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Water related challenges and opportunities for agriculture in the Central and Gippsland regions of southern Victoria

Final

DELWP

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1 Executive summary

1.1 PURPOSE OF THIS REPORT

A new Sustainable Water Strategy (SWS) is being developed for the Central and Gippsland Region of Victoria. To inform this work, this independent report provides an updated understanding of the nature of agricultural water use in the region, and the challenges and opportunities for the agricultural sector in the region in coming decades.

1.2 OVERVIEW

Water is a critical input to all agricultural production in the Central and Gippsland Region and across Victoria. It is necessary for producing crops and pastures on irrigation farms, and on dryland farms it is vital for domestic and stock water supplies. In this way, water for agriculture from all sources – including surface water, groundwater and alternative sources like recycled water – supports a range of industries, economic activity and communities in the region.

It is not widely recognised that agriculture in this region accounts for around of 30% of Victoria’s agricultural production and makes up around a third of the total value of all irrigated production in the state. Major sectors include dairying, horticulture (both fruit and vegetables), viticulture, cropping and livestock production, each of which support flow-on industries including processing, distribution and tourism.

Agricultural production is an important economic driver in the Central and Gippsland regions, particularly in regional areas. Around 36,000 people in the region are directly employed in agriculture, forestry and fishing. In Gippsland around 10% of all jobs are in this sector. In other parts of the region, like Melbourne, agriculture accounts for only a small part of the total economic activity, but provides for critical food production close to urban centres. Some of Victoria’s highest value crops are produced close to Melbourne.

Water availability across Victoria is already being affected by climate change. As a result, agricultural producers in the region are experiencing warmer temperatures and reduced water availability to support their businesses. This has been keenly felt in the challenges to water availability in Werribee and Bacchus Marsh during dry years, as well as consistent drought in Gippsland since 2016.

The Central and Gippsland Region is different to other major irrigation regions of Victoria. In other parts of Victoria, irrigation is more intensive and irrigation applications are consistently required from spring to autumn. In comparison, irrigation in this region has historically been defined by relatively low annual irrigation application rates that supplement relatively reliable rainfall. Irrigation is nonetheless critical to supplying water to crops and livestock during drier months and is a foundational input to many businesses, particularly within irrigation districts.

The major centres of water use for irrigation are in the Werribee, Bacchus Marsh and Macalister Irrigation Districts, which are serviced by major water storages that can supply water over spring, summer, and autumn. In other parts of this region, irrigation development is limited by the relatively low river flows, and low levels of water storage, during summer. Groundwater supplies can be used to offset low surface water availability to some extent, but groundwater pumping is expensive and is often used to supplement rainfall deficiencies during drier periods.

The Central and Gippsland Region has competitive advantages for agricultural production which are recognised by businesses and industries – relatively reliable rainfall, proximity to markets in Melbourne and NSW, and a large pool of labour. These advantages mean that there are remaining opportunities to increase the value of agriculture in the region with optimal use of the available water and the continued development of sustainable farming practices.

Water for agriculture already supports a diverse range of produce and production systems in the region, including dairy, fruits and vegetables, cropping, livestock, viticulture and nurseries. As water availability and regional economic conditions continue to change in the region, opportunities will arise for people to make the most of those areas with reliable access to water to develop high value crops.

There are some opportunities to improve access to water for agriculture, but these will require significant private investment, and their adoption will be dictated by the willingness to pay of agricultural businesses and industries. Public benefits may be supported by public investment in cost-effective opportunities to improve access to recycled water, investigate changes to irrigation infrastructure, and modernise irrigation to generate water savings.

1.3 GROSS VALUE OF AGRICULTURAL PRODUCTION IN THE REGION

The Central and Gippsland Region (The Region) accounts for 30 per cent of Victoria's Gross Value of Agricultural Production (GVAP). Around 36,000 people are employed in agriculture, forestry and fishing – with the proportion of jobs in agriculture being much larger in the rural areas.

In some parts of the region, like Melbourne, agriculture is a small part of economic activity, but it produces extremely high value crops – including fresh fruit, vegetables and nurseries. In other parts, like Gippsland, agriculture is a primary contributor to the local economy, accounting for around ten per cent of jobs.

The region's contribution to Victorian agriculture is summarised in Figure 1-1, and Table 1-1 indicates the extent of land and water use that supports each of the main irrigated enterprises in the region. Figure 1-1 shows that the region accounts for the majority of Victoria's production of eggs and poultry, nurseries and floriculture, and vegetables. It is also evident that the 30 per cent of total production in the Central and Gippsland region is based on under 20 per cent of the state's agricultural land.

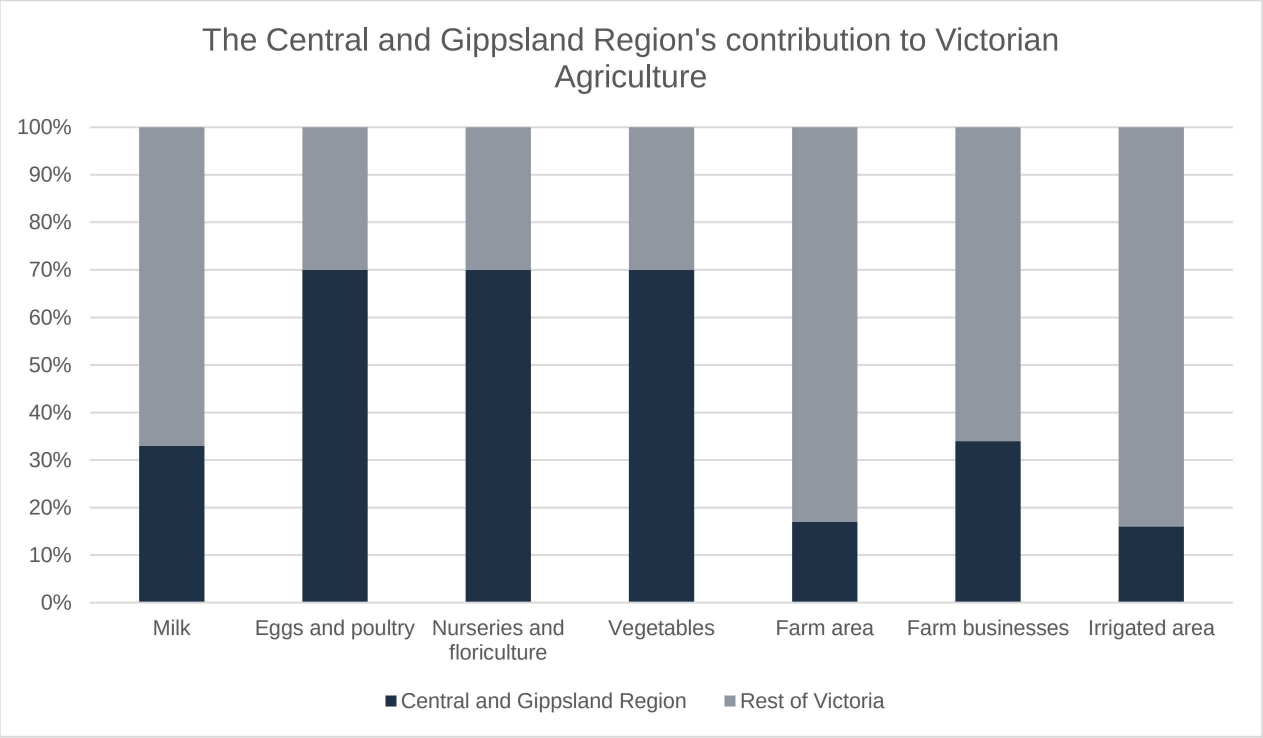

Figure 1-1: The Central and Gippsland Region's contribution to Victorian Agriculture

Table 1-1: The land area and water use associated with different irrigated enterprises in the Central and Gippsland Region

IRRIGATED ENTERPRISE	TOTAL AREA (HA)	AVERAGE ANNUAL WATER USE (GL)
Vegetables	14,000	56
Orchards	2,000	8
Vineyards	5,000	7.5
Nurseries	2,000	4
Broadacre and cereals	5,000	7.5
Pastures/lucerne	55,000	220
Total	**83,000**	**303**

In 2017/18 the Region produced GVAP of $4.7 billion of which the Gross Value of Irrigated Agricultural Production (GVIAP) was $1.5 billion (32 per cent). As summarised in Figure 1-2, this puts it between the GVIAP of around $1 billion from the Victorian Mallee and $2 billion per year from the Goulburn-Murray Irrigation District.

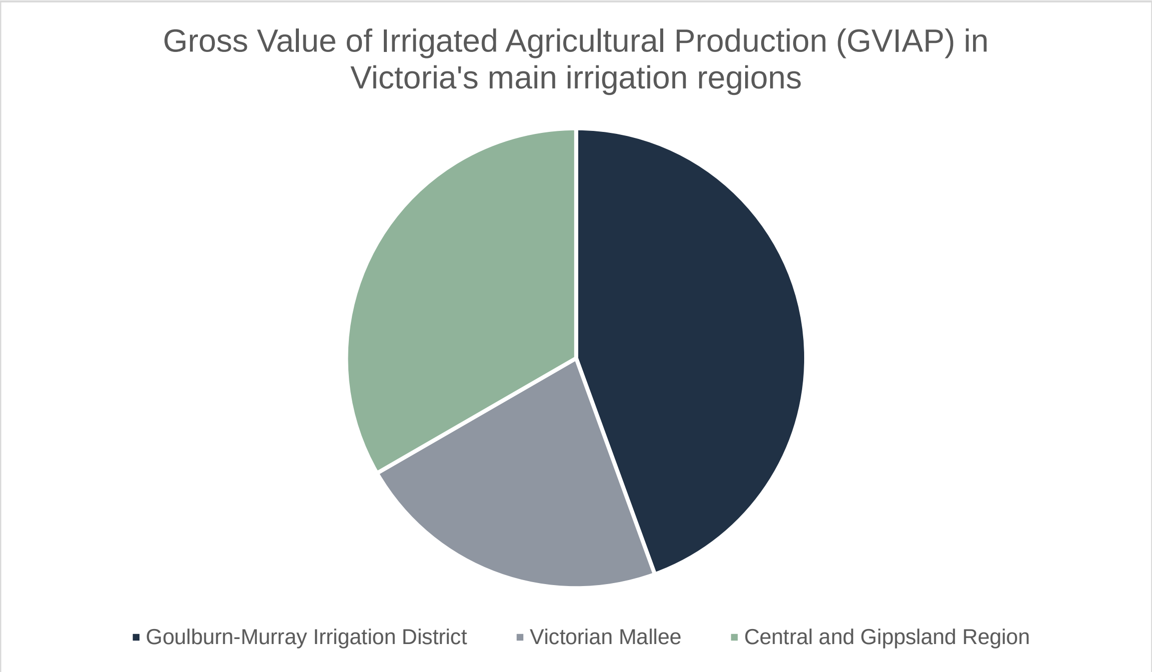

Figure 1-2: Gross Value of Irrigated Agricultural Production (GVIAP) in Victoria's main irrigation regions

Irrigation supports 29 per cent of the Region’s dairy production and over 75 per cent of horticulture. On average, irrigation water use per hectare is around 2 to 4 ML/ha in the region. Vegetables and pastures are the main irrigation enterprises by area and water use. Notably, nurseries and floriculture produce 21 per cent of the regions GVIAP while using only 1 per cent of the region’s irrigation water.

The annual agricultural values change with water availability and rainfall, but they have remained relatively stable over the last decade (Appendix 1 Table A1-2).

1.4 THE UNIQUE NATURE OF AGRICULTURAL WATER USE IN THE REGION

Water is a critical input to all agriculture in the region, both irrigation and dryland. Many dryland farms, and all intensive livestock enterprises, like egg and poultry production, rely on the region's surface and groundwater resources for stock and domestic water supplies.

Irrigation water use per hectare in this region is approximately half that of the same crops in northern Victorian regions due to higher rainfall and lower evapotranspiration. Most of the water used in the region is associated with irrigated pastures for livestock and dairying. The irrigation water supplied to pastures and crops is often supplementary to rainfall, rather than being the main water supply in its own right.

In high rainfall seasons, irrigation demand is very low. For these reasons, water use is characterised in most years by:

- Less than 100 per cent use of the total water entitlements available to farmers (with the remaining unused entitlements being kept for insurance to meet dry year water requirements)
- low prices for traded water entitlements
- low prices for traded water allocations
- low volumes of allocation trade relative to the total available volumes.

Unlike the connected valleys of northern Victoria, which flow into the Murray River, catchments in southern Victoria are mostly unconnected with each other, resulting in fewer opportunities to trade underused entitlements, allocations or licences for water.

