Central and Gippsland Region Sustainable Water Strategy Discussion Draft

Technical guide to figures

October 2021

Accompanying report to the Central and Gippsland Region Sustainable Water Strategy Discussion Draft

VICTORIA State Government | Environment, Land, Water and Planning

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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Technical guide to figures

Central and Gippsland Region Sustainable Water Strategy
Discussion Draft

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Introduction

Purpose of this technical guide

The Central Gippsland Region Sustainable Water Strategy (CGRSWS) Discussion Draft contains many figures that have been developed using a variety of methods and data from a range of sources. This reference guide provides the reader with an explanation of how each of these figures was derived. If you are wondering about the data that sit behind a map or chart, then you might find this report useful. Maps and figures in the CGRSWS Discussion Draft that do not incorporate original data analysis used by the CGRSWS work program or are otherwise non-technical in nature are not covered by this guide.

To enable the reader to easily locate information on a figure of interest, the structure of this report mirrors the relevant chapters of the CGRSWS Discussion Draft, namely:

- Chapter 2: Water sources — now and in the future
    - Long-term available surface water and changes in long-term available surface water
    - Future water availability
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    - Trends in production and use of recycled water
    - Water orders for the desalination project
- Chapter 3: Water users and values — now and in the future
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- Chapter 6: How we grow our water supplies
    - Alternative water resources
- Chapter 7: How we use all sources of water
    - Example of a regional water balance for Bannockburn – volumes 2020 to 2050
    - Recycled water use potential
- Chapter 10, 11 and 12 — the Gippsland, Central, and Barwon, Moorabool and Otways sub-regions
    - Percentage shares of Blue Rock Reservoir
    - Seasonal variation case studies
    - Farm dam density

Developing a consistent and robust approach to the CGRSWS Discussion Draft information base

The water resource assessment methods applied in the CGRSWS Discussion Draft are based on the following key information sources:

1. **The 2020 Long-Term Water Resource Assessment for Southern Victoria**

   Under the *Water Act 1989* [section 22C] the CGRSWS must take into account of the findings from the 2020 Long-Term Water Resource Assessment (LTWRA) for Southern Victoria. To ensure consistency, water resource assessment methods applied in the LTWRA have also been applied in the CGRSWS Discussion Draft, with refinement, such as extending data sets where new data have become available. The Overview Report and Basin-by-Basin Results Report for the LTWRA are both available to be downloaded here: https://www.water.vic.gov.au/planning/long-term-assessments-and-strategies/ltwra or by contacting DELWP Customer Contact Centre on 136 186 for a printed copy.

2. **Victorian Water Accounts**

   The Victorian Water Accounts provide an annual snapshot of current availability and use of our water resources. The 2019/20 edition of the Victorian Water Accounts was the most recent set of accounts at the time the CGRSWS Discussion Draft was developed, and is available to be downloaded here: https://waterregister.vic.gov.au/water-availability-and-use/victorian-water-accounts.

3. **Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria**

   The Guidelines provide a consistent basis for assessing the impact of climate change on water availability that is underpinned by contemporary hydrology and climate science, including findings from the *Victorian Water and Climate Initiative*. The 2020 edition of the Guidelines is available to be downloaded here: https://www.water.vic.gov.au/climate-change/adaptation/guidelines.

In addition, in developing the technical evidence base for the CGRSWS Discussion Draft, DELWP sought advice from across the water industry. A Water Resource Availability Technical Working Group was convened to develop a coordinated approach to water resource assessment that meets the needs of the CGRSWS and aligns with broader water sector planning processes. Group membership comprises representatives from each water corporation and catchment management authority in the region, the Victorian Environmental Water Holder and subject-area experts from the DELWP Water and Catchments Group. Traditional Owner Partnership members have a standing invitation to attend the Water Resource Availability Technical Working Group.

Chapter 2: Water sources — now and in the future

Long-term available surface water[1] and changes in long-term available surface water

Figures in the CGRSWS Discussion Draft

This section provides technical information related to the Figure 2-3, Figure 2-5, Figure 10-4, Figure 11-4 and Figure 12-5 in the CGRSWS Discussion Draft that describe long-term available surface water and changes in long-term available surface water in the Central and Gippsland Region. These figures are reproduced in this report for ease of reference.

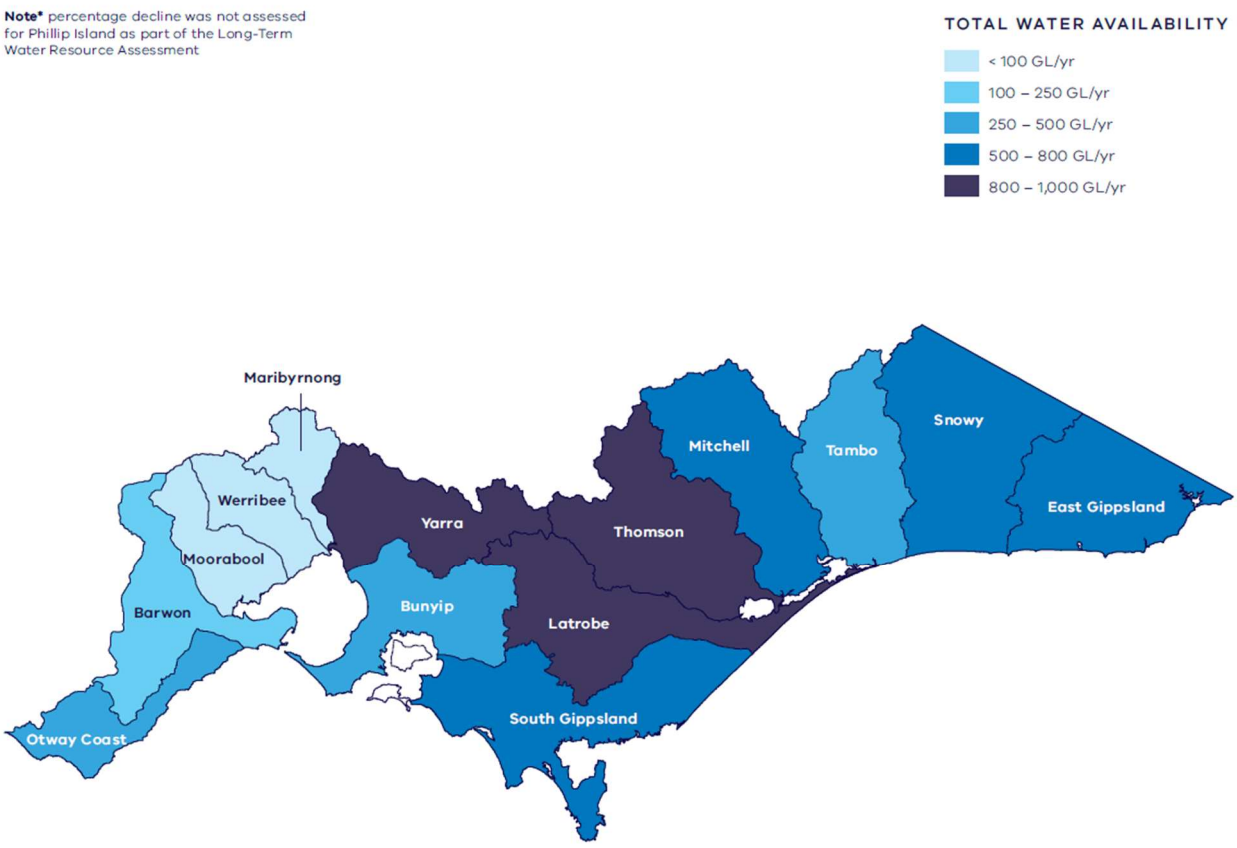


Figure 2-3: Average annual surface water available in each river basin across the Central and Gippsland Region — page 31 of the CGRSWS discussion draft.

[1] Surface water availability in this report is defined consistent with the Long-Term Water Resource Assessment (DELWP, 2020) That is, as water in waterways and in bodies of water that can be allocated under Victoria's water entitlement framework to consumptive users or to the environment.

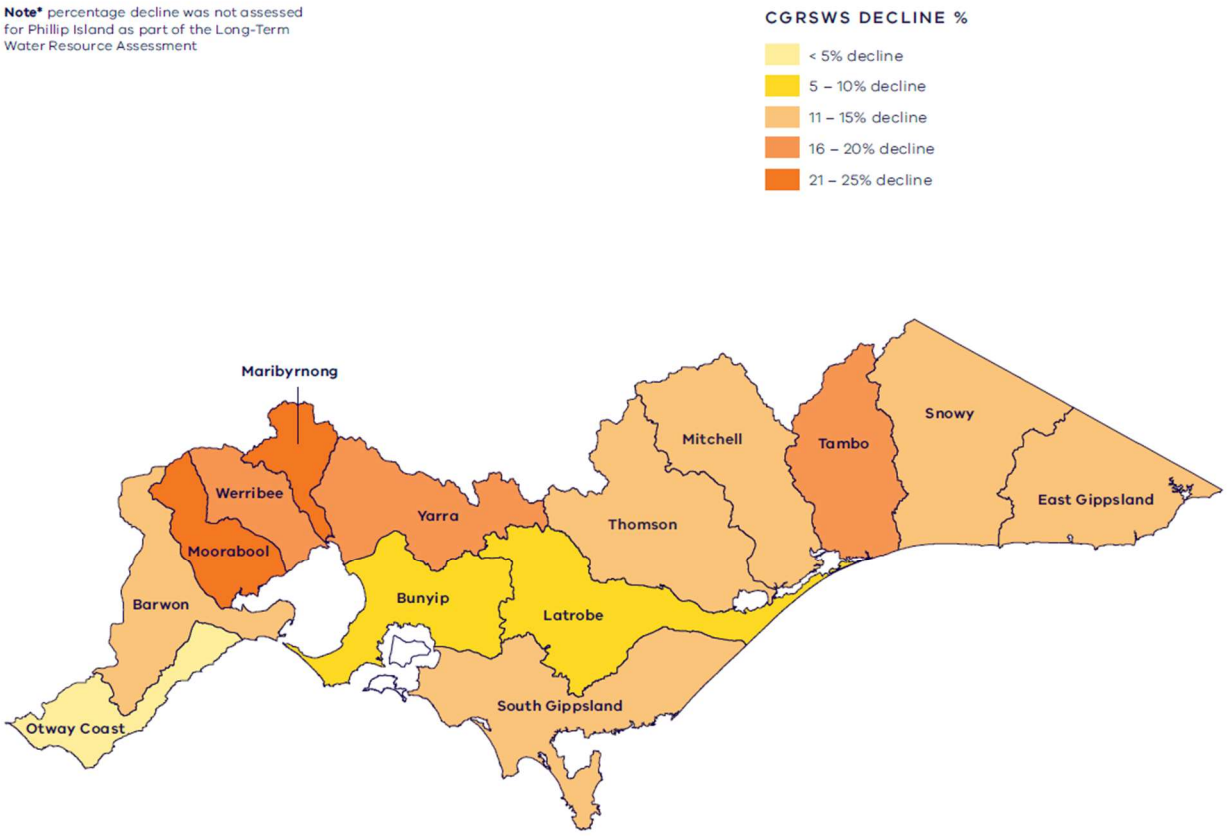


Figure 2-5: Percentage decline in surface water availability in each basin across southern Victoria for 1975–2020, relative to the long-term record — page 34 of the CGRSWS discussion draft.

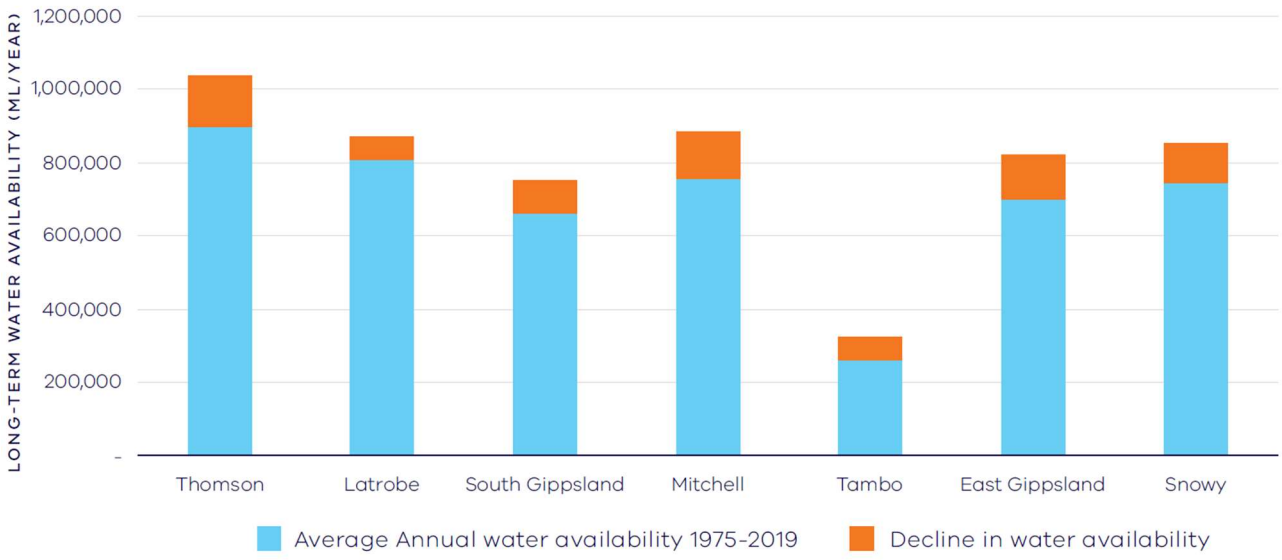


Figure 10-4: Long-term average annual water availability and decline across Gippsland — page 194 of the CGRSWS discussion draft.

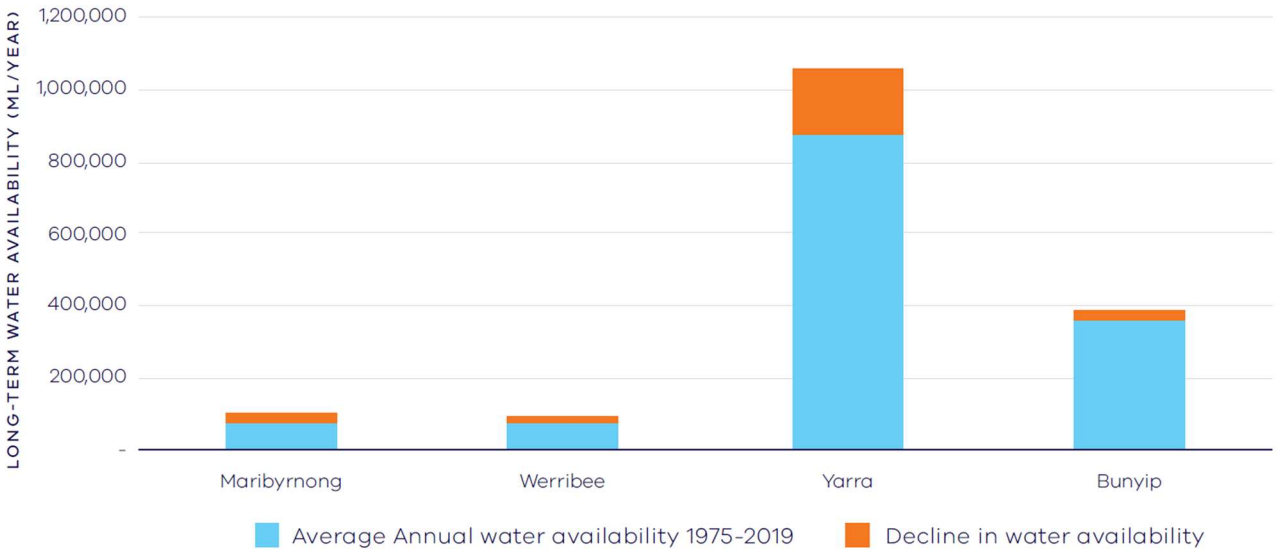


Figure 11-4: Long-term average annual water availability and decline across the Central subregion — page 223 of the CGRSWS discussion draft.

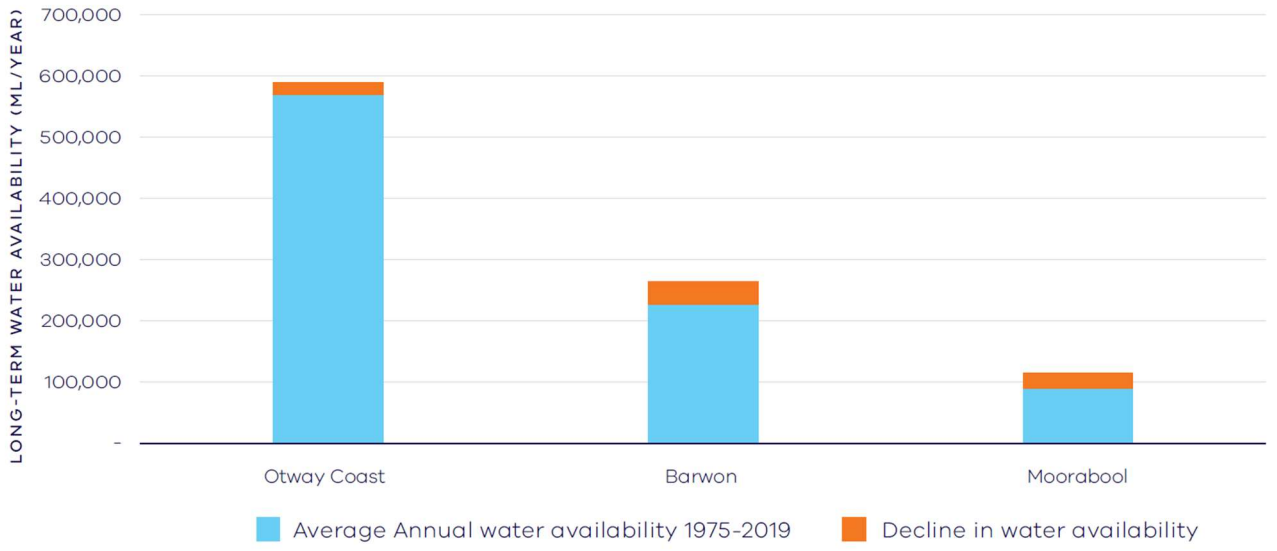


Figure 12-5: Long-term average annual water availability and decline in the Barwon, Moorabool and Otway Basins. Note water availability for the Otway Coast only includes the Gellibrand River — page 261 of the CGRSWS discussion draft.

