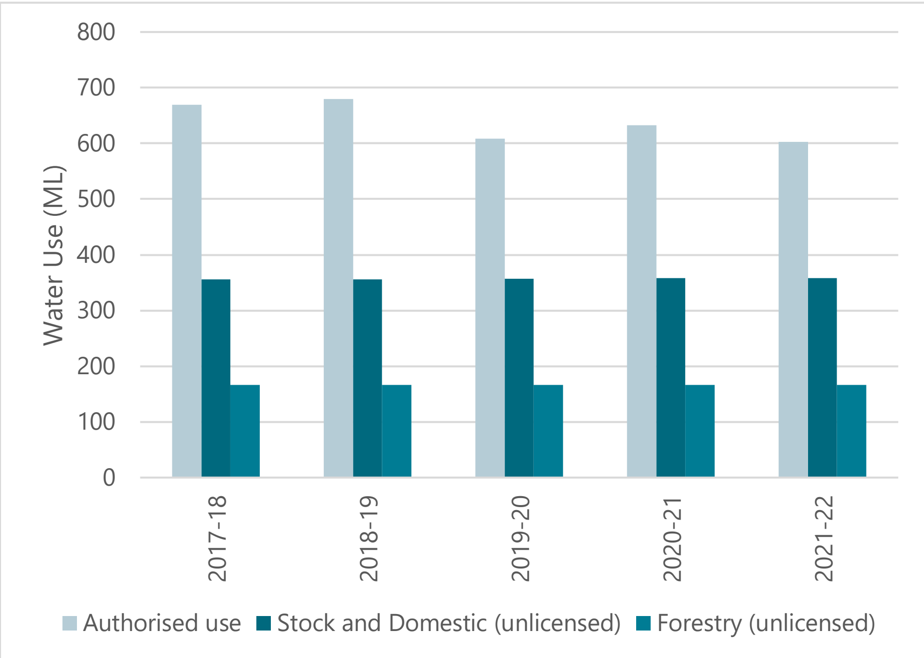


Figure 15. Surface water and watercourse use data in the McLaren Vale GI over the period from 2017–18 to 2021–22

3.6 Stormwater

Assets in the region for the storage and treatment of stormwater include wetlands at Byards Road, Madeira Drive, Dalkeith Road, Brodie Road and Hart Road. There is storage at Candy Road stormwater harvesting pond and the Wilfred Taylor Storage Dam. The water supplied through these systems is predominantly used to irrigate sports grounds (including golf courses), school grounds and public open spaces.

3.7 SA Water residential and non-residential use

It is important to note that the Strategy excludes urban water provided by SA Water. Urban water supply and demand will be considered in the long-term water security strategy for Greater Adelaide that is being developed by SA Water.

3.8 Demand estimation

Demand for water is a crucial aspect of the system and is expected to be impacted in the future as a result of climate change. A method is presented here to relate climate to observed water use for viticulture, specifically annual rainfall and PET. This relationship provides the basis for climate stress testing in subsequent sections of this report.

3.8.1 Viticulture

A simple demand model (as developed by Westra et al. (2022)) is used in this report, which relates the key climate variables of annual average rainfall (P) and PET to observed water use for viticulture. This model provides a basis for estimating future demand. Mathematically, the model takes the form:

$$D = \beta_0 + \beta_1 \left(K_c \, PET - P \right) + \varepsilon$$

$$\varepsilon \sim N(0, \sigma)$$

where D is the irrigation water demand, β_0 and β_1 are the linear regression coefficients, K_c is a crop coefficient (where $K_c = 0.55$ was found to produce the best fit), and ε is the residual between the predicted and actual water use, which is assumed to be normally distributed. The $(K_c \, PET - P)$ term indicates a prediction of water demand based purely on climate factors and the crop coefficient, assuming that the difference between the estimated PET and rainfall represents irrigation demand.

The regression relationship makes the following key assumptions:

- Water use over the calibration period is indicative of water use in the region.
- The effect of fluctuating water supply in the region as a result of availability or changes in management on regression parameters is limited.
- Historical demand behaviours will remain ‘stationary’ with regard to climate.

As discussed in the preceding sections, observed water use data is available in the region for the period from 2007–08 to 2021–22, with the following caveats: surface water use data is only available from 2017–18, and recycled water data for the 2013–14 water year is unavailable. The demand for viticulture from native water sources (groundwater and surface water) and recycled water is assumed to be 93% and 98% respectively.

Figure 16 shows observed water use plotted against predicted water use $(K_c \, PET - P)$ and the linear relationship between these values, with 3 separate relationships representing water use pre-2013, post-2015, and for all years between 2007–08 and 2021–22 for which data was available. Figure 17 shows predicted water use imposed on observed water use for these 3 time periods. A predicted increase in water use can be observed between the pre-2013 and post-2015 regression. Increased water use post-2015 does not appear to correspond to any increase in yield, climate or land use change, nor to a decrease in groundwater use. It is possible this increase in use is due to greater water availability or is related to change in administration of the recycled water source (i.e. introduction of a clause where customers must pay for at least two-thirds of allocation, regardless of whether actual use is less than this amount). Other water uses could also be occurring, such as irrigation of cover crops or additional vegetation; however, there is no concrete explanation for this increase in use. Given the post-2015 regression is a better fit for more recently observed water use, this is the regression that will be used in this report.

The regression therefore takes the form, where demand is in GL:

$$D = 9.2406 + 0.0942(0.55PET - P) + N(0,1.085)$$

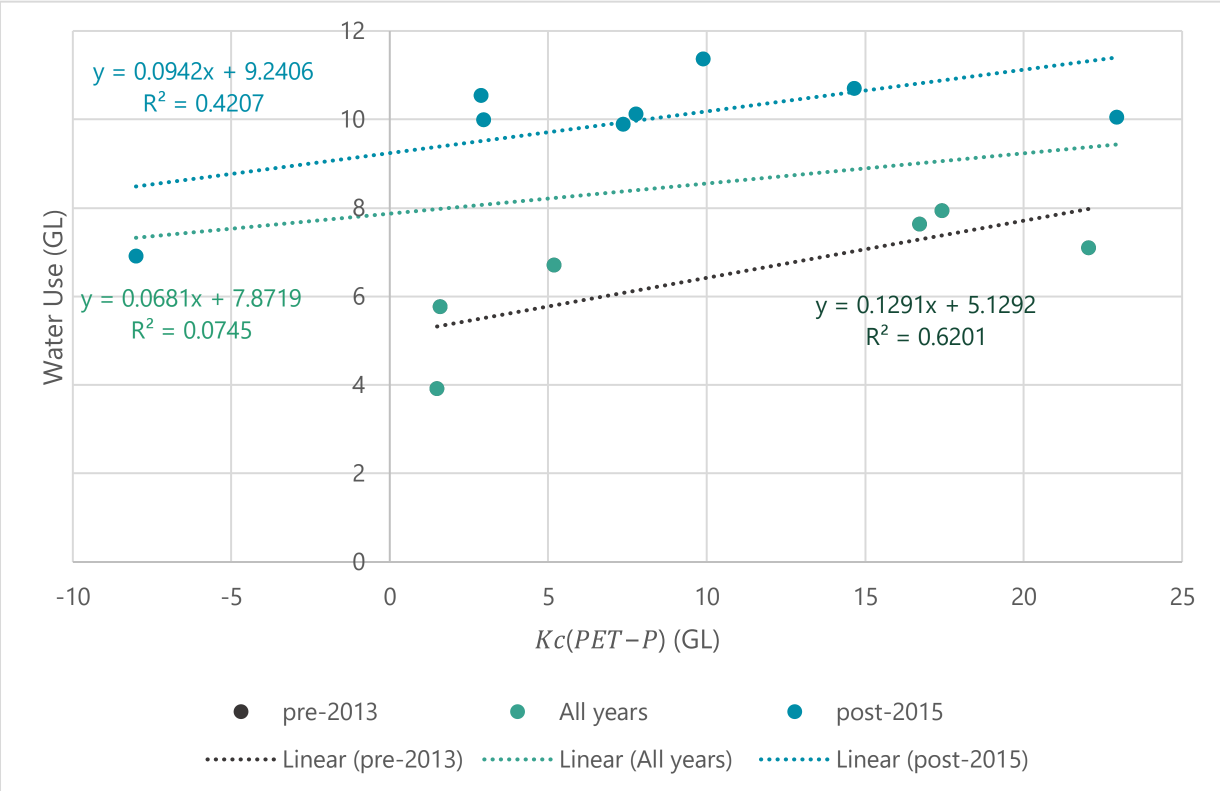


Figure 16. Comparison of regression on observed water use of the regression-based model using water use data pre-2013, for all available years, and post-2015

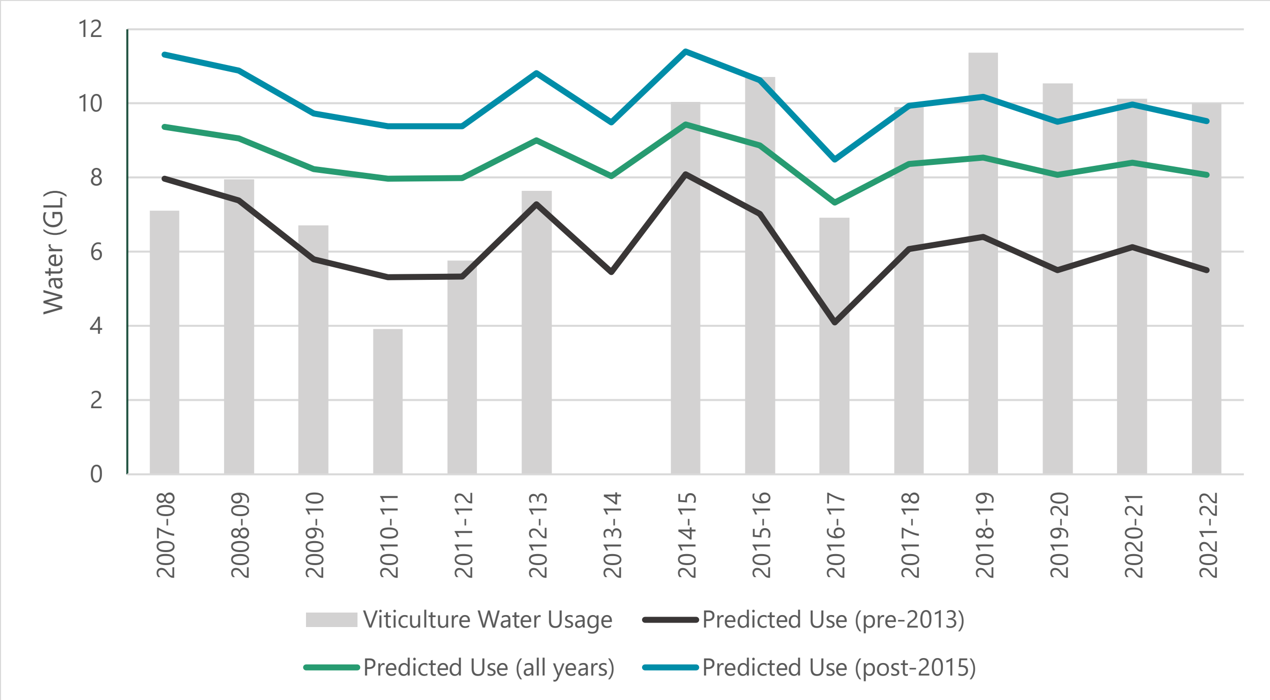


Figure 17. Historical water use (vineyards only), with pre-2013, all years and post 2015 regressions overlaid. Note 2013–14 is missing recycled water data, so was excluded from analysis

3.9 Supply estimation

3.9.1 Recharge

Climate change is likely to impact on groundwater availability, largely due to reduction in rainfall, which in turn causes a reduction in recharge (Walker et al. 2021). Reduced recharge affects the reliability of the groundwater resource in terms of quality and quantity available for use. Recharge and allocation values for the 3 aquifers in the McLaren Vale PWA are provided in Table 2, where the PWF and MS recharge values from Herczeg & Leaney (2002) are split 0.3 and 0.7 respectively based on GIS area assessment.

Table 2. Recharge and allocation values

Aquifer	Allocation (no rollover) (ML/year)	Recharge rate* (ML/year) 1970–2000 average	Source of recharge rate
Fractured Rock	1,650	11,332	Department for Environment and Water (2022a) and Green & Zulfic (2008)
Maslin Sands	1,420	672 to 1,568	Herczeg & Leaney (2002)
Port Willunga Formation	3,540	336 to 672	Herczeg & Leaney (2002)

*Range refers to spatial variability

In the absence of a hydrological model for the region, a relationship is used that relates groundwater recharge to rainfall. This relationship was developed through a series of studies completed on South Australian groundwater resources (Green et al. 2011, Green et al. 2012, Alcoe et al. 2014). These studies modelled groundwater recharge in a range of locations, using a process-based soil water balance model, estimating recharge as the total water flux draining below the root zone with precipitation, AET and other losses accounted for. In each modelled location, the percentage reduction in annual recharge was found to be a multiple of the percentage change in mean annual rainfall under future climate scenarios. In areas with climate similar to that of the McLaren Vale area, a multiple of around 3 was fairly typical. For the purpose of this work, an assumed relationship is shown below[5]:

$$Change\ in\ recharge = 3 \times change\ in\ rainfall$$

[5]From the 3 studies listed, the factor used could be between 2 and 4.

4 Future climate stressors

This section explores future change in climate variables that are agriculturally sensitive using a multiple-lines-of-evidence approach. These climate variables are rainfall, evapotranspiration and temperature. The primary lines of evidence are from the South Australia Climate Ready dataset (SA-CR) (Goyder Institute for Water Research 2015), NARCliM 1.5 dataset (State of NSW and Department of Planning, Industry and Environment 2020), and the Australian Water Outlook (AWO) dataset (Srikanthan et al. 2022). The reference period and dataset projection extent are explained first, followed by the primary lines of evidence and a summary of the projections for each climate variable.

4.1 Reference period and projection extent

The World Meteorological Organization guidelines suggests the use of a 30-year reference period (World Meteorological Organisation 2017). The 'historical' (hindcast) projections for each of the primary lines of evidence end in 2005, so the reference period (climatological baseline) used in this analysis is 1976–2005. Three planning horizons up to 2070 were explored, giving future periods of 2030 (2036–2065), 2050 (2036–2065) & 2070 (2056n2085). Future changes are represented either as relative change (percentage), or absolute change (e.g. °C), and are expressed as the future planning horizon value relative to the reference period.

The NARCliM and AWO are gridded projections (10 km and 5 km respectively). The SA-CR dataset is by weather station, with the Willunga Station (23753) being used in this case. The extent of these datasets is shown in Figure 18. Where applicable, projections were spatially averaged to give a single average value for each primary line of evidence before any other calculations were performed.

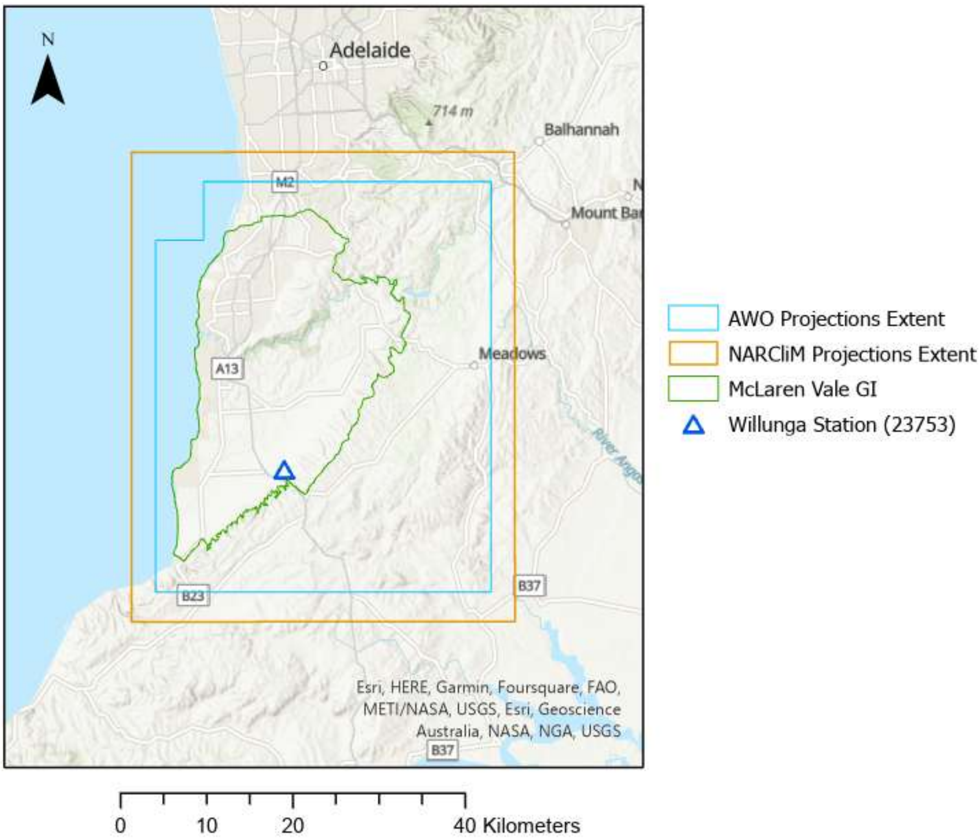


Figure 18. McLaren Vale GI (green) and the extent of projection datasets. NARCliM (orange) has 10 km grids, AWO (light blue) has 5 km grids, and SA-CR (dark blue) uses point data for Willunga Station (23753)

4.2 Sources of climate information

4.2.1 SA Climate Ready

South Australia Climate Ready (SA-CR) is a dataset of climate projections (Goyder Institute for Water Research 2015), specifically downscaled for South Australia, which captures climate variable data at the daily timescale for 6 climate variables: rainfall, areal potential evapotranspiration, minimum temperature, maximum temperature, solar radiation and vapour pressure deficit. Two emissions scenarios, RCP 4.5 and RCP 8.5 (representing ‘intermediate’ and ‘high’ greenhouse gas concentration pathways respectively) are available from 2006 to 2100, as well as hindcast ‘historical’ data for the period from 1961 to 2005. Data is available for weather stations across South Australia, and Willunga Station (23753), which lies within the McLaren Vale GI and has a long and high-quality record, was identified for use in this report.

The data is derived from the CMIP5 suite of model simulations and is a subset of 15 global climate models (GCMs) selected for their ability to capture relevant South Australian climate drives, such as the Indian Ocean Dipole and El Niño–Southern Oscillation (ENSO). Nonhomogeneous hidden Markov modelling (NHMM), a statistical downscaling technique, was used to downscale the GCM outputs and a weather generator was used for the non-rainfall variables, conditional on the rainfall generated using the NHMM method. Each climate model and hindcast/emissions scenario combination is represented by 100 statistical realisations, which are statistically realistic and have similar decadal scale trends but also reflect real-world variability.

The 15 GCMs, 3 scenarios ('historical', RCP 4.5 and RCP 8.5) and 100 statistical replicates give 4,500 time series per climate attribute. These time series are then passed into the *foreSIGHT* software, where specified attributes for each of the climate variables can be calculated. For the 'historical' timeseries, these are calculated for the reference period, and for the 2 emissions scenarios these are calculated for the 3 future planning horizons (2030, 2050 and 2070). This gives 1,500 relative or absolute change values for each variable attribute, GCM, RCP and time slice combination.

4.2.2 NSW and Australian Regional Climate Modelling (NARCliM)

The NSW and Australian Regional Climate Modelling (NARCliM) project is led by the NSW Government in partnership with the Climate Change Research Centre at the University of New South Wales (State of NSW and Department of Planning 2020). Climate projections of postprocessed (i.e. re-gridded) or bias-corrected variables are available for New South Wales, the Australian Capital Territory, Victoria and parts of the Northern Territory and South Australia – including the McLaren Vale region.

The projections are derived from the CMIP5 (IPCC 2014) GCMs, ACCESS1.0, ACCESS1.3 and CanESM2, and downscaled using 2 alternative configurations of the Weather Research and Forecasting model RCMs. The GCMs were selected because they had favourable performance in representing large-scale climate phenomena such as the ENSO, and climate variables such as temperature and precipitation (State of NSW and Department of Planning 2020). The RCMs were selected from 36 combinations of physics schemes (e.g. planetary boundary layer, land surface and cumulus physics, micro physics, and short- and long-wave radiation physics) and, as well as being statistically independent, were the highest ranked in capturing temperature, precipitation and mean sea-level pressure and winds. The 2 emissions scenarios RCP 4.5 and 8.5 are also used in NARCliM 1.5, representing the period 2006–2100, and hindcast data is available from 1951 to 2005 to inform the historical baseline.

In this report climate variables selected were bias corrected for temperature and precipitation, with bias-corrected data shown to have value for analysing the climate change impacts of temperature and precipitation (Gross et al. 2016, Macadam et al. 2016). Climate variables were bias corrected using a quantile matching technique (Piani et al. 2010), and corrected towards the Australian Water Availability Project observations (Jones et al. 2009). Penman-Monteith potential evapotranspiration was also calculated from the NARCliM dataset, using the variables precipitation (bias-corrected), minimum and maximum temperature (bias-corrected), solar radiation, relative humidity and wind speed, using the R package *Evapotranspiration* (Guo et al. 2022).

The resolution of chosen data is the 10-kilometre south-east Australian NARCliM domain. To derive projections for the McLaren Vale region, a boundary was selected that incorporates four-by-four 10 km grid squares in the region. The latitude and longitude of the centre of the north-west and south-east grid squares of this region are represented by the points (-35.05, 138.45) and (-35.35, 138.75) respectively. This gives a total of 16 grid squares over the region. The grid squares corresponding to the latitude 138.45 (4 grid squares) do not contain temperature projections, and none of the precipitation grid squares with latitude 138.45, except the square with longitude -35.35, contain values. Hence, PET calculations could not be performed for the grid squares with latitude 138.45. Future changes are assessed for the same baseline and future windows, and procedure, as for the SA Climate Ready dataset.

4.2.3 Australian Water Outlook

The AWO dataset (Srikanthan et al. 2022) was developed by the Bureau of Meteorology and provides gridded hindcast and future climate projections for the whole of Australia. The dataset consists of national hydrological projections (precipitation, minimum and maximum temperature, solar radiation and wind speed), and results from the Australian Water Resource Assessment Landscape model v6.1 (precipitation, soil moisture, potential evapotranspiration and run-off). There are 4 GCMs considered, as well as one RCM and 3 bias-correction methods, and 2 future emissions scenarios (RCP 4.5 and 8.5), as shown in Figure 19. This gives 16 GCM/RCM/bias-correction combinations for each emissions scenario and climate variable.