Of the 300 GL/y irrigation use, almost half is located in the irrigation districts, which are supported by regulated water systems and public storages. These districts are located in relatively dry parts of the Region where there are good soils. The irrigation districts have been well located for maximising the value from irrigation and from the water storages that support them.

Only a small proportion of the usable groundwater volume is licensed for consumptive use, and an even smaller amount is used on an annual basis – around 30 per cent of the licenced volume. Groundwater usage is only about 100 GL/y from 250 GL of licensed volume and over 300 GL of the permissible consumptive volume of water use.

Many irrigation water licences are not regularly used. These are sometimes referred to as "sleeper" licences. Others are not fully used, and the unused components are sometimes referred to as "dozer" licences. Many farmers prefer to hold these entitlements, rather than use or trade them to others. Retaining unused licences or entitlements can reduce the impacts of water rationing on an irrigated enterprise during periods of restrictions. Others hold onto unused entitlements because of the real or perceived added value to a property with access to a water supply.

The reliability of supply varies with each catchment and each season, particularly in unregulated catchments. All winter-fill licences require on-farm dams to store water in order to ensure a reliable supply through summer. Similarly, because they are subject to rosters, restrictions and bans, which can restrict access to river extractions at certain times, some holders of all-year round licences also have storages or additional entitlements to help manage rationing or pumping bans. Others may manage their risk in other ways. For example, some have production systems that are interruptible, such as lucerne stands that can be treated as dryland plantings if irrigation water is not available. Irrigators will also adjust the area of their irrigated plantings according to the expected water availability in the season ahead.

The costs of storage and double pumping of water can be prohibitive, particularly for low-value or supplementary irrigation. Holding additional entitlement to minimise the impact of rationing can be a much lower cost strategy than building farm storages. This will continue to be the case as long as the price of entitlements is lower than the cost of building farm storages. Therefore, it is expected that large volumes of sleeper and dozer entitlements will continue to be held rather than sold, and this will continue to limit water trade.

Analysis of the major irrigation industries and their likely future demands for water (Appendix 2) indicates that due to the factors described above, there is unlikely to be large-scale increases in irrigated production in the region without a corresponding increase in access to water for agriculture. Depending on future climate conditions, urbanisation and commodity prices ongoing trends of moving to higher value crops, where reliable water supply exists are likely to continue.

1.5 WATER-RELATED CHALLENGES FOR AGRICULTURE

Increased competition for water and land

Agriculture faces a number of water-related challenges in the Region. Key ones include competition for access to water and land from:

- **Power generation**, which has required large volumes of water in the Latrobe valley. Power generation will probably continue to require access to water for 30 years or so after the mines close in order, to the extent possible, to fill the mine voids with water to stabilise the surrounding landscapes. Depending on the final watering regime for the mine voids, they may also provide the opportunity to harvest high flows and enable the creation of new high reliability water share entitlements for agriculture.
- **Population growth**, which fuels increased urban demands for land and water, will affect irrigated agriculture as Melbourne continues to be one of the fast-expanding Australian cities with growth to the east, north and west.
- **Increasing land values**, which are a result of population growth and decreasing land supplies close to Melbourne, Geelong, the Bellarine Peninsula, the Surf Coast and the Mornington Peninsula are expected to further fragment agricultural land uses. However, this may also see the migration of high value irrigated vegetable and nursery businesses to other parts of the region such as the Macalister Irrigation District and the Mitchell River flats.
- **Climate change**, which is reducing rainfall, runoff and stream flows means that more water for the environment, is required to maintain existing ecosystems that support both natural and economic values such as tourism. This will reduce potential access to unused entitlements for the expansion of irrigated agriculture.

Less reliable rainfall for domestic and stock water supplies

As rainfall and runoff is reduced, domestic and stock water supplies for agriculture in the region will become less reliable. An examination of the viability of reticulated domestic and stock water supply systems in Gippsland (Marsden Jacob Associates, 2019) considered areas with rainfall less than 600 mm and identified there were no feasible options to develop reticulated domestic and stock systems in Gippsland.

Key short-term responses identified in the report could help domestic and stock users mitigate the impacts of this:

- *“Continue to upgrade emergency water supply points.*
- *Develop farm management plans that recognise and respond more effectively to drought.*
- *Provide farm practice change information*
- *Clarifying accountabilities across jurisdictions and developing greater alignment of emergency jurisdictional approach.”*

The report identified a number of longer term responses to enable adaptation and reducing impediments to land use change and farm amalgamation. Including:

- *“Drought management and whole farm planning and grazing management practice change*

- *Development of integrated on farm surface water conservation practices and infrastructure – including deepening of farm dams, farm fencing and grazing management systems*
- *Developing land use change policies and reducing red tape associated with land use change."*

Reliability of surface water in unregulated catchments

In the long term, irrigation from unregulated surface water systems is limited by the volume of water available in the driest month of the irrigation season. This limits the area of land that can be developed and prevents the adoption of higher value perennial horticulture. If irrigation does expand beyond this area, then it will inevitably shrink again the next time water availability is limited in that driest month. Without significant on-farm storage to supply water through dry periods, irrigators must make their planting decisions in prospect. That is, because they cannot be sure exactly how an irrigation season will play out, irrigators will usually only plant up the area that they know can be supported through the lowest period of water availability.

In unregulated surface water systems, that is, in those surface water systems where there are no large in-stream storages, irrigators have set up their maximum irrigated area based on dry period availability, and their annual usage is typically 30 per cent of their entitlement volume. The balance (around 70 per cent of the diversion licence volume) has utility and value as an insurance policy that would be available in dry years and it helps sustain the security of supply for the 30 per cent commonly used.

Expansion of irrigation from unregulated surface water can only be achieved by increasing the dry period flows. This requires:

- Accessing water from other dry period users,
- Providing new water sources (e.g. recycled water or water from other existing uses) that are available in the dry months
- Building storages to convert wet month flows to water that can be made available in the dry months.

The last dot point is exactly what has been achieved in the regulated surface water systems that service the irrigation districts. Given that new public storages would take additional water from the environment and environmental water has been identified as being under threat in DELWP's long-term water resource assessment (DELWP, 2019) new public storages are not a feasible solution.

High costs of storages

There may be opportunities for building more private storages, where they are cost effective, to mitigate the impacts of challenges with accessing water in unregulated catchments. There are issues associated with on-farm storages however. These include:

- The large storage size and cost needed for a substantial enterprise. For example, a 100 ha property using 5 ML/ha/year would need a storage capable of holding 500 ML. A storage of that size would take up approximately 17 ha at 3 m depth or 25 ha at 2 m depth. This is a large percentage (14-20%) of the total area needed for the irrigated enterprise, and it represents a large loss of productive land.
  - At $10,000/ha, the land value for the dam is $250,000, which represents additional costs of $500 per ML of water
  - Earthworks cost $3,000/ML to $10,000/ML (at least $3/m^3) depending on storage size, lining and degree of difficulty
- Challenging water pumping regimes for filling. New winter-fill licences are likely to permit pumping only when passing flows are suitable. That is, irrigators cannot count on being able to pump every day in the winter period. And, of course, there can be limits on the daily rate of pumping. These factors limit the viability of winter-fill dams and/or create the need for sophisticated and high-volume pumping arrangements

- Use of storage represents a double-handling of the water, with pumping into the storage as well as to the irrigation system. This creates additional pumping costs and greenhouse gas emissions
- It can be difficult to find suitable sites for winter-fill dams, and it can be particularly difficult finding suitable soils for construction
- Construction on the river floodplain may be technically difficult. There are areas where the water table is close to the surface, or highly permeable soils that make construction difficult. Flooding risk may also require the use of turkey-nest style dams
- There are regulatory issues associated with dam construction – a licence is required for farm dams, and there are limits to dam construction on waterways (including those on the floodplain that only fill in floods)
- Evaporation and seepage losses reduce the efficiency of irrigation
- Storage maintenance costs add to the costs of running the farm.

Putting all these issues together, the high cost of farm storages is an impediment to further irrigation development in most cases. Consequently, there are sometimes calls to for governments to subsidise the costs of constructing private farm storages.

However, any public or private investment in on-farm storages need to consider likely declines in water availability, ecological impacts and availability of water for downstream users.

The Productivity Commission's Draft Report on National Water Reform 2020 (Productivity Commission, 2021) provides high-level cost sharing guidelines for water infrastructure which outline the need to avoid investments for which the total costs exceed the benefits, and avoid subsidising one particularly part of the market over others without an overwhelming public benefit:

- *"Investments that are both economically and commercially viable should be undertaken by the relevant water service provider, with full cost recovery from users and generally without government subsidy[1]. This should be the norm.*
  - *The role of government should be limited to project approval, except in cases of substantial public benefits that impose costs best borne by governments.*
  - *Public benefits can include flood mitigation and recreational use of dams, but do not extend to regional development or similar strategic investments.*
- *Major water infrastructure that is not economically viable should not proceed, except where an equity argument supports provision of an essential service.*
- *Government funding should be transparent, and water service provider planning should guide investments. (However, a transparent community service obligation payment is generally preferable to infrastructure expenditure (chapter 11).)*
- *Where governments choose to subsidise infrastructure in pursuit of a strategic objective, including in support of projects that are not commercially viable, additional scrutiny is required to maximise the effectiveness of that investment while minimising the costs and risks to taxpayers."*

[1] *Economic viability requires a benefit–cost ratio exceeding one, as determined by the business case, whereas commercial viability is determined by whether infrastructure users are willing (and able) to pay the full costs of infrastructure construction and maintenance — simply put, whether the benefits that accrue to infrastructure users are sufficient for them to fund the project without a subsidy, in which case a commercially-focused service provider would have incentive to provide the infrastructure*

1.6 WATER-RELATED OPPORTUNITIES FOR AGRICULTURE

The Region has a number of competitive advantages that will help to maintain investment in developing agriculture production. In understanding these advantages, it is helpful to think about the region as being made up of three zones – Central, West Gippsland and East Gippsland. As outlined in Table 1-2, each of these zones has its own set of advantages.

In the context of climate change impacts across Victoria and Australia, there is interest from agricultural industries in focusing their production in areas that are expected to be less severely impacted by climate change than others, including Gippsland.

Table 1-2: The competitive agricultural advantages for the Region's three zones

ZONE	CENTRAL	WEST GIPPSLAND	EAST GIPPSLAND
Strategic advantage	**Proximity to Melbourne**	**Reliable water supply, land affordability, labour force**	**Proximity to NSW and Vic markets**
Characteristics	Main supply of fresh cut vegetables on Melbourne's doorstep Export vegetables as close to Melbourne's transport hubs and ports Opportunities to irrigate with recycled water achieving supply reliability and growth, while meeting State objectives and community expectation to minimise waste Warm groundwater supply opportunity for aquaculture and heating for greenhouse production Good soil Coastal location, so few frosts.	Affordable land Reliable water supply, particularly MID Adjacent to major freight routes Established dairy and horticultural industries with processing infrastructure Potential target area for "climate refugees". Apple industry moving to Thorpdale, partly due to climate change Significant migration of new agricultural industries (e.g., poultry) is creating critical mass for agricultural services Good soil Potential to develop agricultural industries as part of the transition of the Latrobe Valley away from power generation Potential to take advantage of major modernisation upgrade to MID Region has been a backpacker hub (seasonal labour availability) Unused warm groundwater supply opportunity for protected horticulture (e.g., glasshouse heating) and aquaculture.	Mitchell River flats ideal for vegetables Some winterfill entitlements are currently unallocated Bengworden plain – affordable land, reliable groundwater Warm groundwater supply opportunity for protected horticulture and aquaculture Mild climate, few frosts.

At face value, there appears to be an opportunity to use existing unused allocated water to expand irrigation and increase value created by agriculture. If water were not a limiting resource, water use for agriculture would be expected to grow at around two per cent per annum, depending on price trends for the main commodities, especially the dairy industry.

However, the potential to realise that apparent opportunity depends on the ability to provide water in dry months, which usually requires storage and therefore significant investment that is unlikely to be cost-effective in many cases.

Water trade opportunities

There are opportunities to enhance water trade to make optimal use of the available water entitlements in the Central and Gippsland Region. However, it is unlikely that trade in southern Victoria will ever be as vibrant as trade in the highly connected water supply systems of northern Victoria.

In northern Victoria, many of the catchments are regulated and are connected to each other and interstate systems, which all flow into the Murray system. There, people growing a range of different crops across regions can afford to pay a range of different prices for water in a range of different scenarios of water availability and commodity prices.

By contrast, it is common in many of southern Victoria's non-connected catchments for irrigators to be growing similar crops or pastures. Where everyone is growing similar crops, they are subject to the same economic risks and it is less common for people to be able to pay high enough prices for water to attract it away from existing users.