Water resource assessment methodology (current availability)

These figures have been derived by applying the same methodology used in the 2020 Long-Term Water Resource Assessment for Southern Victoria.

For the LTWRA, the data for water availability under current historical climate span the period 1975 to mid-2017. In the current CGRSWS Discussion Draft, the underlying data has been extended by an additional three water years from mid-2017 to mid-2020 using data from the Victorian Water Accounts. Here we provide a brief summary of the methodology, for a detailed description the reader is referred to the Long-Term Water Resource Assessment for Southern Victoria: Overview Report (DELWP, 2020a).

The method assessed river systems for catchments where there are reliable long-term data, and aggregated findings to the river basin scale.[2]

Current average annual surface water availability (Figure 2-3)

When Victoria's 2006 and 2011 sustainable water strategies were published, they used all historical data (stretching back to the 1890s for some rivers) to calculate the long-term average available surface water. Research now indicates that recent decades provide a better representation of current climate than does the full historical record. Therefore, to calculate available surface water, the assessment changed the reference period to be 1975 to current. That period better reflects the changed climate — a slow, long-term influence — than does the full historical record, while also being long enough to absorb shorter-term influences (such as the Millennium Drought).

There are four main methods to measure or model streamflow: gauged streamflow, water balance method, streamflow transposition method and rainfall-runoff models. The choice of methods applied for the LTWRA depended on the nature of the data available for the sub-catchment. Gauged data were used preferentially because they are generally the most accurate, followed by streamflow transposition methods, water balance methods and rainfall-runoff models. (Streamflow data are adjusted to take account of water diversions, losses and impoundments.)

The Long-Term Water Resource Assessment for Southern Victoria calculated average surface water availability over the period from start July 1975 to end June 2017 (There is necessarily a lag between gathering and analysing data and publishing documents). To ensure currency of the data for the CGRSWS Discussion Draft, the water availability data from the Long-Term Water Resource Assessment were extended using three years of data from the Victorian Water Accounts (VWA)[3]. To maximise consistency between the LTWRA and VWA methods for estimating annual water availability at a basin scale, the following adjustments were made to the VWA data where necessary:

1. Subtracting the volume intercepted by domestic and stock dams
2. Scaling the resultant volume by a catchment area adjustment.

This method was endorsed by the Water Resource Availability Technical Working Group as a pragmatic means to balance comprehensiveness and currency in estimates of long-term surface water availability. These adjustments did not change resultant map significantly and is similar to Figure 11 in the Long-Term Water Resource Assessment for Southern Victoria: Overview Report.[4] Small reductions in long-term average annual water availability resulted from including data from 2017-2019, particularly for rivers in East Gippsland that experienced extremely dry conditions over those years.

Historical change (decline) in surface water availability (Figure 2-5, Figure 10-4, Figure 11-4 and Figure 12-5)

The regional map of observed historical change (decline) in long-term water availability (Figure 2-5) and the charts highlighting regional declines (Figure 10-4, Figure 11-4 and Figure 12-5) share the same underlying data. As for the map of current average surface water availability, the method underpinning the calculation of declines is derived from the Long-Term Water Resource Assessment for Southern Victoria, and incorporates updated data. To recap, the LTWRA method compares the long-term estimates of water availability calculated for the last sustainable water strategies (Step A) with current best estimates of long-term water availability (Step B).

> **Step A: Benchmark — Original estimates of historical water availability updated with better data and methods**
>
> Step A uses better data and better models than were available when the original SWS estimates were made in 2006 (for the Central Region SWS) and 2011 (for the Gippsland Region SWS) to recalculate long-term surface water availability. This recalculation of the original SWS estimates provides a benchmark against which the assessment measures long-term changes in surface water availability.

[2] In regulated systems, the LTWRA analysis predominantly took the form of using established water resource models, whereas in unregulated systems, the WMIS gauge network was utilised to ascertain streamflows. Although the LTWRA presented results at the basin scale, the analysis for each catchment within the basins remains and can be used for further discussion of proportional water sharing at this scale.

[3] Data extracted from the Victorian Water Accounts 2017-18, 2018-19 and 2019-20 reports.

[4] Figure 11 (Map of long-term water availability by volume, by river basin) is on page 47 of DELWP (2020) Long-Term Water Resource Assessment for Southern Victorian: Overview Report https://www.water.vic.gov.au/planning/long-term-assessments-and-strategies/ltwra. (Note that the scale was adjusted for the CGRSWS map of total water availability)

These estimates use data as far back as 1890.[5] Estimates of surface water availability at the sub-catchment level were combined and reported at the basin scale.

Step B: Revised estimates of current water availability — Better representation of current climate

Step B updates the period used to estimate long-term surface water availability to be 1975 to mid-2020 as representative of water availability under climatic conditions with levels of greenhouse gases that are more representative of current levels. That is, the estimate of current average annual surface water availability described above and shown in Figure 2-3.[6]

To determine long-term changes in water availability, the assessment compared the Step B estimates with the Step A estimates for the sub-catchments within each basin. These estimates were then aggregated to basin scale to calculate the decline in water availability for the full historical record undertaken by the previous SWS to the average annual inflows during the period 1975 – 2017 for the LTWRA and 1975 – 2020 for the CGRSWS Discussion Draft.

Although we know that climate change is playing a role in our climate and water resource position today, there is uncertainty about how much it has influenced the observed dry conditions since 1997. It is possible that the reductions in rainfall and water availability we are already experiencing are significantly greater than those shown in Figure 2-5, which were based on the period post-1975. For example, the Long-Term Water Resource Assessment found declines of 5 per cent in the Latrobe River since 1975, but a 25 per cent reduction compared to this river's long-term average has occurred since 1997. Additional information on water availability since 1997 is included in the next section.

Average annual surface water availability for the historical climate (Step A), the climate period from 1975 – 2020 (Step B) and percentage decline are provided in Table 1 for each river basin across the Central and Gippsland Region.In Chapter 10 of the CGRSWS Discussion Draft the estimation of decline in water available in rivers in the Gippsland Region since 1997 is based on average annual inflows at basin scale during the period 1997-2020 and compared with full historical inflows estimate from the LTWRA (i.e. 'Step A').

Table 1: Average annual surface water available and decline in each river basin across the Central and Gippsland Region.

Basin	Step A (GL/yr)	Step B (GL/yr)	Decline (%)
East Gippsland	819.3	700.0	15%
Snowy	851.2	746.1	12%
Tambo	324.0	262.7	19%
Mitchell	882.1	755.7	14%
Thomson[7]	1035.6	897.4	13%
Latrobe	872.2	810.6	7%
South Gippsland	753.1	658.6	13%
Bunyip	388.0	357.1	8%
Yarra	1059.6	871.1	18%
Maribyrnong	102.7	81.2	21%
Werribee	95.4	76.1	20%
Moorabool	114.7	89.6	22%

[5] The length of time for which historical streamflow data are available varies between river systems, being longest for river systems around Melbourne, Geelong and Ballarat and shortest for remote rivers, such as in East Gippsland. For the period of time for which streamflow data are available for each river basin, refer to Figure 6 in the Long-Term Water Resource Assessment for Southern Victoria: Overview Report [DELWP 2020].

[6] Note that while climatic conditions experienced since 1997 are also often used as a second representation of current climatic conditions, for simplicity, only the climatic conditions since 1975 are used for these figures. Refer to 'Future water availability' section for additional information and data on water availability since 1997.

[7] Estimation of annual inflows in the Thomson Basin are based on annual inflows from the Thomson-Macalister River over the period 1955-2017, annual inflows from the Avon River 1977-2017, and basin inflows were extended since 2017 using data from the Victorian Water Accounts.

Barwon	262.1	226.3	14%
Otway Coast[8]	589.6	570.1	3%

Plotted data

Average annual surface water availability for the historical climate (Step A), the climate period from 1975 – 2020 (Step B) and percentage decline are provided in Table 1 for each river basin across the Central and Gippsland Region.

In Chapter 10 of the CGRSWS Discussion Draft the estimation of decline in water available in rivers in the Gippsland Region since 1997 is based on average annual inflows at basin scale during the period 1997-2020 and compared with full historical inflows estimate from the LTWRA (i.e. 'Step A').

Future water availability

Figures in the CGRSWS Discussion Draft

This section provides technical information related to Figure 2-6 and Figure 2-7 in the CGRSWS Discussion Draft that describe plausible scenarios of future water availability in the Central and Gippsland Region. These figures are reproduced in this report for ease of reference.

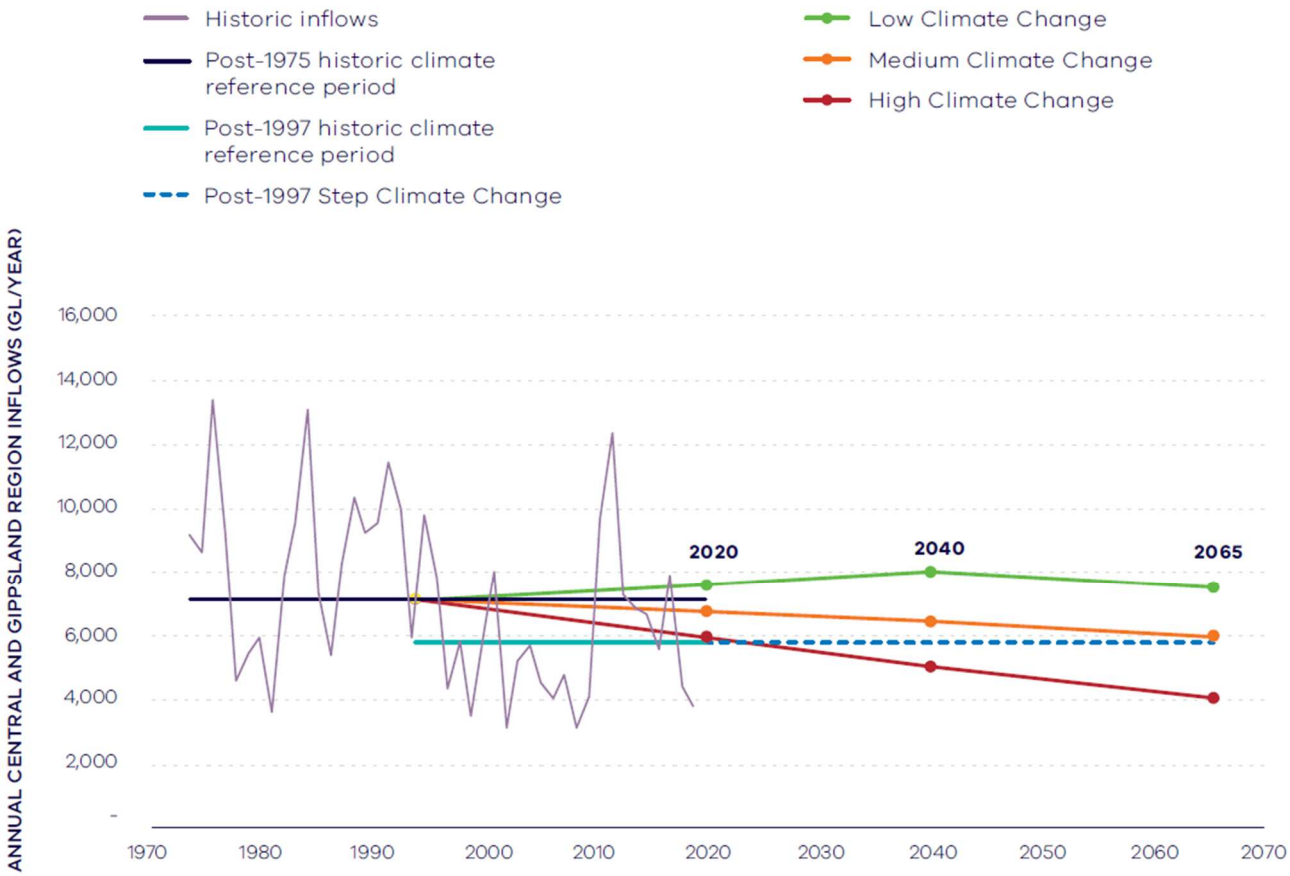


Figure 2-6: Total average annual inflows in the Central and Gippsland Region, current and projected to 2065 under low, medium and high climate change scenarios, and a post-1997 step climate change scenario — page 35 in the CGRSWS discussion draft.

[8] River volumes included in the Otway Coast are the Gellibrand River, Aire River, Barham River, Cumberland River, St George River, Painkalac Creek. The Curdies river is excluded as it lies outside of the CGRSWS region and so the 1975 – 2017 average inflows in the Curdies have been subtracted from the 1975 – 2020 inflows for the whole Otways basin.

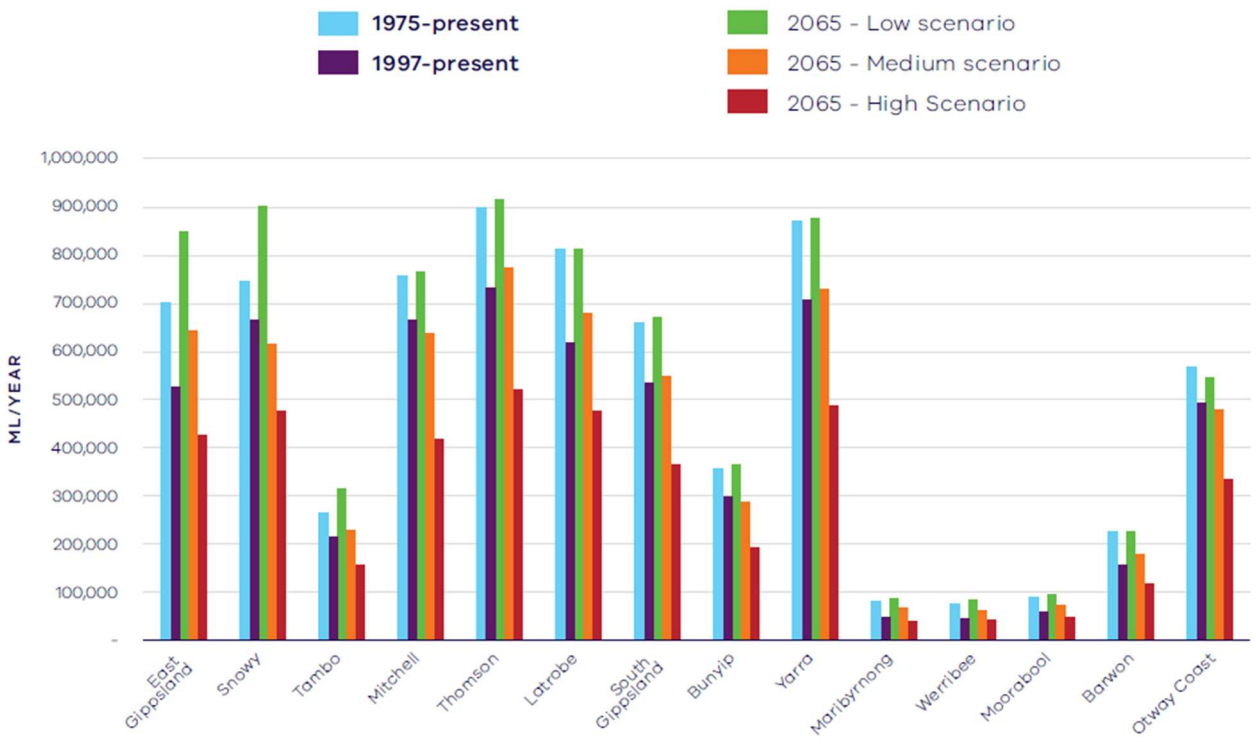


Figure 2-7: Water availability projections for low, medium and high climate change scenarios for 2065, assuming little curbing of greenhouse gas emissions, compared to average annual inflows for two historical reference periods (1975–2018 and 1997–2018) — page 36 in the CGRSWS discussion draft.

Water resource assessment methodology (future availability)

Based on advice from the Water Resource Availability Technical Working group the figures on projected future water availability have been derived by applying the methodology from *The Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP, 2020) referred henceforth as *the Guidelines*. The Guidelines present a consistent approach for considering climate change in water resource modelling and planning in Victoria.

The Guidelines recommend use of two historic climate reference periods and several future climate change scenarios.

If assessing river or supply system behaviour under observed conditions two historic climate reference periods are recommended, namely:

i. A post-1975 historic climate reference period (that is, the current average annual surface water availability calculated as set out for 'Step B' above).

ii. A post-1997 historic climate reference period (this relies on the same underlying annual streamflow data as i) but for a truncated period of 1997-2020).

These historic climate reference periods can be used to communicate streamflow characteristics and supply system performance under historic climate conditions, including historic greenhouse gas concentrations.

If representing river or supply system behaviour under future conditions several climate change scenarios are recommended to represent a plausible range of possible climate futures, namely:

- Low, medium and high climate change scenarios, which are projected from the post-1975 historic climate reference period, with the projected changes commencing from 1995.
- Post-1997 step climate change scenario, which is projected as a continuation of the post-1997 historic climate reference period.

In climate modelling, Representative Concentration Pathways, or RCPs, are scenarios of future greenhouse gas emissions and concentrations over time. Future global greenhouse gas emissions and concentrations are uncertain, so it is unclear which of the RCP pathways the world will ultimately experience. The low, medium and high climate change scenario has been applied to the river basins of the CGRSWS to understand the

impact of projected climate change on water availability to 2065 using the 'RCP8.5 emissions scenario' (which assumes unfettered greenhouse gas emissions).

The Guidelines recommend using the rainfall and streamflow projections based on RCP8.5, because it encompasses the widest range of plausible futures and therefore allows for robust planning. Further information on emissions scenarios is found in Appendix D of the CGRSWS Discussion Draft.