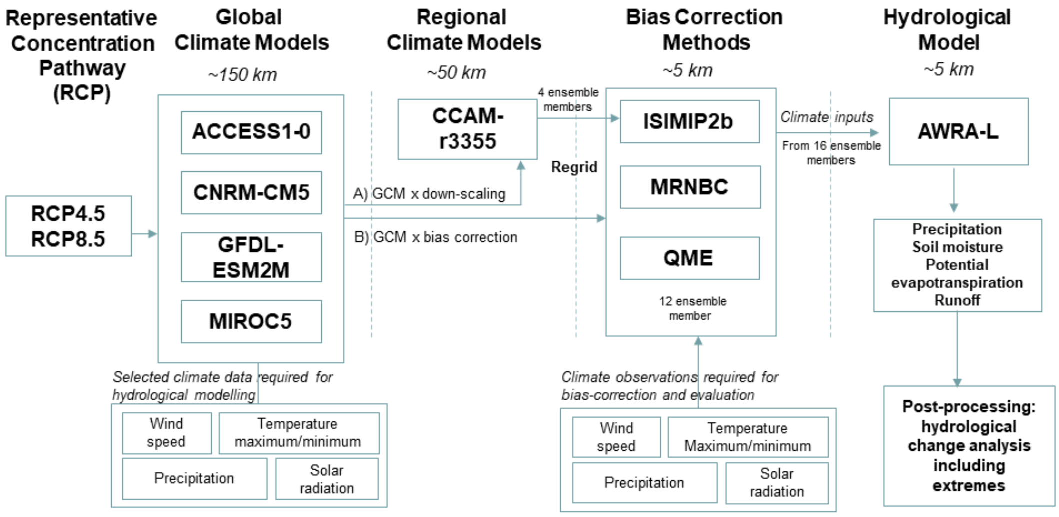


Figure 19. Australian Water Outlook Projections approach, from https://awo.bom.gov.au/about/overview/projections

The regional downscaling is to a 50 km resolution, and bias correction is to a 5 km resolution, giving 5 km grid squares, similar to the NARCliM approach. There are 3 bias-correction methods used, which have different relative benefits. They are Quantile Matching for Extremes (QME, good for extremes), Univariate Intersectoral Model Inter-comparison method (ISIMIP2b, preserves long-term trends and adjusts for dry days), Multivariate Recursive Nested Bias Correction (MRNBC, represents low frequency variability well).

The climate variables temperature and rainfall both come from the National Hydrologic Projections dataset, with FAO56 potential evapotranspiration coming from the AWRA-L model. The method for calculating relative and absolute change in climate attributes is the same as that for the SA-CR and NARCliM datasets. The latitude and longitude of the centre of the northwest and southeast grid squares of this region are represented by the points (-35.05, 138.45) and (-35.35, 138.75) respectively, which is the same as for the NARCliM dataset, although the grid has a higher resolution.

4.2.4 Australia's Wine Future – A Climate Atlas

Australia's Wine Future – A Climate Atlas (Remenyi et al. 2019) is a collaborative research project led by the Antarctic Climate Ecosystems Cooperative Research Centre (University of Tasmania) in partnership with the South Australian Research and Development Institute (SARDI), the Australian Wine Research Institute, CSIRO Marine and Atmospheric Research and the Tasmanian Institute of Agriculture, and funded by Wine Australia. This project provides a climate information for all Australian wine regions.

Table 3 presents mean total growing season rainfall and mean growing season temperature from the Climate Atlas and compares it to equivalent values calculated from the SA-CR, NARCliM and AWO datasets. A visual representation of this data for rainfall and PET is presented in Figure 20 and Figure 21 respectively. Mean total growing season rainfall from the Climate Atlas (230 mm) is comparable to equivalent values from the NARCliM and AWO datasets (220 and 230 mm respectively). Mean growing season temperature is higher for the Climate Atlas (19.8 °C), compared to the other datasets, which are in agreement (~19°C).

Table 3. Mean total growing season rainfall and mean growing season temperature from Australia's Wine Future – A Climate Atlas, SA-CR, NARCliM and AWO

Attribute	Percentile (%)	Emissions scenario	2050 (2041–2060)			
Line of evidence:			Climate Atlas	SA-CR	NARCliM	AWO
Mean total growing season rainfall (mm)	Median	RCP4.5		190	230	230
		RCP8.5	230	180	220	230
	25–75	RCP4.5		180 to 200	230 to 240	220 to 250
		RCP8.5		170 to 190	210 to 220	220 to 240
	2.5–97.5	RCP4.5		160 to 220	220 to 250	220 to 270
		RCP8.5		150 to 210	210 to 240	190 to 270
Mean growing season temperature (°C)	Median	RCP4.5		19	19.1	19
		RCP8.5	19.8	19	19.1	19
	25–75	RCP4.5		19 to 19	19 to 19	19 to 19
		RCP8.5		19 to 20	19 to 19	19 to 19
	2.5–97.5	RCP4.5		19 to 20	19 to 19	19 to 19
		RCP8.5		19 to 21	19 to 19	19 to 20

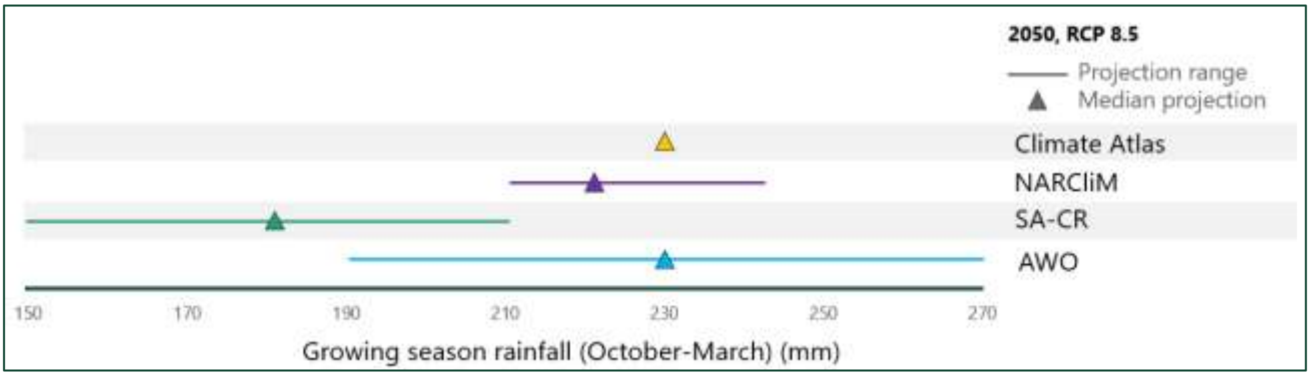


Figure 20. Growing season rainfall (October-March) projections for 2050 under RCP 8.5 from Australia's Wine Future – A Climate Atlas, SA-CR, NARCliM and AWO

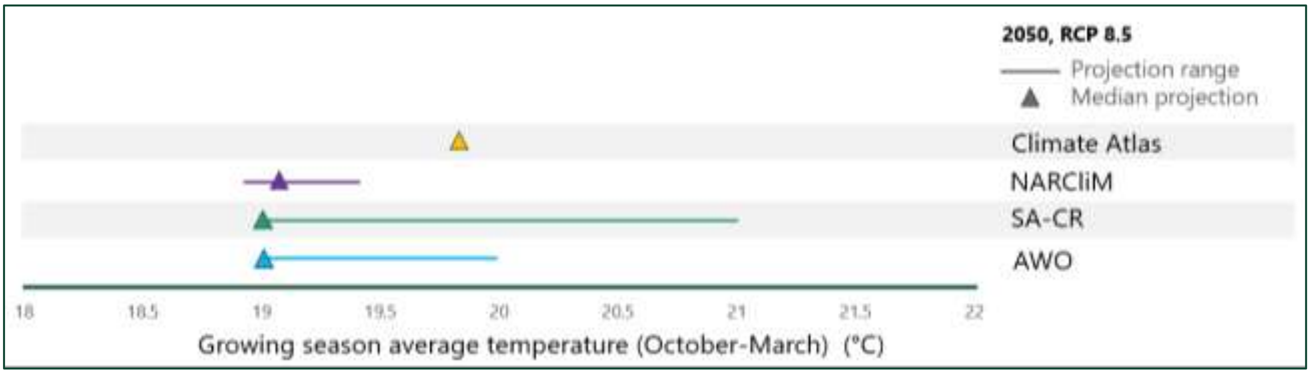


Figure 21. Growing season temperature (October-March) projections for 2050 under RCP 8.5 from Australia's Wine Future – A Climate Atlas, SA-CR, NARCliM and AWO

4.3 Summary of future climate stressors

Table 4 summarises the projected change in a number of climate attributes from the SA-CR, NARCliM and AWO datasets, including attributes related to rainfall, PET, temperature and solar radiation. A more detailed breakdown for each of the attributes can be found in Appendix A: Climate projections. More detailed discussion of each of the attributes is also presented in the following sections.

Table 4. Summary of climate projection ranges

Climate attribute	Range (from 2.5th to 97.5th percentile of AWO, NARCliM and SA-CR projections for RCP 4.5 and 8.5)			
	2030	2050	2070	All years
Average annual rainfall (% change)	-24 to 16	-25 to 5.6	-30 to 9.8	-30 to 16
Number of wet days (change in number of days/year)	-13 to 9.6	-16 to 10	-25 to 8.2	-25 to 10
Daily extremes (99th percentile wet day rainfall) (% change)	-13 to 19	-12 to 21	-16 to 39	-16 to 39
Rainfall seasonality	-16 to 27	-27 to 35	-23 to 48	-27 to 48
Annual average PET (% change)	1.6 to 11	2.5 to 16	3.2 to 26	1.6 to 26
Change in annual average maximum temperature (°C)	0.5 to 1.8	0.9 to 2.9	1.1 to 4.3	0.5 to 4.3
Change in annual average minimum temperature (°C)	0.4 to 1.3	0.5 to 2	0.6 to 2.9	0.4 to 2.9
Change in annual number of days with maximum over 35°C	0 to 8.2	0.5 to 9.9	0.9 to 14	0 to 14
Annual average solar radiation (% change)	-0.1 to 3.6	-0.2 to 5.6	-0.8 to 7.9	-0.8 to 7.9

4.3.1 Changes in rainfall

Rainfall is a critical driver of water demand and supply in the McLaren Vale region. Changes in rainfall impact agricultural demand and surface water availability, and over long periods also impact the quantity and quality of groundwater. Rainfall is also critical for maintaining environmental health.

4.3.1.1 Mean annual rainfall

A median decrease in annual average rainfall is projected by all 3 datasets, with decline generally more significant for later future periods and the more severe emissions scenario. Some deviation from these trends are nevertheless present, and some projections also suggest an increase in rainfall. The range of change in average annual rainfall out to 2070 is projected to be between -30% and +16% relative to the 1976–2005 baseline.

A breakdown of mean annual rainfall projections by season, future period, emissions scenario, projection dataset can be found in Appendix A, Table 16. Figure 22 shows both the percentage change and actual value (mm) of projected average annual rainfall for 2070 from all 3 datasets.

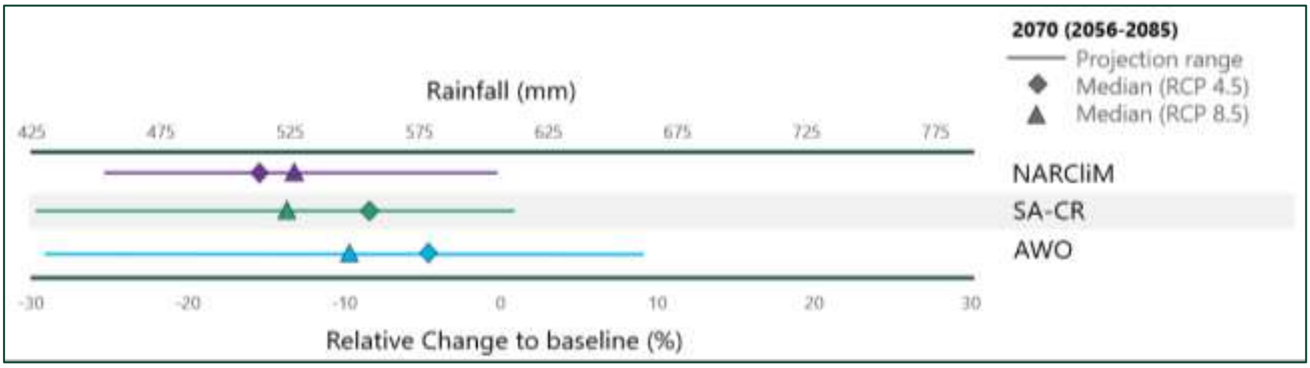


Figure 22. Mean annual rainfall projections for 2070 from the SA-CR, NARCliM and AWO datasets

4.3.1.2 Number of wet days

The number of annual wet days is an important metric which represents rainfall intermittency. Median projections from all models also suggest a decrease in this variable, although projected change over the analysis period ranges from a -25% to +10% change in the number of annual wet days. A breakdown of number of wet days projections by future period, emissions scenario and projection dataset can be found in Appendix A, Table 17.

4.3.1.3 Daily extremes (99th percentile wet day rainfall)

The 99th percentile wet day rainfall is a measure of rainfall extremes, although it should be noted that this attribute should not be used for flood estimation purposes. Change to extreme rainfall may have significant implications for the region, with the potential to impact agricultural production and increase flood risk. The projection range for 99th percentile wet day rainfall percentage change is larger than percentage change in annual rainfall totals and number of wet days for the McLaren Vale region. The projected range of change in the 99th percentile wet day rainfall is between -16 and +39%. A breakdown of projections by future period, emissions scenario, projection dataset can be found in Appendix A, Table 18.

4.3.1.4 Rainfall seasonality

The distribution of seasonal rainfall is also expected to change, and expected to have significant impact on agricultural systems, including length and timing of growing season, product development, yield and harvest. In this report, a rainfall seasonality metric is used which is a ratio of wet month rainfall to dry month rainfall, where wet months are defined as April-September. The projections show both an increase (i.e. the decrease in precipitation in the wet months is less than the decrease in the dry months) and decrease in rainfall seasonality. The range of projected change in this attribute is between -27% and +48%. The breakdown of projections by future period, emissions scenario, projection dataset can be found in Appendix A, Table 19.

4.3.2 Changes in potential evapotranspiration

Potential evapotranspiration (PET) is defined as the amount of evaporation that would occur given unlimited available water. The projection datasets use different PET formulation, so PET between datasets cannot necessarily be compared like for like, although it can be used to compare percentage changes. SA-CR and AWO both provide estimates of areal PET (Morton 1983), and for NARCliM PET (Penman-Monteith formulation, Allen et al. (1998)) is calculated from other projected climate variables using the R package *Evapotranspiration* (Guo et al. 2022). An increase in annual average PET is projected for all datasets, with an overall projected future change between +1.6% and +26% relative to the 1976–2005 baseline. The projection breakdown by season, future period, emissions scenario and projection dataset can be found in Appendix A, Table 20. Figure 23 shows both the percentage change and actual value (mm) of projected average annual PET for 2070 from all 3 datasets.

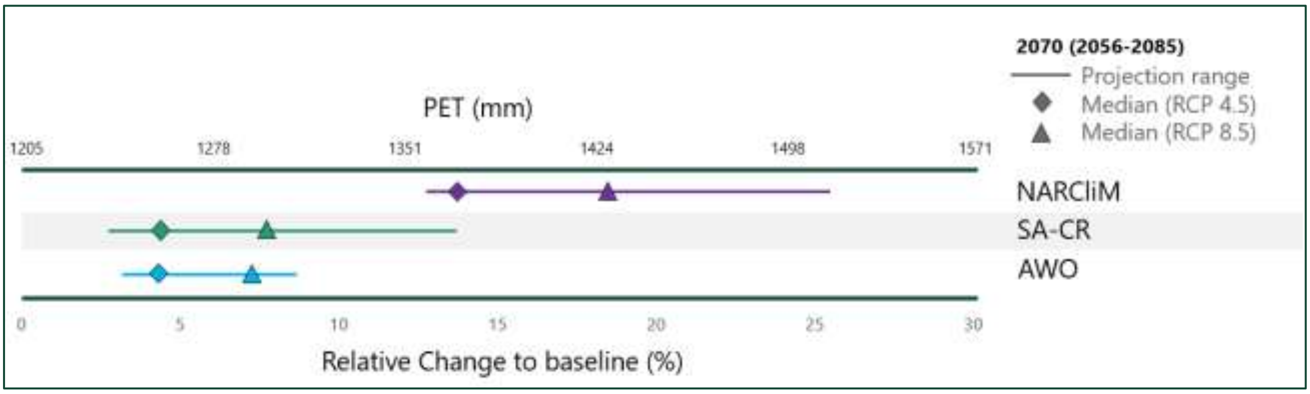


Figure 23. Annual average PET projections for 2070 from the SA-CR, NARCliM and AWO datasets

4.3.3 Changes in temperature

4.3.3.1 Annual average maximum and minimum temperature

Temperature is also a key climate variable, and is directly linked to PET. All datasets project an increase in both minimum and maximum temperature for the scenarios considered. The range of change for annual minimum and maximum temperature is 0.36 to 2.9°C and 0.5 to 4.3°C respectively. The full analysis for these attributes, including breakdown by season, future period, emissions scenario and projection dataset can be found in Appendix A, Table 21 (maximum temperature) and Table 22 (minimum temperature).

4.3.3.2 Annual number of days with a maximum temperature over 35°C

Measures of high temperature can be an important indicator for agricultural production, especially in relation to heat stress. Sustained high temperatures, such as those experienced during heatwaves, can also damage foliage and berries in vineyards. Additional irrigation is often used in an attempt to protect crops from high temperatures. Here we report the number of days over 35°C as a measure of increase in high temperatures. The projected number of additional days with a maximum temperature over 35°C is between 0 and 14 days per year. The breakdown of projection by future period, emissions scenario and projection dataset can be found in Appendix A, Table 23.

4.3.4 Changes in solar radiation

Solar radiation is also linked to calculation of PET. The projected range of change for this attribute is between -0.8 and +7.9%. The breakdown of projections by future period, emissions scenario and projection dataset can be found in Appendix A, Table 24.

4.4 Selection of scenarios for stress testing

Many climate drivers have the potential to impact the McLaren Vale region, with a select few being discussed in the preceding section. For the use in the climate stress test, mean annual total rainfall and mean annual average PET are chosen based on a priori understanding of climatic drivers that are likely to impact demand and supply. These climate drivers are also appropriate to assess changes to viticulture demand and groundwater recharge, as discussed in Sections 3.8 and 3.9.

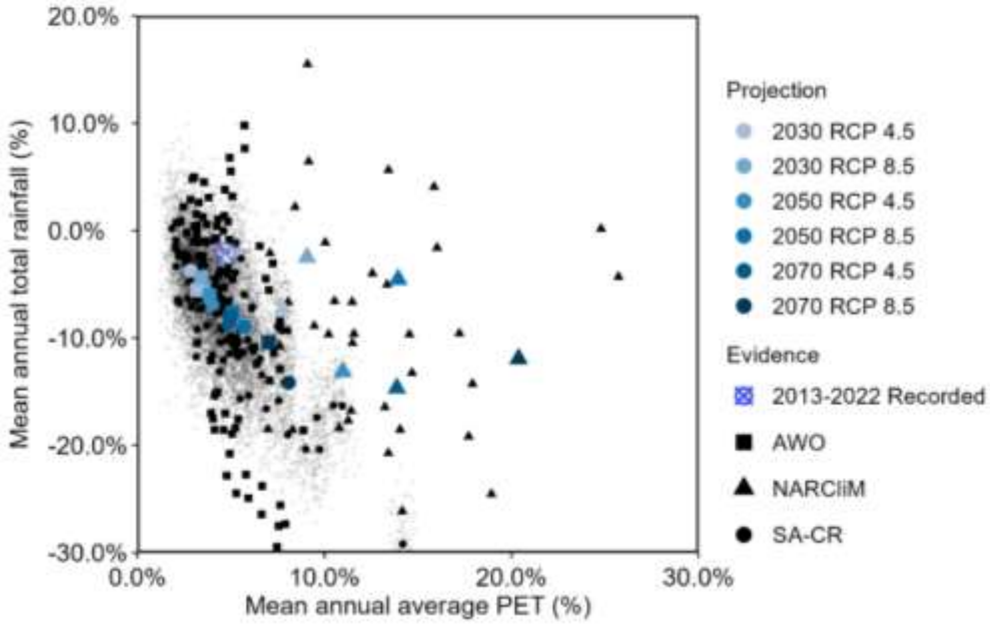
The minimum and maximum change in the attributes, bounds adopted for the stress test, and analysis increments are all displayed in Table 5. The range adopted is determined by extending the range of the minimum or maximum percentage change to the nearest 5% on both sides of the projection range.

Table 5. Future climate ranges for analysis

Climate attribute	Minimum change (%)	Maximum change (%)	Range adopted	Perturbation increments (%)
Mean annual total rainfall	-30	16	-30 to 20	5
Mean annual average PET	1.6	26	0 to 30	5

Note: The faint grey dots represent the 9,000 replicates from SA-CR, the small black circles represent the mean of each of the 15 SA-CR GCMs (15 models for 3 time slices and 2 emissions scenarios, 90 points), the small black triangles represent each of the 6 NARCliM GCM/RCM combinations (36 points), the small squares represent the 16 GCM/RCM/bias-correction combinations from AWO (96 points) and the coloured circles (SA-CR), squares (AWO) and triangles (NARCliM) represent the mean of each of the lines of evidence for the given projection window and emissions scenario. The purple circle cross represents the average rainfall and PET for the most recent decade (2013–2022) relative to the 1976–2005 baseline.

Figure 24 displays projections from all 3 projection datasets imposed on the mean annual rainfall and PET climate exposure space. The majority of projections show an increase in PET of between 0 and 10%, with a smaller number of projections showing a change of between 10 and 20%, and few projections showing more than a 20% increase. Although some projections show an increase in rainfall, the climate over the last decade (2013–2022 recorded, and represented by the purple circle cross) is already changed from the baseline, showing a 2.1% decrease in rainfall and 4.7% increase in PET.



Note: The faint grey dots represent the 9,000 replicates from SA-CR, the small black circles represent the mean of each of the 15 SA-CR GCMs (15 models for 3 time slices and 2 emissions scenarios, 90 points), the small black triangles represent each of the 6 NARCliM GCM/RCM combinations (36 points), the small squares represent the 16 GCM/RCM/bias-correction combinations from AWO (96 points) and the coloured circles (SA-CR), squares (AWO) and triangles (NARCliM) represent the mean of each of the lines of evidence for the given projection window and emissions scenario. The purple circle cross represents the average rainfall and PET for the most recent decade (2013–2022) relative to the 1976–2005 baseline.

Figure 24. Climate projections are overlaid on the mean annual rainfall and mean average PET climate exposure space, which shows change in these attributes relative to the 1976–2005 baseline

5 Future system configurations

Although climate change is a significant driver of uncertainty in the future, there are other potential drivers which influence change in supply and demand. This has been experienced in the region in recent years, with challenges to wine production coming from international markets. Increased urban sprawl is also of concern for a lot of stakeholders in the region. Urban greening targets to achieve cooler suburbs are expected to increase the demand for water for recreational areas and street trees.

5.1 Demand scenarios

Demand scenarios have been used to help explore what the future might look like in terms of water requirements for the region. They are not predictions of demand but rather a foundation for discussing future uncertainties and making more informed decisions. Rapid demand scenarios have been used to help explore potential drivers of demand resulting from changes in planted area, crop/demand type and potential expansion. Four scenarios are presented that represent a spread of potential future changes in the region, and which focus on the likelihood of requiring additional water.