Some of the key elements limiting the ability to enhance water trade in the Central and Gippsland Region are**:**

- In some catchments and aquifers, it is still possible to apply for new water entitlements under existing caps rather than trade existing entitlements
- Water delivery system constraints physically limit the ability to trade
- When trading upstream in unregulated surface water systems, all-year-round licences must be converted to winter-fill licences
- The high cost of building storages for winter fill licences is a barrier to trade (these costs include the loss of productive land, infrastructure costs, and operation and maintenance costs)
- The need for rosters, restrictions and bans on pumping from unregulated systems during times of low flow deters irrigators from growing the high value crops that might encourage trading
- The lack of buyers willing to pay enough to make it attractive for those with storages to sell water and write off sunk costs – in terms of the loss of productive land
- Lack of buyers willing to pay more than the insurance value of sleeper licences
- The activation of sleeper licences may increase the need for rationing in the system which reduces reliability
- There is only a small pool of buyers and sellers
- The transaction costs involved with trade are high (these include the fees for water trade, the costs of infrastructure development and loss of all-year-round licences when converted to winter fill)
- There are third party impacts, such as the potential for increased rosters, restrictions and bans as well as the potential for less water to be available for either the environment or other water users.

Therefore, the opportunity to significantly enhance trade will remain limited given the nature of most of the catchments.

Under the Ministerial Policies for Take and Use Licences 2014 under Clause 27 all-year-round licences can only be transferred downstream. There are no provisions to enable upstream trade unless an all-year-round licence is converted to the less valuable winter-fill licence. The result of this trade rule can mean all-year-round licences at the downstream end of the river can become stranded as a result of land use change, and in some cases they are unused. This is because they cannot be traded upstream to another parcel of land, where they could be activated or used by a higher value user.

It may be appropriate for this trade rule be reviewed, especially in specific catchments where third-party impacts of upstream trade are negligible or can be mitigated. For example, if an upstream trade has no impacts on third parties including impacts on rosters, restrictions and bans – including when assuming all licences (including sleeper and dozer) are active – then the trade could be allowed. If any negative impacts are negligible and/or can be adjusted for (e.g., with an exchange rate to account for resource availability changes in locations), then this may be an area for potential reform that could improve agriculture's accessibility to the water market/resources.

Recycled water opportunities

The Region produces over 400 GL of wastewater, of which less than 80 GL is recycled. Agricultural producers have a demonstrated ability to use recycled water for production where the quality, quantity, cost and reliability of water is appropriate for specific crops and production systems. In the context of increasing climate variability and reduced water availability, these water sources may become more attractive to agricultural producers due to their relatively stable supply regardless of seasonal conditions.

Key issues with accessing wastewater as a potential alternative water source for agriculture are:

- The quality of the recycled water can limit its use. Salinity tends to be moderate to high and pathogen levels are not always appropriate, e.g. for fresh produce crops. Treatment can occur to ensure water quality matches crop needs. However, this is often costly, particularly if salt reduction is required.
- The majority of the recycled water in the region is available from Melbourne's Eastern and Western Treatment Plants. While these locations are suitable to supply some existing irrigation areas (e.g. the Werribee Irrigation District) they do not necessarily correspond to the preferred locations for irrigation development. As such, there can be a significant cost in pipeline networks and pumping to transfer the water from existing treatment sites.
- Ongoing monitoring is required to meet regulatory requirements, which adds another cost
- Potential agricultural customers may be wary of using recycled water due to concerns about impact on produce quality/safety
- High cost of providing water for agriculture relative to the low cost of current disposal methods of treating to an acceptable standard and discharging. The key costs being treatment, winter storage and distribution infrastructure.

Groundwater opportunities

As demonstrated in Section 4.5, there is the opportunity to further develop groundwater usage. The major impediments to further development are the high cost of bores and low aquifer yields.

Total capital costs per ML will depend on yield, and may range from $500/ML to $5,000/ML. At the lower end of these costs, there may be opportunity for additional irrigation use where additional resources are available or increased utilisation of existing licences can be exploited.

Opportunities to improve the efficiency of existing water use on-farm

Another opportunity to maximise agricultural value is improved farm irrigation practice or technology so that farm water use efficiency is higher. This can include a range of practice change and infrastructure upgrades on irrigated farms:

- Conducting irrigation system checks to identify opportunities for improvement
- Converting old less efficient surface irrigations (flood and furrow) systems or sprinkler irrigation systems to drip irrigation,
- Converting to more efficient sprinkler systems such as centre pivots and linear move,
- Installing drainage reuse, improving layout, land grades and flow rates for surface irrigation,
- Making better use of irrigation scheduling tools
- Whole Farm Planning programs – particularly where public infrastructure modernisation provides for large opportunities for public benefits to be realised. For example, West Gippsland CMA and the

DELWP Sustainable Irrigation Program are currently delivering the "*Newry irrigation farm planning project 2020-21",* as part of Southern Rural Water MID modernisation, supporting all farmers within a sub-catchment to improve their irrigation layout.

The benefits from these on-farm improvements include yield improvement, crop flexibility and labour efficiency and these benefits are very important drivers of adoption. The production benefits, labour efficiency savings and ability to have a more flexible range of irrigation crops must be high to justify the cost of upgrades.

The benefit of irrigation water is, on average, lower in southern Victoria, and this means that the drivers for adopting improved farm technology are generally lower. The drivers would be higher if the returns from irrigation are increased by moving to higher value enterprises, but as previously discussed the ability to do this is, in general, constrained by unreliable water supplies in the summer months and the high cost of storages/ bores to overcome unreliable supply. An important exception is probably in the Macalister Irrigation District, where regulated / more reliable supplies and the relatively low rainfall mean that the benefits of upgrades are higher.

Opportunities to increase access to available water for agriculture

Unlike in Northern Victoria, where the vast majority of water resources are fully allocated and governments have actively sought large volumes of water recovery for the environment, there is some unallocated water available to consumptive use in southern Victoria.

Unallocated water volumes are available as winter-fill surface water licences and groundwater licences, which are unlikely to provide scope for significant irrigation development due to the cost limitations to support year-round supply. There may be some opportunities in areas like the Lindenow flats, where existing and/or new businesses can invest in additional water supply for high-value irrigation.

In the Central and Gippsland region, there are also opportunities to increase the access to available water for agriculture in some areas through changes to water sharing in specific areas undergoing transition – like the Latrobe Valley – and capitalising on existing and future investment in large-scale irrigation modernisation projects that secure water savings for agricultural use – like in the Macalister Irrigation District.

2 Introduction

2.1 PURPOSE

A new Sustainable Water Strategy (SWS) is being developed for the Central and Gippsland Region of Victoria, including the following river basins: Otway Coast, Barwon, Moorabool, Werribee, Maribyrnong, Yarra, Bunyip, Latrobe, South Gippsland, Thomson, Mitchell, Tambo, Snowy and East Gippsland. To inform this work, this independent report provides an updated understanding of the nature of agricultural water use in the region, and the challenges and opportunities for the agricultural sector in the region.

This includes both irrigation water and domestic and stock water for agricultural use.

2.2 CONTEXT

The Central and Gippsland Region SWS embraces the previous Central Region and Gippsland Region SWS boundaries, along with some modifications to the western and north-western boundaries. These changes reflect the increasing connectivity of the Melbourne water system and areas of significant population growth. It includes all of the East Gippsland, West Gippsland, and Port Phillip and Westernport Catchment Management Authority (CMA) Regions and parts of the Corangamite CMA region.

Figure 2-1: Map of the Central and Gippsland region (Source DELWP)

2.3 SCOPE

The Water and Catchments Group of the Department of Environment, Land, Water and Planning (DELWP) is developing the new SWS in consultation with water corporations, CMAs, Agriculture Victoria, and other key stakeholders. It will include actions and policies to improve the management of water supplies and demands in the Central and Gippsland Region.

This report investigates the current and potential future water-related challenges and opportunities for agriculture in the Central and Gippsland region of Victoria. It focuses on water supply and water management. It includes overviews of:

- The key agricultural industries in the region, their social and economic values, and the recent changes affecting them
- Different types of water use in the region – including an explanation of the unique nature of irrigation in the region and how it differs from irrigation in other parts of Victoria
- The main water-related challenges facing agriculture in the region
- The main water-related opportunities to enhance agriculture in the region.

2.4 WATER FOR VICTORIA

Water for Victoria provides a plan for the management of Victoria's water resources. Chapter 4 covers water for agriculture and has eleven actions; see Table 2-1. Other important aspects include Chapter 9 – Realising the potential of the water grid and markets; and Chapter 6 – Recognising and managing Aboriginal Values. For example, Traditional Owner's aspirations are starting to be expressed for flows in the Mitchell.

Table 2-1: Water for Victoria agricultural actions relevant to the region

WATER FOR VICTORIA ACTIONS	RELEVANCE TO THIS STUDY
Action 4.1 Supporting regional development and change	Yes, with regard to value that can be created by improved water management. Value adding, agri-tourism, artisanal production.
Action 4.2 Invest in rural water infrastructure	Yes, with regard to economic irrigation schemes and domestic and stock schemes.
Action 4.3 Help irrigation districts adapt	Yes, Werribee, Bacchus Marsh and Macalister.
Action 4.4 Reduce barriers to change and support communities in irrigation districts	Yes, Werribee, Bacchus Marsh and Macalister.
Action 4.5 Improve water delivery efficiency in irrigation districts	Yes, Werribee, Bacchus Marsh and Macalister.
Action 4.6 Manage salinity, waterlogging and water quality	Yes, manage environmental impacts of irrigation.
Action: 4.7 Manage irrigation developments	Yes, potential new development is seen as a priority.
Action 4.8 Improve salinity management in the Mallee	No.
Action 4.9 Improve management of emergency water supply	Yes, drought supplies and bushfires.
Action 4.10 Develop a rural drainage strategy	No, Strategy completed, being implemented.
Action 4.11 Balance water recovery for the Murray-Darling Basin	No, Is for MDB, generally not applicable except for water saving initiatives which may involve share of water savings for the environment or possibly for urbans.

2.5 WATER RESOURCE MANAGEMENT

Southern Rural Water (SRW) is responsible for monitoring and regulating rivers, streams, waterways and aquifers across most of the Region; with Melbourne Water being responsible for surface water management in the Yarra Catchment and parts of the Maribyrnong Catchment. Both water corporations are responsible for licensing water use from the water resources they manage. This includes the use of water from existing and new farm dams, the construction of new bores, the management of permanent and temporary water transfers and new licence applications. If an application for a licence is refused due to the resource being fully allocated, a licence may be able to be obtained by temporary or permanent transfer from an existing licence holder.

Licence conditions include the installation of a meter to measure and monitor water usage, maximum annual and daily volume that may be used and the need to comply with rosters, restrictions, and bans on taking water. They may also include environmental management requirements.

Catchment Management Authorities also have a role in water resource management mainly water quality, drainage, floodplain, works on waterways, new irrigation development approvals, Land and Water Management Plans and the management of environmental water. Melbourne Water are also responsible for Land and Water Management in Melbourne's west (e.g. Kororoit Creek).

3 An overview of Agriculture in the region

3.1 TOTAL AGRICULTURAL PRODUCTION

The Central and Gippsland Region generates a Gross Value of Agricultural Production (GVAP) in the order of $4 billion per year. As shown in Table 3-1 (and Table A1-1 in Appendix 1), the region accounts for 30 per cent of Victoria's Gross Value of Agricultural Production. For example, the region produces:

- 33% of the State's milk
- 70% of the State's eggs and poultry
- 70% of the State's nurseries and floriculture
- 70% of the State's vegetable production.

Table 3-1: Gross Value of Agricultural Production ABS 2015/16 for the Central & Gippsland Region

Sum of Gross value ($)			
Level 1	**Level 2**	**Grand Total**	% of Victoria
Broadacre crops		48,977,802	4.3%
Fruit and nuts		164,997,661	9.9%
Hay		108,636,933	19.7%
Livestock Products		1,079,662,367	30.0%
Livestock slaughtered and other disposals		1,453,221,738	31.3%
Nurseries, cut flowers or cultivated turf		363,927,635	72.5%
Vegetables for human consumption		671,290,292	69.0%
Grand Total		**3,890,714,427**	29.7%

75030DO005_201516 Value of Agricultural Commodities Produced, Australia 2015-16.

Appendix 1 provides a more detailed breakdown of crops and districts within the Region.

The value of agricultural production per hectare varies significantly across the Region.

Figure 3-1 shows the highest values are associated with intensive horticulture on the Mornington Peninsula and the Yarra Valley. High values are also associated with the intensive irrigation in the irrigation districts at Macalister (dairying), Werribee (vegetables) and Bacchus March (orchards/vegetable).