Since 1997, conditions across the region have been drier than that predicted by most global climate models. It is also possible that rather than undergoing a gradual drying trend, streamflows may have undergone a step change, such that drier conditions since 1997 are here to stay. The post-1997 step climate change scenario reflects this possibility.

Total average annual inflows in the Central and Gippsland Region current and projected (Figure 2-6)

The historic total average annual inflows across the entire Central and Gippsland Region are shown in Figure 2-6 along with the post-1975 historic climate reference period and the post-1997 historic climate reference period. Also included in the figure are the average annual inflows projected to 2065 under low, medium and high climate change scenarios and a post-1997 step climate change scenario.

Water availability projections for low, medium and high climate change scenarios for 2065 for each basin in the Central and Gippsland Region (Figure 2-7)

Figure 2-7 contains the same data as Figure 2-6 but presents the water availability estimates for each river basin, rather than the aggregate across the entire Central and Gippsland Region. Figure 2-7 shows the projected average inflows in each river basin under RCP8.5 low, medium and high climate change scenarios, as well as historic inflows in the post-1997 historic reference period. Together the low, medium and high climate change and post-1997 step climate change scenarios illustrate a plausible range of future average annual water availability.

Plotted data

The data used to plot Figure 2-6 is provided in Table 2 which is based on historical inflow data to mid-2020 and climate change projections documented in the Guidelines. For comparative purposes Figure 2-6 also has the post-1975 historic climate reference period average annual inflows which are 7102 GL/year, and the post-1997 historic climate reference period average annual inflows which are 5825 GL/year.

Table 2: Total average annual inflows (GL/year) in the Central and Gippsland Region, current and projected to 2065 under RCP8.5 low, medium and high climate change scenarios.

	Time slice			
Scenarios	**1995**	**2020**	**2040**	**2065**
RCP8.5 Low Climate Change	7102	7615	8026	7502
RCP8.5 Medium Climate Change	7108	6737	6446	5996
RCP8.5 High Climate Change	7108	5976	5073	4087

The data used to plot water availability projections in each basin across the Central and Gippsland Region in Figure 2-7 is provided in Table 3 which is based on historical inflow data to mid-2020.

Table 3: Average annual water availability under scenarios of projected (proj.) low, medium and high climate change for 2065, assuming little curbing of greenhouse gas emissions (RCP8.5), compared to average annual inflows for two historical climate reference periods (1975–2020 and 1997–2020).

Basin	Post-1975 historic climate reference period	Post-1997 historic climate reference period	RCP8.5 Low climate change in 2065		RCP8.5 Medium climate change in 2065		RCP8.5 High climate change in 2065	
			Factor*	Proj. (GL/year)	Factor*	Proj. (GL/year)	Factor*	Proj. (GL/year)
East Gippsland	700.0	526.2	21.4%	849.8	-8.1%	643.3	-39.3%	424.9
Snowy	746.1	666.5	21.0%	902.8	-17.9%	612.5	-36.1%	476.8
Tambo	262.7	215	20.6%	316.8	-13.1%	228.3	-40.0%	157.6
Mitchell	755.7	665.5	1.5%	767.0	-15.6%	637.8	-44.7%	417.9
Thomson	897.4	732.7	2.0%	915.3	-13.9%	772.7	-41.9%	521.4
Latrobe	810.6	617.7	0.1%	811.4	-16.3%	678.5	-41.5%	474.2
South Gippsland	658.6	535.2	1.6%	669.1	-16.9%	547.3	-44.8%	363.5
Bunyip	357.1	299.5	1.5%	362.5	-19.1%	288.9	-47.0%	189.3
Yarra	871.1	708.7	0.8%	878.1	-16.4%	728.2	-44.3%	485.2
Maribyrnong	81.2	48.6	5.1%	85.3	-20.0%	65.0	-55.4%	36.2
Werribee	76.1	43.8	7.5%	81.8	-18.1%	62.3	-45.5%	41.5
Moorabool	89.6	57	5.5%	94.5	-17.3%	74.1	-45.6%	48.7
Barwon	226.3	155.9	-0.8%	224.5	-21.6%	177.4	-47.6%	118.6
Otway Coast	570.1	494.2	-4.7%	543.3	-15.8%	480.0	-41.9%	331.2

* Projected change in average annual runoff from Table 6 of the *Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP, 2020).

Unallocated water

Figures in the CGRSWS Discussion Draft

This section provides technical information related to Figure 2-8 (repeated as Figure 4-9) and Figure 2-9 (repeated as 4-10) in the CGRSWS Discussion Draft that describe unallocated surface water and groundwater in the Central and Gippsland Region. These figures are reproduced in this report for ease of reference.

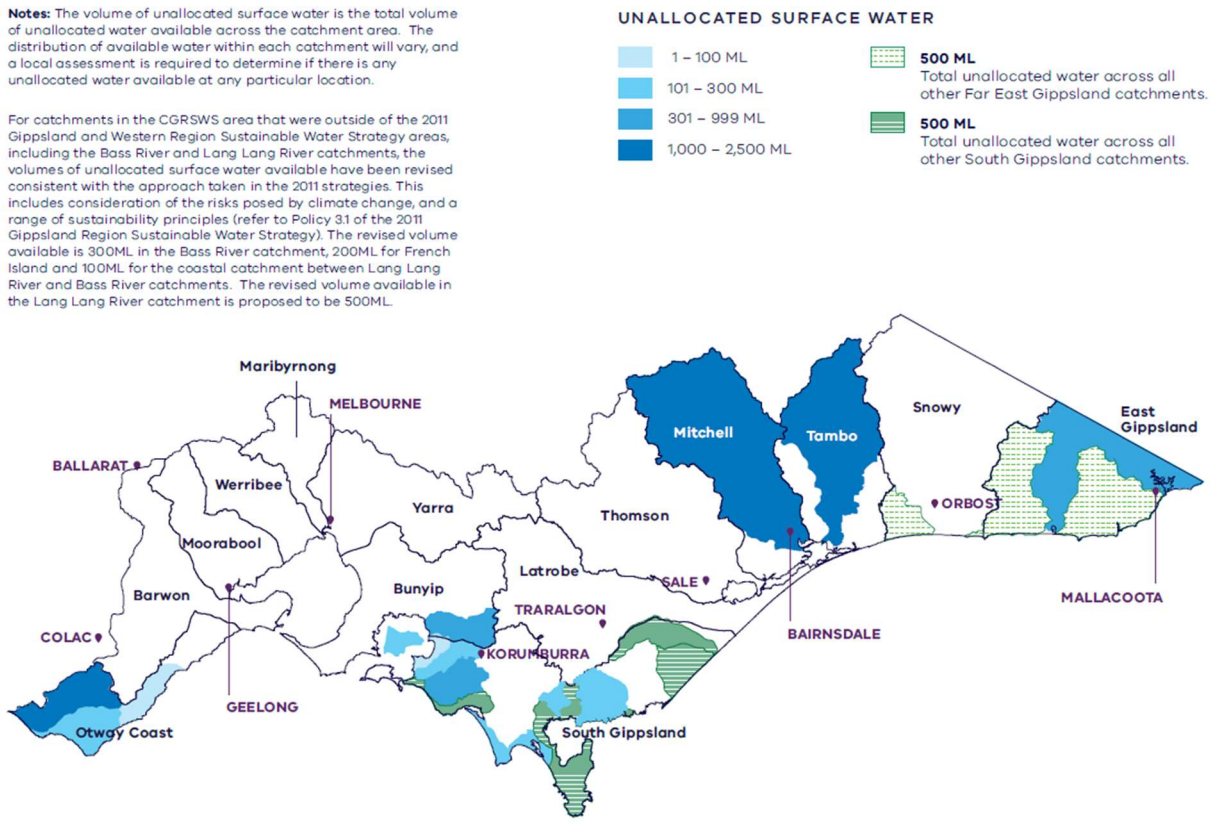


Figure 2-8: Unallocated surface water in the Central and Gippsland Region[9] — page 37 in the CGRSWS discussion draft.

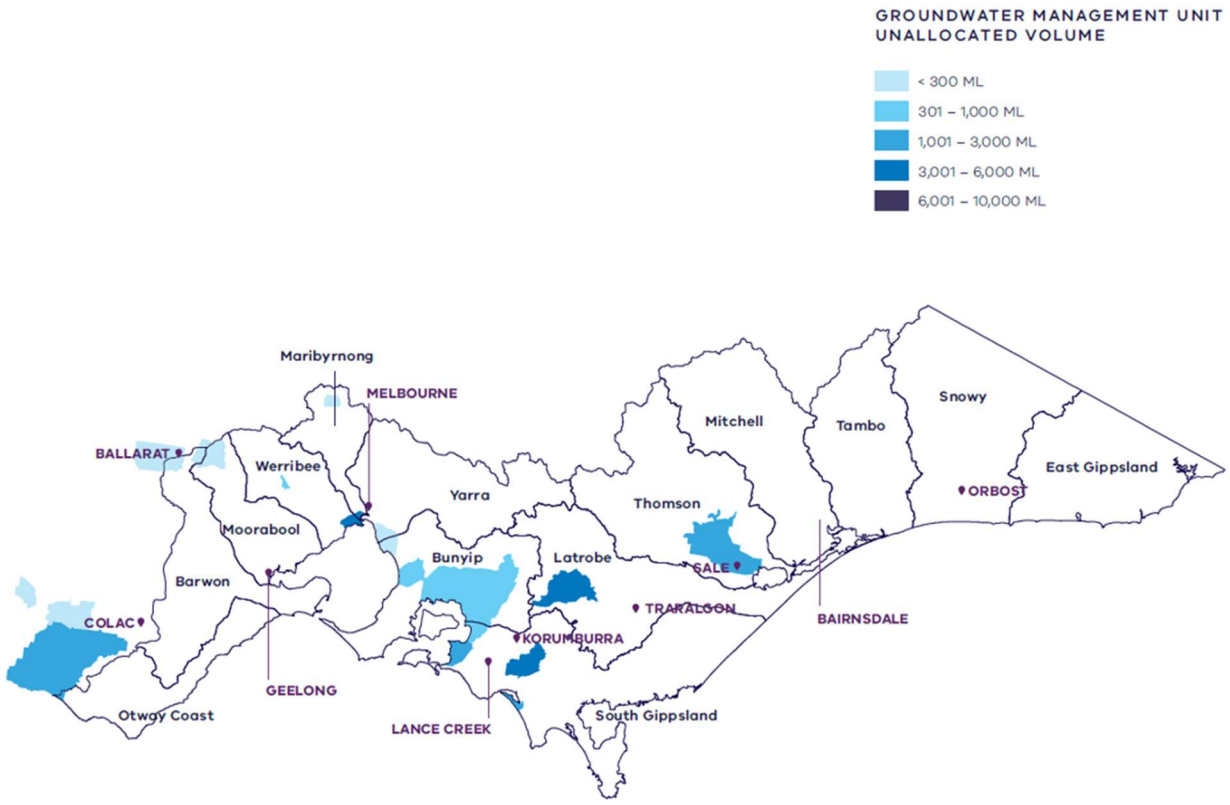


Figure 2-9: Unallocated groundwater across the Central and Gippsland Region — page 39 in the CGRSWS discussion draft.

[9] Takes account of recent allocation of 2 GL of water to Traditional Owners and the auction of 2 GL of entitlements to irrigators.

Water resource assessment methodology (unallocated water)

Surface water

The volume of unallocated (available) water for consumptive use in the river basins of the CGRSWS region has been identified considering the potential for impacts on water supply security, reduced stream flows and baseflows in waterways and declines in water quality and health. Sustainable diversion limits have been developed across Victoria and represent the upper limit on winterfill diversions, beyond which there is an unacceptable risk that additional extractions may degrade the environment. The sustainable diversion limits guide decisions about whether any new entitlements (take and use licences) may be issued.[10] Most river basins in the region are already fully allocated and there is limited potential for further development. There is approximately 18.5 GL of unallocated water across the region — which is less than 0.3% of the average flow in rivers annually.

Unallocated water figures in the CGRSWS Discussion Draft were sourced from work undertaken during previous SWSs and matched to catchment sustainable diversion limits. During the past SWSs, the cap on the amount of unallocated surface water available for winterfill was revised (reduced) in several catchments. Since then, there have been some allocations of water made by SRW in the South Gippsland, Mitchell and Tambo basins. 2 GL/year was recently allocated to the Gunaikurnai Land and Waters Aboriginal Corporation under a Section 51 licence for cultural water. Furthermore, an auction of take and use licences (under section 51) for unallocated Mitchel River winterfill was opened by SRW in May 2021. As a result, 2 GL/year was allocated to 36 bidders, ranging in volume from 30 ML to 100 ML.

The volumes of unallocated surface water available in the Bass River and Lang Lang River catchments have been revised consistent with the approach taken in the 2011 Gippsland Region SWS.

Groundwater

In most areas of the region with available good quality and high yielding groundwater resources, use of groundwater is capped and fully allocated. The potential for further development could occur through trade from licences holders who do not fully use their entitlement. Groundwater use fluctuates year to year between 30-40 per cent of the entitlement volume. In some places, up to 70 per cent of groundwater allocated under the entitlement system is unused.

Volumes are current as per June 2020. ‘Refer Southern Rural Water’s website on groundwater management rules to determine if new entitlements may be available. Note that areas with volumes of unallocated groundwater below 40 ML are not shown.

Plotted data

Unallocated surface water is provided in Table 4 for each river in the Central and Gippsland Region.

[10] Victoria winterfill sustainable diversion limits are different to sustainable diversion limits defined for the Murray-Darling basin..

Table 4: Unallocated surface water in each river basin across the Central and Gippsland Region.

River	Unallocated surface water (ML)
Aire River	300
Albert River	300
Bass River[6]	300
Cann River	500
Coastal	501
Dividing Creek	300
Franklin River	300
French Island[11]	200
Johanna River	300
Parker River to Skenes Creek	300
Powlett River	500
Shady Creek & Nine Mile Creek	300
Tambo River	1476
Ten Mile Creek	300
Mitchell River	2000
Otways other	90
Genoa River	500
Gellibrand River	1000
Lang Lang River[8]	500
South Gippsland Coastal[8]	100
South Gippsland other	500
Far East Gippsland other	500

11. For catchments in the CGRSWS area that were outside of the 2011 Gippsland and Western Region Sustainable Water Strategy areas, including the Bass River and Lang Lang River catchments, the volumes of unallocated surface water available have been revised consistent with the approach taken in the 2011 SWS. This includes consideration of the risks posed by climate change, and a range of sustainability principles (refer to Policy 3.1 of the 2011 Gippsland Region Sustainable Water Strategy). The revised volume available is 300ML in the Bass River catchment, 200ML for French Island and 100ML for the coastal catchment between Lang Lang River and Bass River catchments. The revised volume available in the Lang Lang River catchment is proposed to be 500ML.

Unallocated groundwater is provided in Table 5 for each system in the Central and Gippsland Region.

Table 5: Unallocated groundwater in each system across the Central and Gippsland Region.

System	Unallocated groundwater (ML)
Bungaree	41
Cardigan	78
Colongulac	291
Corinella	1888
Cut Paw Paw	3139
Frankston	988
Glenormiston	62
Koo Wee Rup	340
Lancefield	108
Leongatha	4697
Merrimu	441
Moe	4315
Moorabbin	76
Paaratte	1394
Tarwin	1242
Wa De Lock	1670

Trends in production and use of recycled water

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 2-11 in the CGRSWS Discussion Draft that describes trends in production and use of recycled water in the Central and Gippsland Region. This figure is reproduced in this report for ease of reference.

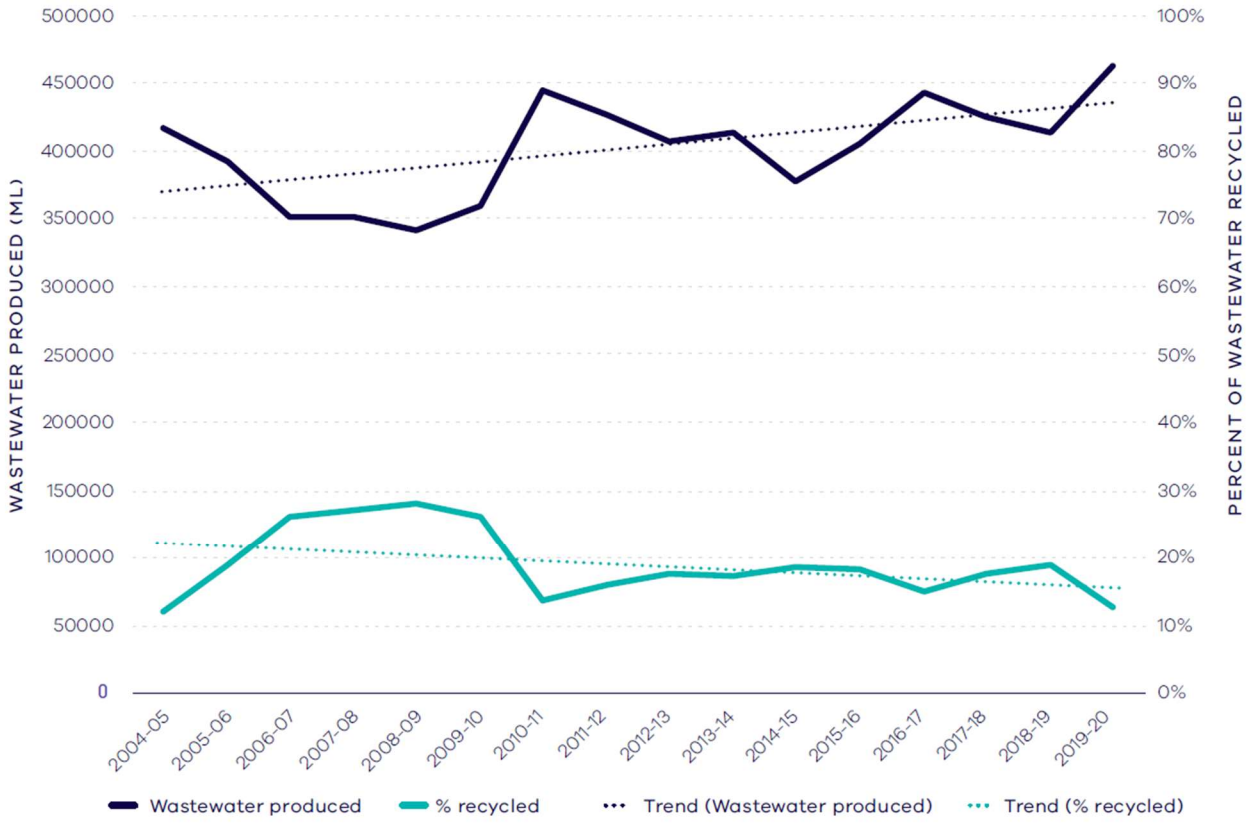


Figure 2-11: Trends in production and use of recycled water in the Central and Gippsland Region - page 42 in the CGRSWS discussion draft.