Each scenario is a combination of 4 separate demand components that were identified as key drivers of future demand for water in the McLaren Vale region. The components (further discussed in Sections 5.1.1 to 5.1.4) are:

- **viticulture** – water demand from the viticulture industry, used for winemaking grapes. The majority of existing demand in McLaren Vale is attributed to viticulture water demand, and under all demand scenarios viticulture is assumed to remain a viable industry in the region.
- **other irrigated agriculture** – water demand from irrigated crop types other than viticulture. Currently, there is little water demand attributed to other crop types, and it is assumed the water use intensity (ML per hectare (ha)) is similar to or less than viticulture. However, if the future vision of increased crop diversification progresses, high-value and more water-intensive crops may account for a larger share of water demand.
- **Stock and Domestic (S&D)** – water demand from stock and domestic water users. Currently, it is estimated that around 500 ML of groundwater is used by S&D water users.
- **urban greening** – water demand from irrigating urban green spaces. State government and city council targets to increase urban greening areas are expected to also increase associated water demand.

The 4 scenarios that combine each of these demand components are:

- a business-as-usual scenario, which represents current practices, including the current area and demand of viticulture, current area and demand of other irrigated agriculture, stock and domestic water demand and estimated green space irrigation.
- a 'low diversification' scenario, which represents moderate growth and moderate diversification. This scenario includes expansion of both viticulture and other irrigated agriculture. Stock and domestic and green space irrigation also increase.

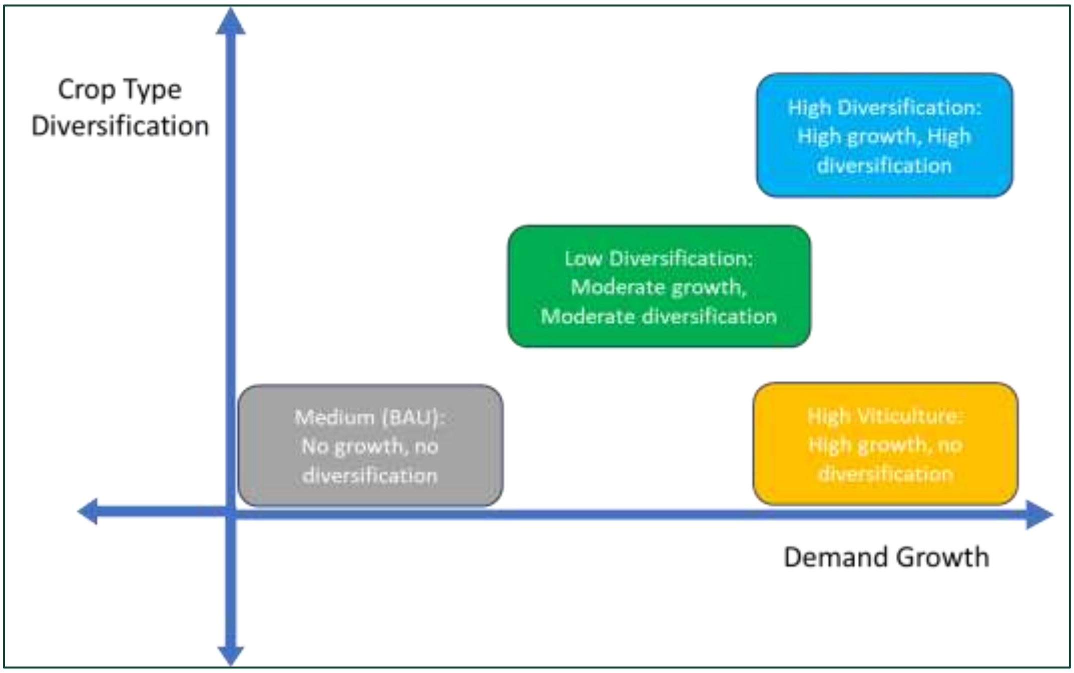
- a 'high viticulture' scenario, which represents moderate growth with no diversification. In this scenario, other irrigated agriculture is replaced with viticulture, which expands to all suitable land. Stock and domestic and green space irrigation increase.
- a 'high diversification' scenario, which represents high growth and high diversification. In this scenario, available land is split 50/50 between viticulture and other irrigated agriculture. Stock and domestic and green space irrigation increase.

These 4 demand scenarios are summarised in Table 6 and Figure 25, Source: (van 't Veld et al. 2024)

Figure 25 and the chosen value for each demand type and scenario is discussed in subsequent sections. The impacts of climate change on the demand scenarios are applied later and discussed in Section 6.

Table 6. Business as usual, low diversification, high viticulture and high diversification demand scenarios

	Business as usual **No growth, no diversification**	**Low diversification** **Moderate growth, moderate diversification**	**High viticulture** **Moderate growth, no diversification**	**High diversification** **High growth, high diversification**
Irrigation demand				
Viticulture water demand	Current area (7,377 ha)	Area expands to all suitable land, with the exception of land attributed to other agriculture (10,697 ha)	Area expands to all suitable land (12,161 ha)	Area decreases to half of all suitable land (6,080 ha)
Other irrigated agriculture water demand	Current area (523 ha)	Area expands to include current irrigated and dryland agriculture, as well as 10% of the current area of viticulture (1,464 ha)	No area (0 ha)	Area expands to half of all suitable land (6,080 ha)
Stock and domestic water demand	Current demand	20% increase from current demand	20% increase from current demand	20% increase from current demand
Green space irrigation	Current demand	Demand doubles by 2045 and continues increasing at same rate	Demand doubles by 2045 and continues increasing at same rate	Demand doubles by 2045 and continues increasing at same rate



Source: (van 't Veld et al. 2024)

Figure 25. Demand scenarios in relation to diversification and growth

5.1.1 Viticulture cropping potential

Future land use potential for viticulture is assessed against 3 factors – current land use, land use potential for viticulture based on soil type and land development zones. This analysis gives 3 land use layers that are classed according to whether or not they have potential for supporting viticulture. Where all 3 of these layers show potential, the land is categorised as being suitable for viticulture (Figure 26). The method for assessing land use potential is detailed in Appendix B: Viticultural land use potential.

When the land use potential for viticulture is subtracted from the current viticultural area, approximately 5,980 ha of additional area is indicated as having potential for viticulture use. Given the limitations of the land use dataset (see footnote 1), a conservative estimate of 80% of this additional area is assumed. Therefore, in the 'high viticulture' scenario, an upper bound of 12,161 ha of viticultural area is assumed, equating to 17.1 GL of water use per year.

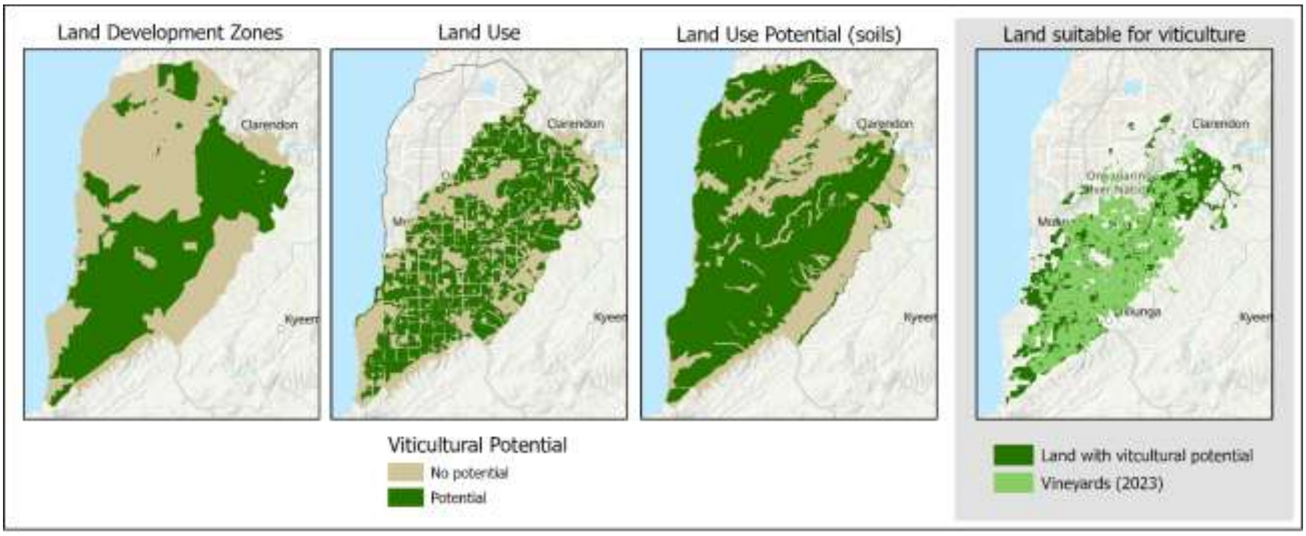


Figure 26. Viticultural land use potential

5.1.2 Alternate crop types

A range of potentially irrigated/non-irrigated and perennial/seasonal horticultural production currently occurs in the region, including apples, pears, nectarines, pomegranates, cherries, peaches, plums, avocados, mangoes, loquats, table grapes, mulberries, olives, almonds, asparagus, lettuce, salad greens, zucchinis, kale, corn, tomatoes, carrots, cucumbers, broccoli, spinach, beetroots, onions, broad beans, carob, cabbages and chard (Bardsley et al. 2017). Although grains and pasture are currently grown in the region, horticultural crops are more likely to be viable. Using tertiary land categorisations from the ALUM dataset (ABARES, 2016) and typical crop water use from the FAO-56 irrigation paper, an estimate of water demand for other crop types can be determined. The full methodology for this analysis can be found in Appendix C: Alternate crop type mix and demand. An average demand for 'Other irrigated agriculture' was calculated at 5.8 ML/ha per year.

The current land use for other irrigated horticultural crop types is estimated to be 523 ha, with the current dryland horticulture area estimated at 207 ha. The demand scenarios 'low diversification' and 'high diversification' both assume that any expansion of other crop types could occur within the maximum viticulture imprint of 12,161 ha.

5.1.3 Stock and domestic

The scenarios 'low diversification', 'high viticulture' and 'high diversification' all assume that stock and domestic use increases 20% from the current estimation, giving 600 ML. It is assumed that demand for stock and domestic water will not decrease over time.

5.1.4 Green space irrigation

Based on information available at the time, green spaces were assumed to total 106 ha, with an irrigation rate of approximately 5.3 ML/ha per year. These assumptions can be used to determine average water use for currently irrigated green spaces in 2045 and linearly extrapolated past this, assuming the same trend in greening by 2070. The scenarios 'low diversification', 'high viticulture' and 'high diversification' all use this assumption, totalling a demand of 1,779 ML in 2070.

5.1.5 Summary of demand scenarios

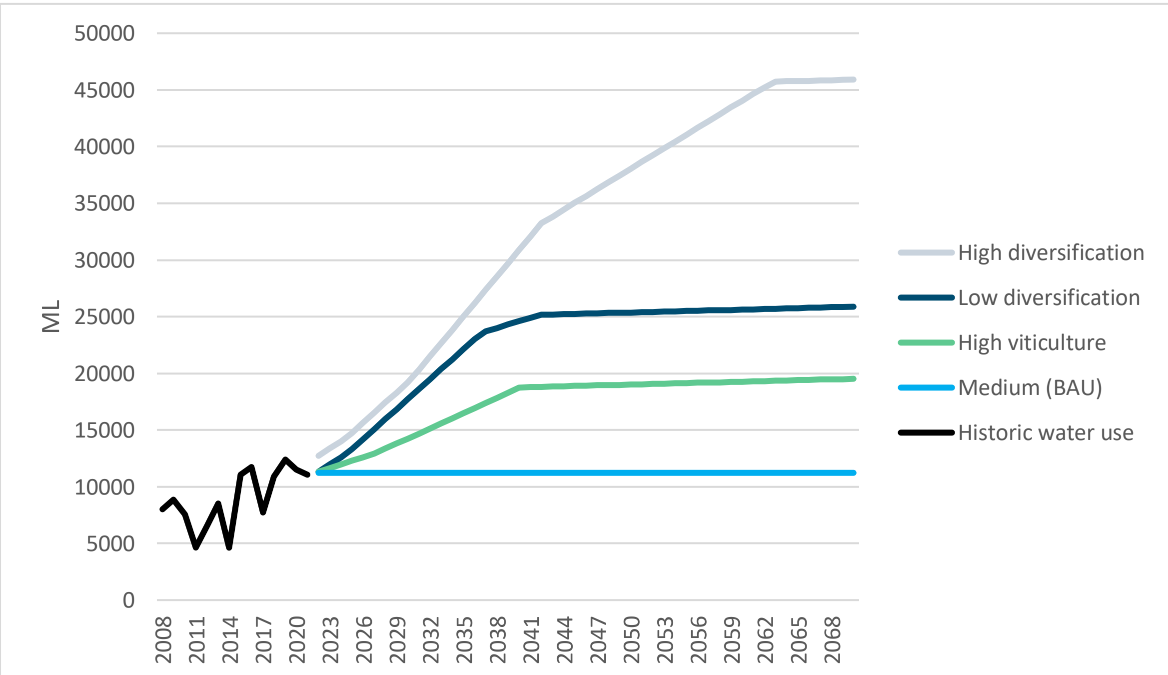
Table 7 summarises the estimated demand for each of the 4 scenarios based on the assumptions discussed in Sections 5.1.1 to 5.1.4 and areas given in Table 6.

Table 7. Assumptions for medium, low diversification, high viticulture and high diversification

Demand (ML)	Business as usual	Low diversification	High viticulture	High diversification
Irrigation demand				
Viticulture water demand	10,388	15,063	17,124	8,562
Other irrigated agriculture water demand	664	8,441	0	34,963
S&D water demand	500	600	600	600
Urban demand				
Green space irrigation	559	1,779	1,779	1,779
Total demand	**12,111**	**25,882**	**19,503**	**45,904**

Source: (van 't Veld et al. 2024)

Figure 27 depicts what these demand scenarios look like over the 50-year assessment period, allowing lag time for growth to occur.



Source: (van 't Veld et al. 2024)

Figure 27. Four future demand scenarios over time

5.2 Supply scenarios

Another key uncertainty in the future is potential access to supply. Recycled water is one of the main water sources in the region and the amount available is expected to be affected by population size in the regions where water is delivered to the relevant WWTPs.

5.2.1 Recycled water availability

The methodology for determining future available recycled water is presented in Appendix D: Recycled water availability. Table 8 summarises the potential recycled water availability in 2030, 2050 and 2070 under low, medium and high population projections from Plan SA (2023). The 'low' population estimate of available recycled water in 2070 will be used in the remainder of this report as a conservative estimate of availability for irrigation use, totalling 14.6 GL.

Table 8. Wastewater treatment plant (WWTP) inflows and available water based on Plan SA (PLUS) population projections and WWTP inflow projections from SA Water.

		2030			2050			2070		
Population projections	2021–22	Low	Medium	High	Low	Medium	High	Low	Medium	High
Aldinga WWTP										
Population	11,026	11,422	11,692	11,970	12,412	13,357	14,330	13,401	15,021	16,691
Inflow (GL)	0.71	0.73	0.75	0.76	0.79	0.85	0.92	0.86	0.96	1.1
Christies Beach WWTP										
Population	154,973	160,537	164,332	168,243	174,447	187,730	201,418	188,357	211,129	234,594
Inflow (GL)	12.2	12.4	12.6	13.0	13.4	14.4	15.5	14.5	16.2	18.1
Total recycled water available* (GL)	**12.4**	**12.4**	**12.7**	**12.8**	**13.5**	**14.5**	**14.7**	**14.6**	**16.3**	**16.5**

*Assuming 5% loss from inflow

6 Summary of future supply and demand

This section explores changes to the system as a result of climate change and provides a summary of the future system supply and demand values based on future system configurations and climate change.

6.1 Influence of climate on supply and demand

Exploration of how key supply and demand metrics are affected by climate change is critical to determine the changes in these variables over time. This section outlines the potential effect of climate on viticulture demand and groundwater recharge, especially in relation to groundwater use for irrigation.

6.1.1 Viticultural demand

The sensitivity of the viticultural demand (under the 'Business-as-usual' scenario) to changes in mean annual rainfall and PET was tested by incrementally modifying these parameters between the ranges specified in Table 5, using a simple change factor approach (Prudhomme et al. 2010, Westra et al. 2022). Running this sensitivity analysis for the viticultural regression model (Section 3.8.1) produces the exposure space shown in Figure 28, which shows predicted viticultural demand using the post-2015 regression. Average annual demand is shown on the exposure space as colour contours (where demand is averaged over the 30-year simulation), with climate projections from the 3 climate datasets overlaid on top, as well as average climate from 2013–2022 compared to the baseline.

Figure 29 shows annual demand through time, with the red line representing observed viticultural water use, the blue line representing the median value for projections in that year, and the blue shaded area representing potential year-to-year variability. This variability is also displayed in Table 9 as a minimum and maximum value for 2030, 2050 and 2070.

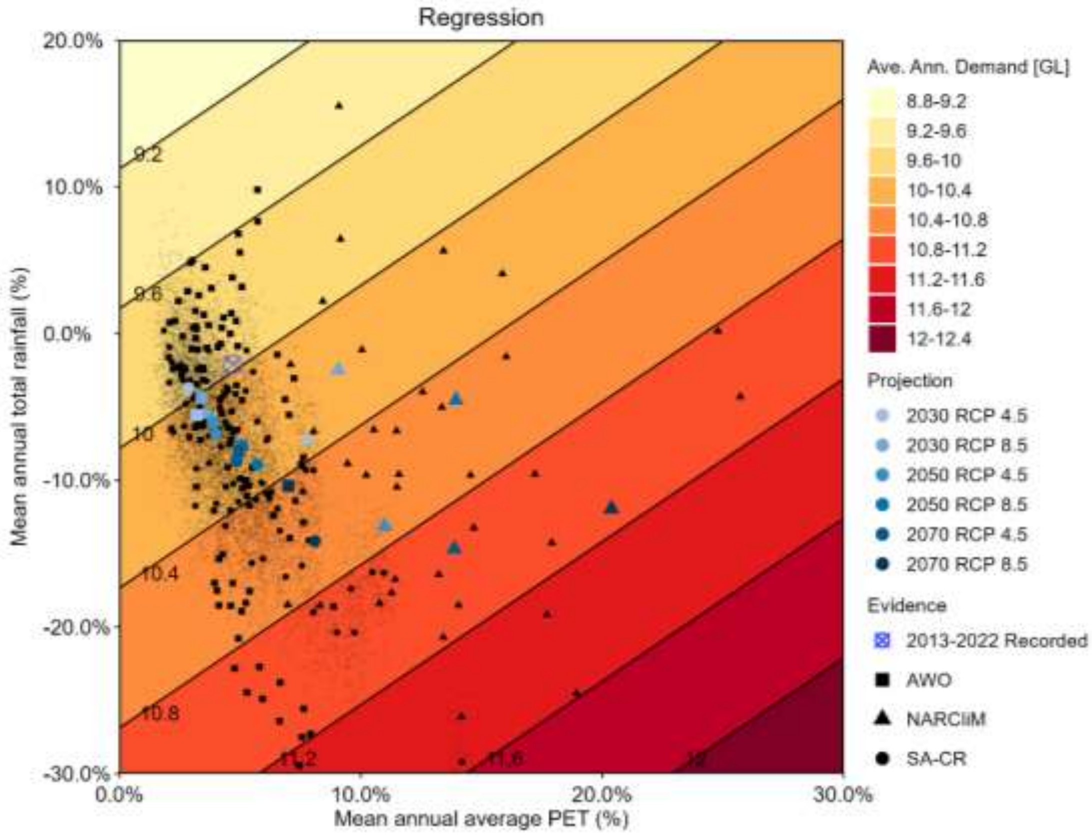


Figure 28. The performance space of absolute change in viticultural water demand from the post-2015 regression on observed water use

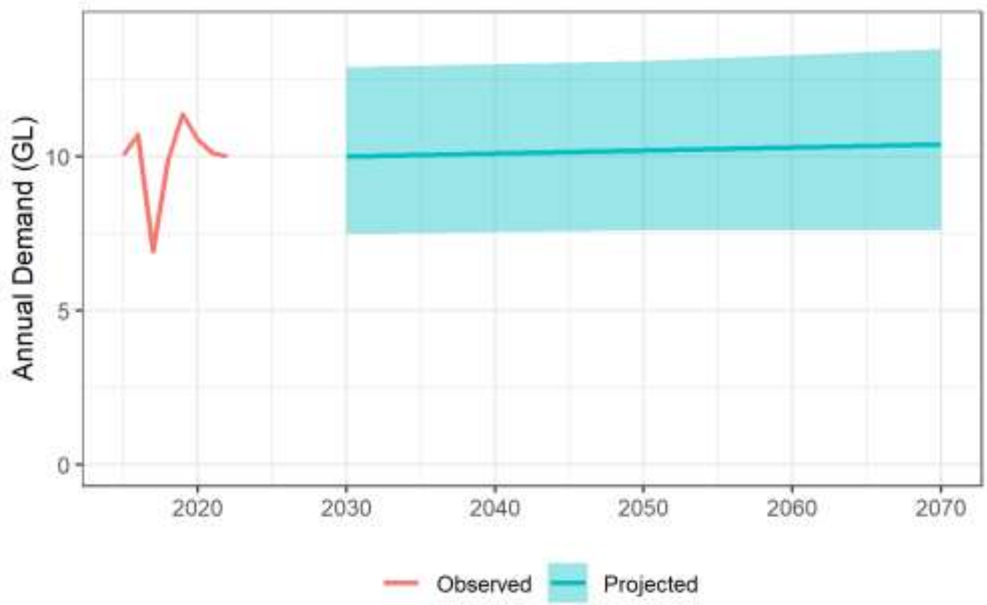


Figure 29. Annual demand. The red line shows the observed water demand for viticulture and the blue line shows the median of all future projections. The shaded blue ribbon shows the range of potential demand in any given year, from the variation in the 30-year baseline plus the error term.

Table 9. Projections for minimum and maximum viticultural demand for 2030, 2050 and 2070 under the 'business-as-usual' scenario

	2017–18 to 2021–22	2030		2050		2070	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Average viticulture demand (GL)	10.4	7.5	12.9	7.6	13.1	7.6	13.5
Percentage change		-27.9	24.0	-26.9	26.0	-27.0	29.8

6.1.2 Recharge and groundwater supply

Using the methodology presented in Section 3.9.1, change in recharge into the future can be assessed in relation to rainfall. When considering change in rainfall based on the projections shown in Table 5 and Figure 24, estimates of recharge across the suite of climate projections can be determined. Projected recharge for each aquifer (FRA, MS and PWF) for 2030, 2050 and 2070 is shown in Figure 30.