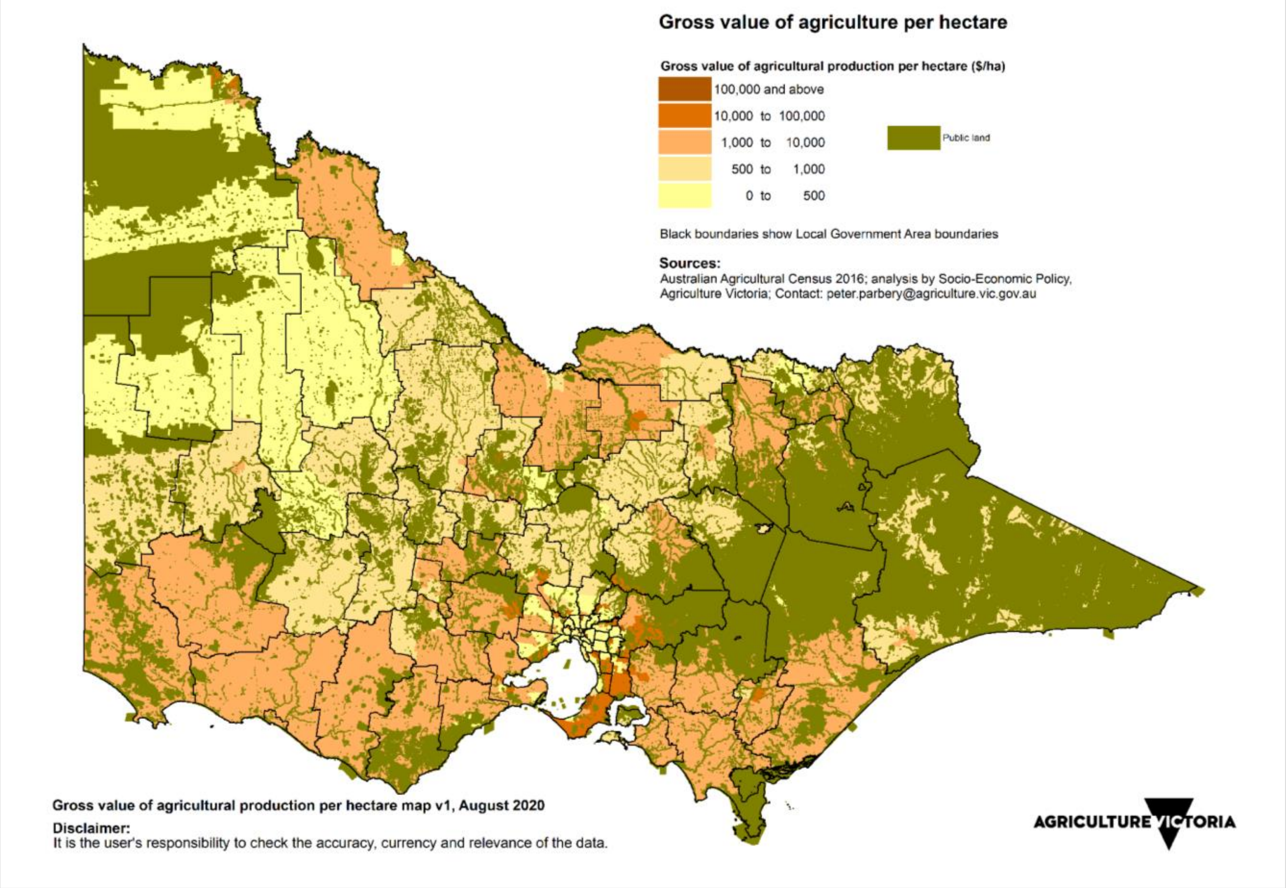

Figure 3-1: GVAP per hectare 2016

3.2 IRRIGATED AGRICULTURAL PRODUCTION

The Gross Value of Irrigated Agricultural Production (GVIAP) is a subset of the GVAP. It describes the value produced with the assistance of irrigation, not the value created by irrigation.

The production figures from 2017/18 are useful in comparing this region's GVIAP with those in other regions. This is because 2017/18 was a typical irrigation year in terms of irrigation allocations across the State, but it was also a low rainfall year, and therefore it can be expected to reflect long term averages. Nonetheless, the relative importance of different regions and industries will change according to regional water allocations, climatic conditions, and commodity prices.

In 2017/18 the Region produced GVAP of $4.7 billion of which the GVIAP was $1.5 billion (32 per cent). This region's GVIAP made up 31 per cent of Victoria's total GVIAP of $4.9 billion. This compares with around $2 billion per year from the GMID and $1 billion from the Victorian Mallee. Details are provided in Table A1-1 and Table A1-2 in Appendix 1.

Table A1-1 in Appendix 1 also shows that of the regional total of $1.5 billion in GVIAP:

- 29% of dairy production is attributable to irrigation
- Over 75% of horticulture value is attributable to irrigation
- Most of the value of production (81 per cent in total) is generated in West Gippsland ($445K) and Port Phillip and Westernport ($770K):
  - West Gippsland irrigation is primarily dairying and vegetables
  - The main irrigation in Port Philip & Western Port is vegetables and horticulture
- Irrigation is relatively small in Corangamite and even smaller in East Gippsland.

It is worth noting here that, given the importance of wineries in the Yarra Valley and the Mornington Peninsula the value of grape production appears to be low in both the ABS 2015/16 survey ($7.9 M) and the 2017/18 survey ($25.3 M), when a much higher value would be expected given the size of the industry. A possible explanation is that:

- The 2015/16 survey only includes grapes sold from one business to another, and it therefore misses those grapes grown and converted into wine by the same business
- The 2017/18 survey does appear to include this[2]
- Both figures understate the value due to wine making and wine tourism, which can multiply the value of the grapes many times.

3.3 THE SOCIAL AND ECONOMIC VALUES OF AGRICULTURE

3.3.1 POPULATION

The Region includes 5.5 million people or 84% of the state of Victoria in 2019. The more detailed table below shows that there is strong population growth in the agricultural areas close to Melbourne.

Table 3-2: Population in the Region, ABS March 2020 – SLA4 (some areas overlap outside study area)

Row Labels	Sum of 2018 no.	Sum of 2019 no.
Geelong	301,832	310,128
Latrobe - Gippsland	283,025	286,952
Melbourne - Inner	682,375	701,634
Melbourne - Inner East	391,246	397,108
Melbourne - Inner South	439,622	445,903
Melbourne - North East	545,317	556,655
Melbourne - North West	406,246	419,348
Melbourne - Outer East	530,366	534,485
Melbourne - South East	842,769	866,324
Melbourne - West	819,102	846,457
Mornington Peninsula	307,670	310,279
Grand Total	**5,549,570**	**5,675,273**

The ABS[3] projected population growth for Victoria's population of 6.3 million in 2017 is projected to:

- Increase by between 1.0% and 1.7% per year, slightly higher than the average annual growth rate projected for Australia
- Reach a population of between 10.1 million and 14.5 million by 2066
- Most of Victoria's growth is projected to occur in Greater Melbourne and have between 5.9 million and 6.2 million by 2027

This will increase competition for land and water pressures on agriculture, but also increase the domestic market demand for foods/products.

[2] The 2020 National Vintage Report (Wine Australia, 2020) indicates that the estimated total value of all grapes (sold and winery grown) was:
- Yarra Valley crushed 6,206 tonnes worth $12.7 M ($5.7 M purchased) or $2,046/t
- Mornington Peninsula crushed 1,703 tonnes $6.4 M ($2.4 M purchased) or $3,758/t
- Gippsland crushed 149 t
- Geelong crushed 984 t.

Adopting $3,700/t for the Gippsland and Geelong grapes give a value of grapes grown of $4.2 M for these regions. This gives a total value of $23.3 M similar to the GVIAP in 2017/18.

[3] https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release

Table 3-3: Population in the Region, ABS March 2020 – SLA3

3218.0 Regional Population Growth, Australia		
Released at 11.30am (Canberra time) 25 March 2020		
Row Labels	**Sum of 2019 no.**	**Sum of 2018 no.**
Banyule	131,700	130,319
Barwon - West	20,732	20,219
Baw Baw	53,486	52,107
Bayside	106,862	105,745
Boroondara	183,172	181,349
Brimbank	200,346	199,615
Brunswick - Coburg	99,584	97,285
Cardinia	112,441	107,385
Casey - North	141,691	140,594
Casey - South	212,181	199,849
Creswick - Daylesford - Ballan	29,625	29,309
Dandenong	205,582	203,015
Darebin - North	105,882	104,212
Darebin - South	58,302	57,441
Essendon	74,831	73,553
Frankston	142,643	141,847
Geelong	206,080	201,938
Gippsland - East	47,422	46,939
Gippsland - South West	66,346	65,023
Hobsons Bay	92,256	90,947
Keilor	64,567	63,427
Kingston	128,401	126,577
Knox	164,510	163,185
Latrobe Valley	75,390	75,028
Macedon Ranges	32,429	31,892
Manningham - East	27,552	27,535
Manningham - West	100,093	98,065
Maribyrnong	93,448	91,413
Maroondah	118,204	117,141
Melbourne City	179,021	170,358
Melton - Bacchus Marsh	184,425	176,226
Monash	194,429	191,926
Moreland - North	85,383	83,726
Mornington Peninsula	167,636	165,823
Nillumbik - Kinglake	69,181	68,994
Port Phillip	115,586	113,257
Stonnington - East	45,711	45,094
Stonnington - West	72,057	71,187
Sunbury	44,193	42,770
Surf Coast - Bellarine Peninsula	83,316	79,675
Tullamarine - Broadmeadows	192,776	184,431
Wellington	44,308	43,928
Whitehorse - East	65,626	65,182
Whitehorse - West	113,843	111,832
Whittlesea - Wallan	249,892	241,792
Wyndham	275,982	260,901
Yarra	102,253	99,294
Yarra Ranges	158,593	157,323
Grand Total	**5,539,969**	**5,416,673**

3.3.2 EMPLOYMENT

The Region includes Metropolitan Melbourne and includes almost 3 million jobs (Table 3-4).

Around one per cent or 36,000 people are employed in agriculture, forestry and fishing. But the proportion is much larger in the rural areas. For example, in Gippsland around ten per cent of jobs are in this sector.

The employment associated with agriculture is not expected to change significantly. Although, there may be some decline with new technology and mechanisation that provides improvements in labour efficiency.

Table 3-4: Employment in the Region, ABS November 2020

Sum of Persons Employed	Column Labels								
Row Labels	Barwon	Gippsland	Metropolitan Melbourne	North East melbourne	North west melbourne	south east melbourne & Peninsula	Western Melbourne	Grand Total	% of total
Accommodation and Food Services	10,000	4,800	50,000	24,900	14,200	26,600	22,000	152,500	5%
Administrative and Support Services	3,400	5,500	25,900	18,100	4,900	20,900	18,100	96,800	3%
Agriculture, Forestry and Fishing	2,900	12,300	3,600	5,700	-	9,100	2,600	36,200	1%
Arts and Recreation Services	1,900	2,200	22,800	9,300	1,600	8,300	6,400	52,500	2%
Construction	19,900	13,200	50,500	60,700	21,200	64,200	33,800	263,500	9%
Education and Training	19,200	10,900	86,800	53,100	14,900	47,900	28,300	261,100	9%
Electricity, Gas, Water and Waste Services	2,000	3,100	9,600	4,000	2,000	10,000	5,600	36,300	1%
Financial and Insurance Services	3,600	1,000	56,500	22,200	8,600	19,900	22,600	134,400	5%
Health Care and Social Assistance	26,100	17,100	128,300	80,400	22,000	87,600	42,400	403,900	14%
Information Media and Telecommunications	800	100	24,100	8,500	1,100	7,600	7,600	49,800	2%
Manufacturing	9,000	8,500	47,800	53,000	17,100	64,100	35,500	235,000	8%
Mining	-	1,400	1,600	100	100	1,200	800	5,200	0%
Other Services	5,900	4,500	22,700	23,500	5,800	19,600	11,000	93,000	3%
Professional, Scientific and Technical Services	8,900	7,100	150,700	48,400	13,900	42,400	35,100	306,500	11%
Public Administration and Safety	14,800	6,000	44,100	27,000	14,100	22,400	24,700	153,100	5%
Rental, Hiring and Real Estate Services	2,300	1,900	20,700	5,700	1,400	10,100	4,200	46,300	2%
Retail Trade	17,700	15,000	77,300	52,800	20,800	69,300	41,300	294,200	10%
Transport, Postal and Warehousing	5,400	4,800	31,400	23,500	18,300	29,500	45,100	158,000	5%
Wholesale Trade	5,000	3,600	30,400	23,900	6,500	22,900	14,100	106,400	4%
Grand Total	**158,800**	**123,000**	**884,800**	**544,800**	**188,500**	**583,600**	**401,200**	**2,884,700**	**100%**

Source https://lmip.gov.au/maps.aspx?layer=EmploymentRegions&region=EmploymentRegion.