In Figure 2-11 the percent recycled shows a downward trend for the plotted period (green dotted line). This downward trend occurs due to higher recycling rates during the driest years of the Millennium Drought (solid green line in 2005-2010). During these dry years lower volumes of wastewater were produced (solid black line in 2005-2010) and there was likely to have been a temporary increase in the use of recycled water to off-set water restrictions.

Plotted data

Figure 2-11 was produced using the data supplied by water corporations as part of their Victorian Water Account reporting. This data is published in the Victorian Water Accounts 2019/2020 (DELWP, 2020c).

Water orders for the desalination project

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 2-12 in the CGRSWS Discussion Draft that describes water orders for the Victorian Desalination Project. This figure is reproduced in this report for ease of reference.

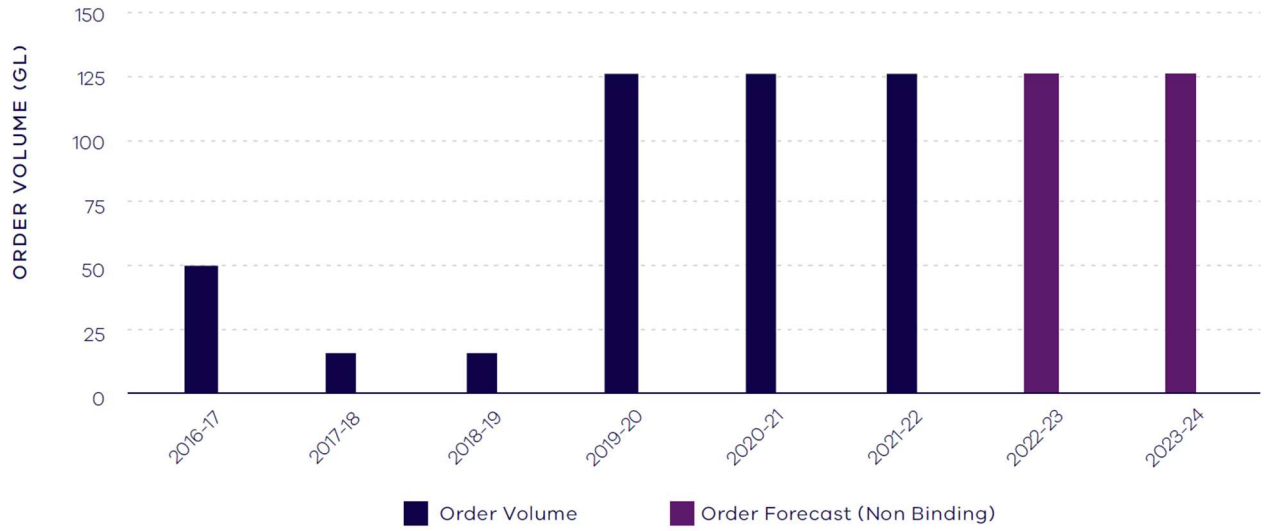


Figure 2-12: Water orders for the Victorian Desalination Project, 2016–24 - page 43 in the CGRSWS discussion draft.

Plotted data

The data used to plot Figure 2-12 is provided in Table 6. Note that the orders forecast in 2022-23 and 2023-24 are non-binding and will be revised at the actual time of future order placement to reflect prevailing conditions.

Table 6 – Water orders (GL) for the Victorian Desalination Project, 2016–24.

Financial year	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Ordered volume/order forecast (non-binding)	50	15	15	125	125	125	125	125

Chapter 3: Water users and values — now and in the future

Sharing of surface water

Figures in the CGRSWS Discussion Draft

This section provides technical information related to Figure 3-2 and Figure 3-3 in the CGRSWS Discussion Draft that describe sharing of surface water in the Central and Gippsland Region. These figures are reproduced in this report for ease of reference. Additional sharing of surface water figures that are not included in this technical guide for the sake brevity are those included in Table 10-1, Table 11-1, and Table 12-1 of the CGRSWS Discussion Draft. These figures highlight an approximate distribution of surface water and groundwater entitlements across different users in the Central and Gippsland Region.

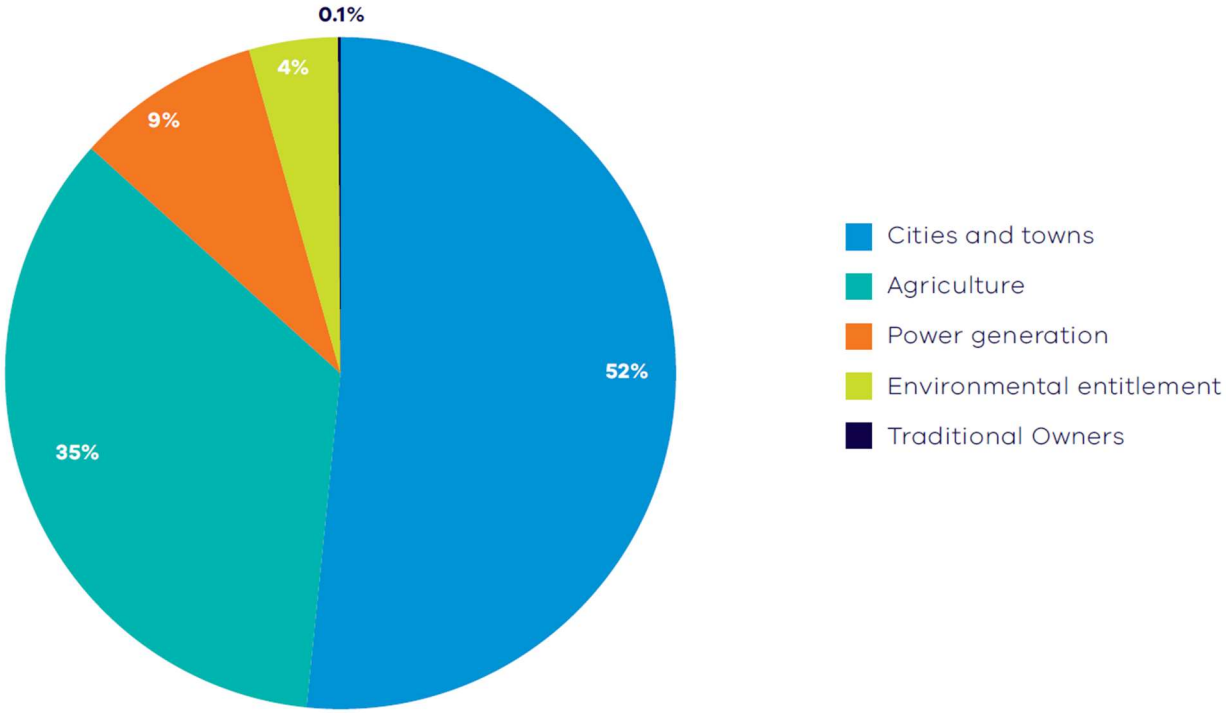


Figure 3-2: Approximate distribution of surface water and groundwater entitlements across different uses in the Central and Gippsland Region. Surface water makes up 85 per cent of entitlements, while groundwater is 15 per cent — page 47 in the CGRSWS discussion draft.

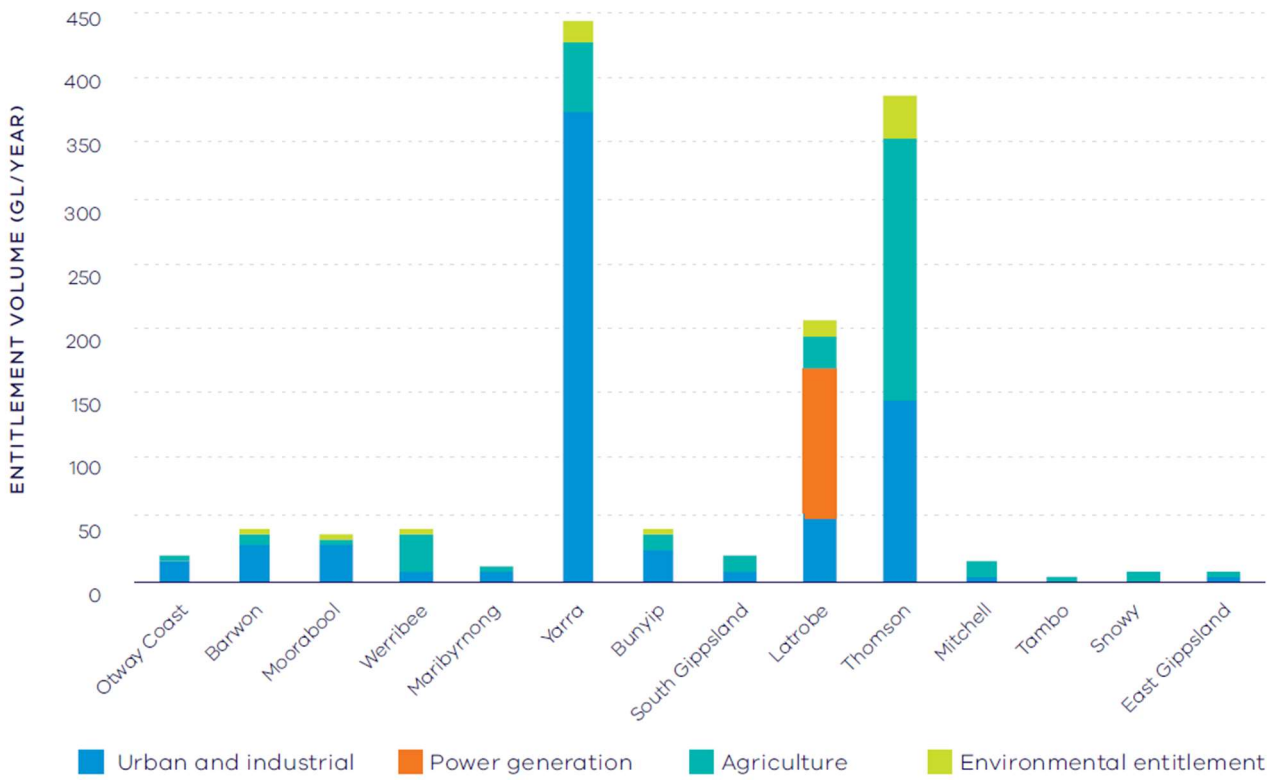


Figure 3-3: River water allocated for consumptive uses and sharing arrangements in the region's basins — page 48 in the CGRSWS discussion draft

Water resource assessment methodology (water allocation)

Groundwater

Note that Figure 3-2 combines data on both surface (river) water and groundwater allocation into a single pie chart. The groundwater data is simply entitlement volume, taken from the Victorian Water Accounts 2018/19 edition (DELWP, 2019b) and categorised according to use type. This assumes that all water allocated under groundwater entitlements is available every year.

Surface water

These figures have been derived by applying the same method used in the 2020 Long-Term Water Resource Assessment for Southern Victoria. Here we provide a brief summary of the methodology, for a detailed description of this methodology the reader is referred to the LTWRA Overview Report (DELWP, 2020a).

Under the water entitlement framework, the Minister for Water issues bulk entitlements to urban and rural water corporations to take water from waterways to supply their customers for consumptive uses. Latrobe Valley power stations also hold bulk entitlements. Bulk entitlements impose conditions on take for reasons such as to maintain passing flows in waterways. The Minister also issues licences (such as Section 51 licences to almost 19,000 private diverters across the state to take and use water for consumptive uses).

The Minister also issues environmental water entitlements to the Victorian Environmental Water Holder.

An entitlement is to a share of a nominal volume of water that the entitlement holder is authorised to take, store and use under specific conditions if it is available: it is not an entitlement to actual water under all conditions.

The volume of water actually available for consumptive uses depends on:

- the rules in each water entitlement: for example, typically the entitlement holder is only allowed to take up to a specified volume of water, although there may be much more than that available in the system
- the volume of water available at the point of diversion: in dry years, when there is less water than average, the volume of available water is likely to be less than the face-value volume of the entitlement. In wet (above-average) years, there is normally enough water for the entitlement holder to take up to the face value of their entitlement

- the ability to store and deliver water: for example, the water is available for taking, but the entitlement holder doesn't have the infrastructure to take / store it
- the timing of the demand for water: for example, the water is available, but not when it's needed (such as if it is available in winter but the entitlement holder's crops need water in summer)
- water security considerations: for example, a water corporation will typically hold back some water in reserve in storage to manage the risk of future drought and ensure that water is available for the following year.

Water available is water that is actually available to be taken under the terms and conditions of entitlements and licences by those who hold them, on average, under long-term climatic conditions. It is also referred to as water available for allocation. **Water available is not the same as the face value of the entitlement**.[12]

Nor is water available the same as the volume actually taken in the past: that is, the historical level of use. Water entitlements typically have been issued with an allowance for future growth in demand for water, so actual use can be below the volume allocated to that user. Some water-taking does not require the Minister's approval: for example, people can take water from a range of sources for domestic and stock purposes as a 'Section 8 private right'. This water is outside of the water entitlement system and therefore, has not been allocated to consumptive use in the assessment.

Figure 3-2 (surface water component) and Figure 3-3 use data on water allocation taken directly from the 2020 Long-Term Water Resource Assessment for Southern Victoria. That is, the data represent average annual water available to be taken under climatic conditions over 1975-2017, with water entitlements in place at 2017. [There have been some small changes to water entitlements since 2017; notably the allocation of 2 GL/year in the Mitchell River to Traditional Owners, an additional 2 GL/year of Mitchell River water entitlements purchased by irrigators in 2021, and recently Barwon Water has updated the yield level of demands for Geelong and Colac supply systems. The figures on surface water allocated have been updated accordingly for the CGRSWS Discussion Draft.]

Plotted data

Sharing of surface water for each river basin across the Central and Gippsland Region is provided in Table 7. Groundwater used for consumptive purposes in the region's Groundwater Catchments is provided in Table 7. Power generation in the Latrobe valley accounts for 116.3 GL/year[13] and water for Traditional Owners in the Mitchell accounts for 2.0 GL/year. Water available for consumptive uses is not the same as the volume actually taken in the past: that is, the historical level of use. Water entitlements typically have been issued with an allowance for future growth in demand for water, so actual use can be below the volume allocated to that user.

[12] The Victorian Water Accounts report the face value of entitlements issued for each river basin and groundwater catchment in Victoria as well as annual usage for each bulk entitlement. For example, the annual entitlement volume in the Yarra basin on 30 June 2019 was 466,037 ML whilst water taken for the same year was 395,856 ML.

[13] 116 GL/year allocated to power generation assumes conservative use against power generation entitlements as follows, supply to: Yallourn 29.2 GL/yr; Loy Yang A 32.0 GL/yr, Loy Yang B 16.0 GL/yr; Loy Yang 3-4 Bench 20.0 GL/yr; total other supply under supplement by agreement with Gippsland Water 19.1 GL/yr.

Table 7: Average annual river water available (1975 – 2017) and sharing arrangements in the region's basins.

Basin	Urban and industrial (GL/year)	Power generation (GL/ year)	Agriculture [14] (GL/ year)	Environmental entitlement (GL/ year)	Traditional Owners (GL/year)
Otway Coast	16	-	3	0	-
Barwon[15]	25	-	7	1	-
Moorabool[15]	27	-	3	2	-
Werribee[16]	4	-	25	1	-
Maribyrnong[17]	3	-	3	0	-
Yarra	373	-	53	17	-
Bunyip	26	-	12	2	-
South Gippsland	8	-	10	0	-
Latrobe	52	116	26	14	-
Thomson	142	-	209	33	-
Mitchell	4	-	10	0	2
Tambo	0	-	4	0	-
Snowy	0	-	5	0	-
East Gippsland	1	-	1	0	-

Notes to table:
a. Calculated from water system modelling
b. These estimates are on the basis of full uptake of entitlements
c. Does not include stock & domestic dams
d. Only regulated environmental entitlements are included

14. Includes licensed farm dams.
15. In 2020, Barwon Water updated the yield level of demands for Geelong and Colac systems.
16. The supply from Melbourne interconnected system to urban demands in the Werribee basin has increased due to recent changes in operational rules; hence, less local catchment water is required to supply urban users.
17. Western Water made de decision to supply Sunbury entirely from the Melbourne system – a decision that increased supply from Melbourne by 2,433 ML/year and decreased supply from Rosslynne Reservoir by an equivalent amount.

Table 8: Groundwater used for consumptive purposes in the region's Groundwater Catchments 2019-20

Groundwater catchment	Irrigation / commercial (GL/year)	Salinity control (GL/year)	Domestic and stock[18] (GL/year)	Urban (GL/year)	Power generation (GL/year)
Central Gippsland	38	1	2	2	23
East Gippsland	0	-	0	0	-
East Port Phillip Bay	6	-	4	-	-
Moe	1	-	0	-	-
Otway Torquay	0	-	0	2	-
Seaspray	7	-	0	0	-
Tarwin	0	-	1	-	-
West Port Phillip Bay	2	-	2	0	-
Westernport	3	-	1	0	-

Projected populations

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 3-4 in the CGRSWS Discussion Draft that describes past and projected populations of major Victorian regions, 2016 to 2056 Central and Gippsland Region. This figure is reproduced in this report for ease of reference.