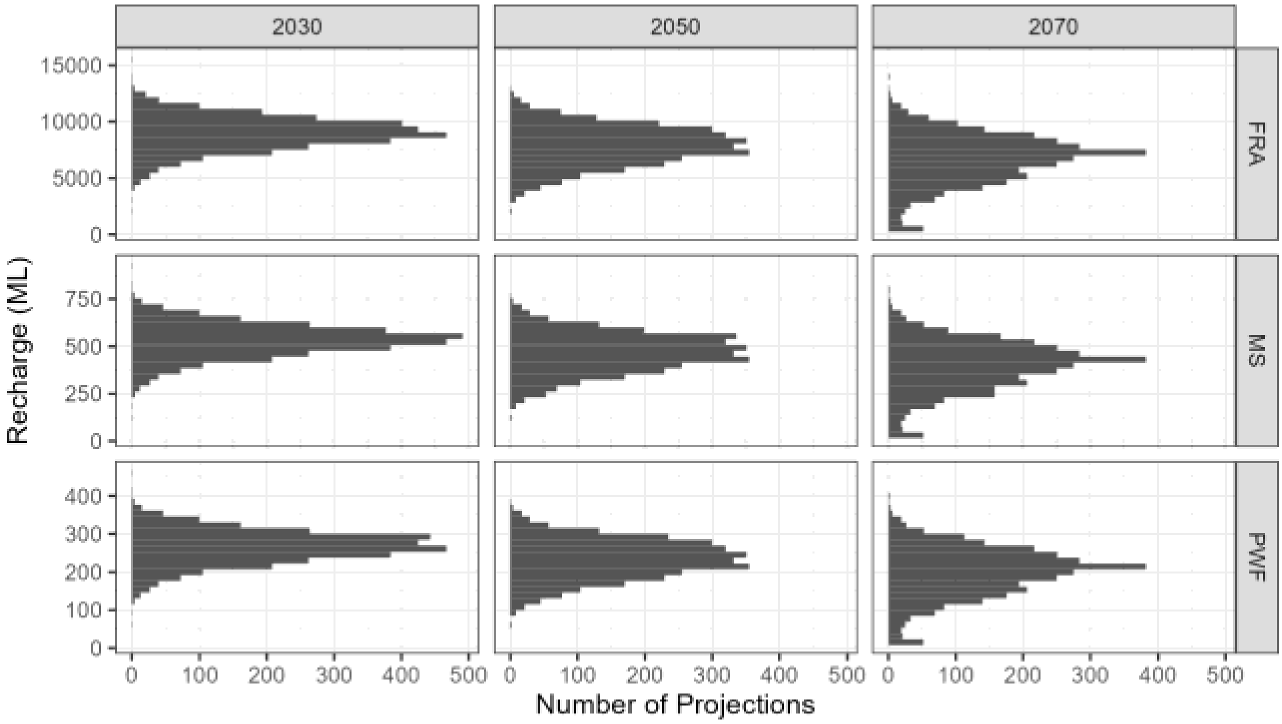


Figure 30. Histogram of recharge based on estimation from different projections for 2030, 2050 and 2070 for the Fractured Rock aquifer, Maslin Sands aquifer and Port Willunga Formation

There is also a strong desire from stakeholders within the McLaren Vale GI to protect groundwater aquifers to promote the health of groundwater dependent ecosystems and preserve the resource and the amenity it brings for future generations. The approach taken below assumes that future groundwater take be limited by recharge. Table 10 shows the projected recharge for each aquifer, as well as the total available water for use where allocation is capped at the estimated recharge for each of the aquifers, or the allocated volume (Table 2), whichever is smaller.

Table 10. Recharge

	2030			2050			2070		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
Fracture Rock aquifer									
Recharge (ML)	2,324	9,016	15,548	1,965	7,937	13,057	522	6,934	13,735
Allocation capped at recharge (ML)	1,650	1,650	1,650	1,650	1,650	1,650	522	1,650	1,650
Maslin Sands									
Recharge (ML)	138	535	923	116	471	774	31	411	813
Allocation capped at recharge (ML)	138	535	923	116	471	774	31	411	813
Port Willunga Formation									
Recharge (ML)	69	267	461	58	235	387	16	206	406
Allocation capped at recharge (ML)	69	267	461	58	235	387	16	206	406
Take capped at recharge (GL)	**1.86**	**2.45**	**3.04**	**1.83**	**2.36**	**2.81**	**0.57**	**2.27**	**2.87**

Note: Minimum (Min), Median and Maximum (Max) refer to the values with reference to the climate projections, where Minimum refers to the most severe (hottest and driest) projection, and Maximum refers to the least severe projection.

6.2 Summary of demand and supply for use in options analysis and economic assessment

Table 11 shows the upper and lower (minimum and maximum) bounds of the demand scenarios (Table 7) for the 2070 future time window due to climate change, using the percentage change values presented in Table 9 in 2070. It is assumed that other irrigated agriculture is affected to the same degree as viticulture, hence the same percentage change values from Table 5 are applied here. The stock and domestic and green space demand scenarios do not factor in climate change. Values for other years will be determined in subsequent sections based on the assumptions of how land use might change over time. Figure 31 also demonstrates the upper and lower bands for each demand scenario.

Table 11. Demand scenarios under climate change for 2070

Demand (ML)	Business as usual		Low diversification		High viticulture		High diversification	
Climate projection	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Viticulture water demand*	7,591	13,484	11,008	19,553	12,514	22,228	6,257	11,114
Other irrigated agriculture water demand**	485	862	6,168	10,957	0	0	25,550	45,385
S&D water demand^	500	500	600	600	600	600	600	600
Green space irrigation^	559	559	1,779	1,779	1,779	1,779	1,779	1,779
Total demand	**9,135**	**15,405**	**19,555**	**32,889**	**14,893**	**24,607**	**34,186**	**58,878**

Note: Min = minimum; Max = maximum

*Effects of climate change using multipliers in Table 6

**Assume same demand multipliers (climate) as for viticulture (from Table 6)

^No change due to climate applied

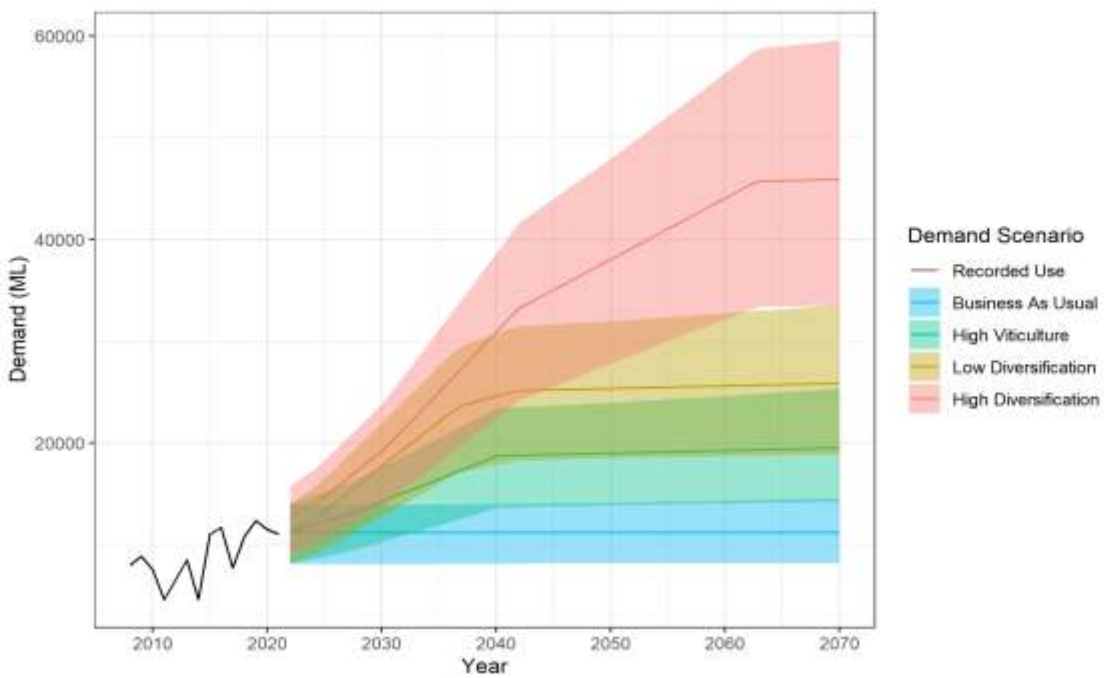


Figure 31. Future demand scenarios incorporating projected climate change impacts

Table 12 summarises the current maximum supply available in the region.

Table 12. Summary of current maximum supply

Source	Current maximum supply (GL)
Recycled water (WBW)	7.2
Groundwater (licensed)	6.6
Groundwater (unlicensed)	0.5
Surface water (licensed)	0.64*
Stormwater / recycled water (CWMS[a])	0.04**

*2017–18 to 2021–22 average observed use

**2021–22 observed use

[a] community wastewater management system

Table 13 and 14 show the maximum values for supply of groundwater and recycled water (WBW) due to climate change and population respectively.

Table 13. Summary of groundwater available under climate change

	Scenario	All scenarios
	Climate	Maximum
	Year	
Groundwater available (GL)*	2030	1.86
	2050	1.83
	2070	0.57

*Supply for stock and domestic demand is additional to this and should be assumed to be met as it is currently unlicensed.

Table 14. Summary of recycled water available from Christies Beach and Aldinga (WBW)

	Scenario	All scenarios
	Population projection	Low
	Year	
Total recycled water available (GL)	2030	12.4
	2050	13.5
	2070	14.6

7 Options analysis and economic assessment

This section is based on a separate analysis conducted by Marsden Jacob Associates and is detailed in (van 't Veld et al. 2024). Based on the supply and demand scenarios set out in Section 6, potential options to meet the supply gap are considered in this section. To compare options, levelised costs have been used. Investment portfolios have been constructed based on varying criteria and the objectives of each portfolio. This analysis has formed the start of an adaptive pathways process. Limitations in availability of local data for each option has meant that further work is required to build out adaptive pathways to inform decision-making into the future. The next steps required to build on the analysis are outlined at the end of this section.

7.1 Future supply demand and supply through time

As discussed in Section 6, both demand and supply are likely to change between now and 2070. Figure 32. Potential impacts on water supply over time shows how the availability of water in the McLaren Vale region could be impacted in the future, based on 2 key assumptions:

- Groundwater supply drops from 6.6 GL (current) to 0.57 ML by 2070, based on factors such as the impact of climate change on recharge rates, or policy changes that limit the extraction of groundwater. This outcome is shown in dark blue below.
- Surface water supply drops from 0.64 GL (current) to 0 ML in 2030 and beyond. This could also be a result of climate change, or policy changes such as the retirement of existing surface water licences. This outcome is shown in light grey below.

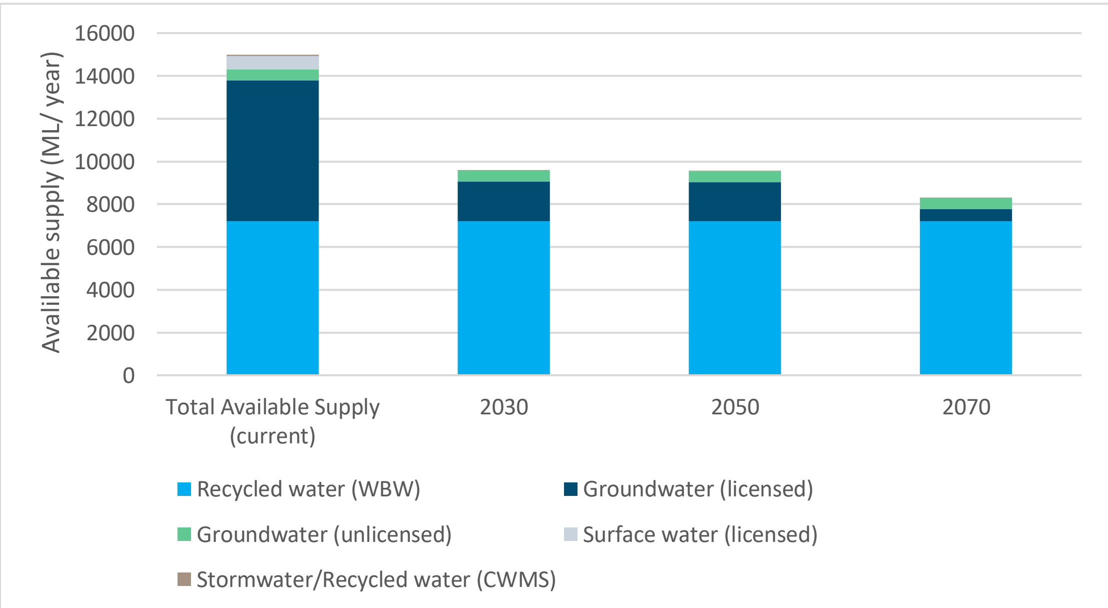


Figure 32. Potential impacts on water supply over time

Figure 33 shows how water supply could change year-on-year based on the conservative assumptions listed above.

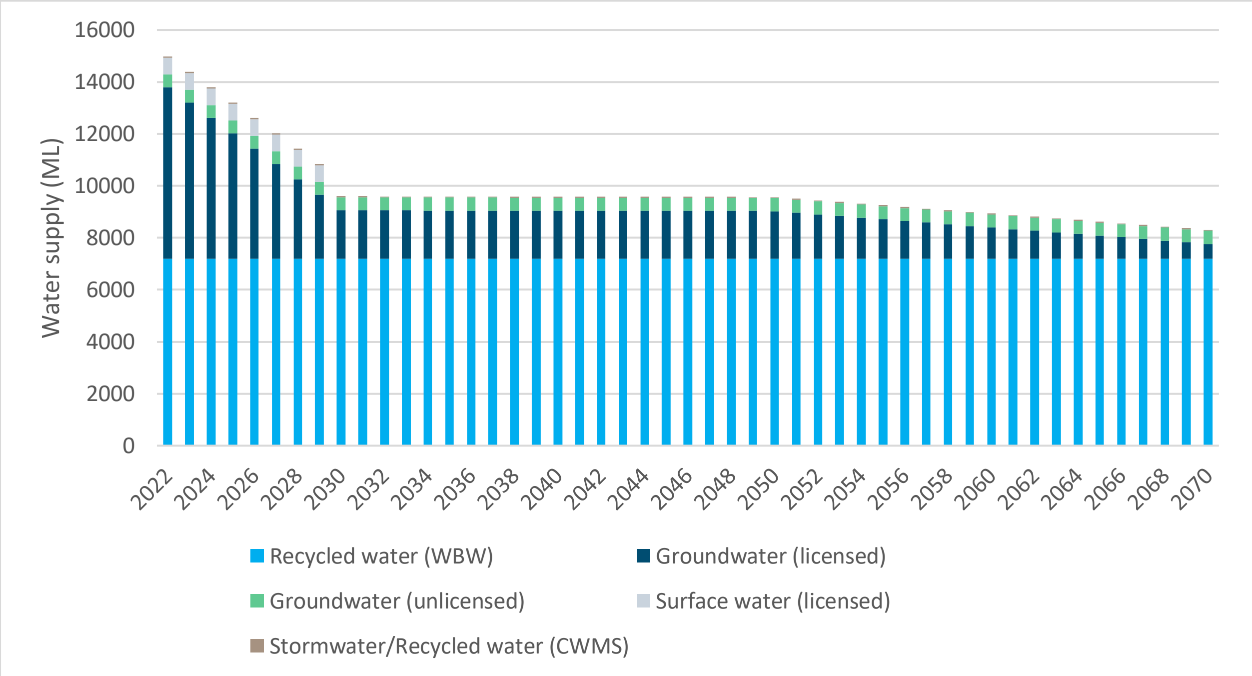


Figure 33. Potential water supply changes over time

7.1.1 Demand scenario variations

Two variations to the demand scenario graph are shown below. Figure 34 shows minimum and maximum sensitivity bands attributed to the potential impacts of climate change on irrigation water use in the McLaren Vale region. The sensitivity bands graphed are a linear extrapolation of outcomes from DEW's regression analysis, which shows the predicted percentage change (maximum and minimum) in irrigation water use due to climate change impacts (such as impacts to annual average rainfall and evapotranspiration).

The base case assumptions used in DEW's regression model include no change in demand behaviours with regard to climate, and historic water use (the calibration period) is indicative of future water use patterns in the region. The impacts of climate change were attributed in the demand scenarios only to the irrigated agriculture demands (viticulture and other irrigated crops), which was deemed appropriate due to irrigated agriculture making up the vast majority of demand in the region.

Other impacts of climate change on agricultural production and watering practices that could be considered as part of a future analysis include:

- changes to optimum viticulture and horticulture crop growing periods or seasons and shifts in optimum crop production locations
- changes to the distribution or abundance of pests and diseases that could harm crops
- changes to watering behaviours, including inter-row watering or overhead misting of crops
- changes to crop varieties to better suit the projected climate.

Figure 35 shows the demand scenarios, including a lag in the timing of irrigation expansion and development.

Aside from urban greening water use, water use for agriculture and stock and domestic production is a derived demand, meaning water is used as an input to produce something else. Business growth and expansion, including greenfield development and irrigation diversification, will only occur if the customer base is confident in profitability of their future business. This is highly dependent upon the future water availability of the region, as well as other various market factors such as irrigated crop gross margins and commodity prices. If growers and producers are experiencing water insecurity, growth in the region is highly unlikely until a water supply alternative is committed.

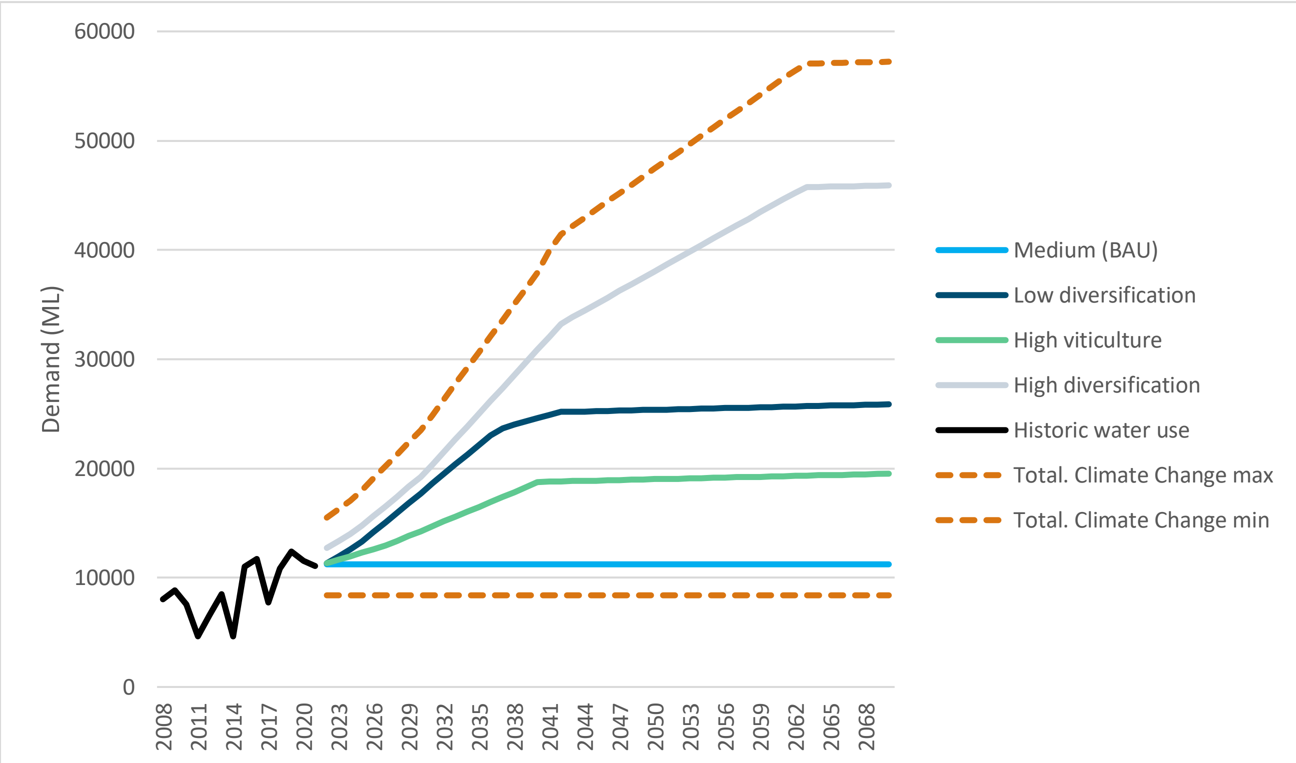


Figure 34. Four McLaren Vale future demand scenarios with climate change sensitivity

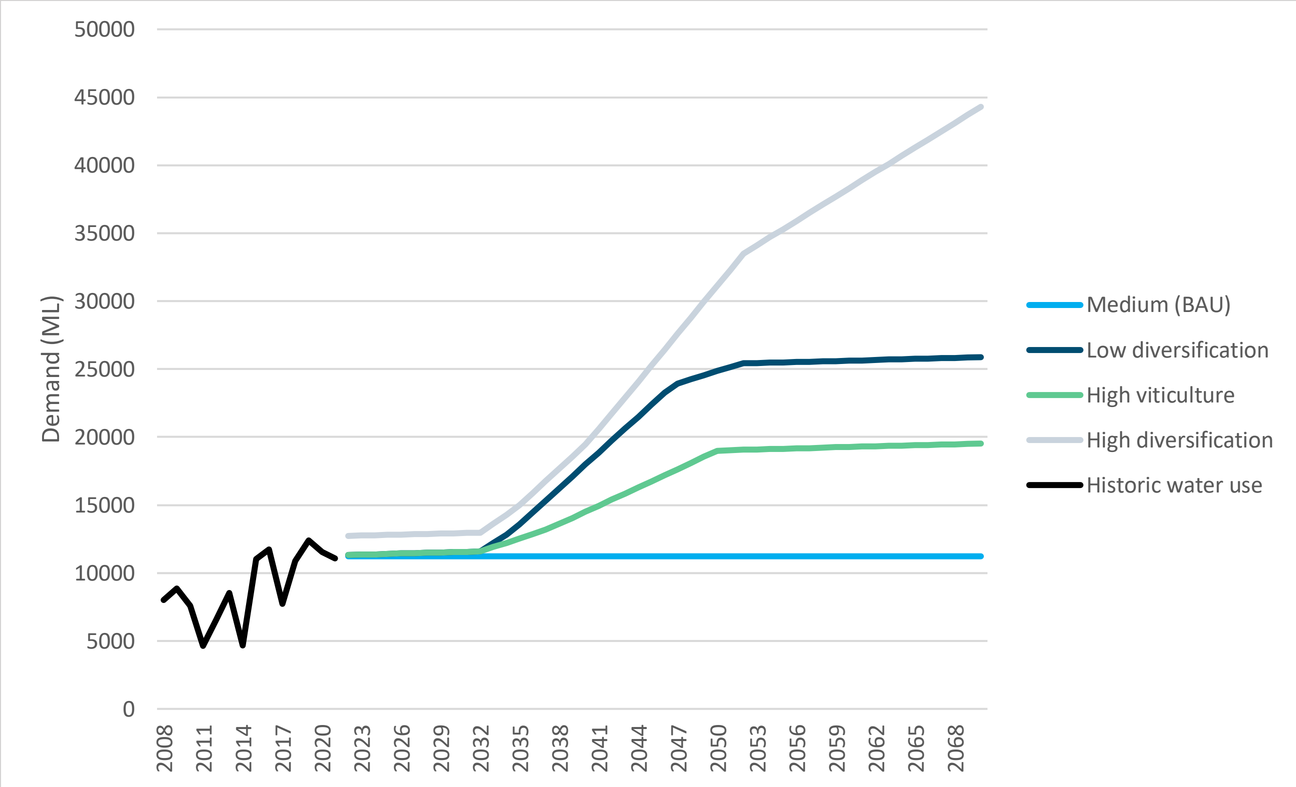


Figure 35. Four McLaren Vale future demand scenarios with lag

7.1.2 Demand attributed to land use change

The graphs below break down the 4 demand scenarios in relation to their underlying land use change assumptions.