3.3.3 LAND VALUES

Land values are particularly high on the fringe of Melbourne. Farms are sometimes bought as rural residential properties or 'hobby' farms. This can mean that some commercial producers find it more cost effective to move their production systems to areas of lower land values. This has occurred in the vegetable industry over time as producers have moved from the urban fringe to Gippsland and northern Victoria.

The Australian Farmland Values report (Rural Bank, 2020) outlines:

For Gippsland:

- The median price per hectare in Gippsland decreased by 5.9 per cent in 2019 to $11,002 per hectare. The decrease in 2019 follows two consecutive years of growth of 15.4 and 15.2 per cent
- There was a greater proportion of larger parcels of land sold in 2019 and these characteristically sell for a lower value per hectare. This was due to a supply shortage in small to medium sized parcels as a result of rural property being held on to. This changed the overall transaction mix and led to a decline in median price per hectare for the region.
- East Gippsland and Bass Coast had the largest declines in median price per hectare both falling 7.5 per cent and 7.4 per cent respectively. Whilst Latrobe and Wellington recorded the highest growth in median price per hectare due to the water security offered with some of these properties.
- The volume of transactions dropped in 2019 by 25.7 per cent to 243. Drought was a key factor leading to a lower number of listings in the area
- Median price for blocks 30–50 ha was $13,274/ha; median price for blocks 90 ha plus was $6,906/ha
- Median prices in 2019 varied by district:
  - Bass Coast $15,904/ha
  - Baw Baw $18,650/ha
  - Cardinia $19,242/ha
  - East Gippsland $4,898/ha

- Latrobe $14,832/ha
- South Gippsland $14,431/ha
- Wellington $10,421/ha.

For the South West (which is broader than the Region):

- The median price per hectare of farmland in South West Victoria increased by 16.7 per cent in 2019 to $8,649 per hectare. This follows an increase of 13.3 per cent in 2018. An increase in the number of investors from the city often outcompeting local buyers pushed land values higher.
- Areas of high rainfall were sought after especially from farmers outside of the region looking to purchase cropping land with the intention of running livestock
- There was a notable increase of 61.4 per cent in the volume of transactions between $12,000–$15,000/ha and an increase of 38 per cent in the greater than $15,000/ha range. The increase in high value transactions was a key driver of median price per hectare growth in 2019.
- At municipality level, a 55 per cent increase to the number of transactions in Corangamite, a high value municipality, contributed to the 16.7 per cent increase to the median price per hectare for the region. In contrast, transaction volume declined significantly in Ballarat and Moorabool 42.9 per cent and 35.3 per cent lower.
- Median price for blocks 30–50 ha was $10,384/ha; median price for blocks 150 ha plus was $5,672/ha
- Median prices in 2019 varied by district (note some of these areas are only partly in the Region):
  - Colac/Otway $11,013/ha
  - Corangamite $10,749/ha
  - Golden Plains $9,899/ha
  - Macedon Ranges $15,659/ha
  - Moorabool $11,223/ha
  - Surf Coast $8,846/ha.

4 An Overview of Water Use in the Region

4.1 THE UNIQUE NATURE OF IRRIGATION IN SOUTHERN VICTORIA

Water budgets for irrigated crops must take account of both rainfall and irrigation. For that reason, irrigation in southern Victoria is a different proposition to irrigation in the lower rainfall areas in northern Victoria just over the Great Dividing Range. It is a very different proposition again to irrigation in the semi-arid Victorian Mallee.

One way to think about this is to look at the ratio between mean annual evaporation rates and mean annual rainfall rates in those various locations. For example, mean annual evaporation at Scoresby on the eastern edge of Melbourne, is 1,188 mm, while mean annual rainfall is 855.4 mm – giving an evaporation to rainfall ratio of 1.4:1. By contrast, the ratio at Tatura is 3:1 and at Mildura it is 7.7:1.[4]

In each of these regions, irrigation is applied to make up for the rainfall deficit in supplying the crop's total water requirements. Because it is solar energy that drives irrigation demands, the higher the ratio between evaporation and rainfall, the greater the volume of irrigation water that must be applied to each planted hectare to meet crop needs.

While it has been illustrative to focus on the ratio between evaporation and rainfall, calculating crop water requirements in real time requires more information. Irrigation scientists have developed widely accepted understandings of how much water a non-water-stressed crop can be expected to 'use' each day for a given stage of crop growth and for a given amount of solar energy. That 'use' is a combination of how much water the crop transpires and how much water is evaporated from the soil surface. The effect of both crop transpiration and soil evaporation are integrated into a single measure called evapotranspiration (ET).

The Food and Agriculture Organisation (FAO) of the United Nations has prepared Guidelines for computing crop water requirements. They describe in some detail how irrigation scientists have developed techniques to calculate the level of solar energy the crops they are monitoring are being exposed to on a daily basis.

The principal weather parameters affecting evapotranspiration (ET) are radiation, air temperature, humidity and wind speed. Several procedures have been developed to assess the evaporation rate from these parameters. The evaporative power of the atmosphere is expressed by the reference crop evapotranspiration (ETo). The reference crop evapotranspiration represents the evapotranspiration from a standardised vegetated surface.

Evapotranspiration from the crop being studied (ETc) is calculated by multiplying the reference crop evapotranspiration (ETo) by a crop coefficient (Kc) determined for the crop being studied. Crop yields respond to applied irrigation up to the point that full evapotranspiration (ETc) requirements are met for the crop being studied.

Figure 4-1 shows the generalised relationship between yield, ETc, and applied irrigation water. Irrigation areas like Mildura would occupy Zone E of that curve, while in average years Tatura would occupy Zone D and irrigators to the east of Melbourne would occupy Zone C. In dry years those irrigators east of Melbourne would occupy Zone D, and in very dry years Zone E. (As will be discussed in more detail in Section 5.4.1, the limited water available to southern Victorian irrigators on unregulated streams in these dry and very dry scenarios effectively puts a cap on their total area of irrigation.)

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[4] Mean annual evaporation at Tatura is 1,460 mm and rainfall is 479 mm. Mean annual evaporation at Mildura is 2,190 mm and rainfall is 285.4 mm. http://www.bom.gov.au/climate/data/index.shtml?bookmark=200 (accessed 3 February 2021.

In southern Victoria, in most years rainfall can meet more than 50% of crop requirement, which means that irrigation is more ‘supplementary’ than ‘core’.

In high rainfall seasons in southern Victoria, irrigation demand is very low and there may be no yield benefit from irrigation. That is, irrigators are operating in Zone A in wet years, or even worse they may be operating in Zone B and suffering a yield decline because of waterlogging and drainage issues. This means that the value of seasonably available irrigation water, (expressed as a percentage of the value of that season’s crop yield) can fall quite quickly from high to zero once crop demands are met.

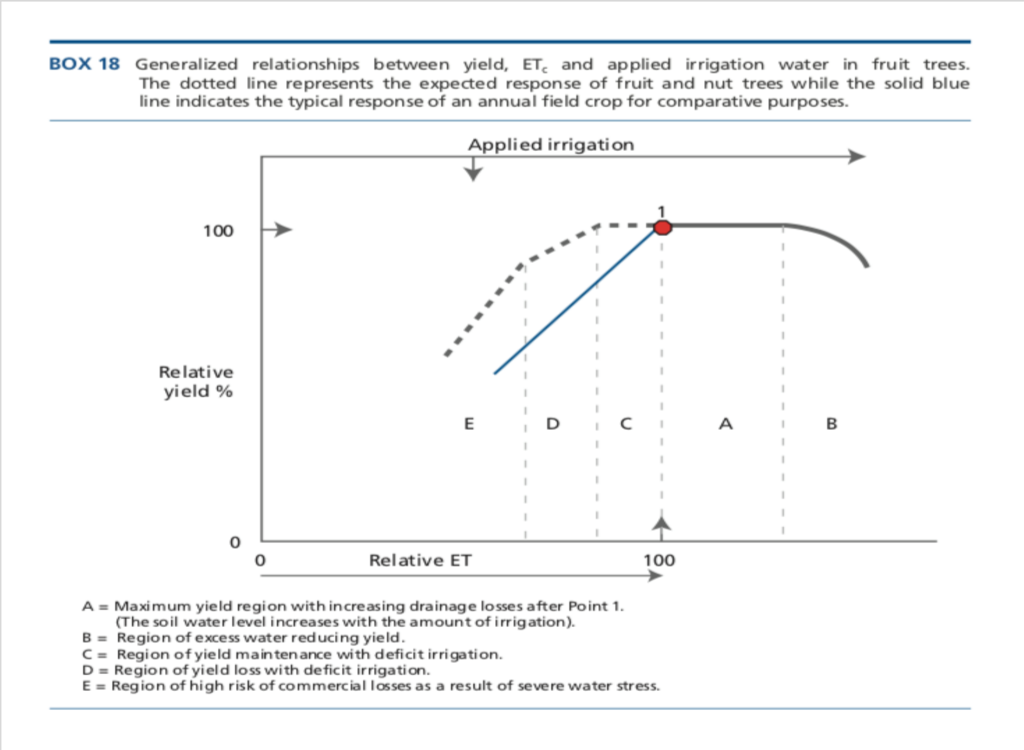

Figure 4-1: Yield response to water (FAO, 2012)

For these reasons, water trade in southern Victoria, compared to trade in northern Victoria, is characterised in most years by:

- Less than full use of water entitlements, as the remaining “sleeper and dozer” entitlements are kept for insurance to meet dry year water requirements when irrigators find themselves in Zones D or E of Figure 4-1
- low prices for traded water entitlements
- low prices for traded water allocations
- low volumes of allocation trade relative to the total available volumes.

In addition, 73 per cent of the irrigation water use is associated with pastures (See Table 4-1 later in this report), and most irrigation outside the irrigation districts takes place in catchments that are unconnected with each other. Therefore, there are few opportunities to trade unused entitlements to those catchments where perennial horticultural crops have relatively constant demands for water and where they would expand to take full advantage of the maximum water available in the summer months.

Put differently, water trade is highest where there is a greater heterogeneity of irrigation enterprises, high levels of connectivity, and where different irrigators are exposed to different sorts of risks. It is easier to swap risks when different people face different risks. It is harder to swap risks when all people face the same risks (i.e., they are all growing the same crops).

This means that, even if market trade rules were made easier in southern Victoria, there are fewer commercial drivers to enhance the value of water through trade than there are in northern Victoria.

4.2 ABS 2018/19 WATER USE ON AUSTRALIAN FARMS

Water use in agriculture is dominated by irrigation requirements. This is the water demand remaining after effective rainfall. Therefore, it is important that water use in any one year references the rainfall that year. The figures below indicate that the 2018/19 water year was one of low rainfall and high irrigation demand. This is particularly important in southern Victoria.