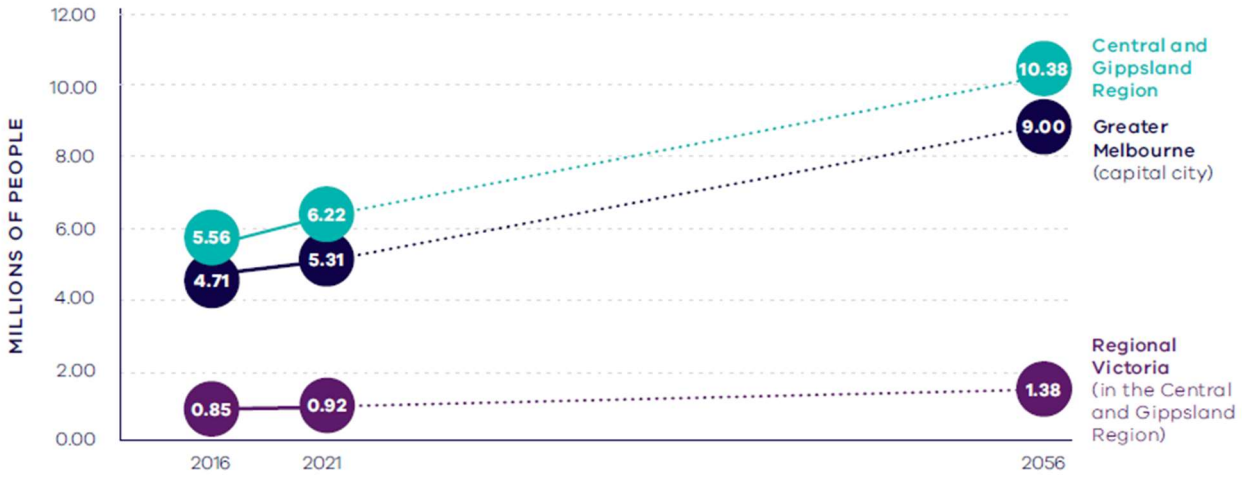


Figure 3-4: Past and projected populations of major Victorian regions, 2016-2056 - page 49 in the CGRSWS discussion draft.

Population projection methodology

Victoria in Future (VIF) is the official State government projection of population and households. Projections are based on trends and assumptions for births, life expectancy, migration, and living arrangements across all of Victoria.

Figure 3-4 has been derived by applying the VIF components of population change, households, dwellings and population by age and sex, for Victoria's Major Regions from 2016 to 2056. Major Regions include the state, Greater Melbourne GCCSA (Greater Capital City Statistical Area) and four of the eight non-metropolitan SA4s (Statistical Area Level 4) that are within the Central and Gippsland Region boundary. Grand totals for four regions are labelled here as "Regional Victoria (in the Central and Gippsland Region)". The Warrnambool and south west SA4 is included even though part of the SA4 is outside the Central and Gippsland Region SWS

18. Domestic and stock usage data is an estimate only.

border as a proportion of this spatial area includes the Otways region and Colac which rely on water from catchments within the Central and Gippsland Region. Figures are rounded to the nearest 10,000.

Plotted data

Past and projected populations of major Victorian regions are provided in Table 9.

Table 9: Past and projected populations of major Victorian regions, 2016-2056

Region	2016	2021	2056
Greater Melbourne Capital City Statistical Area	4,714,387	5,306,133	9,001,273
Ballarat SA4	159,99	172,273	259,456
Geelong SA4	286,384	324,756	569,426
Latrobe - Gippsland SA4	275,780	293,555	413,727
Warrnambool and South West SA4	124,491	126,069	133,438
Central and Gippsland Region Total	5,401,042	6,222,785	10,377,320

Environmental water deficits

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 3-8 in the CGRSWS Discussion Draft that describes environmental water deficits in the Central and Gippsland Region. This figure has been reproduced in this report for ease of reference.

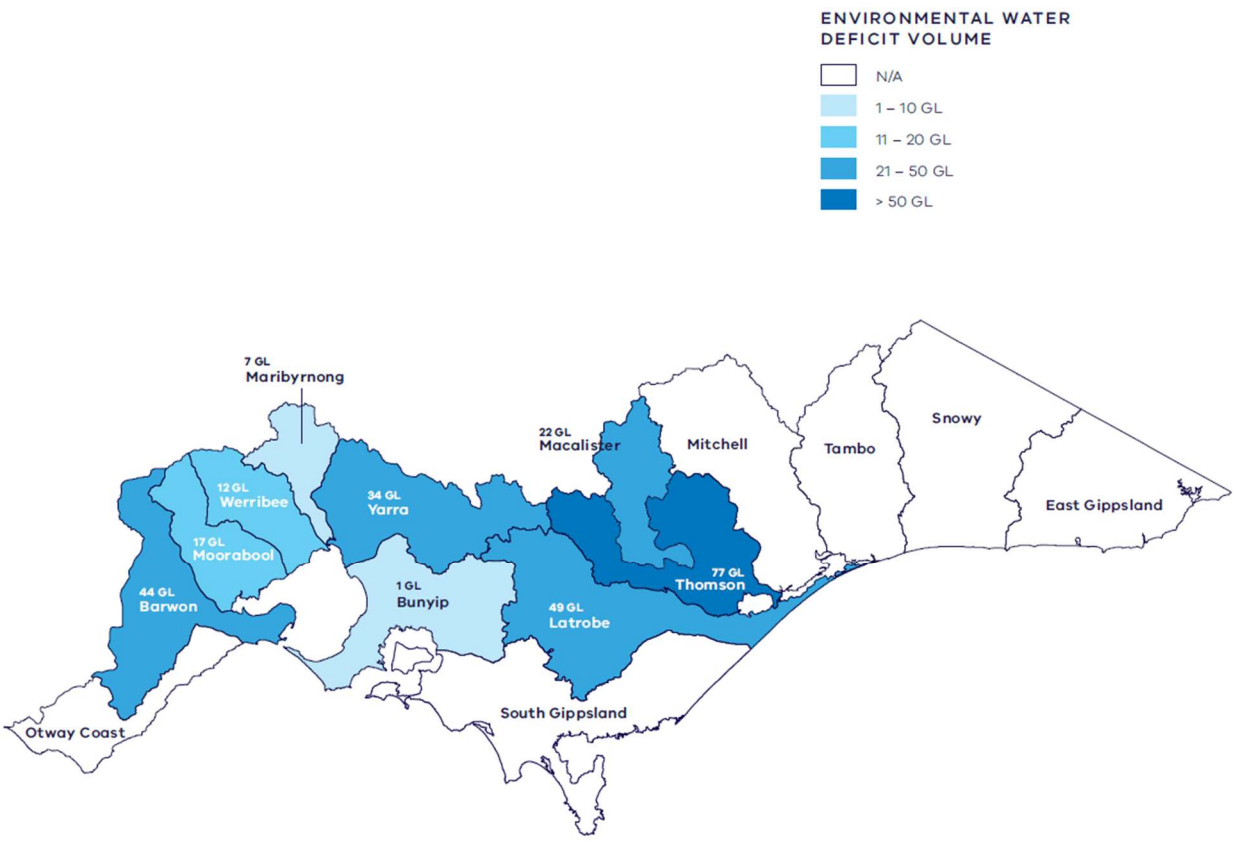


Figure 3-8: Total environmental water deficits (based on post-1975 baseline) — page 55 in the CGRSWS discussion draft.

Water resource assessment methodology (environmental water deficits)

Environmental water deficits are the additional volume of water required (or deficit) to move from the current flow regime in a particular waterway to that required to meet the recommended environmental flows to support the values in that waterway.

Figure 3-8 is a map of environmental water deficits for each catchment area map based on data from FLOWS studies.

FLOWS studies tell us about the timing, duration and amount of water needed by native plants and animals. FLOWS studies also:

- Determine the water (flow) regime required to support environmental values and objectives identified for a river or estuary system.
- Are best practice science (robust and transparent).
- Provide the evidence base for negotiations and decision-making on water recovery projects.

Generally, Figure 3-8 is a straight-forward data visualization with a “neatness” belying the underlying complexity of the data derivation. The Macalister River has been identified separately to the Thomson River- even though both lie within the Thomson river basin to better spatially represent environmental water deficits that accumulate along a river system.

Within the context of the environmental water deficits maps, the ‘N/A’ categorisation in Figure 3-8 refers to sites that have not been identified as priority flow-stressed waterways and/or have not yet determined future environmental water requirements using robust hydrological modelling (i.e. through a FLOWS study).

Plotted data

The environmental water deficit for each river basin across the Central and Gippsland Region used data up to mid-2017. Data to plot Figure 3-9 in the CGRSWS Discussion Draft appears in Table 3-1 of the CGRSWS Discussion Draft. Note that these environmental water deficits are based on a baseline of climatic conditions experienced since 1975.

Chapter 5: How we use water efficiently

Main components of the Victorian Government's current Water Efficiency Program

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 5-1 in the CGRSWS Discussion Draft that describes the main components of the Victorian Government's current Water Efficiency Program. This figure is reproduced in this report for ease of reference.

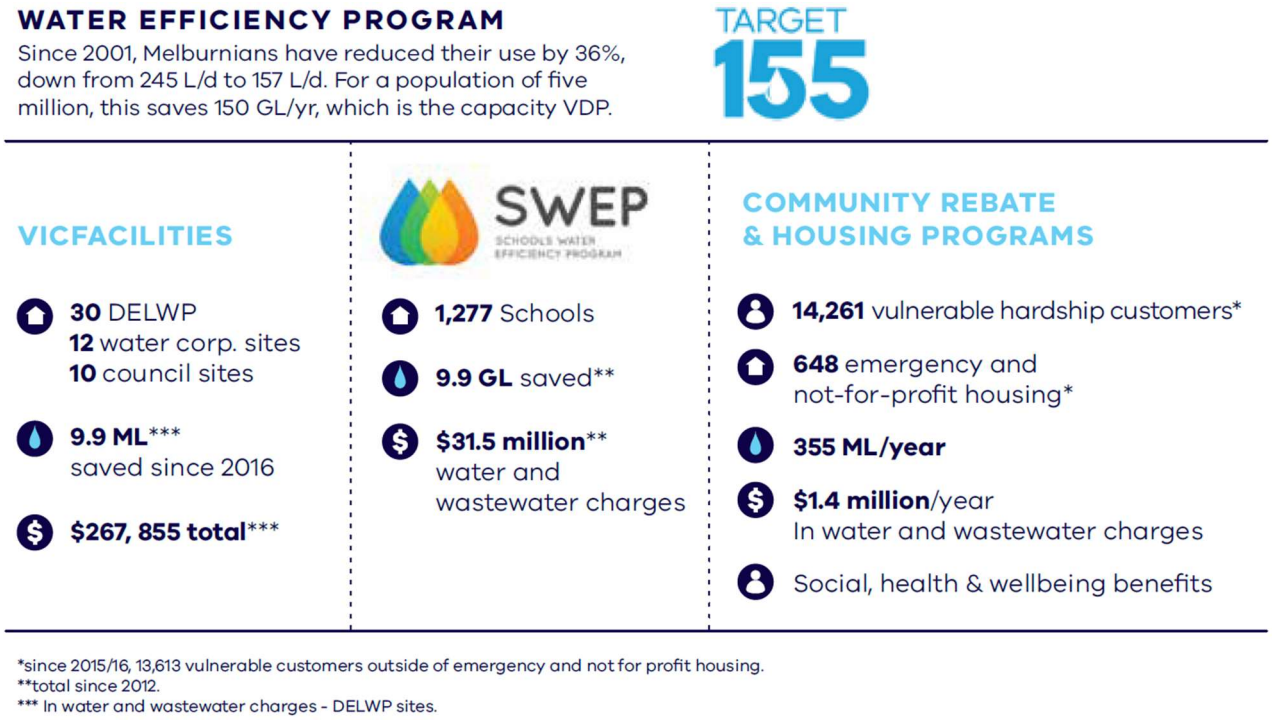


Figure 5-1: Main components of the Victorian Government's current Water Efficiency Program - page 99 in the CGRSWS discussion draft.

Water resource assessment methodology (water efficiency)

The Melbourne annual per capita water consumption data (in L/person/day) is provided by the metropolitan water corporations, through their Annual Reports. The Schools Water Efficiency Program (SWEP) figures are taken from DELWP's evaluation of the program. The remaining figures have been calculated from data provided by the water corporations delivering these programs.

Breakdown of total water demand within cities and towns across the Central and Gippsland Region 2019-2020

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 5-2 in the CGRSWS Discussion Draft that describes a breakdown of total water demand within cities and towns across the Central and Gippsland Region 2019-2020. This figure is reproduced in this report for ease of reference.

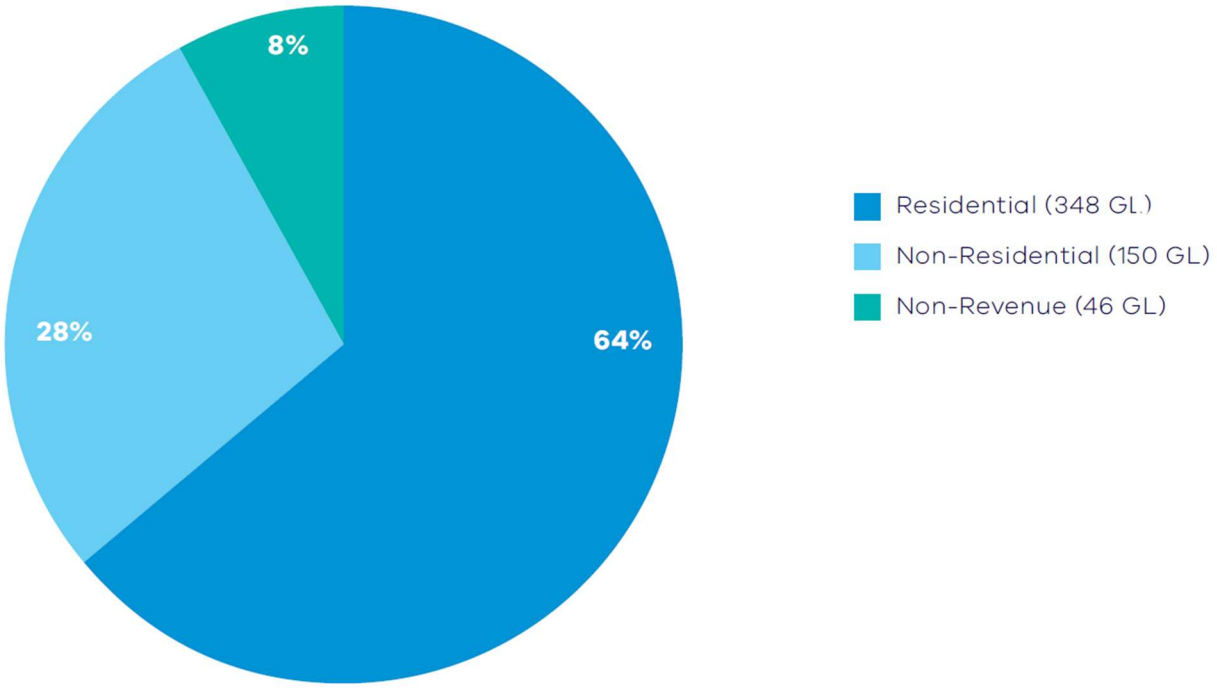


Figure 5-2: Breakdown of total water demand within cities and towns across the Central and Gippsland Region (where the majority of non-revenue water is system leakage) - page 100 in the CGRSWS discussion draft.

Plotted data

The data underlying Figure 5-2 was provided directly to DELWP by the CGRSWS water corporations.

Chapter 6: How we grow our water supplies

Manufactured water resources for Greater Melbourne

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 6.1 in the CGRSWS Discussion Draft that describes the current and possible projected uptake of future water sources in the Central and Gippsland Region. This figure is reproduced in this report for ease of reference.

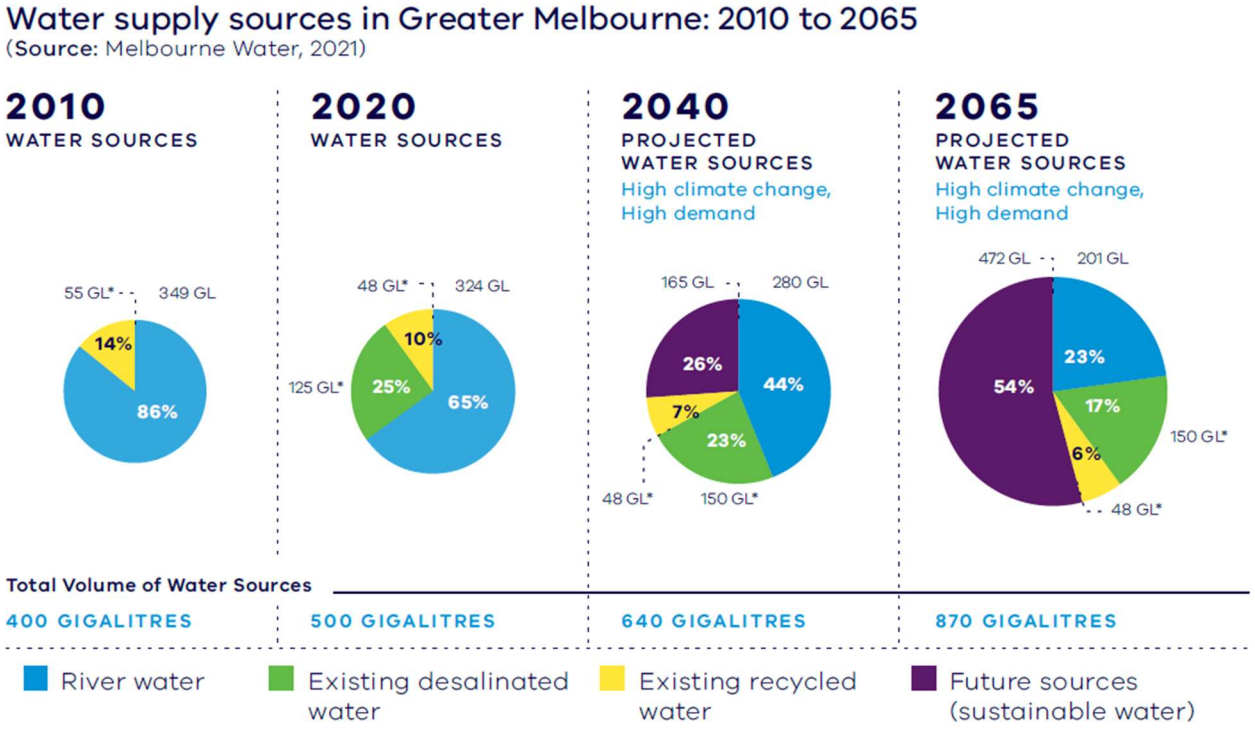


Figure 6-1: Expected transition from reliance on river water to more manufactured water for Greater Melbourne (prepared by Melbourne Water, 2021) - page 121 in the CGRSWS discussion draft.