The 4 graphs in Figure 36 show stacked year-on-year land use change in hectares across the region, including: hectares attributed to viticulture; current irrigated crop type land use; future, more water-intensive irrigated crop type land use; and urban greening land use. The 4 graphs in Figure 37 show how current and future irrigated land use (including greenfield land available for additional development) changes year-on-year. These graphs do not include urban greening land use because these hectares are not part of the total area identified as suitable for irrigated cropping development.

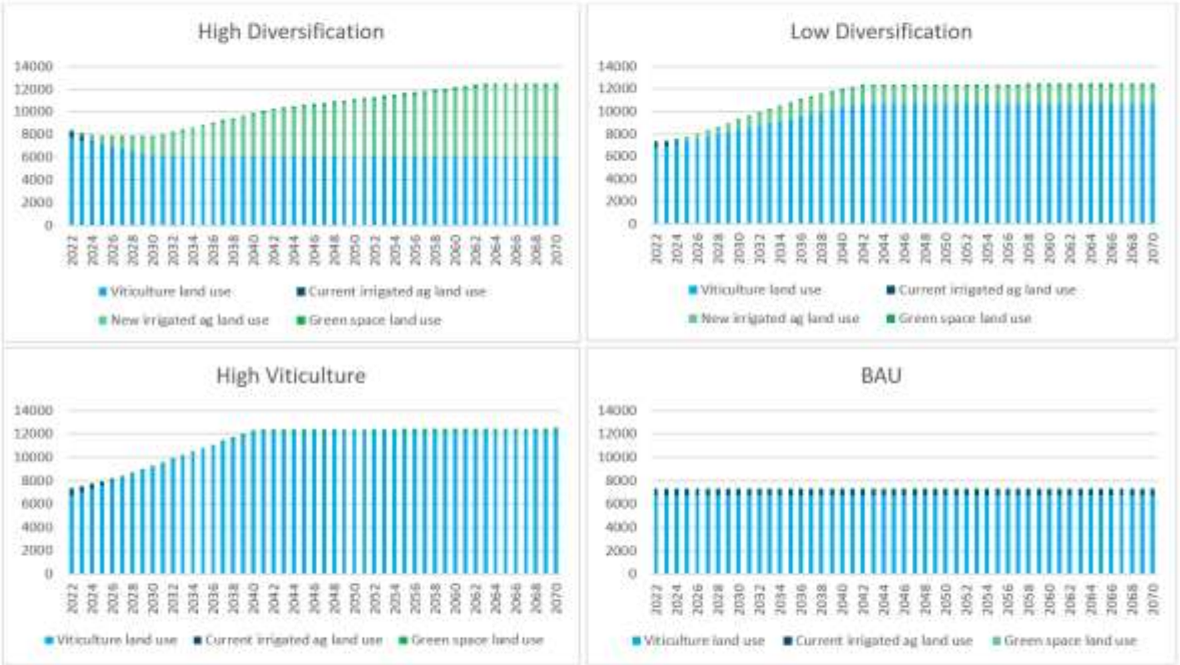


Figure 36. Land use change assumptions per scenario

Figure 37. Land use change scenarios out of 100% (including greenfield)

7.1.3 Supply

Graphs comparing the potential future change in supply with the 4 different demand scenarios were developed to help visualise the potential gap between supply and demand for future McLaren Vale scenarios. Figure 38 shows a supply baseline that drops over time due to potential water availability from groundwater and surface water declining over time. The graph also includes 4 demand scenarios with a lag for comparison.

It should be noted that this graph is not meant to represent a year-on-year water supply and demand gap in the region, and is more a visualisation for discussion, based on the reasons listed in Section 7.1.1 relating to water being a derived demand. If growers and producers are experiencing water insecurity or see that their water supply is decreasing without any prospects for alternatives, growth in the region is highly unlikely. At best, the demand in the Medium (BAU) scenario could be maintained, but it is more likely that demand will drop without any water supply alternatives.

The demand graph that includes a development lag is also used in the supply–demand comparison in Figure 38. Should a new water supply option come online in the next decade, growth in water demand may follow.

Figure 39 and the adaptive pathways graphs in Section 7.2 show straight-line supply baselines for comparison instead. The top line shows the current maximum supply baseline, and the bottom line shows the future potential supply baseline without reliance on surface water and with a diminishing groundwater source.

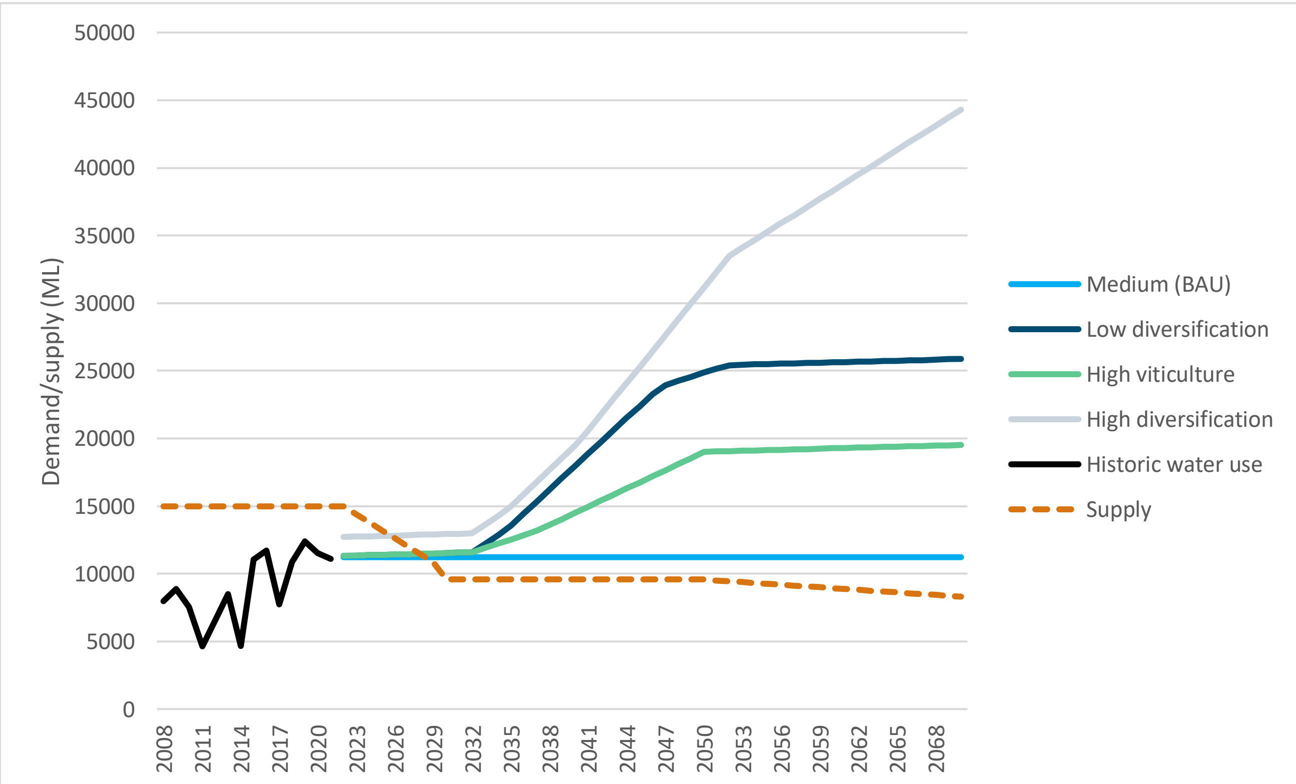


Figure 38. Supply and demand (with lag) scenarios, reduction in supply line for reference

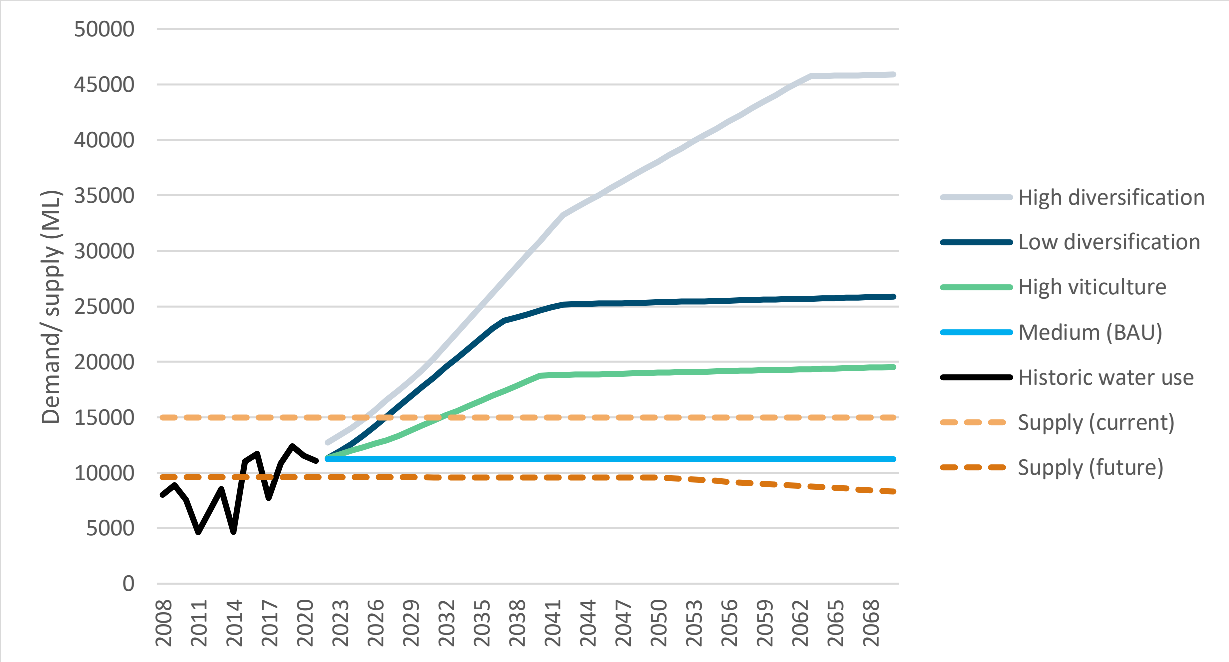


Figure 39. Supply and demand scenarios, current and future supply lines for reference

Another visual to represent the gap in potential future supply and demand (for the year 2070) is shown in Figure 40. The left-most column shows a stack of available water supply based on the future assumptions listed in Section 7.1. As discussed, DEW used a scenario in which the future water supply will include primarily recycled water but also marginal quantities of groundwater and recycled stormwater. The next 4 columns show stacks of potential future demand per demand scenario, which are primarily viticulture and other irrigated agriculture demands. To meet some of the demand scenarios, such as the high diversification demand scenario, significant investment in supply options is required.

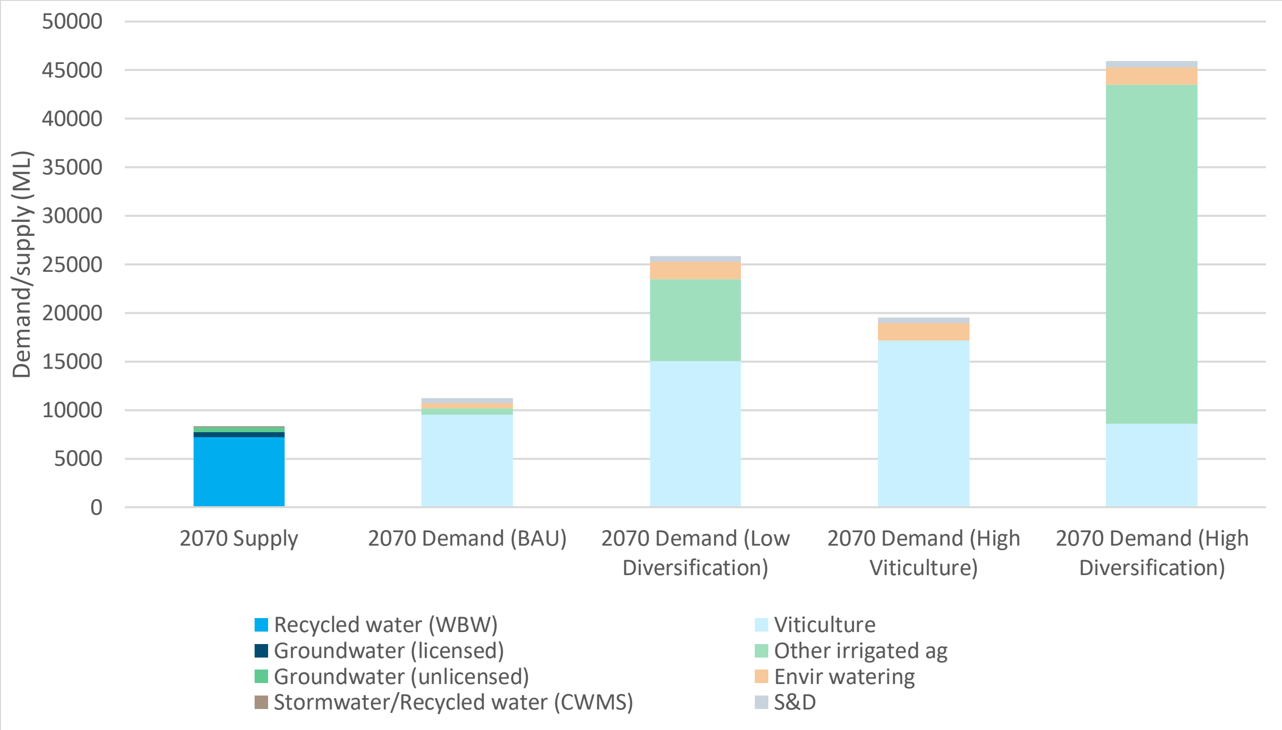


Figure 40. Projected 2070 supply vs demand volumes for 4 demand scenarios. The left column in the legend shows the supply components and the right column shows the demand components.

7.2 Investment options

A longlist of water infrastructure and non-infrastructure options with the potential to meet future water demand within the region was identified through stakeholder workshops. In addition to existing water supply options discussed in earlier sections of this report, potential new water supply options include building additional surface water storages, importing River Murray water to the region and building new infrastructure to deliver desalinated seawater.

7.2.1 Levelised costs and marginal abatement curve

Levelised costs are a standardised way to measure the costs that go into producing a kilolitre (kL) of water supply. Levelised cost provides a useful measure to easily compare water supply or conservation options across varying scales, types of infrastructure, and timeframes, on an equivalent basis. It is a measure of lifecycle costs for a project, not just the upfront costs.

Equation 1 shows the standard levelised economic cost calculation. The levelised project cost excludes the indirect and externality costs.

Equation 1. Levelised project cost calculation

$$Levelised\ project\ cost\ (\$/kL) = \frac{PV(project\ costs)}{PV(water\ yield)}$$

Due to constraints with investment specifications for each supply option (cost, volume, timing etc.) this analysis has been supplemented by the Water Services Association of Australia database to provide estimations of the cost of, and volume provided by, potential infrastructure options used in other regions around Australia.

Figure 41 is a representation of the investment options assessed, their levelised cost and potential supply capacity. It should be read as an example of how the investments may be presented once data specific to the McLaren Vale region becomes available.

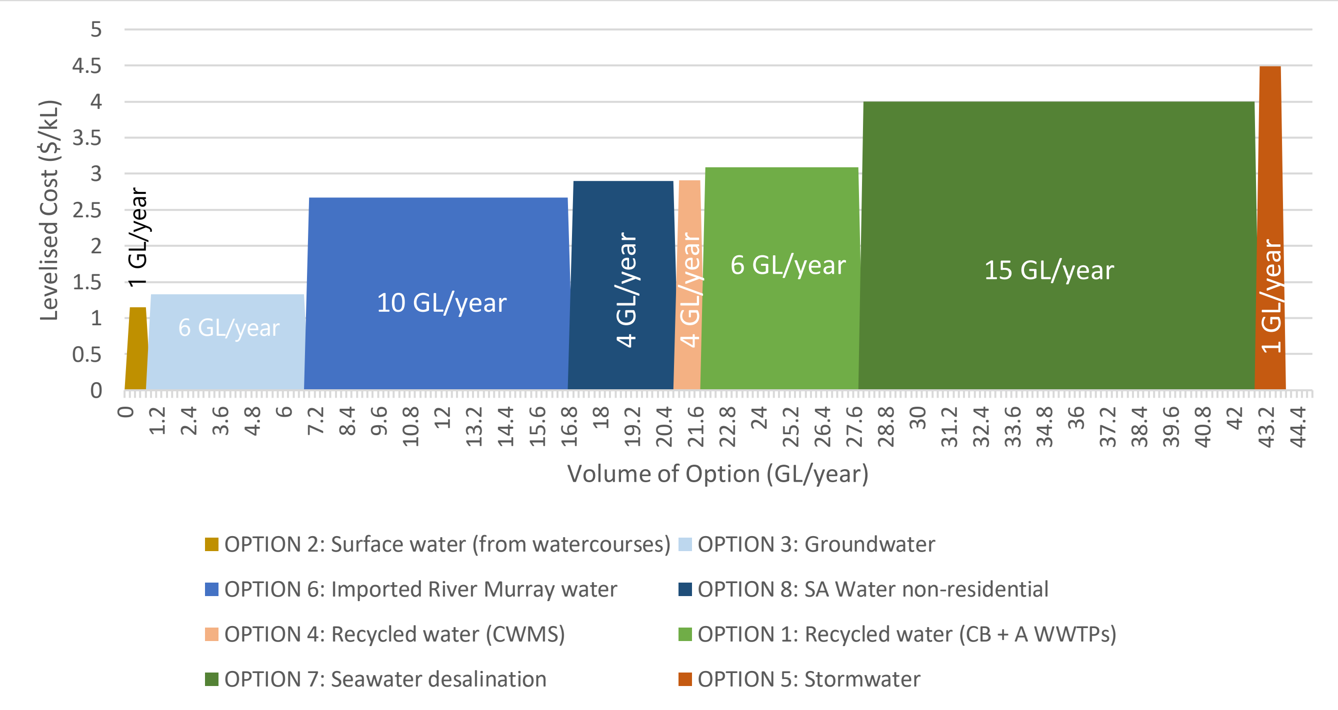


Figure 41. Levelised cost for water supply options

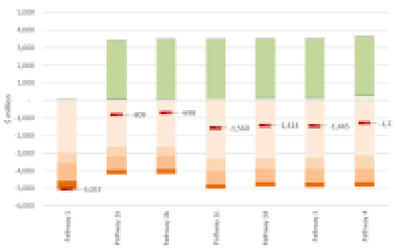
To further examine the investment options, Marsden Jacob Associates sought stakeholder feedback to assist with identifying the region's preferences. This is not incorporated into Figure 41, which is purely an exercise in identifying cost-efficient investments.

To ensure that findings are comprehensive and realistic, stakeholder feedback can be incorporated into the analysis once investment specifications have been provided. A key consideration for this process is that although groundwater has been identified as a cost-effective option, it is currently overdrawn within the region and should have dependence reduced rather than expanded.

7.2.2 Adaptive pathways and investment portfolios

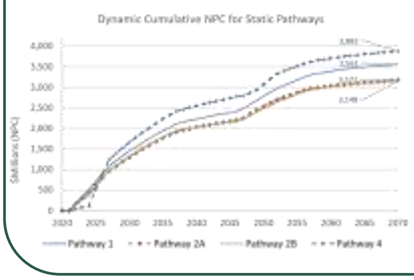
Adaptive planning can be used for decision-making in the face of long-term uncertainty. An adaptive pathways framework considered 4 different future pathways to achieve various future visions for the McLaren Vale region. This analysis informed the initial steps of an adaptive pathways process, but further work is required to fill knowledge gaps about local water supply options.

Adaptive pathways evaluations generally follow the 4 steps outlined below.



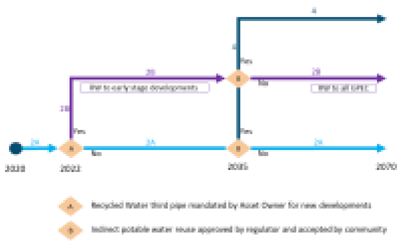
Step 1: Assess pathways and options to be analysed

The static evaluation of future pathways and options based on the outcomes of past stakeholder workshops. Information is reviewed and summarised as key inputs for developing the adaptive pathways. The static evaluation will show results for the end state and 50-year horizon.



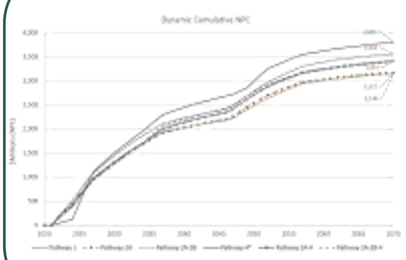
Step 2: Develop investment staging and sequencing

Based on feedback from stakeholders and information available about the investment options, we develop the investment sequencing and staging. Considerations include forecast demand and supply-side considerations that can be used to form new pathways.



Step 3: Develop enablers and barriers

Enablers and barriers for the staged pathways will be considered based on input data and consultation. We will consider whether a probabilistic approach should be applied to each decision point based on input information available.



Step 4: Develop adaptive pathways

The results of the individual pathway analysis and consideration of enablers and barriers will be used to develop adaptive pathways showing net benefit over the 50-year horizon.

Marsden Jacob Associates assessed 4 portfolios that prioritise investments that achieve the following outcomes:

- having lowest cost
- being climate independent
- having lower environmental impact
- being part of the McLaren Vale region's 'vision'.

The pathways presented here illustrate a framework that can be employed to prioritise water supply investments to address the future potential demand. The framework was developed based on the information available and with input from external datasets. The framework can be used to update the evaluation when bespoke water supply asset information is available.

Other considerations when interpreting the graphs include:

- Investments have been selected and prioritised based on how well they support the intended outcome (and, where relevant, their levelised cost) and on the option's ability to meet various demand scenarios. Prioritisation does not take into account potential lead time required before construction or the cost of construction and delivery.
- Options are to be viewed as additions to the existing system capacity (called 'Supply Baseline'). They are expansions or new investments of assets similar to those currently existing in the McLaren Vale system.
- Volumes and costs in most instances have been based on similar projects within the Marsden Jacob Associates database and therefore would benefit from additional localised assumptions once they become available.

Table 15 (below) is a stylised representation of the inputs used in the evaluation process of infrastructure options that could be staged and sequenced to fulfil the requirements of the 4 identified portfolios. Different metrics have been used in the evaluation, but for simplicity inputs have been colour-coded based on whether they are deemed to be positive (green) or less favourable (red) attributes according to DEW and workshop participants.

A short description of each of the portfolios and their key attributes is included below.

Low-cost portfolio (Figure 42) **–** This portfolio prioritises low-cost options. Prioritisations are based on levelised cost, calculated by blending Marsden Jacob Associates database values with available localised McLaren Vale cost data. While this portfolio provides the highest volume and can meet all future demand scenarios (except for the maximum volume for the high diversification scenario factoring in climate change), it comes with other trade-offs and does not reflect a number of goals associated with the regional vision; for example, reducing volumes of wastewater being discharged to the Gulf. It also assumes a level of ongoing groundwater use, which could put at risk environmental outcomes sought by the region because groundwater availability is expected to decline over time. Maintaining a high level of groundwater use is unlikely to be sustainable into the longer term.