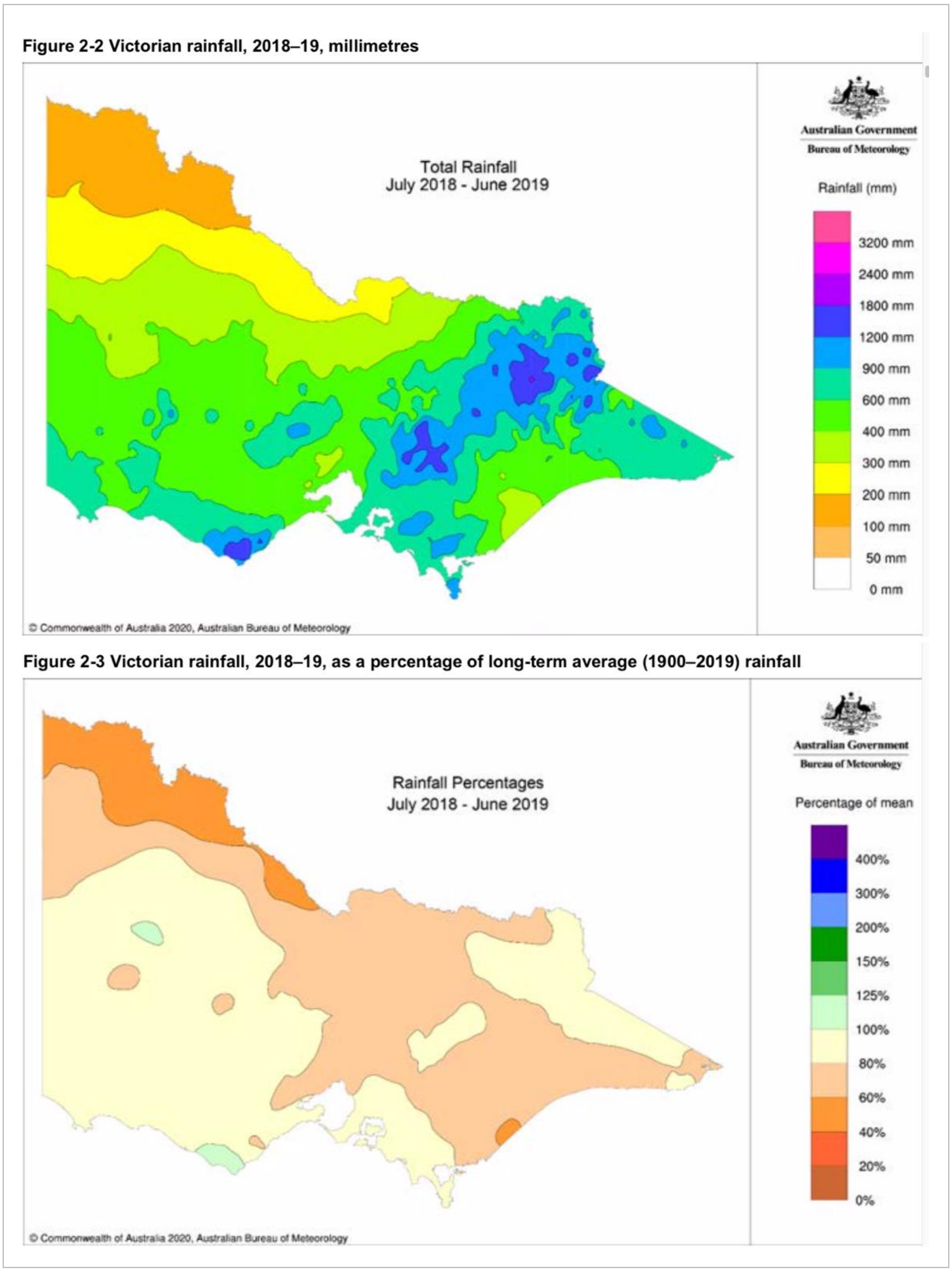

Figure 4-2: BoM rainfall for Victoria in 2018/19

2018/19 was dry with rainfall being around 60% to 100% of long-term average in the Region. This would tend to suggest water usage in this year may have been high, until limited by low water availability, e.g. bans on summer pumping from unregulated streams.

Key features of the area from the 2018/19 ABS Water Use on Australian Farms are shown below. Appendix 3 provides the full data set.

In summary in 2018/19 the Region included:

- 1.9 Million hectares of farms or 17% of Victoria's farm holding area
- 7,500 farm businesses or 34% of Victorian farm businesses
- 1,800 irrigation farms or 30% of Victoria's irrigation businesses
- 83,000 ha irrigated (16% of State):
  - 14,000 ha vegetables
  - 2,000 ha orchards
  - 5,000 ha vineyards
  - 2,000 ha nurseries
  - 5,000 ha broadacre and cereals
  - 55,000 ha pastures/lucerne.

Table 4-1: Study Area ABS 2018/19 Water Use on Australian Farms with 2017/18 ABS GVIAP

	18/19 AREA	18/19 ML/HA	18/19 ML	% OF WATER USE	17/18 $GVIAP	17/18 % OF VALUE
Vegetables	14,000	4	56,000	18%	$546,107,533	36%
Orchards	2,000	4	8,000	3%	$143,256,376	9%
Vineyards	5,000	2	7,500	2%	$ 25,349,359	2%
Nurseries	2,000	2	4,000	**1%**	$313,069,930	**21%**
Crops	5,000	2	7,500	2%	$ 15,419,544	1%
Pastures	55,000	4	220,000	73%	$465,296,910	31%
Total	**83,000**		**303,000**		**$1,508,499,652**	

While comparing two different water years, which complicates the picture, the data in Table 4-1 indicates:

- Irrigation water use per hectare is around 2 to 4 ML/ha
- Vegetables and pastures are the main irrigation enterprises
- The importance of nurseries, including flower growing to GVIAP. This industry uses 1% of the water to produce 21% of the GVIAP.

The detailed data in Appendix 3 shows that:

- Total farm water use in the Region is 16% of State farm water use 49 GL of water taken from farm dams (52% of State)
- 83 GL from groundwater (26% of State)
- 9 GL from town supplies
- 79 GL from channels

- 43 GL from rivers, creeks, lakes
- 43 GL of recycled water (71% of State), this includes Western and Eastern Treatment Plants and other wastewater sources sourced from off farm. This is in broad agreement with the 33 GL reported in the Victorian Water Account 2018/19 (Table 4-2), which shows the vast majority of recycled water is used at the Western Treatment Plant and Werribee Irrigation District.

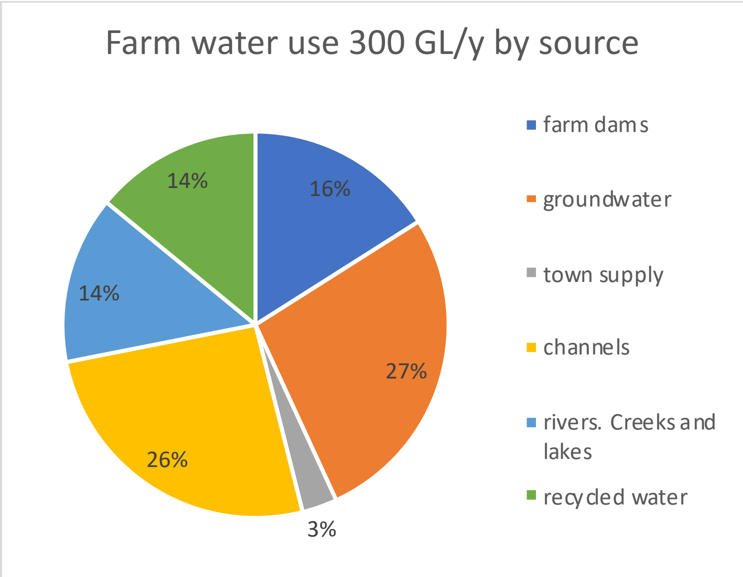

Figure 4-3 Farm water use by water source (ABS 2018/19 Water Use on Australian Farms)

Irrigation water use is approximately half that of Northern Victorian Regions (Figure 4-4) due to higher rainfall and lower evapotranspiration requirement. The irrigation water supplied to pastures and crops is often supplementary to rainfall, rather than being the main water supply in its own right.

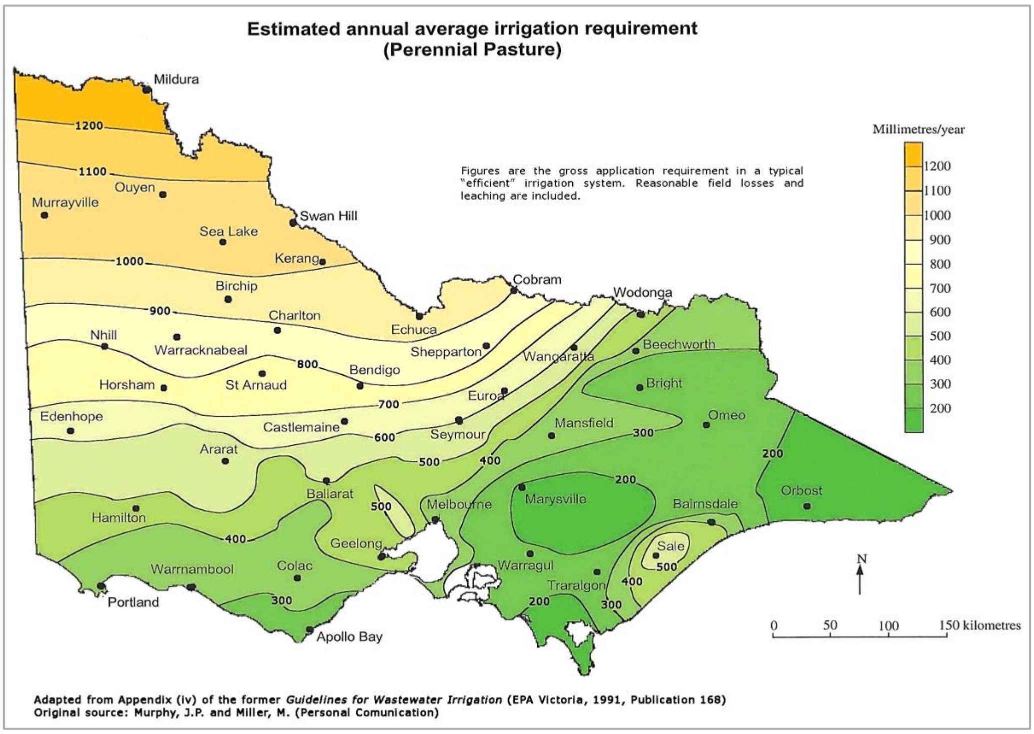

Figure 4-4: Perennial pasture average irrigation requirements across Victoria

4.3 WATER ENTITLEMENTS AND USE

Of the 300 GL/y irrigation use, almost half is located in the irrigation districts. These areas are located in relatively dry parts of the Region on good soils, and they have been well located for maximising the value from irrigation and the water storages that support the districts. The overall entitlements and typical year annual usage is tabulated below.

Table 4-2: Volumes of annual water usage

SUPPLY SOURCE	ENTITLEMENTS HRWS OR LICENCED VOL	ESTIMATED TYPICAL DELIVERIES GL/Y	COMMENT
Macalister Irrigation District	144	126	Most important irrigation district. Average 2010/19 usage.
Regulated mid Thomson	12	8	Linked with MID.
Werribee Irrigation District	12	9	Average 2012/19 usage.
Bacchus Marsh Irrigation District	3	2	Average 2012/19 usage.
Groundwater – unregulated	250 (some for non agriculture)	100 (includes non agriculture) 80 GL estimated for agriculture	Bore yields often lower than entitlement allocated, limiting use to well below entitlement issued. Shallow systems may be unreliable, deeper systems more reliable but more expensive to access/pump.
Surface Water – unregulated	190 (some for non agriculture)	90 (includes non agriculture) 70 GL estimated for agriculture	Tends to be unreliable in dry summers, which limits deliveries to a lower level than entitlements.
Total	**611**	**485 GL in total** **Approx. 300 GL for agriculture**	

(Pers. Comm. T. Flynn, SRW, Victorian Water Account and Victorian Water Register).

Some of the water licences are not regularly used. These are sometimes referred to as “sleeper” licences. Many others are not fully used, and the unused components are sometimes referred to as “dozer” licences. Many farmers prefer to hold these entitlements, rather than use or trade them, so that the impacts of water rationing during periods of restrictions are lessened on their enterprise. Others hold onto unused entitlements, because they believe it adds value to their property.

The reliability of supply varies with each catchment and each season. All winter-fill licences require farm dams to store water to ensure a reliable supply through summer. Similarly, some holders of all-year round licences, because they are subject to rationing, have storage and/or additional entitlement to manage rationing or pumping bans. Others may manage their risk in other ways, or have production systems that are interruptible, such as lucerne stands that can be treated as dryland plantings if irrigation water is not available. Irrigators will also adjust the area of their irrigated plantings according to the expected water availability.

The costs of storage and double pumping of water can be prohibitive, particularly for low-value or supplementary irrigation. Holding additional entitlement to minimise the impact of rationing can be a much lower cost strategy than building farm storages. This will continue to be the case as long as the price of entitlements is lower than the cost of building farm storages. Therefore, it is expected that large volumes of sleeper and dozer entitlements will continue to be held rather than sold and this will limit water trade.

4.4 STREAM DIVERSIONS

4.4.1 TOTAL RESOURCE

Adopting 2018/19 (a dry year) as the baseline annual water balance for the purposes of this report, there were 4,900 GL of surface water inflows.

Table 4-3 indicates that surface water diversions in 2018/19 were almost 1,200 GL. Of those:

- Urban water use represented 71% or 800 GL
- Licensed stream diversions represented 25% or 290 GL, made up of:
  - Irrigation districts 200 GL (includes losses)
  - Stream diversions 90 GL (including non agricultural use).