Water resource assessment methodology (manufactured water)

The 2010 and 2020 data are based on actual demands and water being used from sources as recorded by Melbourne Water.

The 2040 and 2065 river water, existing desalinated water and existing recycled water data are based on projected yields under a high climate change high demand scenario. The future sources volumes are based on shortfalls between projected yields and demands (Melbourne Water, 2017). Current environmental water requirements have been included as allocations in 2040 and 2065 projections.

In all four time-horizons, observed and projected water source yields were then converted to a percentage based on the total water volume for that time-period. Total volumes were rounded to the nearest 10 gigalitres.

Plotted data

The data supporting Figure 6-1 on the expected transition from reliance on river water to more manufactured water for Greater Melbourne is provided in Table 10.

Table 10: Expected transition from reliance on river water to more manufactured water for Greater Melbourne.

Year	Surface Water (GL)	Desalination (GL)	Recycled water (GL)	Future water sources (manufactured water) (GL)	Total (GL)
2010	349	0	55	0	**404**
2020	324	125	48	0	**497**
2040	280	150	48	165	**643**
2065	201	150	48	472	**871**

Chapter 7: How we use all sources of water

Example of a regional water balance for Bannockburn – volumes 2020 to 2050

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 7-2 in the CGRSWS Discussion Draft that describes an example of a regional water balance for Bannockburn with volumes in 2020 and 2050. This figure is reproduced in this report for ease of reference.

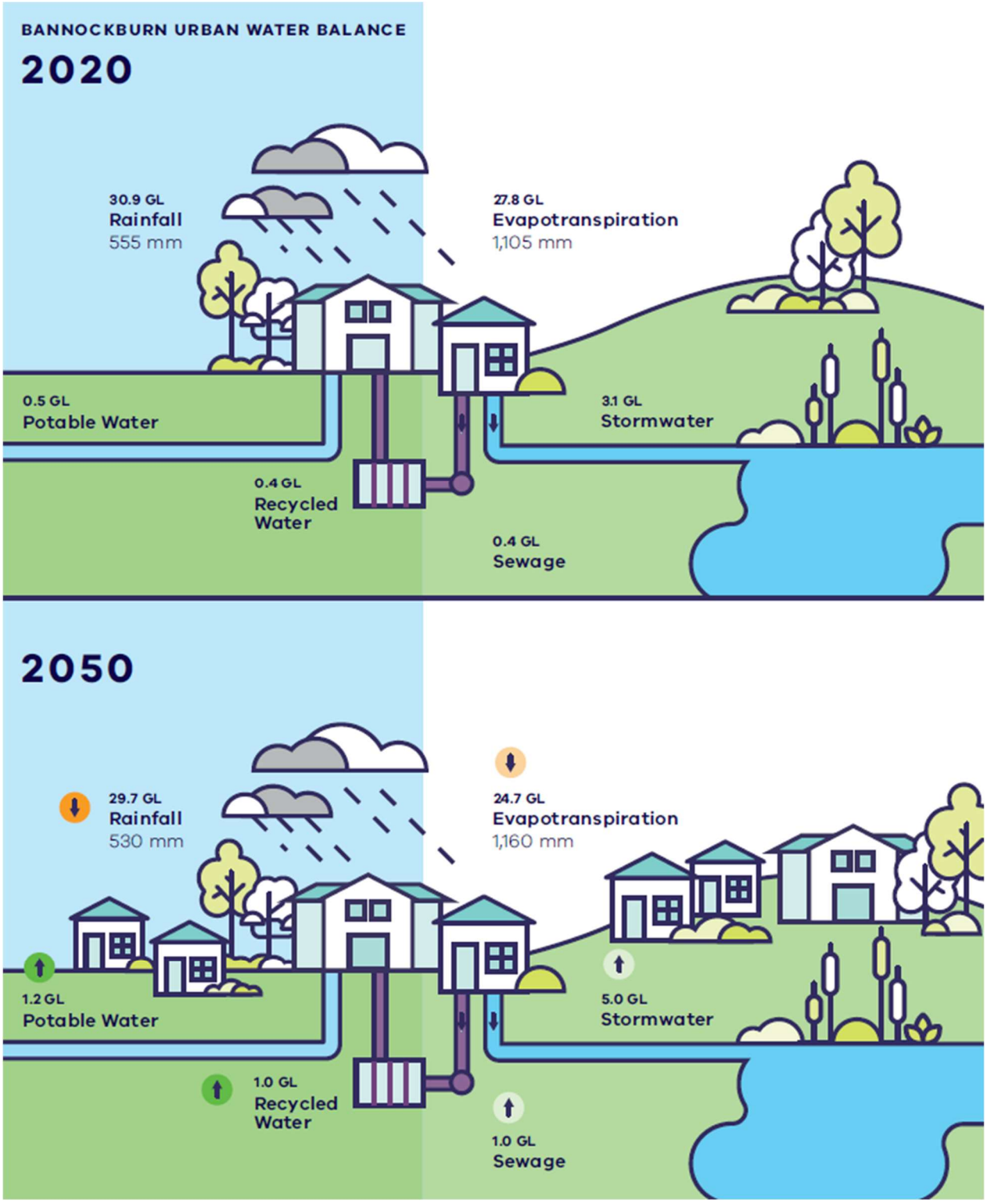


Figure 7-2: Example of a regional water balance for Bannockburn — volumes 2020 to 2050 - page 140 in the CGRSWS discussion draft.

Regional water balance methodology

The aim of the water balance is to quantify the impact of urbanisation, population growth, land use change and climate change on the urban water cycle over time by comparing two water balance scenarios (2020 and 2050) for the township of Bannockburn.

The 2020 scenario (top) depicts the key water balance aspects (i.e. potable water, sewage, and recycled water) for Bannockburn under current urban development and climate conditions. The 2050 scenario (bottom) depicts water values for Bannockburn under predicted future development (based on planned development) and with changed climate (median climate change) conditions.

Stormwater run-off and pollutant load values were modelled with eWater's Source hydrological model software. eWater's Source software simulates key characteristics of the township's water system, providing decision support for water system planning and operation, and catchment processes. The overall model included a rainfall-runoff model that estimated surface runoff volumes with a given rainfall at a specific location (e.g., within a sub-catchment) and a constituent model to estimate the pollutant loads generated or transported at the same location.

Plotted data

A summary of the data sources and analysis approach for preparing Bannockburn's 2020 and 2050 water cycles is provided in Table 11.

Table 11 - A summary of data sources and analysis approach for preparing Bannockburn's 2020 and 2050 water cycles.

Category	Data inputs/sources	Use in water summary	Analysis	
			2020	**2050**
Population	Victoria in Future (DELWP), Census (ABS)	Future potable water and sewage volumes	Scaled linearly between 2016 and 2021 data	Scaled linearly from last ViF data point (2036)
Potable water	Barwon Water supplied data FY15-FY20	Current and future volumes	Barwon Water supplied data FY15-FY20	2020 data scaled in line with population growth
Sewage volumes	Barwon Water supplied data assumes 80% of potable water	Current and future volumes	Barwon Water supplied data assumes 80% of potable water	Assumed as 80% of potable water in line with Barwon Water
Recycled water	Barwon Water Urban Water Strategy (2017). No metered data available.	Current and future volumes	Assumed all treated water is reused	Assumed 100% reuse target continues
Land use (use type and impervious fraction)	DELWP *Vicmap*, satellite aerial imagery / Melbourne Water MUSIC guidelines	*Model input*	Land use zones compared with aerial imagery for undeveloped areas	Assumed all zones developed to extents. Included Bannockburn Growth Areas
Pollutant load generation	Australian and Victorian case studies / Melbourne Water MUSIC guidelines	*Model input*	Applied to land use zones	Applied to land use zones
Climate (precipitation and PET)	SILO July 1974 to December 2019, Station *87147 (Bannockburn Hillside*)	*Model input*	Historical data	Historical data scaled by DEWLP climate factors
Stormwater (runoff, pollutant loads)	*Model output*	Stormwater and pollutant volumes	Source catchment model (uncalibrated) 2020 land use and climate	Source catchment model (uncalibrated) 2050 land use and climate

Recycled water use potential

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 7-3 in the CGRSWS Discussion Draft that describes the volumes of wastewater produced and treated and the potential for this water to be used in each basin in the Central and Gippsland Region. This figure is reproduced in this report for ease of reference.

Plotted data

For each basin in the Central and Gippsland Region the pie chart shows the proportion of treated wastewater that was used as recycled water or released to the environment in the 2019-20 financial year. This data is published in the Victorian Water Accounts 2019/2020 (DELWP, 2020c).

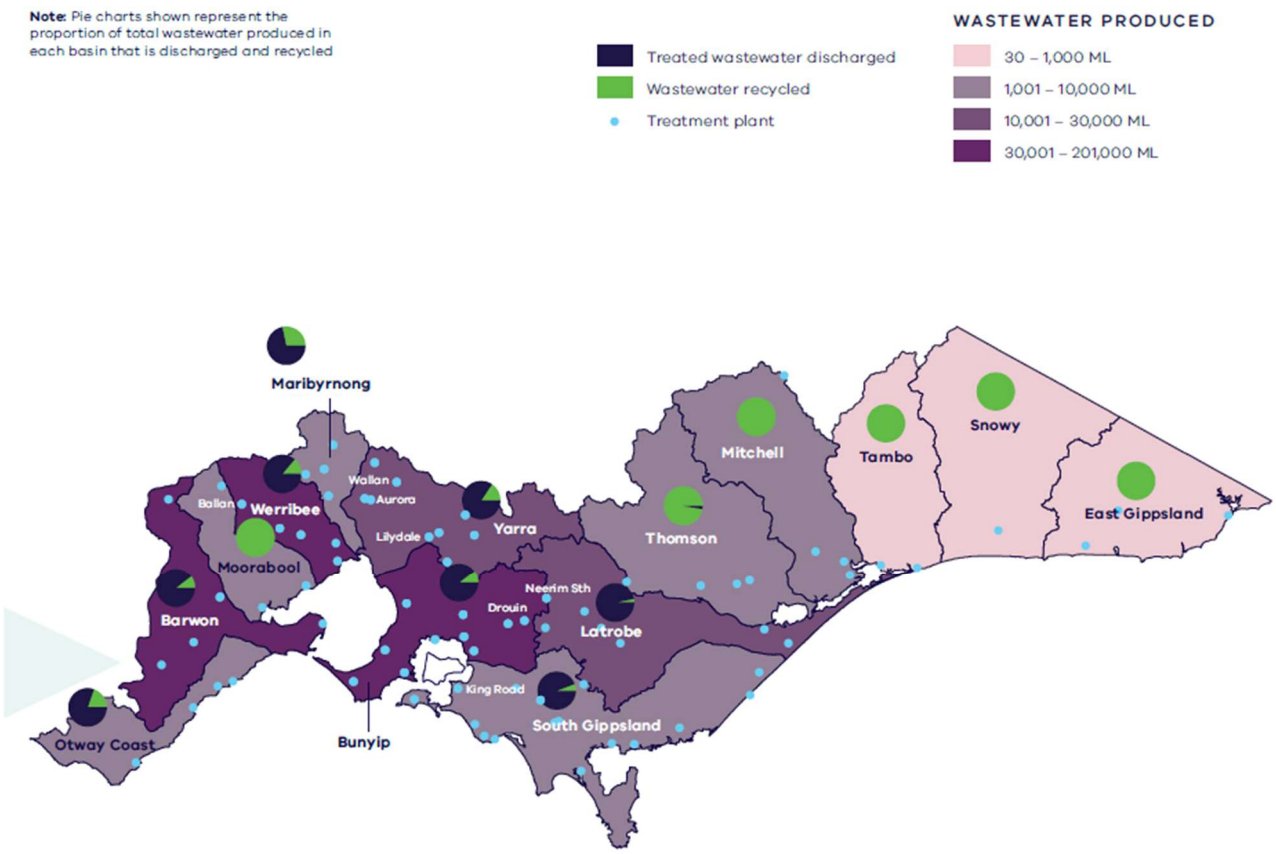


Figure 7-3: Potential for use of recycled water.

Chapter 10, 11 and 12 — the Gippsland, Central, and Barwon, Moorabool and Otways sub-regions

Percentage shares of Blue Rock Reservoir

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 10-5 in the CGRSWS Discussion Draft that describes percentage shares of Blue Rock Reservoir. This figure is reproduced in this report for ease of reference.

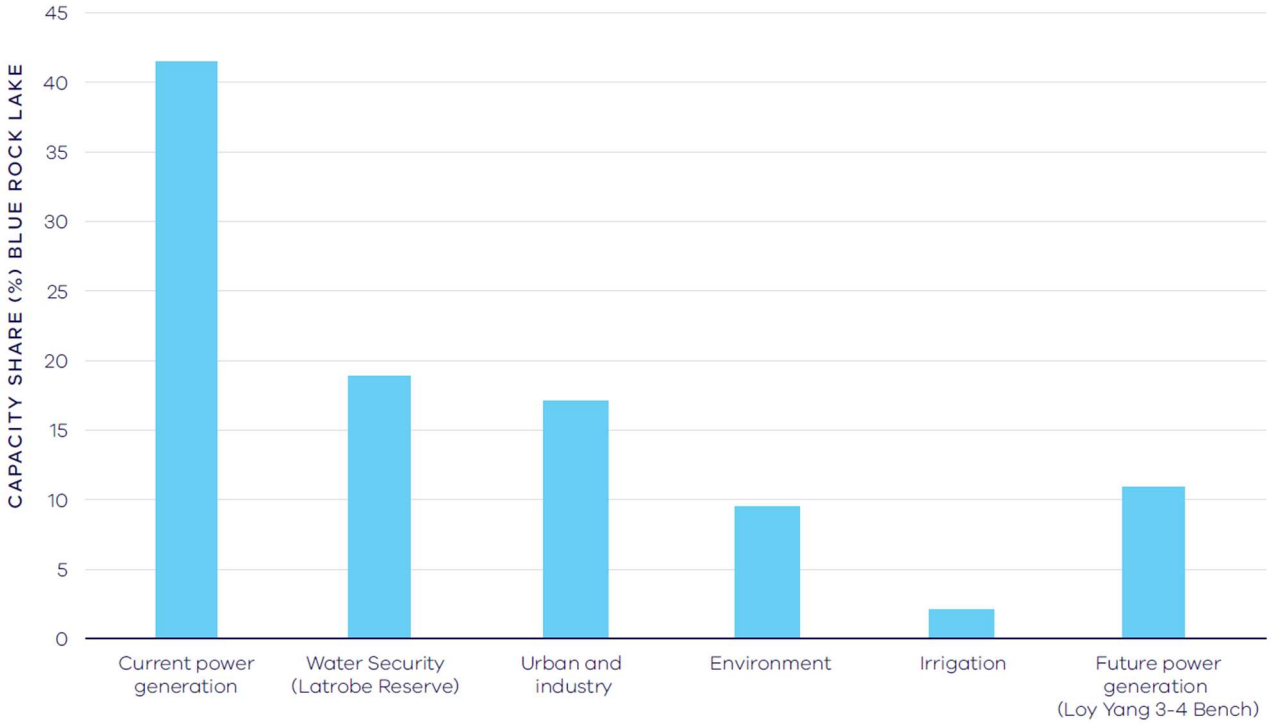


Figure 10-5: Current shares of Blue Rock Reservoir reflect the storage's historical importance in providing water for electricity generation — page 199 of the CGRSWS Discussion Draft.

Plotted data

The percentage shares of Blue Rock Reservoir are based on the current bulk entitlements held for storage and inflows shares to Blue Rock Reservoir (Table 12).

Table 12: Current Blue Rock Reservoir bulk entitlements.

Entitlement	Holder	Purpose	Blue Rock Reservoir	
			Share of inflows (%)	Capacity share (%)
Gippsland Water –Blue Rock	Gippsland Water	Urban and industrial	17.08	17.08
Yallourn	Energy Australia	Power Generation	15.72	15.72
Loy Yang A	AGL	Power generation	17.22	17.22
Loy Yang B	SRW	Power generation	8.61	8.61
Loy Yang 3/4 Bench	Environment Minister	Future power generation	10.95	10.95
Latrobe – Southern Rural	SRW	Irrigation	2.1	2.1
Latrobe Reserve	SRW	Water security	18.87	18.87
Blue Rock Env. Entitlement	VEWH	Environment	9.45	9.45

Seasonal variation case studies

Figures in the CGRSWS Discussion Draft

This section provides technical information related to the figures in the CGRSWS Discussion Draft that describe seasonal variations in the Central and Gippsland Region. These figures are reproduced in this report for ease of reference. Water availability and the way water is shared are typically expressed as average annual volumes. However, both the natural flow in rivers and demands for water vary substantially between seasons each year.

Gippsland region

Seasonal variation analysis was conducted using gauge data for Site 224203, Mitchell River at Glenaladale over the period 1/1/2016 to 31/12/2020. These data are available for download from Victoria's Water Monitoring Information System at https://data.water.vic.gov.au/.

Daily mean flow was aggregated to monthly and plotted by season to show how average monthly inflow varies with season (Figure 10-2) and plotted by month to show how flow changes over the course of the year and over successive years (Figure 10-3).