Climate independent portfolio (Figure 43) **–** This portfolio depicts the climate independent infrastructure options. The infrastructure options here ensure greater reliability in times of drought and therefore greater resilience. Recycled water, as in the Community Waste Management Service and Christies Beach and Aldinga wastewater treatment plants, are the lowest cost options that are climate independent. Recycled water is therefore prioritised and are sequenced as the first infrastructure options to be further investigated. If additional capacity is required, the only remaining option is seawater desalination which is available at a higher levelised cost.

This portfolio would meet 3 out of 4 of the demand scenarios, however, it would be heavily reliant on seawater desalination, which comes with other environmental considerations.

Environmental outcome portfolio (Figure 44) **–** This portfolio has been ranked according to Environmental Impact scoring by DEW (Table 15). Three main components were considered to be particularly relevant to the region, that is the option:

- reduces wastewater outflow or effluent to ocean
- reduces impact on native water resources
- has a low energy requirement.

An aggregate score of these 3 components were used to rank each option. While this portfolio achieves environmental outcomes, it would only meet the 'business-as-usual' future demand scenario. If any growth is desired, there are limited supply options under this portfolio. Other portfolios would provide for growth while still having consideration for environmental outcomes (i.e. the 'meeting the regional vision' portfolio).

McLaren Vale 'Meeting the regional vision' portfolio (Figure 45) - The options in this portfolio have been assessed relative to whether they meet the vision set by McLaren Vale. The vision is assessed across the dimensions:

- climate independence
- treatment
- source can be part of an integrated network
- additional infrastructure
- environmental outcomes

This portfolio would meet 3 of the 4 future demand scenarios including the minimum volume expected for the high diversification scenario. It would not meet the maximum volume for the high diversification scenario factoring in climate change. It is noted that volumes have been assumed and there may be capacity to access higher volumes of seawater desalination or River Murray water, should this demand scenario eventuate, noting that these options come with other constraints.

Table 15. Investment options considered for adaptive pathways analysis – ranking table

	Option	Recycled water (CB + A WWTPs[a])	Surface water (from watercourses)	Groundwater	Recycled water (CWMS[b])	Stormwater	Imported River Murray water	Seawater desalination	SA Water non-residential
Water availability	Climate independence	Yes	No	No	Yes	No	No	Yes	No
	Treatment required	Some (primary and secondary)	None	None	Some (primary and secondary)	Minimal (wetlands)	None	Extensive	Extensive
	Source can be part of an integrated network	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Additional infrastructure	Additional infrastructure	Medium	Low	Low	Medium	Medium	High	High	High
Environmental impact	Reduces wastewater or effluent to ocean	Yes	No	No	Yes	Yes	No	No	No
	Reduces impact on natural sources	Yes	No	No	Yes	Yes	No	Yes	No
	Energy requirement	Medium	Low	Low	Medium	Medium	High	High	Medium
Low cost	Levelised cost ($/kL)	3.0	1.0	1.30	3	4.5	2.5	4	2.9
Volume	Volume	Not ranked – numbers included are illustrative only (based on similar projects from within Marsden Jacob Associates database)							

[a] WWTP = wastewater treatment plant

[b] CMWS = community wastewater management system

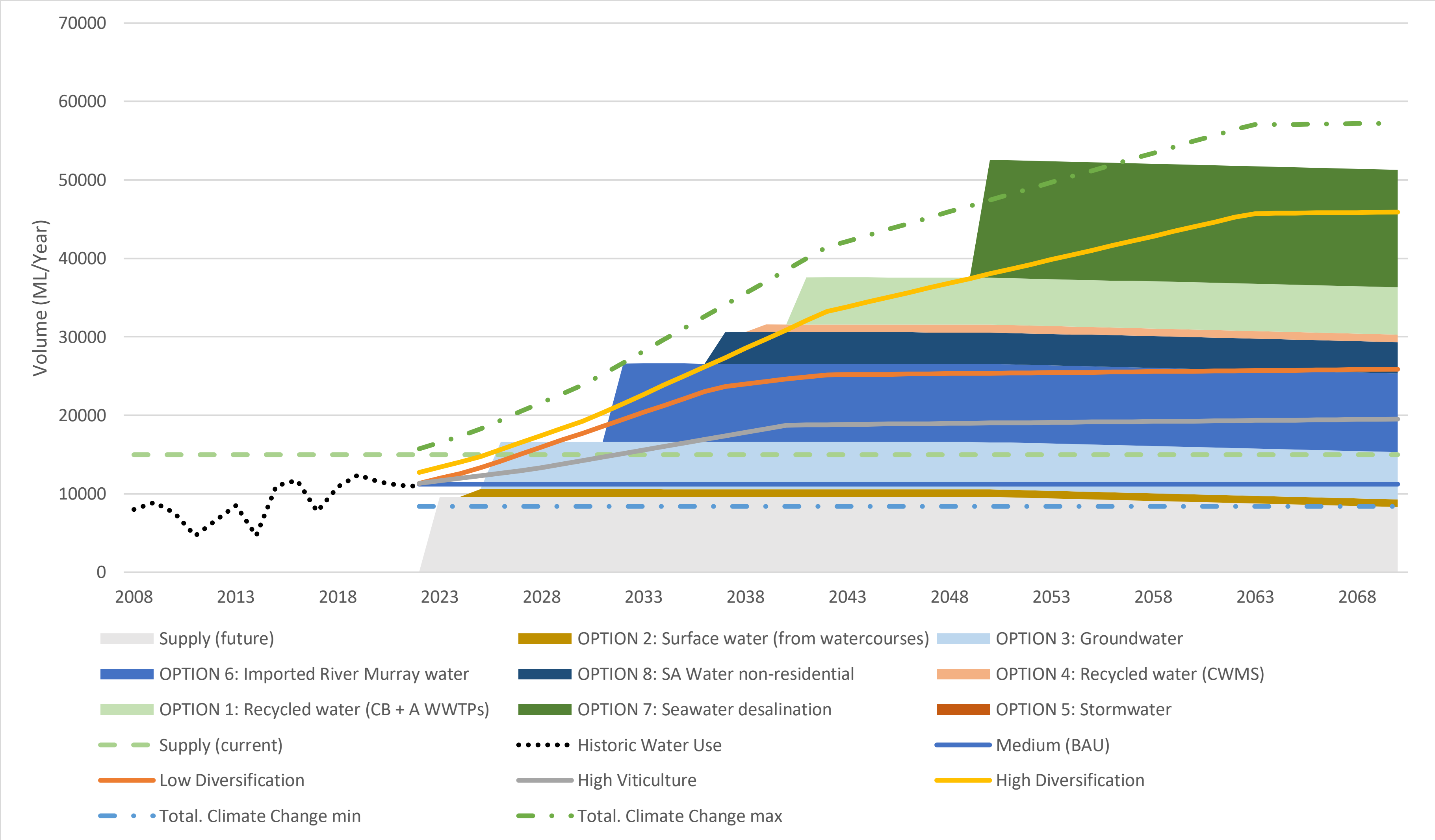


Figure 42. Low-cost portfolio

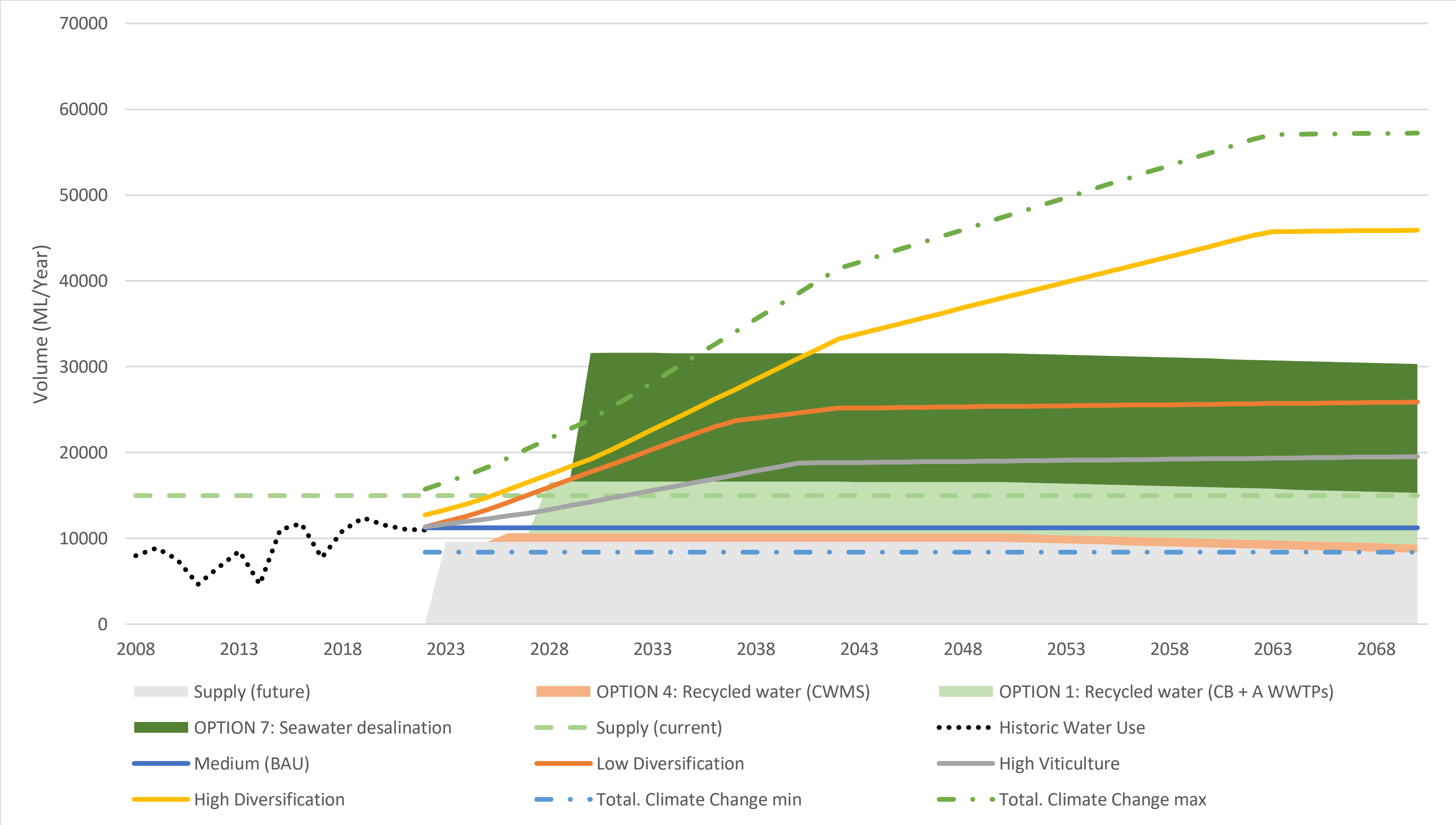


Figure 43. Climate independent portfolio

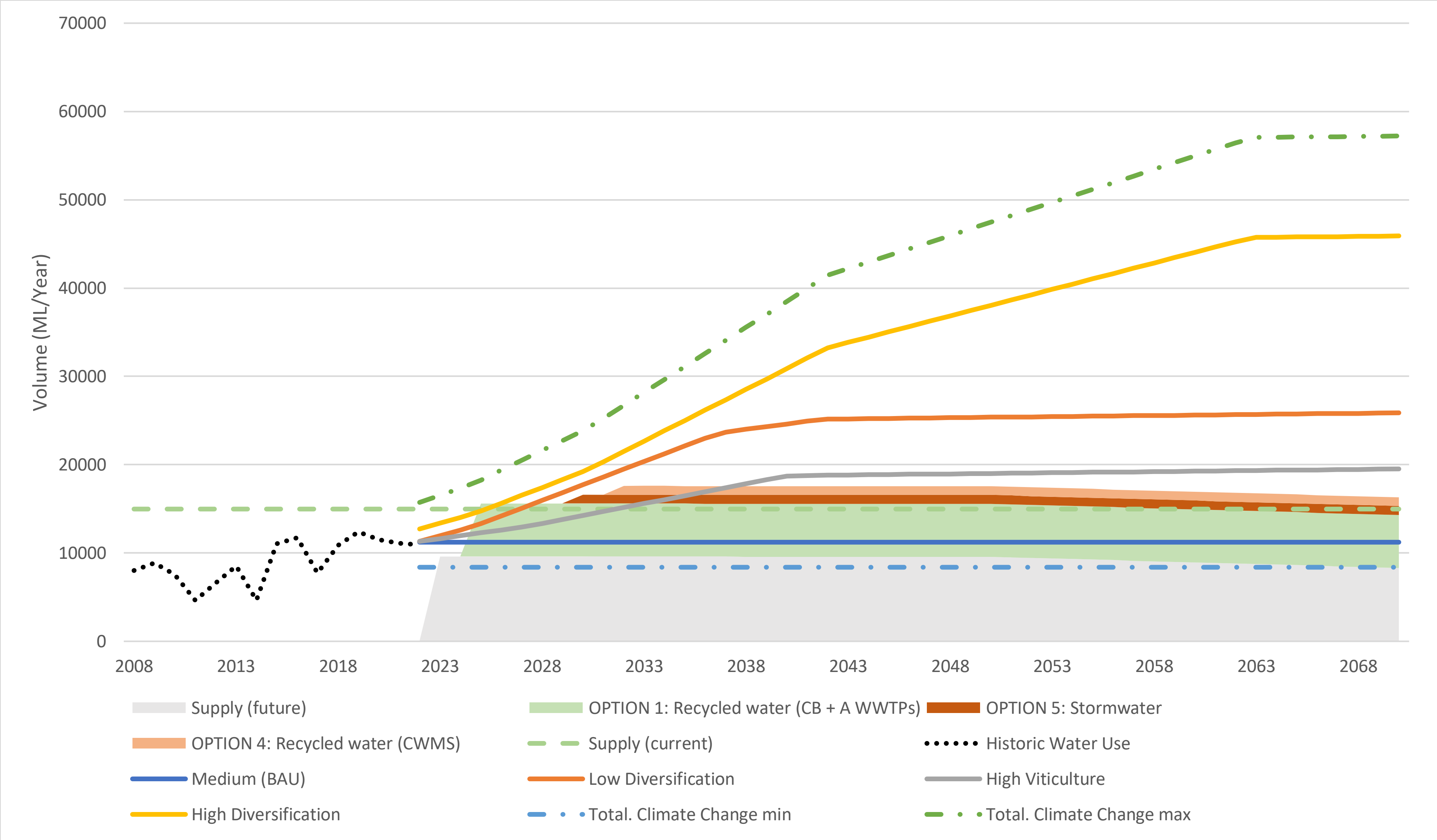


Figure 44. Environmental outcome portfolio

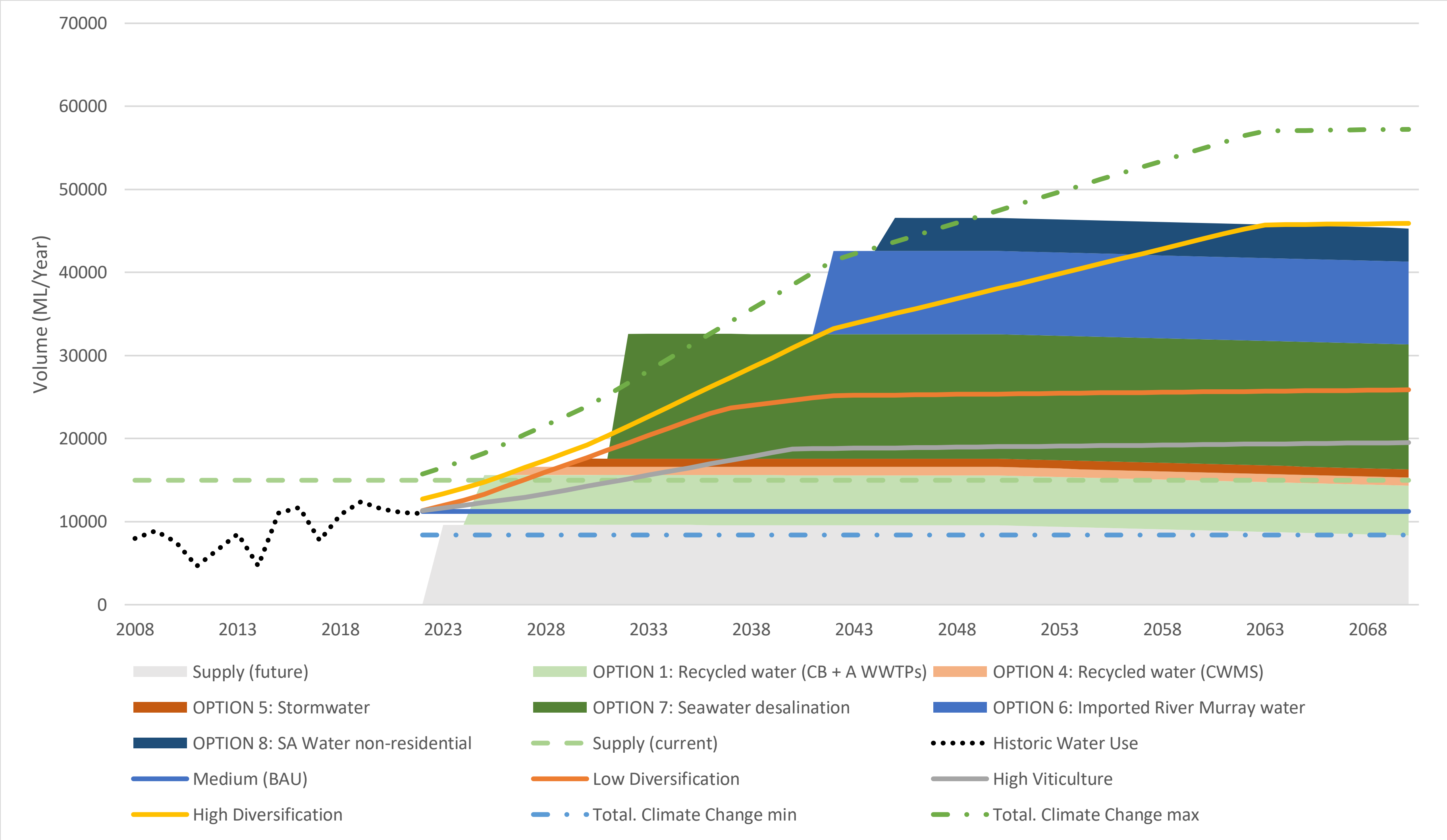


Figure 45. McLaren Vale regional vision portfolio

7.3 Recommended additional information

When viewing the investment portfolios above, it is important to note the limitations in availability of local data. More information is needed to better inform the portfolios and pathway analysis. To progress long-term water security analysis and enable the development of a pipeline of prioritised infrastructure project options for the region, additional information would be beneficial, as outlined below.

Undertake a detailed demand assessment of the McLaren Vale region, including stock and domestic, irrigation, urban and environmental watering demand, and demand from other water end users.

The assessment undertaken by Marsden Jacob Associates as part of this scope of works is a *rapid* demand assessment to illustrate potential future demand scenarios in the region, including capturing the upper and lower bounds of potential future demand. Further analysis of the 'most likely' future demand for the region is recommended. This can be done through deterministic or statistical (regression) analysis using inputs such as customer meter data, agronomic analysis, customer surveys and stakeholder consultation. When investigating potential future agricultural diversification, regional agronomic inputs to assess the feasibility of new high-value crops in McLaren Vale will also be key.

Demand assessments should incorporate sensitivity testing to ensure that most, if not all, potential future demand scenarios are captured. The demand scenarios and underlying assumptions tested as part of this scope of works can be used as part of this sensitivity test.

Aggregate investment option information, including proposed capital expenditure, operational expenditure and yield (in ML) for McLaren Vale.

A robust and comparable dataset of water security options will allow for further analysis and prioritisation of the options to develop informed adaptive pathways. Estimates of indirect and externality costs and benefits, as well as costs for supporting infrastructure, can also be valuable decision-making inputs for investment options.

Undertake economic and financial modelling for selected water infrastructure concepts to develop a prioritised list of options. The adaptive pathways framework can be applied at this stage.

The economic analysis will help determine if the project opportunities are welfare generating and if they could form the basis of a funding application for external funding sources. In contrast, the financial analysis will test whether, if the options are implemented, there is short- and long-run capacity to pay for operation, maintenance and renewal requirements.

The economic and financial modelling will enable infrastructure concepts to be prioritised. The prioritised list will be an input to the adaptive pathways framework. The adaptive pathways framework considers appropriate staging and sequencing of concepts as well as key enablers and barriers to implementation.

The benefits of obtaining this additional information were considered when determining the actions outlined in the Strategy.

8 Conclusions

This report presents the outcomes of a climate 'stress test' of water resources in the McLaren Vale region over the next 50 years to 2070, alongside an economic and options analysis. Future system configurations and the influence of climate on supply and demand have been used together to best explore future outcomes in the region. Alongside a stakeholder and community workshop process, which identified options and actions to address water security risks, results have informed the development of the McLaren Vale Regional Water Security Strategy.

The primary findings of the study are summarised next, followed by a brief overview of key assumptions and limitations.

8.1 Summary of results

8.1.1 Recent system dynamics

The points below summarise the current and recent dynamics discussed in this report (Sections 1, 2 and 3), which are useful when considering future changes.

- There has been a decline in rainfall over the historical record (from 1900 to 2022) as well as an increase in potential evapotranspiration (PET).
- Excluding domestic and commercial demand (which is supplied by SA Water), viticulture is the largest user of water in the region.
- Viticultural area in the region has been relatively stable over the last decade (2013–2022), although yield (t/ha) shows a slight declining trend over this period.
- Viticultural demand is mainly supplied by groundwater and recycled water. Surface water availability and use is minimal.
- Groundwater use has been relatively stable over the last decade (2013–2022). Groundwater use is spatially restricted and salinity is generally increasing. There are 3 identified hotspot areas where salinity has markedly increased as a result of extraction and changing climate. Extraction is below allocation in 2 of the 3 aquifers, although allocation and use are similar in the Port Willunga Formation, suggesting possible strain on this aquifer.
- Recycled water use has increased in the region (2013–2022) but is not available to all growers in the region due to the location of water supply infrastructure. Currently, total annual use is less than the annual system capacity, although use is limited by system capacity during periods of high demand (e.g. heatwaves). Additional recycled water, which currently goes out to sea, could be utilised if there was an increase in demand and system capacity.

8.1.2 Projected climate changes

Climate change is a main driver of change considered in this report. Climate change is expected to affect both demand and supply of water. We consider evidence from 3 climate change projection datasets (SA Climate Ready, NARCliM and Australian Water Outlook (AWO)), as well as supplementary evidence from Australia's Wine Future – A Climate Atlas. An historical baseline of 1976–2005, to which future changes are compared, was considered.

Projected climate changes include:

- The projection datasets considered generally agree that future climate in the region will be warmer and drier than the historical baseline. Projections generally worsen under more severe emissions scenarios and further into the future. Average climate over the 2013–2022 period is already warmer and drier than the baseline period.
- Average annual rainfall is projected to decrease by up to 30% from the baseline, although a few projections (mainly from AWO) suggest it may become wetter (by up to 16%). The number of wet days is expected to change (-25% to +10%), and extreme rainfall (99th percentile wet day) is projected to change between -16% and +39%. A change in rainfall seasonality is also likely (ratio of wet month rainfall to dry month rainfall), which will impact viticultural production (between -27 to +48%).
- All climate projection datasets considered suggest an increase in annual average PET in the future of between +1.6% and +26% from the baseline.
- Annual average temperature is also expected to increase by up to +4.3°C and +2.9°C for maximum and minimum temperatures respectively. The number of hot days (specifically, days with a maximum >35°C) is expected to increase by up to +14%.
- Annual average solar radiation is also expected to increase by up to 7.9%, although some projections suggest a decrease of as little as -0.8%.