Table 4-3: Surface water basin water balances

From Victorian Water Account Water Balances					*= does not match report exactly but close, probably due to storage changes							
	2018/19 use											
Basin	Inflows	Diversions	Losses	Outflows		urban	licensed stream diversions	catchment dams	total		less irrigation districts	Not irrigation districts
East Gippsland	182,905	446	165	182,294		97	64	285	446			64
Snowy	552,421	3,151	896	548,374		755	1,433	963	3,151			1,433
Tambo	43,687	1,710	929	41,048		29	900	781	1,710			900
Mitchell	385,935	17,899	1,976	366,060		4,654	12,746	499	17,899			12,746
Thomson	465,237	425,406	27,652	12,179	*	200,464	224,607	335	425,406		191,057	33,550
Latrobe	425,963	122,451	9,715	293,797	*	101,196	15,106	6,149	122,451			15,106
South Gippsland	530,970	21,270	7,064	502,636	*	7,207	2,327	11,736	21,270			2,327
Bunyip	494,725	40,516	7,848	446,361	*	24,094	7,395	9,027	40,516			7,395
Yarra (inflows inc. 200 GL Thomson 21 GL desal)	726,850	423,971	14,363	288,516	*	412,237	6,835	4,899	423,971			6,835
Maribyrnong	29,322	4,636	7,165	17,521	*	2,038	765	1,833	4,636			765
Werribee	47,850	14,593	6,447	26,810	*	2,549	10,996	1,048	14,593		10,819	177
Moorabool	41,291	17,900	13,955	9,436	*	11,999	3,254	2,647	17,900			3,254
Barwon	120,133	39,386	15,851	64,896	*	34,123	1,140	4,123	39,386			1,140
Otway Coast	816,710	22,620	4,086	790,004		13,531	175	8,914	22,620			175
Total	**4,863,999**	**1,155,955**	**118,112**	**3,589,932**		**814,973**	**287,743**	**53,239**	**1,155,955**		**201,876**	**85,867**
						71%	25%	5%				

Source: 2018/19 Victorian Water Accounts.

Further detail on the usage by irrigation districts and stream diversions is described below.

4.4.2 IRRIGATION DISTRICTS

Southern Rural Water (SRW) provides water services to three irrigation districts, Macalister, Werribee and Bacchus March. In each case, SRW manages the storage of the water owned by the irrigators, coordinates its delivery to the district, and maintains the supply infrastructure. This gives irrigators in the districts the ability to grow high value crops and products with confidence about their ability to access the water when they need it.

Macalister Irrigation District (MID)

The MID uses around 150 GL/y or around half the irrigation use in the Region. The dairy industry in the MID produces around 300 million litres of milk a year with a value at the farm gate of around $150 million. This supports significant milk processing in the region. There is also irrigation for vegetable growing, cropping and beef cattle and sheep grazing.

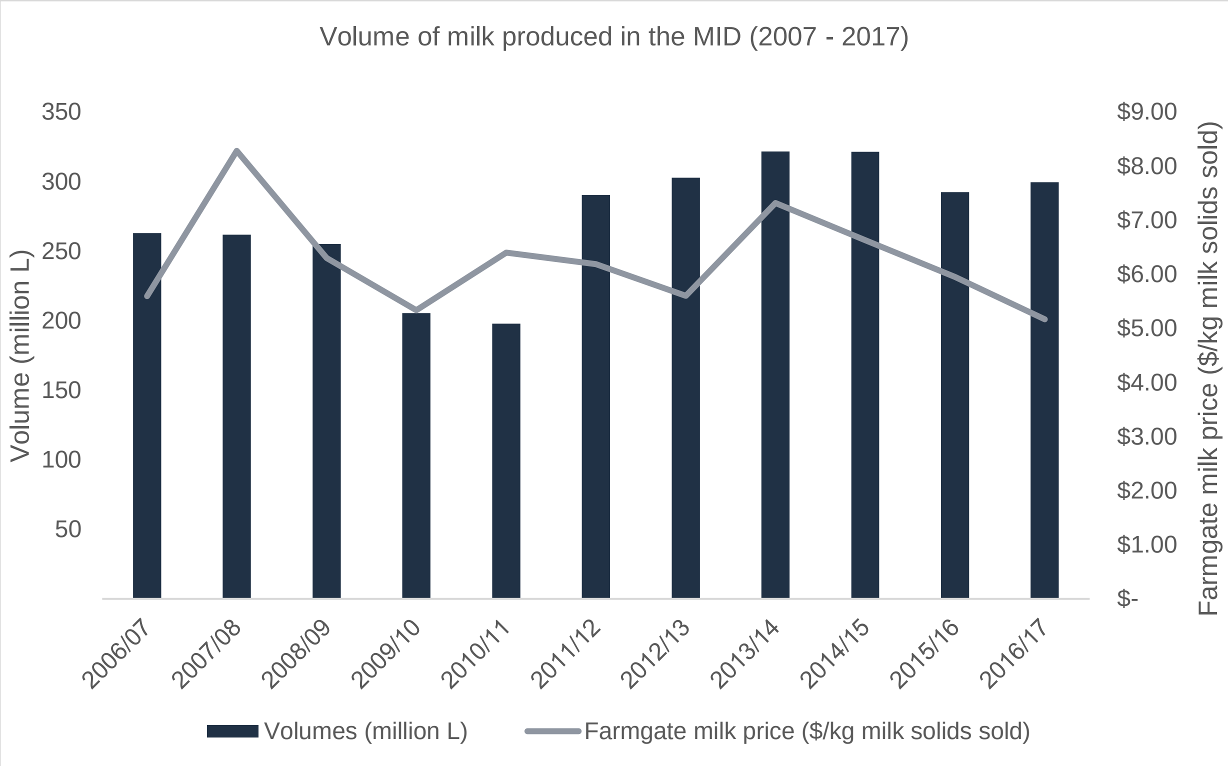

Figure 4-5: Volume produced and farmgate milk price in the MID from 2007 to 2017 (data source: Volumes – Dairy Australia, 2018 – adjusted for CPI)

The gross agriculture value increased from $135 million in 2010/11 to $214 million in 2015/16, as shown in Figure 4-6. The value of irrigated beef, sheep and grain production is not included as it is small and difficult to estimate.

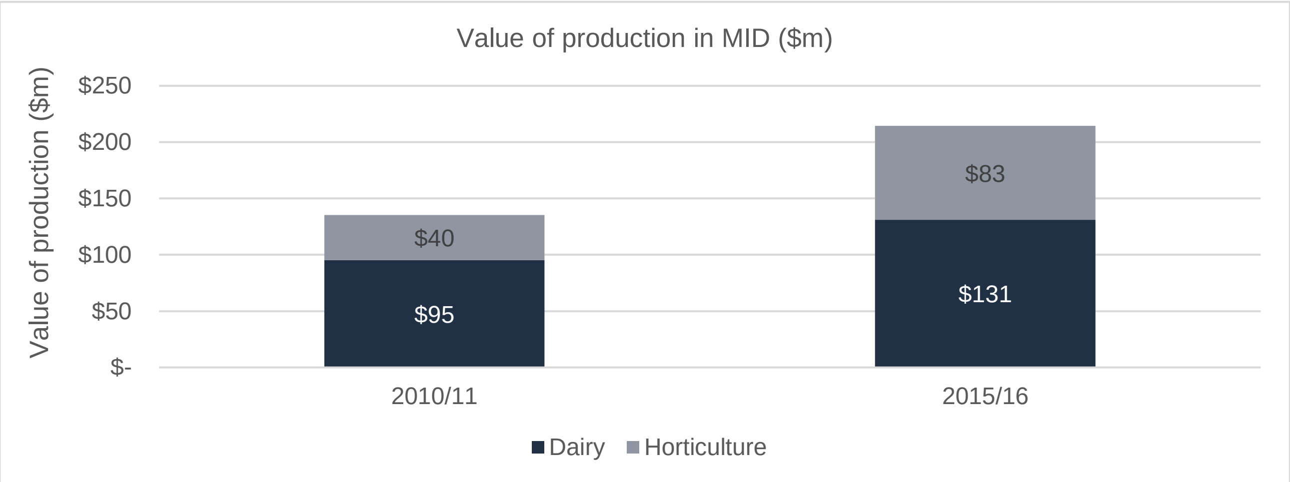

Figure 4-6: Farmgate value of irrigated agricultural production, MID, 2010/11 and 2015/16[5]

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[5] Data source: ABS.

The value of horticulture production increased significantly over the period. This was because of an increase in the area under production, and it is likely to reflect a permanent shift towards horticulture in the MID. SRW's modernisation activities support horticultural growth by providing a more consistent and reliable supply of water

The change in value of horticulture production in the MID is influenced by the overall demand for horticultural land and water in Victoria. The proxy for this demand is Victorian horticultural production. Across Victoria, there has been a 22% increase in value of horticulture production since 2011. By comparison the MID has performed particularly well by increasing 108% since 2011, suggesting that local changes, such as modernisation in the MID, and the movement of horticulture producers from the fringe of Melbourne have played a role.

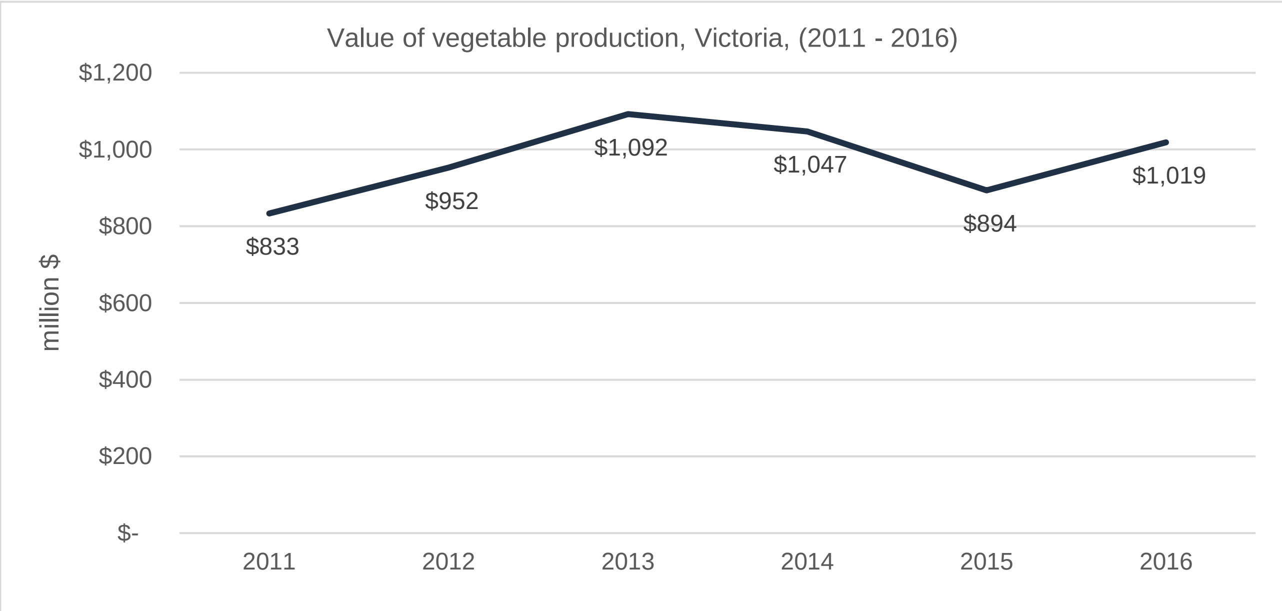

Figure 4-7: Value of vegetable production, Victoria 2011-2016[6]

Werribee Irrigation District (WID)

The Werribee Irrigation District covers an area of 3,000 ha of which 2,350 ha is used for intensive horticulture, chiefly broccoli, lettuce and cauliflowers, around 9 GL/y is used.

The WID receives its irrigation supply from the combination of three storages at Pykes Creek, Merrimu Reservoir and Melton Reservoir. These storages hold water from both the Werribee and Lerderderg River systems. Following several years of extreme drought conditions, the WID Recycled Water Scheme was implemented in 2004 to supplement water supply with recycled water from the Western Treatment Plant.

Pipelining has been carried out as a result of urban development and to replace older channels. Recent works include 39 km of open channels replaced with pipelines, saving 5 GL/y (Minister for Environment, Climate Change & Water, 2021).

The WID is one of the premier vegetable growing locations in Australia, with lettuce, broccoli and cauliflower the main crops with an annual value of production approximately $80 million. Growers provide a range of value-adding prior including packing, chilling and transport. These activities increase the effective value of the products grown. This value increased from $66 million in 2010/11 to $77 million in 2015/16 in the WID, as shown in Figure 4-8 below.

[6] Data source: ABS.