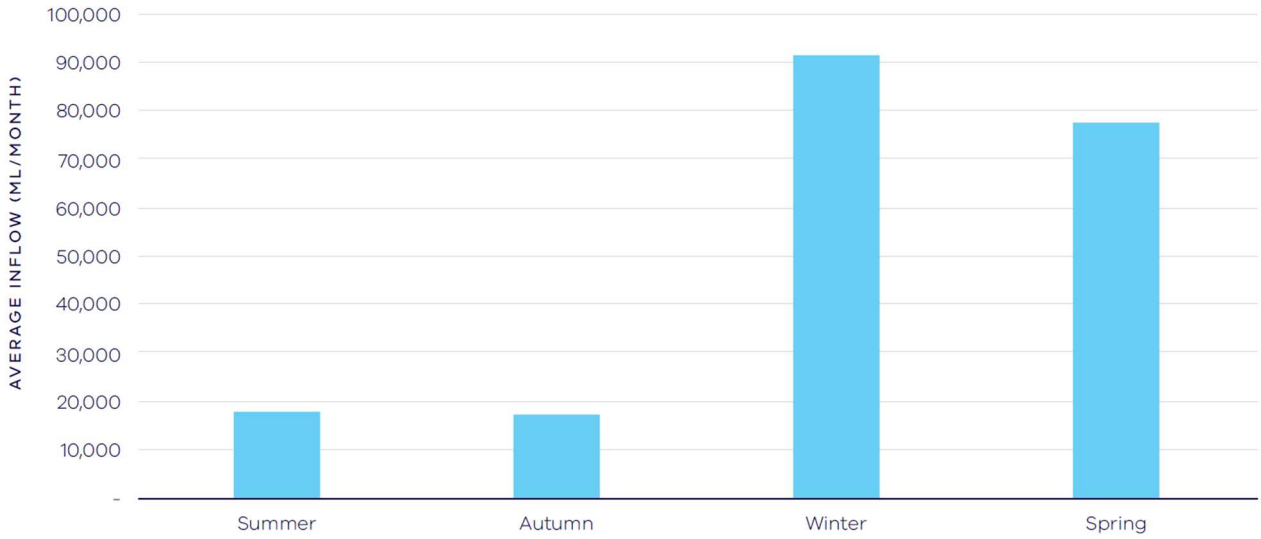


Figure 10-2: Seasonal variation in flow in the Michell River (at Glenaladale) 2016–20 — page 192 in the CGRSWS discussion draft.

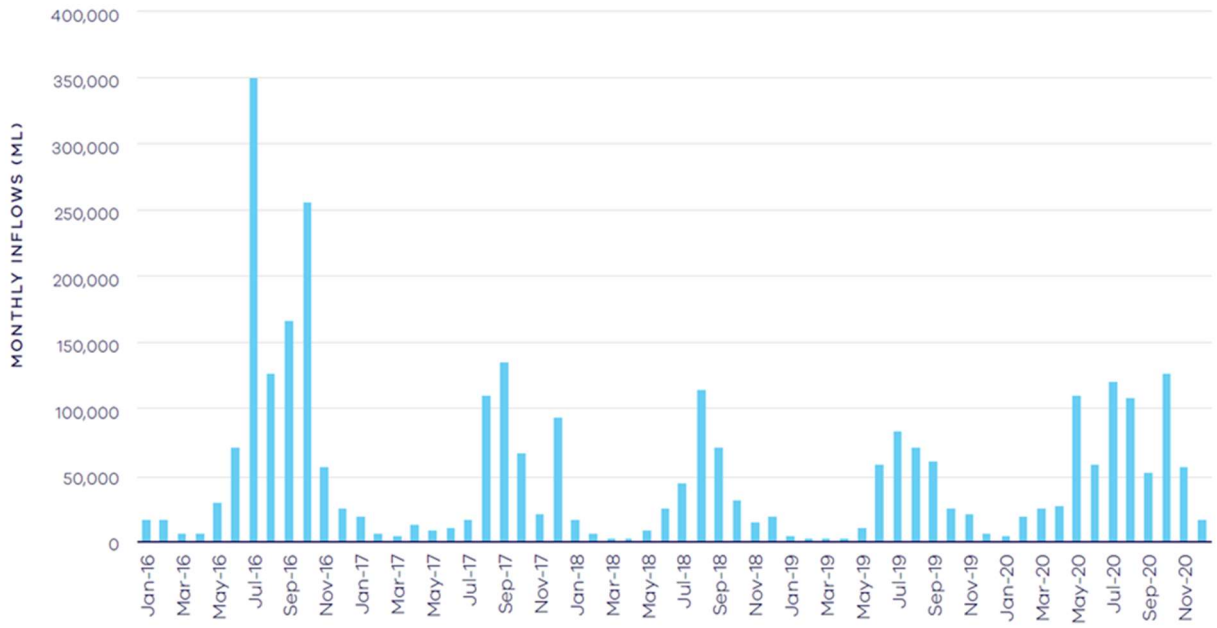


Figure 10-3: Average monthly inflows in the Mitchell River (at Glenaladale) 2016–20 — page 193 in the CGRSWS discussion draft

Central region

Seasonal variation analysis was conducted using modelled inflow data for the Maribyrnong River (to Rosslynne Reservoir) over the period 1/1/2012 to 31/12/2016.

Daily mean flow was aggregated to monthly and plotted by season to show how average monthly inflow varies with season (Figure 11-2) and plotted by month to show how flow changes over the course of the year and over successive years (Figure 11-3).

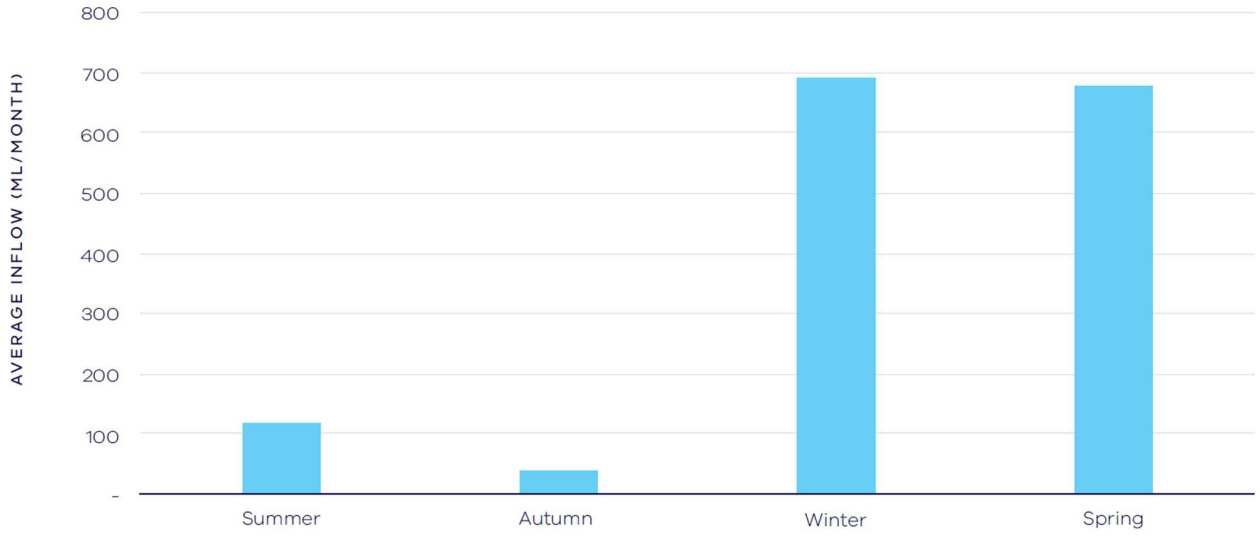


Figure 11-2: Average monthly inflows by season in the Maribyrnong River (to Rosslynne Reservoir) 2012–16— page 230 in the CGRSWS discussion draft

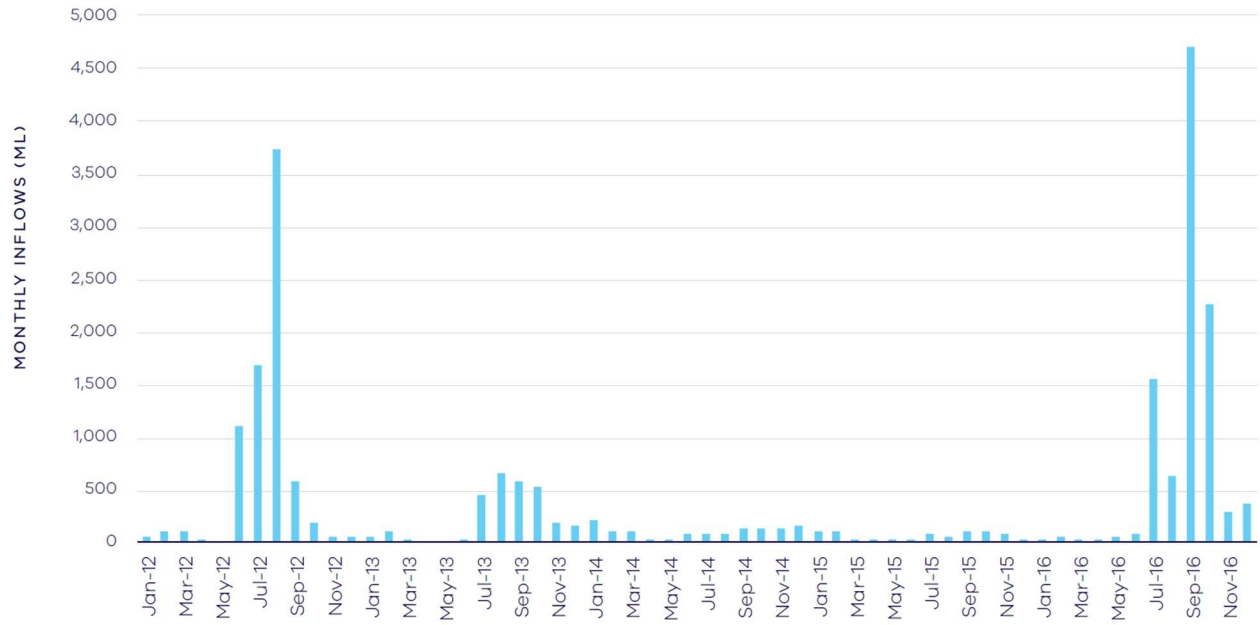


Figure 11-3: Average monthly inflows in the Maribyrnong River (to Rosslynne Reservoir) 2012–16 — page 230 in the CGRSWS Discussion Draft

Barwon Moorabool and Otways region

Seasonal variation analysis was conducted using modelled inflow data for the Gellibrand River (upstream of Lardners Creek) over the period 1/1/2011 to 31/12/2015.

Daily mean flow was aggregated to monthly and plotted by season to show how average monthly inflow varies with season (Figure 12-2) and plotted by month to show how average monthly inflow varies over the course of the year and over successive years (Figure 12-3).

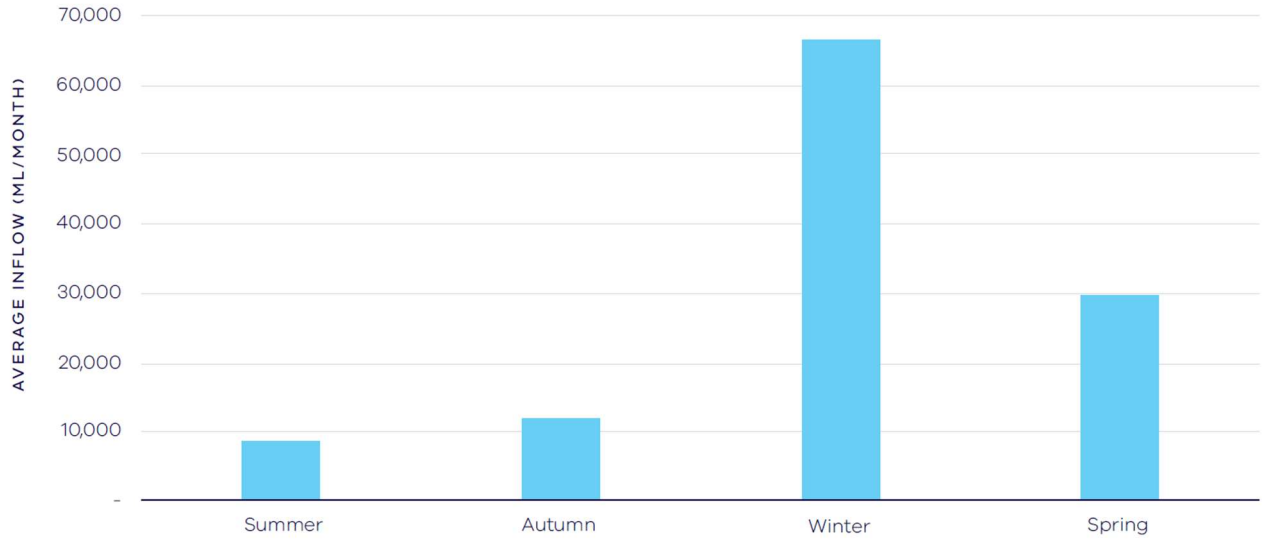


Figure 12-2: Seasonal variation in flow in the Gellibrand River (upstream of Lardners Creek), 2011–15 — page 258 in the CGRSWS discussion draft

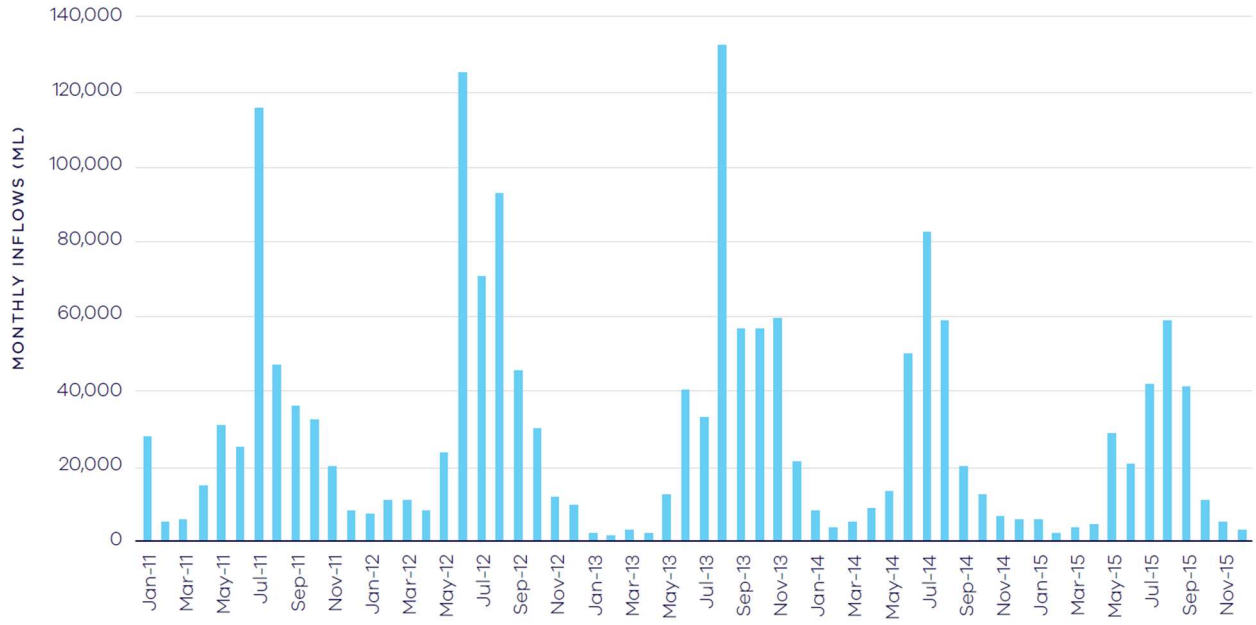


Figure 12-3: Average monthly inflows in the Gellibrand River ((upstream of Lardners Creek), 2011–15 — page 258 in the CGRSWS discussion draft

Farm dam density

Figure in the CGRSWS Discussion Draft

This section provides technical information related to Figure 12-4 in the CGRSWS Discussion Draft that describes farm dam density across the State of Victoria. This figure is reproduced in this report for ease of reference.

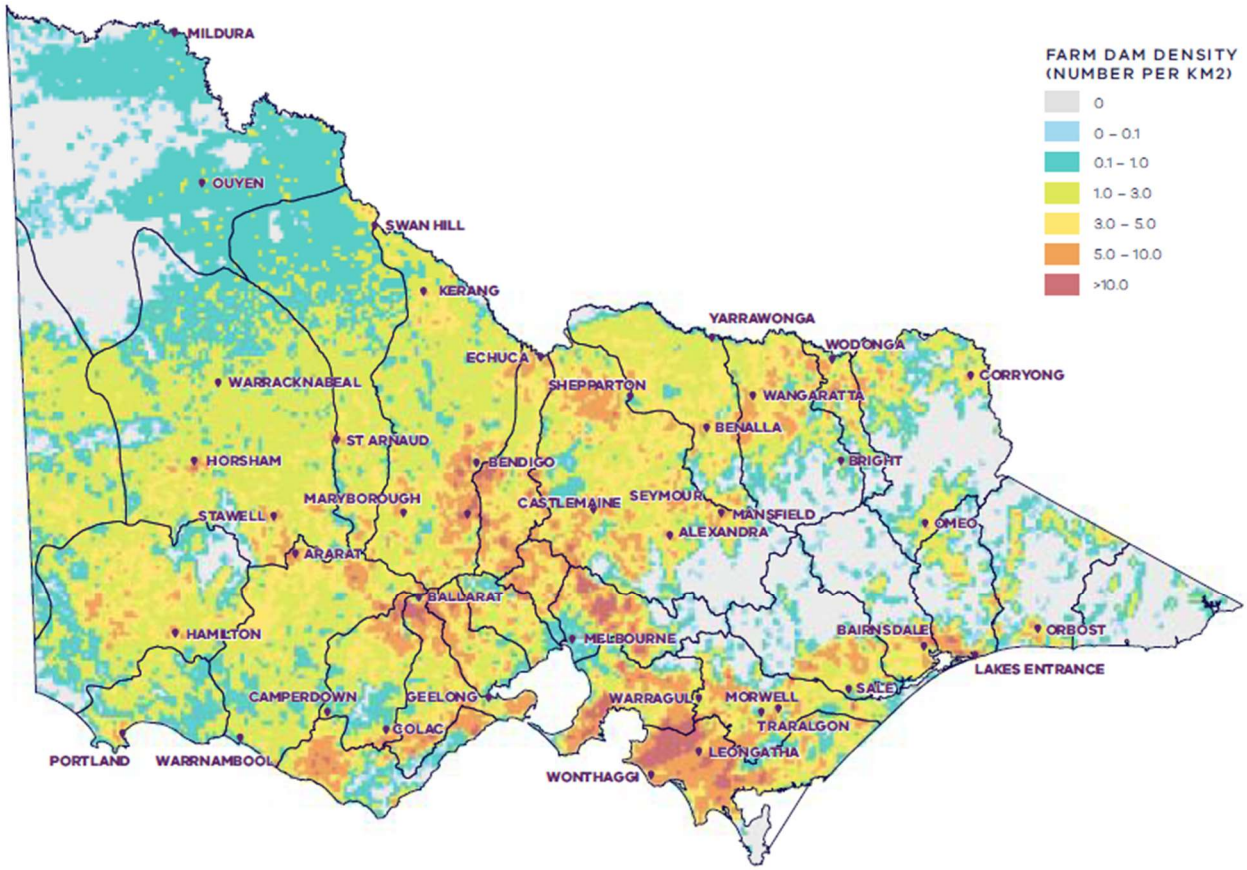


Figure 12-4: Heat map showing the density of farm dams (number of dams per unit area), including both small catchment dams and licensed commercial and irrigation dams - page 260 in the CGRSWS discussion draft.