8.1.3 Demand under change

Demand is likely to change between now and 2070 as a result of climate and land use change, as well as a range of other factors. Changes due to climate and land use change are explicitly considered in this report (Sections 5 and 6).

As a result of climate change, viticultural demand is expected to be affected and will increase under hotter and drier climates. A regression relationship was developed between the climate drivers of mean annual rainfall and annual average PET and observed viticultural water use. Maximum annual viticultural demand for the current (2022) area of vines is estimated at 13.5 GL/yr in 2070. Average use from 2017–18 to 2021–22 was 10.4 GL, with a maximum use of 11.4 GL in 2018–19.

To explore change in demand due to land use change, 4 future demand scenarios were developed that consider a change in demand from viticulture, other irrigated agriculture, stock and domestic use and urban greening. Changes in climate were also considered. The 4 scenarios are summarised as:

- **business-as-usual**, which represents current practices (representative of 2018–2022), including the current area and demand of viticulture, current area and demand of other irrigated agriculture, stock and domestic water demand and green space irrigation. Demand ranges between 9.1 GL and 15.4 GL in this scenario as a result of climate.
- **low diversification**, which represents moderate growth and moderate diversification. This scenario includes expansion of both viticulture and other irrigated agriculture. Stock and domestic and green space irrigation also increase. Demand ranges between 19.6 GL and 32.9 GL in this scenario (as a result of climate and climate change).

- **high viticulture**, which represents moderate growth with no diversification. In this scenario, other irrigated agriculture is replaced with viticulture, which expands to all suitable land. Stock and domestic and green space irrigation increase. Demand in this scenario is between 14.9 GL and 24.6 GL as a result of climate and climate change.
- **high diversification**, which represents high growth and high diversification. In this scenario, available land is split 50/50 between viticulture and other irrigated agriculture. Stock and domestic and green space irrigation increase. Demand in this scenario is highest, between 34.2 GL and 58.9 GL as a result of climate and climate change.

8.1.4 Supply under change

Supply from groundwater is expected to be impacted by climate change, with changes in climate most likely causing a decrease in groundwater recharge, which affects water available for use.

Changes in recharge were considered for all 3 aquifers in the study region. Recharge is directly impacted by changes in rainfall. Among the various climate models, the majority project a decline in rainfall in the region; however, a few project a moderate increase. Hence, some projections suggest an increase in recharge, while the majority suggest a decrease. In 2070, if allocation is capped at the mean projected recharge (or maximum allocation, whichever is lower), the amount available for extraction would reduce to between 0.57 and 2.87 GL.

Recycled water availability is largely driven by population. As a result of a 'low' population change scenario (conservative assumption when considering supply availability), in 2070, the total volume of recycled water would be 14.6 GL.

8.1.5 Adaptive pathways and investment options

Infrastructure and non-infrastructure options were considered to increase the existing system capacity and meet the demand volumes under the 4 demand scenarios. Due to constraints with region-specific information, data to obtain levelised costs has been supplemented by estimates based on the costs and volumes from options used in other regions around Australia.

Four investment portfolios were used to assess the ability to meet future demand scenarios. The results are summarised as follows.

- The **low-cost portfolio** prioritises low-cost options first, provides the highest volume and can meet all future demand scenarios (except the maximum volume for the high diversification scenario factoring in climate change). However, it does not reflect some goals associated with the regional vision.
- The **climate independent portfolio** provides supply options with the greatest reliability in times of drought and would meet 3 out of the 4 demand scenarios. However, it would be heavily reliant on seawater desalination, which comes with other environmental considerations.
- The **environmental outcome portfolio** prioritises options based on environmental impacts and achieves environmental outcomes. However, it would only meet the business-as-usual future demand scenario and not allow for future growth.

- The **meeting the regional vision portfolio** prioritises options based on whether they meet the vision for the McLaren Vale region and would meet 3 of the 4 demand scenarios, including the minimum volume expected for the 'high diversification' scenario. If this demand scenario eventuates, there may be opportunities to increase the supply volume if capacity exists to access greater volumes of seawater desalination or River Murray water, noting that these options come with other constraints.

8.2 Assumptions and limitations

Best available data and scientific understanding has been used to generate the analysis in this report; however, there are limitations to the analysis, as outlined below.

- No environmental metrics are considered as part of this analysis, so effect on the environment of any of these changes cannot be assessed. In particular, effect of changes in surface water and groundwater for supporting ecosystems has not been considered. Potential effects of any changes in land use have also not been analysed.
- The viticultural model applied (regression) was simple and only considered changes at the annual scale to rainfall and PET. A more complex representation of viticultural demand would provide greater insight into potential changes in viticultural demand and allow for stress testing of different climate variables. This relationship also assumes that future irrigation behaviour and its relationship to climate will be the same as what has been observed. This is particularly important considering spatial access to both groundwater and recycled water, which may have limited some irrigators' water usage.
- Changes to groundwater recharge were not modelled, and instead a simplified relationship between rainfall and recharge was used. Analysis of potential changes to groundwater would likely be improved through use of a model.
- The simple scaling approach used for analysing sensitivity to climate does not allow for testing of patterns of variability outside of the baseline period. Extremes, in particular, may not be captured well.

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Appendix A: Climate projections

Table 16. Percentage change of seasonal and annual precipitation. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	-3.5	-7.7	-2	-6.6	-14	-6.1	-8.7	-15	-4.7	-15 to -1.7
		RCP8.5	-5.2	-4.3	-1.7	-8.8	-3.3	-8.2	-13	-12	-9.9	
	25–75	RCP4.5	-6.3 to -0.9	-10 to -2.5	-7.8 to 0.5	-9.9 to -3.7	-17 to -9.3	-9.5 to -0.75	-12 to -5	-18 to -11	-11 to -0.9	-18 to 4.3
		RCP8.5	-8 to -2.7	-8.9 to 4.3	-9.2 to 1	-13 to -5	-8.5 to 2.7	-14 to 0.99	-18 to -9.1	-18 to -5.6	-21 to -2.6	
	2.5–97.5*	RCP4.5	-13 to 4.2	-18 to 2.2	-24 to 2.6	-16 to 0.9	-18 to -6.6	-19 to 4.5	-19 to 1.3	-26 to -4	-26 to 1.1	-30 to 16
		RCP8.5	-14 to 2.2	-19 to 16	-19 to 5	-19 to 1.1	-21 to 5.6	-25 to 5.5	-30 to -3.7	-25 to 0.2	-29 to 9.8	
DJF	Median	RCP4.5	-7.5	-15	-1.3	-9.6	-9.1	9.2	-11	-18	2.1	-22 to 9.2
		RCP8.5	-7.6	-6.5	2.6	-13	-15	1.3	-17	-22	-2.8	
	25–75	RCP4.5	-17 to 2.2	-16 to -8.6	-11 to 5	-21 to 0.62	-19 to -7.7	-4.2 to 17	-21 to -0.5	-26 to -12	-6.6 to 6.5	-28 to 17
		RCP8.5	-17 to 3.7	-9.0 to 3.7	-4 to 14	-22 to -2.7	-18 to -9.9	-6.5 to 14	-28 to -6.9	-26 to -18	-12 to 6.3	
	2.5–97.5*	RCP4.5	-33 to 20	-20 to -3.3	-16 to 17	-37 to 20	-24 to -0.09	-20 to 27	-36 to 23	-30 to -6.8	-19 to 21	-46 to 33
		RCP8.5	-30 to 25	-17 to 15	-10 to 33	-38 to 18	-22 to 0.8	-18 to 30	-46 to 13	-33 to -1.2	-16 to 29	
MAM	Median	RCP4.5	-3	-5.8	-4.9	-4.7	-7.4	-3.8	-6.3	-15	-6.6	-15 to -3
		RCP8.5	-4.7	-4.9	-4.3	-6.3	-4.4	-5	-12	-15	-7.7	
	25–75	RCP4.5	-9.8 to 3.5	-13 to 2.2	-9.9 to -1.5	-11 to 2	-11 to -4.1	-9.7 to -2.3	-13 to -0.3	-17 to -6.8	-10 to 0.57	-20 to 3.5
		RCP8.5	-11 to 1.9	-9.5 to -0.2	-12 to 2.9	-13 to -0.3	-11 to -0.6	-12 to -0.96	-18 to -6.1	-20 to -8.7	-18 to -2.3	
	2.5–97.5*	RCP4.5	-21 to 17	-15 to 17	-24 to 7.4	-22 to 15	-17 to 5.5	-25 to 19	-25 to 13	-23 to 3.1	-19 to 3.6	-39 to 27
		RCP8.5	-22 to 14	-19 to 7.4	-28 to 12	-26 to 11	-25 to 0.5	-27 to 27	-39 to 6.5	-31 to -2.7	-31 to 18	
JJA	Median	RCP4.5	-1.4	-5.5	-4.9	-5.1	-9.2	-10	-6.4	-3.7	-9	-11 to 5.7
		RCP8.5	-2.6	-3.9	-4.2	-5.3	5.7	-8.4	-9.7	-2.7	-11	

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
	25–75	RCP4.5	-6 to 3.8	-9.3 to 0.7	-10 to -1.7	-9.7 to 0.7	-17 to -5.4	-13 to -4.3	-11 to -0.6	-16 to 0.8	-15 to 2.3	-26 to 14
		RCP8.5	-6.1 to 1	-7.8 to 14	-13 to 2.5	-9.8 to -1.1	-3.8 to 9.6	-18 to -1.8	-14 to -4.4	-7.7 to 4.8	-26 to -3.7	
	2.5–97.5*	RCP4.5	-13 to 13	-14 to 11	-22 to 13	-15 to 9.9	-20 to -3.4	-27 to 19	-19 to 11	-33 to 3.1	-32 to 7.3	-36 to 28
		RCP8.5	-14 to 6.8	-11 to 28	-25 to 8.9	-19 to 6.5	-11 to 21	-32 to 9.3	-28 to 4	-12 to 12	-36 to 19	
SON	Median	RCP4.5	-8.2	-15	-1.9	-13	-23	-7.9	-16	-24	-12	-24 to -1.9
		RCP8.5	-11	-9.1	-2.5	-15	-15	-12	-21	-23	-11	
	25–75	RCP4.5	-13 to -2.4	-17 to -9.7	-14 to 2.7	-17 to -7.4	-29 to -17	-14 to -2.7	-22 to -10	-31 to -21	-20 to -1.1	-36 to -0.7
		RCP8.5	-16 to -5.5	-12 to -3.6	-10 to -0.7	-22 to -9.4	-23 to -0.2	-15 to -5.7	-29 to -15	-36 to -12	-19 to -3.8	
	2.5–97.5*	RCP4.5	-22 to 9.7	-28 to -5.5	-41 to 8.2	-27 to 2.3	-35 to -13	-44 to 8	-30 to 2.4	-34 to -18	-48 to 1.4	-48 to 9.7
		RCP8.5	-25 to 7.7	-30 to 4.0	-32 to 2.7	-34 to 1.7	-35 to 7.2	-39 to 1.9	-40 to -2.3	-42 to -8.6	-48 to 2	

*For the NARCliM and AWO datasets, the value displayed in the 2.5-97.5th percentile row is the minimum and maximum GCM/RCM scenario for the given attribute

Table 17. Percentage change of annual number of wet days (>1mm). The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	-3.2	-4.3	-3	-5.9	-6.9	-3	-7.7	-9.4	-4.4	**-9.4 to -2.9**
		RCP8.5	-4.7	-5.3	-2.9	-8	-4.7	-4.4	-11	-7.9	-6.8	
	25–75	RCP4.5	-5.1 to -1.4	-6.2 to -2.5	-4.5 to -1.6	-8.5 to -3.6	-8.7 to -3.7	-5.9 to -1.6	-11 to -4.9	-12 to -5.4	-7.4 to -2.1	**-16 to 3.2**
		RCP8.5	-6.7 to -2.8	-8.5 to 2.5	-5.5 to 3.2	-11 to -4.7	-8.5 to -3.6	-6.4 to 1.1	-16 to -8.1	-15 to -4.8	-9.3 to -0.51	
	2.5–97.5	RCP4.5	-11 to 1.9	-11 to 2	-6.6 to 8.7	-13 to -0.3	-13 to -2.7	-7.4 to 8.7	-15 to -0.1	-14 to -1.5	-11 to 7.7	**-25 to 10**
		RCP8.5	-11 to 0.5	-13 to 8.3	-7.3 to 9.6	-16 to -0.3	-15 to 4.5	-10 to 10	-25 to -4.6	-18 to -2.2	-14 to 8.2	

Table 18. Percentage change of annual number of 99th percentile wet day rainfall (>1mm). The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	-1.6	-4.5	-0.17	-2.5	-7.1	0.44	-3.3	-4.3	6.9	**-7.1 to 6.9**
		RCP8.5	-2.1	0.37	2.6	-3.3	-2.4	2.3	-5.5	-2.9	4.4	
	25-75	RCP4.5	-4.1 to 1.2	-7.8 to -2.4	-2.4 to 3.3	-5.3 to 0.2	-8.4 to -1.9	-1.8 to 6	-6.2 to -0.3	-9.1 to -0.04	-4.7 to 12	**-13 to 11**
		RCP8.5	-4.9 to 0.7	-4.9 to 1.4	-2.2 to 7.2	-6.4 to-0.4	-5.7 to 6.6	-2.4 to 8.5	-8.9 to -2.3	-13 to 11	-2 to 9.2	
	2.5-97.5	RCP4.5	-9.8 to 6.5	-12 to 6.9	-13 to 19	-11 to 6	-9.1 to 4.1	-7.8 to 19	-12 to 5.4	-14 to 5.4	-12 to 18	**-16 to 39**
		RCP8.5	-10 to 6	-7 to 7.5	-8.8 to 14	-12 to 5	-12 to 16	-9.8 to 21	-16 to 3.6	-16 to 21	-9.3 to 39	

Table 19. Percentage change in rainfall seasonality. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	4.7	11	3.2	4.8	10	-0.54	5.3	24	4.4	**-3.2 to 34**
		RCP8.5	3.4	13	-0.43	5	29	-3.2	4.8	34	-0.4	
	25–75	RCP4.5	-2.3 to 12	8.4 to 14	-1.3 to 7.4	-2.7 to 13	10 to 14	-4.4 to 4.4	-2.4 to 12	15 to 34	-3.8 to 11	**-7.5 to 42**
		RCP8.5	-2.6 to 9.6	5.2 to 19	-3.4 to 2.5	-1.7 to 13	14 to 33	-7 to -1.2	-2.6 to 13	26 to 42	-7.5 to 3	
	2.5–97.5	RCP4.5	-13 to 27	5.9 to 15	-7.5 to 19	-14 to 30	-2.3 to 16	-23 to 11	-14 to 29	-7.6 to 47	-22 to 21	**-27 to 48**
		RCP8.5	-13 to 24	1.5 to 19	-16 to 9.5	-13 to 28	0.71 to 35	-27 to 4.7	-16 to 29	0.31 to 48	-23 to 5.4	

Table 20. Percentage change of seasonal and annual PET. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	2.7	7.8	2.9	3.8	11	3.5	4.6	14	4.6	**2.7 to 18**
		RCP8.5	3.3	9.1	3.3	5.2	13	5	7.6	18	7.1	
	25–75	RCP4.5	2.3 to 3.3	7.1 to 8.3	2.4 to 3.6	3.2 to 4.5	11 to 11	3.2 to 4.5	4 to 5.6	13 to 14	4.3 to 5.2	**2.3 to 23**
		RCP8.5	2.7 to 4.6	8.5 to 10	3.1 to 3.7	4.4 to 7.2	13 to 15	4.7 to 5.2	6.2 to 9.5	18 to 23	6.6 to 7.6	
	2.5–97.5	RCP4.5	1.6 to 4.7	5.6 to 10	2 to 5.3	2.5 to 6.7	9.5 to 11	3.1 to 5.4	3.2 to 8	13 to 15	3.9 to 7.6	**1.6 to 26**
		RCP8.5	1.8 to 5.9	7.1 to 11	2.3 to 4.3	3.5 to 9.7	12 to 16	4.2 to 6.4	5.4 to 14	17 to 26	4.9 to 8.9	
DJF	Median	RCP4.5	2.1	6.4	2.1	2.9	8.1	2.1	3.6	10	3.2	**2.1 to 14**
		RCP8.5	2.7	6.6	2.1	4.3	11	4.1	6	14	4.8	
	25–75	RCP4.5	1.5 to 2.8	5 to 6.9	1.5 to 3.1	2.2 to 3.7	7.7 to 8.4	1.6 to 2.9	2.8 to 4.4	9.3 to 11	2.5 to 3.4	**1.9 to 16**
		RCP8.5	1.9 to 3.7	5.3 to 8.8	1.3 to 2.8	3.3 to 5.6	7.6 to 12	3.1 to 4.4	4.8 to 7.5	9.5 to 16	4.3 to 5.4	
	2.5–97.5	RCP4.5	0.3 to 5.4	4.5 to 7.4	-0.2 to 3.7	0.9 to 7.4	6.9 to 8.9	1.2 to 3.7	1.4 to 8.7	7.9 to 11	1.3 to 4.8	**-0.4 to 18**
		RCP8.5	-0.4 to 6.6	4.8 to 9.9	0.8 to 3.8	0.7 to 10	6.6 to 12	1.9 to 4.9	2.7 to 15	8.4 to 18	4 to 6.5	
MAM	Median	RCP4.5	2.4	7	2.7	3.5	9	3.6	4.5	12	5	**2.4 to 16**
		RCP8.5	3.3	8.7	3.5	5.2	11	4.1	7.4	16	7.1	
	25–75	RCP4.5	1.5 to 3.4	6.1 to 7.7	1.7 to 4.4	2.4 to 4.6	8.6 to 11	2.3 to 4.3	3.4 to 5.5	11 to 14	4.3 to 5.7	**1.5 to 22**

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
		RCP8.5	2.4 to 4.3	5.6 to 11	2.4 to 4.2	4.1 to 6.4	9.5 to 14	3.2 to 5.7	6.1 to 9	16 to 22	5.7 to 7.5	
	2.5–97.5	RCP4.5 RCP8.5	0.4 to 5.1 1 to 6.1	5.5 to 8.1 4.3 to 11	0.6 to 5.6 0.24 to 5.5	1.1 to 6.5 2.7 to 10	7.6 to 12 7.9 to 16	1.9 to 6.5 2.1 to 7.1	1.8 to 7.5 4.7 to 15	9.8 to 15 14 to 25	2.1 to 7.8 4.7 to 8.4	**0.4 to 25**
JJA	Median	RCP4.5 RCP8.5	2.7 3.3	9.6 11	3.7 3.6	4 5.4	16 25	5.3 5.9	4.8 8	23 36	6.4 7.9	**2.7 to 36**
	25–75	RCP4.5 RCP8.5	2.1 to 3.3 2.6 to 4.1	9.2 to 15 11 to 18	3.2 to 4.6 3.1 to 4.7	3.2 to 4.7 4.4 to 6.8	15 to 17 20 to 27	4.6 to 6.3 5.4 to 6.3	3.9 to 5.8 6.6 to 10	21 to 23 31 to 40	5.2 to 6.9 7.3 to 9	**2.1 to 40**
	2.5–97.5	RCP4.5 RCP8.5	1 to 4.3 1.7 to 6	8.8 to 18 9.8 to 20	1.1 to 5.9 2.4 to 6	1.4 to 5.9 3.2 to 8.8	14 to 19 18 to 29	2.9 to 7.6 5 to 9.5	2 to 7.1 4.7 to 13	18 to 23 28 to 41	3.5 to 10 5.5 to 14	**1 to 41**
SON	Median	RCP4.5 RCP8.5	4.1 4.7	8.1 9.9	4.3 5.2	5.5 7.2	14 15	5.4 7.4	6.5 10	15 21	7 9.6	**4.1 to 21**
	25–75	RCP4.5 RCP8.5	3.3 to 4.7 3.8 to 5.8	7.5 to 9.7 8.3 to 10	3.7 to 4.9 4.1 to 5.9	4.6 to 6.3 5.9 to 8.9	13 to 15 14 to 16	4.4 to 7.1 6.1 to 7.9	5.6 to 7.6 8 to 12	14 to 17 20 to 25	5.9 to 8.7 8.8 to 11	**3.3 to 25**
	2.5–97.5	RCP4.5 RCP8.5	2 to 5.8 2.4 to 7.4	4.9 to 12 7.7 to 13	3.2 to 7.3 2.7 to 8.1	3.1 to 7.5 4.2 to 11	11 to 15 14 to 16	3.9 to 8.6 4.5 to 9.8	3.5 to 8.9 6 to 15	13 to 21 19 to 26	3.9 to 11 5.5 to 13	**2 to 26**

Table 21. Degree change in seasonal and annual maximum temperature. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5 RCP8.5	0.9 1	1.1 1.1	0.9 1	1.2 1.6	1.6 1.6	1.2 1.6	1.5 2.3	1.9 2.5	1.6 2.4	**0.9 to 2.5**
	25–75	RCP4.5 RCP8.5	0.7 to 1 0.9 to 1.4	0.97 to 1.2 0.86 to 1.4	0.8 to 1 0.9 to 1	1.1 to 1.4 1.5 to 2.2	1.4 to 1.7 1.5 to 1.8	1.1 to 1.3 1.3 to 1.7	1.3 to 1.7 2.1 to 3	1.8 to 2 2.3 to 2.7	1.4 to 1.7 2 to 2.6	**0.7 to 3**
	2.5–97.5	RCP4.5 RCP8.5	0.5 to 1.4 0.7 to 1.8	0.82 to 1.3 0.83 to 1.4	0.76 to 1 0.78 to 1.1	0.9 to 1.9 1.3 to 2.9	1.2 to 1.8 1.4 to 2	1 to 1.5 1.2 to 1.9	1.1 to 2.4 2 to 4.3	1.5 to 2.2 2 to 2.8	1.2 to 2.2 2 to 2.8	**0.5 to 4.3**
DJF	Median	RCP4.5 RCP8.5	0.9 1.1	1.3 1.3	0.9 0.9	1.3 1.7	1.7 1.8	1.1 1.6	1.5 2.3	1.9 2.3	1.4 2.3	**0.9 to 2.3**

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
	25–75	RCP4.5	0.7 to 1.2	1.1 to 1.5	0.68 to 1	1 to 1.6	1.5 to 1.8	1.0 to 1.2	1.3 to 1.9	1.7 to 2	1.2 to 1.6	**0.7 to 2.9**
		RCP8.5	0.8 to 1.5	0.9 to 1.7	0.7 to 1.1	1.4 to 2.3	1.4 to 2.1	1.3 to 1.9	2 to 3.1	1.7 to 2.9	2 to 2.5	
	2.5–97.5	RCP4.5	0.4 to 2.1	0.74 to 1.6	0.65 to 1.1	0.6 to 2.8	1.2 to 1.8	0.8 to 1.3	0.9 to 3.4	1.7 to 2.4	1 to 1.9	**0.4 to 5.3**
		RCP8.5	0.4 to 2.2	0.75 to 1.8	0.43 to 1.4	1 to 3.7	1.1 to 2.3	1.0 to 2.1	1.6 to 5.3	1.6 to 3	1.7 to 2.9	
MAM	Median	RCP4.5	0.7	1.0	0.9	1	1.4	0.9	1.3	1.8	1.4	**0.7 to 2.4**
		RCP8.5	1	1.0	0.9	1.5	1.5	1.2	2.2	2.4	2.2	
	25–75	RCP4.5	0.6 to 0.9	0.8 to 1.1	0.8 to 0.9	0.9 to 1.3	1.2 to 1.5	0.9 to 1.2	1.1 to 1.6	1.5 to 2	1.4 to 1.7	**0.6 to 2.9**
		RCP8.5	0.8 to 1.2	0.9 to 1.5	0.6 to 1.0	1.3 to 1.9	1.4 to 1.8	1.1 to 1.6	2 to 2.8	2.2 to 2.9	2 to 2.5	
	2.5–97.5	RCP4.5	0.1 to 1.5	0.6 to 1.2	0.4 to 1.1	0.5 to 1.9	1.1 to 1.6	0.87 to 1.7	0.7 to 2.3	1.5 to 2.1	1.3 to 2.3	**0.1 to 4.1**
		RCP8.5	0.3 to 1.9	0.5 to 1.7	0.4 to 1.2	0.9 to 2.9	1.1 to 2	1 to 1.8	1.6 to 4.1	2 to 3.1	1.9 to 2.8	
JJA	Median	RCP4.5	0.7	0.8	0.8	1.1	1.2	1.2	1.3	1.6	1.5	**0.7 to 2.5**
		RCP8.5	0.9	0.9	0.8	1.5	1.5	1.4	2.3	2.5	2.1	
	25–75	RCP4.5	0.6 to 0.9	0.7 to 1.2	0.7 to 0.8	0.9 to 1.3	1.1 to 1.7	1.1 to 1.3	1.1 to 1.6	1.5 to 2.1	1.3 to 1.6	**0.6 to 2.8**
		RCP8.5	0.7 to 1.2	0.9 to 1.2	0.7 to 0.9	1.2 to 1.9	1.5 to 1.7	1.3 to 1.7	1.9 to 2.8	2.3 to 2.5	1.7 to 2.4	
	2.5–97.5	RCP4.5	0.3 to 1.1	0.61 to 1.5	0.5 to 0.9	0.6 to 1.6	1.0 to 1.8	0.9 to 1.5	0.7 to 1.9	1.2 to 2.3	1 to 2.1	**0.3 to 3.4**
		RCP8.5	0.5 to 1.6	0.66 to 1.3	0.7 to 1	1 to 2.3	1.3 to 2	1.0 to 1.9	1.6 to 3.4	1.9 to 2.7	1.7 to 2.9	
SON	Median	RCP4.5	1.1	1.1	1	1.5	1.8	1.4	1.9	2	2	**1.1 to 2.8**
		RCP8.5	1.4	1.3	1.3	2.1	1.6	1.9	3	2.6	2.8	
	25–75	RCP4.5	0.9 to 1.3	1 to 1.3	1.0 to 1.2	1.4 to 1.7	1.4 to 2.3	1.3 to 1.8	1.6 to 2.1	1.8 to 2.5	1.8 to 2.1	**0.9 to 3.5**
		RCP8.5	1.1 to 1.6	0.7 to 1.3	1.2 to 1.4	1.8 to 2.5	1.5 to 1.7	1.6 to 2.1	2.5 to 3.5	2.5 to 2.7	2.5 to 3	
	2.5–97.5	RCP4.5	0.6 to 1.6	0.8 to 1.5	0.8 to 1.4	1 to 2	1.4 to 2.3	1.1 to 1.9	1.3 to 2.4	1.6 to 3	1.5 to 2.7	**0.4 to 4.4**
		RCP8.5	0.8 to 2	0.4 to 1.9	1 to 1.5	1.4 to 3.1	1.5 to 2.4	1.5 to 2.5	2 to 4.4	2.2 to 2.9	2.1 to 3.4	

Table 22. Degree change in seasonal and annual minimum temperature. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5 RCP8.5	0.69 0.85	0.77 0.9	0.67 0.75	0.97 1.4	1.1 1.3	0.93 1.2	1.2 2	1.4 1.8	1.3 1.9	**0.67 to 2**
	25–75	RCP4.5 RCP8.5	0.55 to 0.81 0.7 to 1.1	0.7 to 0.82 0.84 to 0.98	0.51 to 0.72 0.57 to 0.9	0.79 to 1.2 1.2 to 1.7	1.1 to 1.1 1.3 to 1.5	0.81 to 1 0.97 to 1.5	1 to 1.4 1.8 to 2.4	1.3 to 1.4 1.8 to 2.3	1 to 1.5 1.6 to 2.2	**0.51 to 2.4**
	2.5–97.5	RCP4.5 RCP8.5	0.36 to 1 0.52 to 1.3	0.56 to 0.99 0.7 to 1	0.39 to 0.77 0.39 to 0.96	0.56 to 1.3 0.98 to 2	0.93 to 1.1 1.1 to 1.6	0.49 to 1.1 0.72 to 1.6	0.67 to 1.6 1.5 to 2.9	1.2 to 1.4 1.7 to 2.5	0.64 to 1.5 1.2 to 2.4	**0.36 to 2.9**
DJF	Median	RCP4.5 RCP8.5	0.73 0.92	0.83 0.87	0.68 0.85	1 1.5	1.1 1.4	0.96 1.5	1.2 2.1	1.3 1.8	1.4 2.2	**0.68 to 2.2**
	25–75	RCP4.5 RCP8.5	0.51 to 1 0.67 to 1.3	0.66 to 0.91 0.7 to 1.2	0.62 to 0.83 0.58 to 0.97	0.75 to 1.4 1.2 to 1.9	1 to 1.1 1 to 1.6	0.84 to 1 1.1 to 1.8	0.94 to 1.7 1.7 to 2.7	1.2 to 1.4 1.3 to 2.1	1.1 to 1.4 1.6 to 2.4	**0.51 to 2.7**
	2.5–97.5	RCP4.5 RCP8.5	0.23 to 1.5 0.35 to 1.7	0.6 to 0.96 0.64 to 1.3	0.49 to 1 0.41 to 1.3	0.42 to 1.9 0.81 to 2.6	0.9 to 1.2 0.87 to 1.6	0.61 to 1.4 0.86 to 1.9	0.51 to 2.2 1.4 to 3.7	1 to 1.5 1.1 to 2.3	0.49 to 1.9 1.3 to 2.7	**0.23 to 3.7**
MAM	Median	RCP4.5 RCP8.5	0.68 0.88	0.78 0.97	0.53 0.61	0.97 1.4	0.99 1.3	0.88 1.1	1.2 2.1	1.4 1.8	1.3 1.8	**0.53 to 2.1**
	25–75	RCP4.5 RCP8.5	0.51 to 0.89 0.71 to 1.2	0.67 to 0.86 0.62 to 1.2	0.47 to 0.64 0.47 to 0.67	0.79 to 1.2 1.2 to 1.9	0.95 to 1.2 1 to 1.6	0.74 to 0.95 0.92 to 1.3	0.99 to 1.5 1.8 to 2.8	1.2 to 1.5 1.7 to 2.5	0.98 to 1.4 1.7 to 2.2	**0.47 to 2.8**
	2.5–97.5	RCP4.5 RCP8.5	0.23 to 1.3 0.45 to 1.5	0.61 to 0.91 0.47 to 1.2	0.22 to 0.82 0.1 to 0.94	0.43 to 1.6 0.93 to 2.3	0.85 to 1.3 0.87 to 1.7	0.38 to 1.2 0.53 to 1.6	0.59 to 1.8 1.5 to 3.3	1.1 to 1.7 1.6 to 2.8	0.6 to 1.6 1.1 to 2.7	**0.22 to 3.3**
JJA	Median	RCP4.5 RCP8.5	0.59 0.78	0.63 0.74	0.64 0.71	0.85 1.3	1 1.6	0.98 1.2	1.1 1.9	1.5 2.4	1.2 1.8	**0.59 to 2.4**
	25–75	RCP4.5 RCP8.5	0.45 to 0.71 0.6 to 0.94	0.61 to 0.97 0.71 to 1.2	0.51 to 0.69 0.54 to 0.74	0.65 to 0.98 1.1 to 1.5	0.97 to 1.1 1.3 to 1.8	0.74 to 1 0.79 to 1.4	0.77 to 1.3 1.6 to 2.1	1.4 to 1.5 2 to 2.6	0.97 to 1.4 1.4 to 2.1	**0.45 to 2.6**
	2.5–97.5	RCP4.5 RCP8.5	0.23 to 0.95 0.38 to 1.2	0.58 to 1.2 0.64 to 1.3	0.34 to 0.77 0.32 to 0.94	0.41 to 1.3 0.78 to 1.7	0.89 to 1.2 1.2 to 1.9	0.53 to 1 0.63 to 1.5	0.52 to 1.4 1.2 to 2.4	1.2 to 1.5 1.8 to 2.7	0.68 to 1.5 1 to 2.2	**0.23 to 2.7**
SON	Median	RCP4.5 RCP8.5	0.7 0.88	0.69 0.84	0.55 0.85	1 1.4	1.2 1.3	0.92 1.2	1.2 2	1.3 1.8	1.2 1.8	**0.55 to 2**

Season	Percentile	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
	25–75	RCP4.5	0.55 to 0.83	0.64 to 0.82	0.54 to 0.74	0.8 to 1.1	1.1 to 1.3	0.73 to 1.1	0.99 to 1.4	1.2 to 1.5	0.97 to 1.4	**0.54 to 2.3**
		RCP8.5	0.72 to 1	0.71 to 0.88	0.65 to 0.92	1.2 to 1.6	1.2 to 1.4	0.97 to 1.4	1.8 to 2.3	1.7 to 2.1	1.6 to 2.1	
	2.5–97.5	RCP4.5	0.22 to 1	0.43 to 1	0.32 to 0.92	0.38 to 1.4	0.98 to 1.3	0.33 to 1.2	0.62 to 1.7	1.2 to 1.8	0.72 to 1.6	**0.22 to 2.8**
		RCP8.5	0.46 to 1.3	0.66 to 1.1	0.57 to 1	0.98 to 1.9	1.2 to 1.4	0.87 to 1.6	1.5 to 2.8	1.6 to 2.2	1.2 to 2.4	

Table 23. Change in annual number of days with maximum temperature greater than 35°C. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile (%)	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	1.2	4.8	3.4	1.7	6.3	4.1	2.2	7.8	6.3	**1.2 to 9.8**
		RCP8.5	1.5	4.6	3.6	2.6	6.8	7.3	3.9	9.3	9.8	
	25–75	RCP4.5	0.8 to 1.7	3.3 to 5.2	2.7 to 3.9	1.3 to 2.3	5.3 to 7.4	3.7 to 5.1	1.7 to 2.9	6.9 to 9	5.7 to 7.1	**0.8 to 11**
		RCP8.5	1 to 2.2	3.1 to 5.7	3.2 to 4.5	2 to 3.7	5.4 to 7.6	5.1 to 7.8	3.2 to 5.8	7.8 to 11	8.9 to 11	
	2.5–97.5	RCP4.5	0 to 3.1	0.6 to 5.6	1.8 to 6	0.5 to 4.5	4.5 to 7.8	3.1 to 7.2	0.9 to 5.9	6.1 to 11	4.1 to 8.2	**0 to 14**
		RCP8.5	0.1 to 3.7	1.6 to 8.2	1.6 to 6.3	0.9 to 7.4	4.3 to 8.5	3.5 to 9.9	2.1 to 14	7.1 to 13	6.7 to 13	

Table 24. Percentage change in annual solar radiation. The median value, upper and lower quartile (25th and 75th percentile) and 2.5th to 97.5th percentile values are quoted.

Season	Percentile (%)	Emissions scenario	2030			2050			2070			Range of future change
Line of evidence:			SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	SA-CR	NARCliM	AWO	
Annual	Median	RCP4.5	1.4	0.58	1.2	1.7	0.8	1.2	2.1	1	1.5	**0.54 to 3**
		RCP8.5	1.7	0.54	1.7	2.5	0.34	2	3	0.78	2.3	
	25–75	RCP4.5	0.91 to 2	0.49 to 1.2	0.81 to 1.9	1.2 to 2.8	0.15 to 1.9	0.7 to 2.2	1.5 to 3	0.58 to 2.1	1.2 to 2.4	**0.02 to 4.6**
		RCP8.5	0.98 to 2.6	0.03 to 0.9	1.1 to 2.5	1.4 to 3.5	0.1 to 0.86	1.6 to 2.7	1.8 to 4.6	0.02 to 1.5	1.7 to 3	
	2.5–97.5	RCP4.5	0.08 to 3.2	0.36 to 1.5	0.37 to 3.5	0.5 to 4.1	0.03 to 2.3	0.63 to 3	0.64 to 4.7	0.37 to 3.1	0.62 to 3.3	**-0.8 to 7.9**
		RCP8.5	0.05 to 3.6	-0.14 to 1.3	0.02 to 3.3	0.45 to 5.6	-0.19 to 1	0.6 to 3.6	0.81 to 7.9	-0.83 to 1.7	0.88 to 4.6	

Appendix B: Viticultural land use potential

The sections below describe the 3 factors for determining whether land has potential for supporting viticulture, with the factors being land development zones, current land use and land use potential for viticulture based on soil type.

Land development zones

Land development zones come from the Department for Trade and Investment (2013) and are shown in Figure 46. Table 25 shows whether land development zones are classified as having potential for viticulture or no potential.

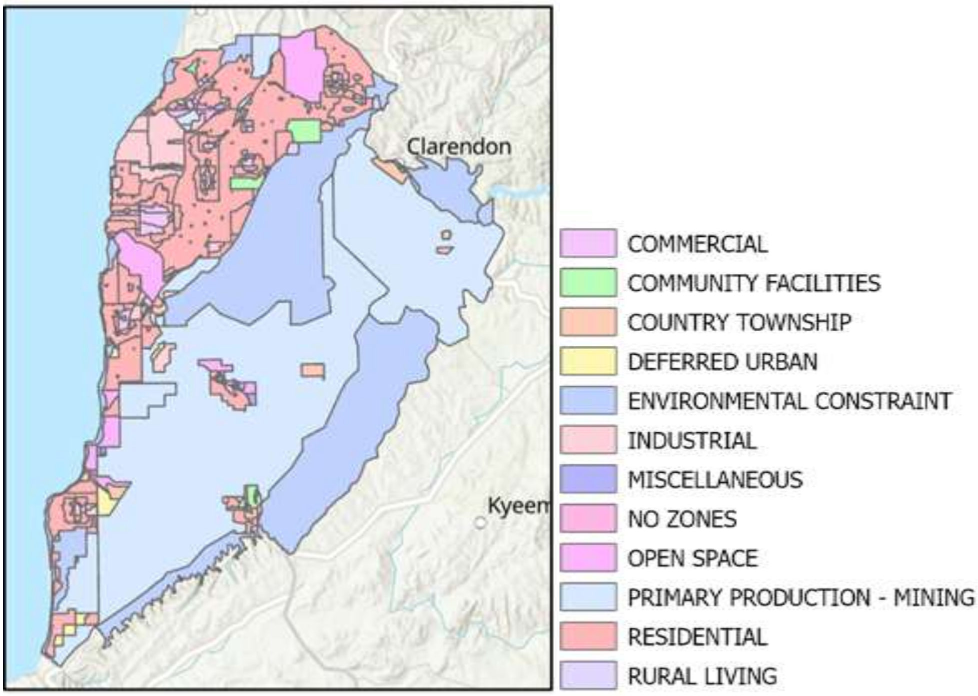

Figure 46. Land development zones

Table 25. Land use development zones

Irrigated use potential	Land development zone	Area (ha)
Potential	Open space	1,766
	Primary production	18,403
	Miscellaneous	99
	Rural living	109
	TOTAL	**20,376**
No potential	Commercial	554
	Community facilities	402
	Country township	435
	Deferred urban	247
	Environmental constraint	11,154
	Industrial	1,274
	Residential	8,385
	TOTAL	**22,451**

Current land use

Listed below are all the tertiary land classes that were determined, using the 2016 ALUM dataset, to have current or future land potential. The tertiary land uses quoted here are the same as for the work done by Jacobs (2024).

Irrigated grapes, Pasture legume/grass mixtures, Rural residential with agriculture, Rural residential without agriculture, Grazing modified pastures, Cereals, Irrigated olives, Other forest plantation, Softwood plantation forestry, Pulses, Olives, Landscape, Irrigated tree nuts, Irrigated land in transition, Tree nuts, Horse studs, Irrigated tree fruits, Irrigated perennial horticulture, Grazing native vegetation, Sown grasses, Production nurseries, Plantation forests, Poultry farms, Abandoned perennial horticulture, Cropping, Irrigated seasonal vegetables and herbs, Irrigated sown grasses, Abandoned irrigated perennial horticulture, Irrigated hay and silage, Hardwood plantation forestry, Perennial flowers and bulbs, Pasture legumes, No defined use – irrigation, Land in transition, Perennial horticulture, Dairy sheds and yards, Other forest production, Abandoned irrigated land, Irrigated seasonal horticulture, Glasshouses, General purpose factory, Irrigated seasonal flowers and bulbs, Tree fruits, Irrigated legume/grass mixtures, Aquaculture, Irrigated perennial flowers and bulbs, Shade houses, Oilseeds, Abandoned intensive horticulture, Intensive horticulture, Grazing irrigated modified pastures

This gives 20,747 ha of land use classes with current or future potential.

Land use potential viticulture (soil)

Soil land use potential for viticulture comes from the dataset created by Rowland et al. (2016). Potential for viticulture based on soil type is shown in Figure 47, and Table 12 shows whether these soil types are considered to have potential for viticulture.

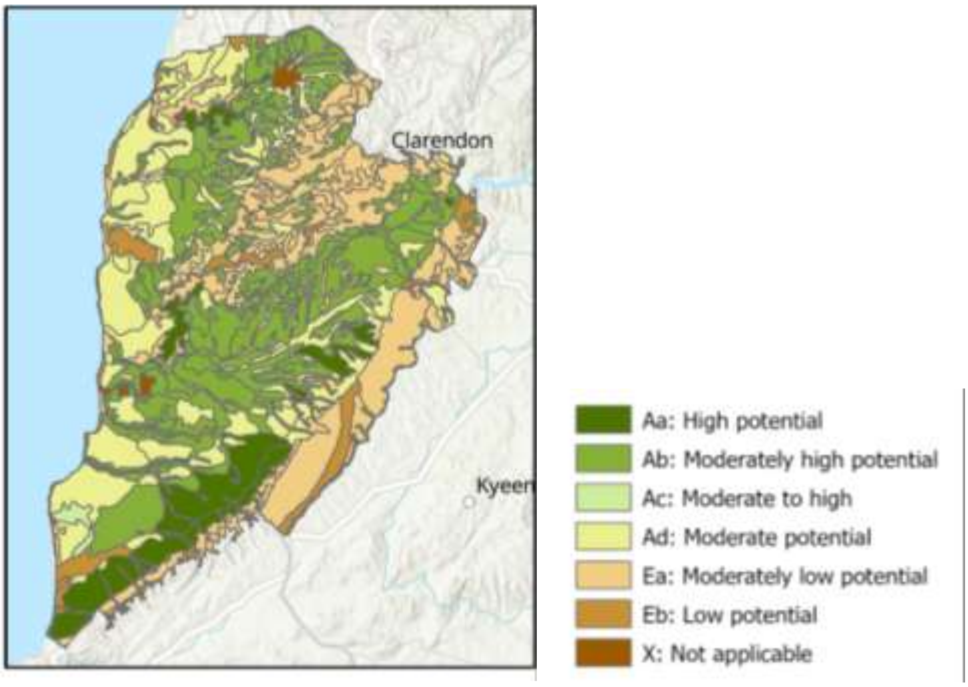

Figure 47. Potential for viticulture based on soil type

Table 26. Soil potential for grapevines

	Category	Description	Area
Potential	Aa		4,014
	Ab		14,801
	Ac		226
	Ad		10,394
	TOTAL		**29,435**
No potential	Ea		10,926
	Eb		2,481
	X		330
	TOTAL		**13,737**

Appendix C: Alternate crop type mix and demand

The ALUM dataset (ABARES, 2016) includes tertiary land use attribution, including key categories such as 'Irrigated tree fruits' and 'Seasonal vegetables and herbs'. In Table 27, the crops identified from Bardsley et al. (2017) are attributed to one of these tertiary categories and then an area percentage is attributed to this from the land use dataset (of both irrigated and dryland horticulture). Typical water use is also taken from the FAO-56 irrigation paper (Allen et al. 1998, Jacobs 2024). For each tertiary category, an average water use is then assumed. A generalised average irrigation for 'Other irrigated agriculture' is then calculated using a weighted average of typical water use by area. This gives an average water use of 5.8 ML/ha.

Table 27. Alternate horticulture (to wine grapes) grown in McLaren Vale

Broad categorisation	**Specific crops** (Bardsley et al. 2017)	**Percentage estimate of all horticulture (irrigated and not irrigated) in the region, not including wine grapes (%)** (ABARES 2016)	**Typical water use (ML/ha)** (Allen et al. 1998, Jacobs 2024)	**Value assumed (ML/ha)**
Tree fruits*	Apples, pears, nectarines, pomegranate, cherries, peaches, plums, avocados, mangoes, loquats, table grapes, mulberry	3.6	4–4.9 (mulberry) 6–6.9 (stone fruit) 7–7.9 (orchard, pear, quince) 8–8.9 (apple, cherry)	6.9
	Olives	64	4–4.9	4.9
Tree nuts	Almond	23	7–7.9	7.9
Vegetables and herbs	Asparagus, lettuce, salad greens, zucchini, kale, corn, tomatoes, carrot, cucumber, broccoli, spinach, beetroot, onion, broad beans, carob, cabbage, chard	1.9	0–1.9 (spinach) 3–3.9 (beans, herbs) 4–4.9 (brassica, lettuce) 5–5.9 (sweetcorn) 6–6.9 (vegetables, mixed) 7–7.9 (cucumber, onion) 8–8.9 (tomatoes)	6
Flowers and bulbs		2.1	4–4.9 (native flowers)	4.9
Other perennial		3.7		6
Other seasonal		1.9		6
			Area averaged water use (ML/ha)	5.8

*Typical wine grape use in the region is 1.1–1.8 ML/ha (Allen et al. 1998, Jacobs 2024)

Appendix D: Recycled water availability

Data for Aldinga and Christies Beach wastewater treatment plants (WWTPs) including inflow, government inspection points (GIPs) and current population were obtained from SA Water. Population projections are sourced from Plan SA Outer South projections (Plan SA 2023). The methodology for determining the recycled water availability is presented below:

1. Calculate current population per GIP for each WWTP.
2. Calculate average inflow/GIP/year and convert to inflow/population/year.
3. Calculate inflows based on population projections from PLUS, extrapolating linearly past 2041 for low, medium and high population scenarios.
4. Apply 5% loss of inflow due to treatment processes (estimated) to determine recycled water available for use.

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