Farm dam density methodology

Figure 12-4 shows the density of farm dams across Victoria, including both small catchment dams and licensed commercial and irrigation dams. This figure was produced using two datasets that are freely available on DataVic – Victoria's open data platform (Discover and access Victorian Government open data | Data Vic):

- **Farm Dam Boundaries** - This dataset contains the digitised boundaries of all human-made waterbodies (including farm dams) in southern Victoria and all larger human-made waterbodies in northern Victoria using a combination of satellite and aerial imagery. Should be used in conjunction with FARM_DAMS_POINT. This data was updated in January 2019 to improve the usefulness of the attribute data.
- **Farm Dam Points** - This dataset contains the digitised centroids of smaller human-made waterbodies (including farm dams) in northern Victoria using a combination of satellite and aerial imagery. Should be used in conjunction with FARM_DAMS. This data was updated in January 2019 to improve the usefulness of the attribute data.

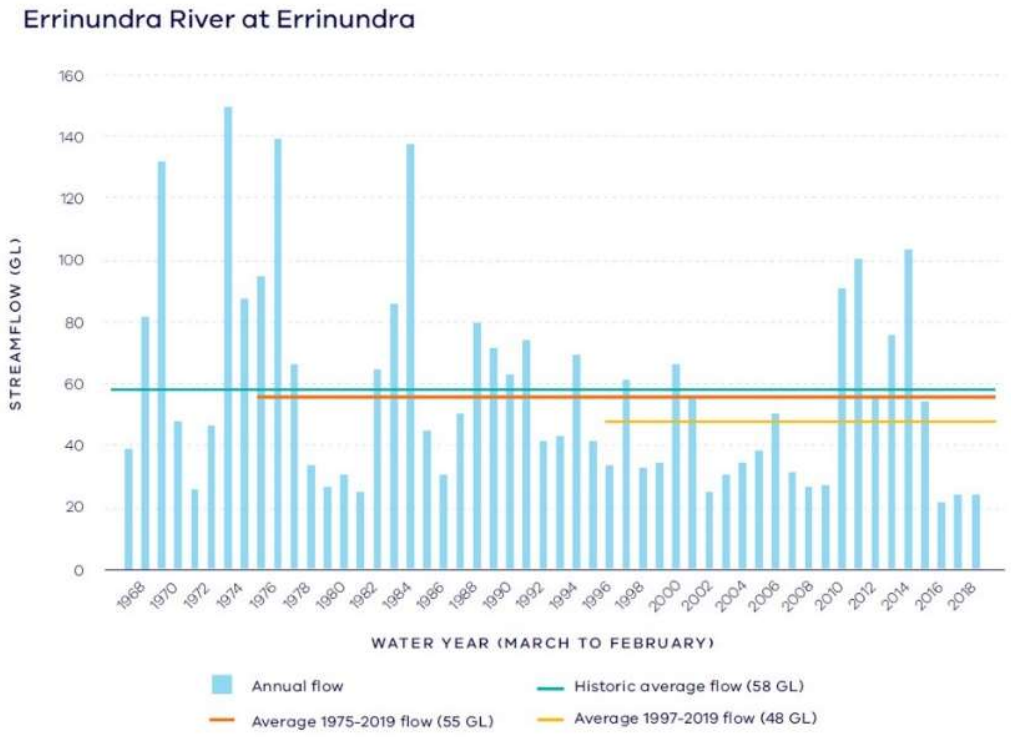
Graphical Information System (GIS) software was used to process the input data to produce the density map, using the following steps:

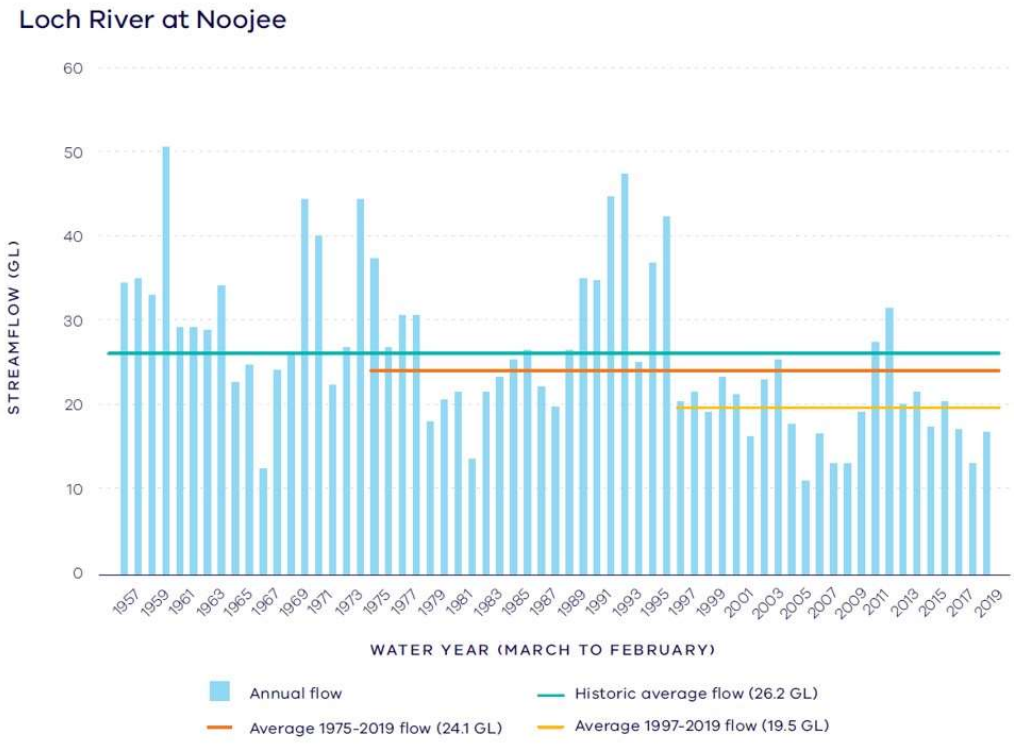
1. Polygons (**Farm Dam Boundaries**) were converted to points (as per **Farm Dam Points**) and the two datasets merged for the State of Victoria.
2. Water bodies which were not farm dams (e.g. wetlands or major reservoirs) were removed from the combined dataset.
3. The Point Density tool in the GIS software ArcMap was used to convert the farm dam points into a density layer.

Additional figures outside of the main body of the CGRSWS Discussion Draft

Figures in the CGRSWS Discussion Draft

This section provides technical information related to Figure D-1 and Figure D-3 in the CGRSWS Discussion Draft that appear in the draft CGSWS Appendix D: A variable and drying climate. These figures have been reproduced in this report for ease of reference. Figure D-1 is presented one panel at a time for increased readability.





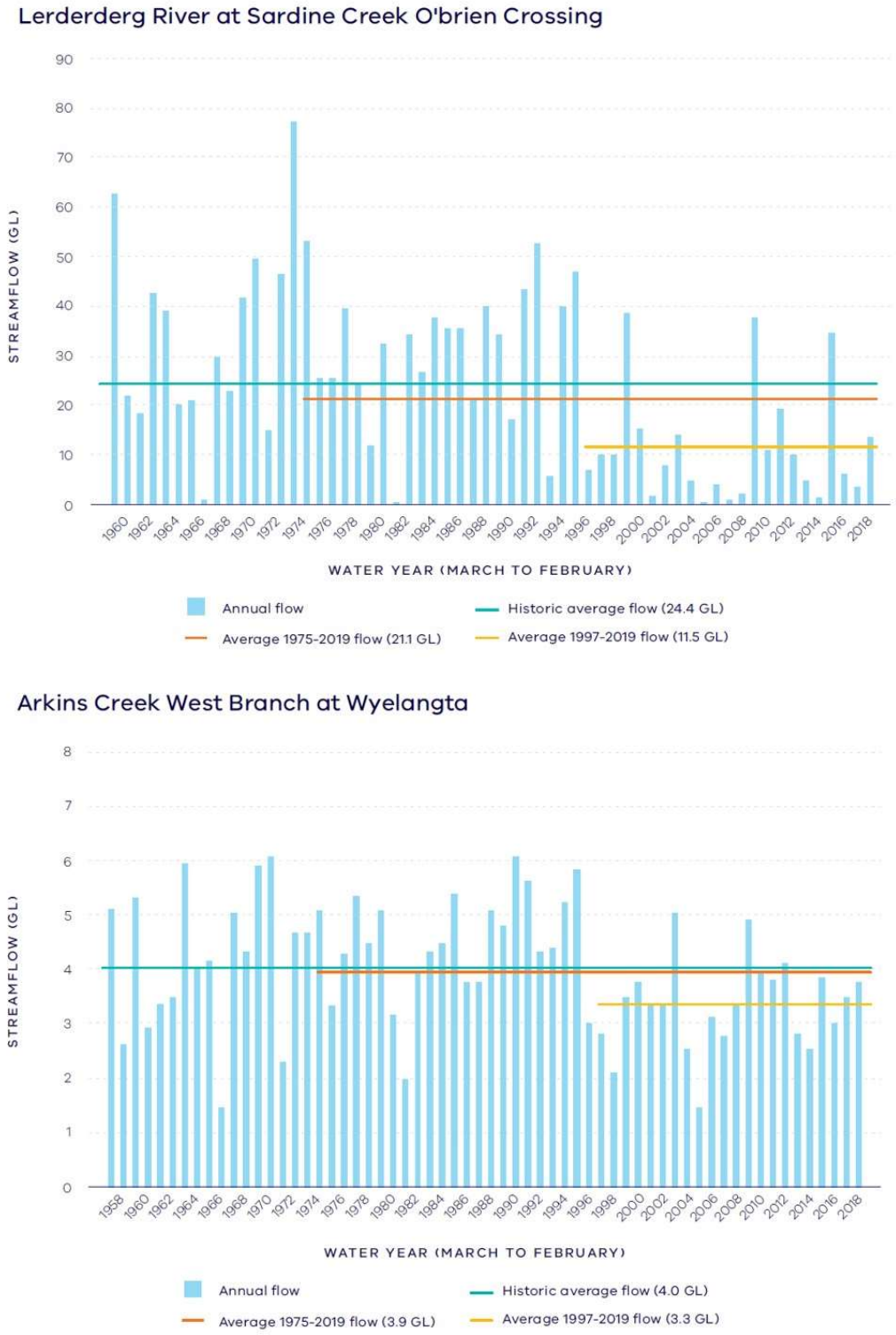


Figure D-1: Recorded streamflow at four hydrologic reference stations in the Central and Gippsland Region, demonstrating variability from year to year, with periods of above-average and below-average streamflow. page 310-312 in the CGRSWS discussion draft.

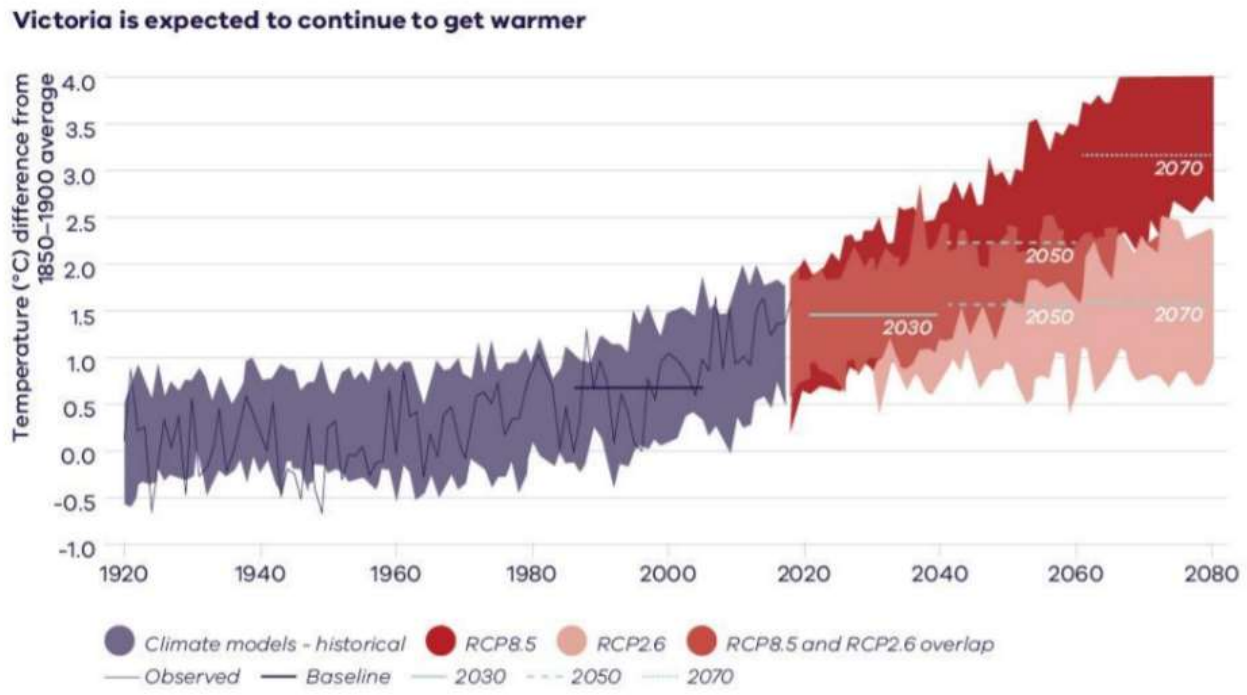


Figure D 3: Average annual temperature of Victoria in observations and models relative to the pre-industrial era, showing the highest emissions pathway (RCP8.5) and the lowest (RCP2.6) separately page 315 in the CGRSWS discussion draft

Water resource assessment methodology (recorded streamflow at four hydrologic reference stations)

All available streamflow data for the four sites was sourced from two data sources:

- Bureau of Meteorology (BOM) – Hydrologic Reference Stations: Water Information: Bureau of Meteorology (bom.gov.au)
- Water Measurement Information System (WMIS) – DELWP's Water Measurement Information System

As missing periods had already been infilled in the BOM data the BOM data was used in preference to the WMIS data.

Table 13 – Site information for four hydrologic reference stations in the Central and Gippsland Region.

River basin	Site number	Site name
East Gippsland	221207	ERRINUNDRA RIVER @ ERRINUNDRA
La Trobe	226220	LOCH RIVER @ NOOJEE
Werribee	231213	LERDERDERG RIVER @ SARDINE CREEK O'BRIEN CROSSING
Otway	235205	ARKINS CREEK WEST BRANCH @ WYELANGTA

At each site the following analysis method was applied:

1. An annual histogram was constructed (BOM annual water year - March to February).
2. Historic averages were calculated by averaging the annual data over the entire period of record, the 1975-2019 historic reference period and the 1997-2019 historic reference period.

Note that the reference periods used to produce these graphs differ slightly to the reference periods recommended in the *Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP, 2020b) as the guidelines recommend that the reference period commence in June (not March). In this instance March to February was used to be consistent with the data provided by BOM.)

Water resource assessment methodology (average annual temperature of Victoria)

This figure has been taken from Victoria's Climate Science report (DELWP, 2019a, Figure 11, pg. 28, available here: climatechange.vic.gov.au) and first appeared in the Victorian Climate Projections 2019: Technical Report (CSIRO 2019, Figure 2, pg. 39).

References

CSIRO (2019) Victorian Climate Projections 2019: Technical Report. Available: www.climatechangeinaustralia.gov.au/vcp19

DELWP (2019a) Victoria's Climate Science report, Department of Environment, Land, Water and Planning, Victoria. Available: Victoria's Climate Science Report 2019.pdf

DELWP (2019b) Victorian Water Accounts 2018-2019, Department of Environment, Land, Water and Planning, Victoria. Available: Victorian Water Accounts 2018-19.pdf

DELWP (2020a) Long-Term Water Resource Assessment for Southern Victoria. Overview Report. ISBN 978-1-76077-924-5 (pdf/online/MS word). Available: LTWRA for southern Victoria.pdf

DELWP (2020b) Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria. Final, November 2020, Department of Environment, Land, Water and Planning, Victoria. Available: Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria.pdf

DELWP (2020c) Victorian Water Accounts 2019–2020 A statement of Victorian water resources, Department of Environment, Land, Water and Planning, Victoria. Available: Victorian Water Accounts 2019-20.pdf

Melbourne Water (2017) Melbourne Water System Strategy, Melbourne Water, Victoria. Available: Melbourne Water System Strategy.pdf