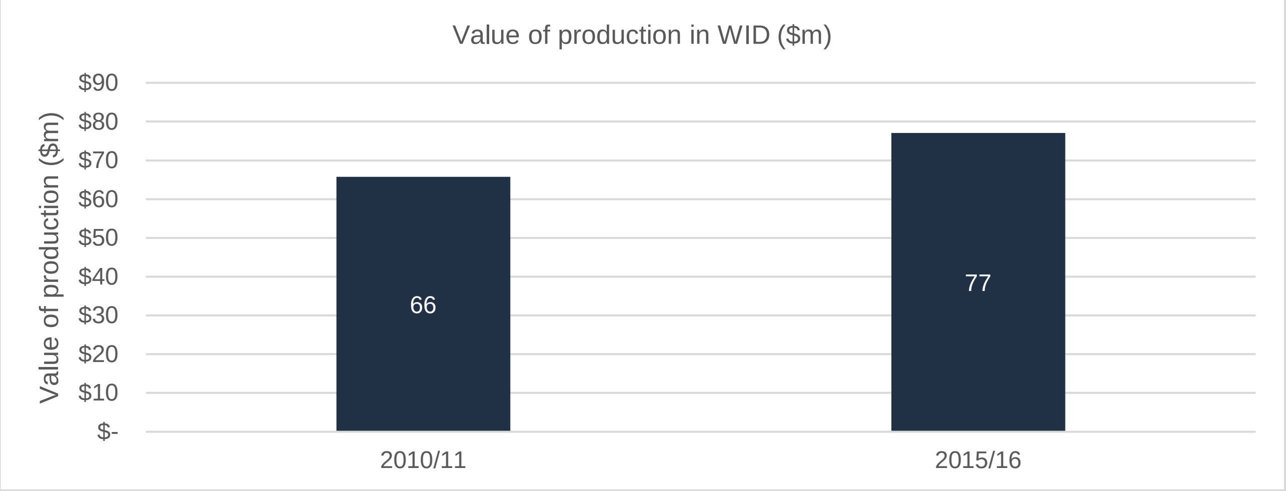

Figure 4-8: Farmgate value of irrigated agricultural production, WID, 2010/11 and 2015/16[7]

Bacchus Marsh Irrigation District (BMID)

The 1,000 ha BMID receives its irrigation supply via a weir on the Werribee River just east of Ballan, which diverts water via a tunnel and Myers Creek to Pykes Creek Reservoir. Water from Pykes Creek Reservoir is released into the Werribee River via the Korweinguboora Creek. A second diversion weir located west of Bacchus Marsh on the Werribee River diverts irrigation supplies into the BMID. The recent Bacchus Marsh upgrade commenced modernising 43km of irrigation infrastructure, mainly through replacing open channels with pipelines, saving 1.1 GL/y. (Minister for Environment, Climate Change & Water, 2021).

Around 2 GL/y is used for vegetable growing, turf and orchards as the dominant enterprises, with loose leaf lettuce and broccoli the main vegetable crops, while orchards are primarily pome fruit (apples) with an increasing emphasis on cherries. The growers generate an annual commodity value of around $40 M. There is considerable value-adding prior to market – particularly in the speciality salad crops.

The value of production from the BMID increased from $24 million in 2010/11 to $44 million in 2015/16 in the BMID as shown in Figure 4-9.

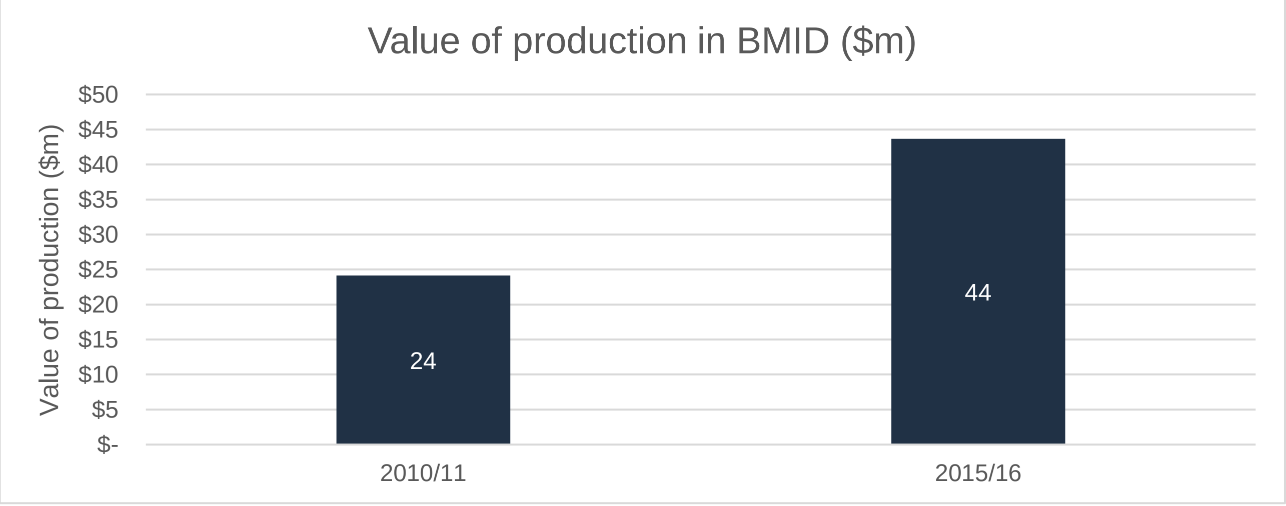

Figure 4-9: Farmgate value of irrigated agricultural production, BMID, 2010/11 and 2015/16[8]

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7 Data source: ABS.

8 Data source: ABS.

Figure 4-10 shows the dollar value of farmgate production for SRW's irrigation districts in 2010/11 and 2015/16.

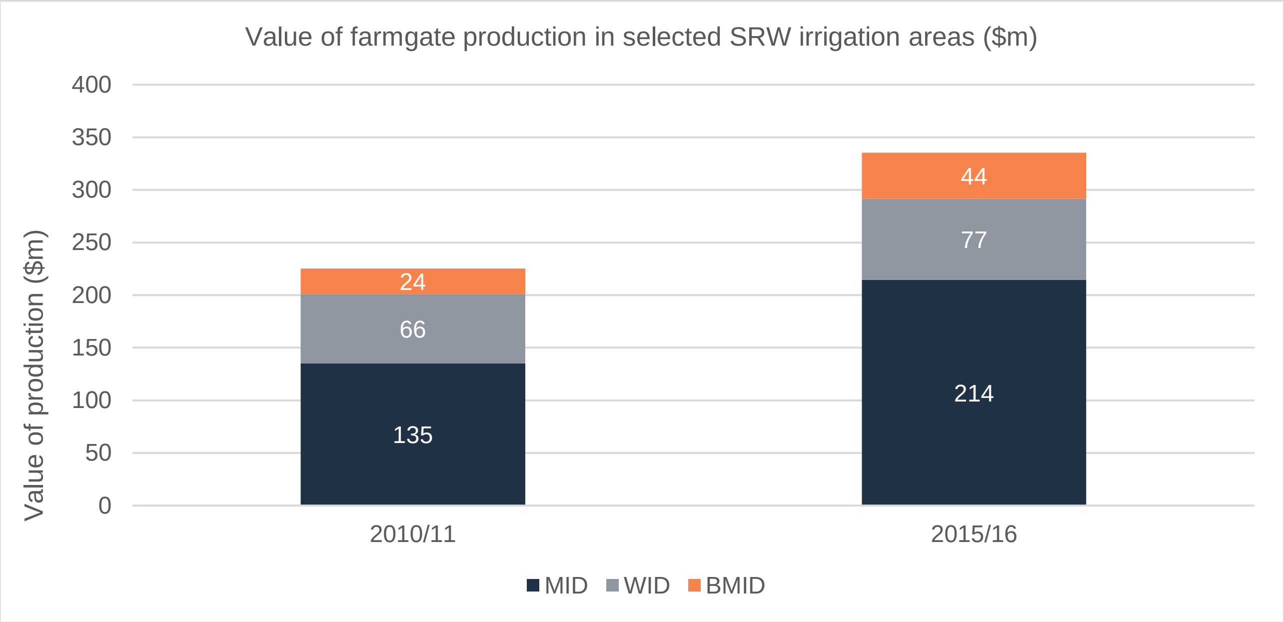

Figure 4-10: Farmgate production value in key SRW irrigation districts in 2010/11 and 2015/16[9]

4.4.3 LICENSED DIVERSIONS OUTSIDE OF IRRIGATION DISTRICTS

SRW licenses the right to take and use water from rivers, except for the Yarra River, where Melbourne Water issues licences. Most streams are unregulated, but there are significant regulated diversions from the Latrobe and Thomson rivers.

This licensing role protects the property rights of the individual licence holders as well as ensuring that the needs of the environment are protected for the benefits of the wider community. This water is used to support irrigation, provide water for urban consumption and commercial use. It is also available for Stock and Domestic use.

Of the 90 GL of annual diversions, it is estimated agriculture uses 70 GL, with industrial use the remainder.

The following table captures the value of those diversions, based on the 2006/7 to 2008/9 period, which was drier than average. These exclude the Yarra River, which has a high proportion of high value horticulture.

[9] data adjusted for CPI.

Table 4-4: Diversion usage by River Basin (ML) average 2006/7-2008/9

	LOWER VALUE (BEEF)	MEDIUM VALUE (DAIRY)	HIGHER VALUE (HORTICULTURE)	TOTAL IRRIGATION
Barwon	295	443	591	1,329
Bunyip	426	426	2,554	3,406
Corangamite	101	34	17	151
East Gippsland	0	313	0	313
Latrobe	3,810	2,078	693	6,581
Maribyrnong	18	0	97	115
Mitchell	1,137	1,137	5,687	7,962
Moorabool	428	0	535	963
Otway Coast	98	393	393	884
Portland Coast	9	5	1	14
Snowy	0	478	478	956
South Gippsland	354	1,769	1,415	3,538
Tambo	418	418	0	835
Thomson	562	3,933	562	5,057
Werribee	0	0	0	0
Yarra (2018/19)			6,835	6,835
Totals	**7,656**	**11,427**	**19,858**	**38,939**

(Source (RMCG, 2010) and ABS Water Account 2018/19 for Yarra).

This table understates current diversions in an average year, but does identify the mix of low, medium and high value irrigation users. It also shows the importance of high value horticulture that is grown mainly in the Yarra and also on the Lindenow Flats along the Mitchell River.

4.5 GROUNDWATER

4.5.1 TOTAL VOLUMES OF GROUNDWATER

The table below indicates that only a small proportion of the usable groundwater volume is licensed, and an even smaller amount is used. Usage is only about 100 GL/y from 250 GL of licensed volume and over 300 GL of usable volume.

This suggests there is large potential for expansion, provided the water is of suitable quality and is economic to access and use.

Table 4-5: Volumes of groundwater (includes south west outside study area)

Looking at the numbers in detail

Region	Total volume	Usable volume	Licensed volume
Gippsland	250,000 GL	175,000 GL	160 GL
Port Phillip & Western Port	29,000 GL	3,660 GL	22 GL
South West	300,000 GL	150,000 GL	79 GL
All Aquifers in Southern Victoria	579,000 GL	328,660 GL	261 GL

* All figures presented in this table are our best estimates. It is very difficult to accurately measure the volume of aquifer systems.

http://gwhub.srw.com.au/how-much-groundwater-there.

Table 4-6: Volumes of licensed groundwater

AQUIFER TYPE	PORT PHILLIP AND WESTERNPORT ML	GIPPSLAND ML	COMMENT
Upper	20,015.7	68,300	Shallow, least reliable and low cost.
Middle	20,771.8	55,300 Includes 10 GL for Latrobe Valley mines.	
Lower	35,391.9	71,500 Includes 36 GL for Latrobe Valley mines.	Deep, most reliable, high cost.
Total	**56,179.4**	**195,000**	

Source T. Flynn.

Table 4-7: Volumes of licensed groundwater Use includes non-agricultural use

BASIN	ML ENTITLEMENT	18/19 USE ML
East Gippsland	2,105	942
Central Gippsland	162,172	85,806
Seaspray	25,867	17,994
Moe	5,213	1,358
Tarwin	2,205	1,163
Westernport	17,673	6,001
East Port Phillip	27,998	10,603
West Port Phillip	18,093	4,535
Otway Torquay	14,403	246
Total	**275,729**	**128,648**

Source 2018/19 Victorian Water Accounts.

It is estimated that agriculture uses around 80 GL. Of the other users urban water use accounts for 8 GL and mine dewatering extracts around 33 GL, much of which is ultimately is returned to surface water. (DELWP, 2019).

4.5.2 OWNERSHIP OF GROUNDWATER ENTITLEMENTS

Data from SRW (tabulated below for Gippsland and Port Phillip/Western Port)) shows that agriculture holds most of the groundwater entitlements (licences) by volume followed by industrial users.

Table 4-8: Proportion of groundwater entitlement held by user group in Gippsland

	AGRIBUSINESS	INDUSTRIAL	URBAN	DOMESTIC AND STOCK
Upper	92%	<1%	1%	7%
Middle	72%	17%	7%	4%
Lower & basement	49%	47%	2%	2%

Source http://gwhub.srw.com.au/groundwater-use-gippsland.

While there is a high number of domestic and stock users who, while they do require licences to construct their bores, do not require licences to take and use water. Based on metred stock and domestic usage elsewhere, it is possible to estimate their actual use. They generally access very small volumes so they account for a small proportion of potential use overall. SRW estimates that there are 4,067 domestic and stock bores in Gippsland and that on average each uses 1.3 ML/year giving a total of 5,287 ML/year.

Table 4-9: Proportion of groundwater entitlement held by user group in Port Phillip and Westernport

	AGRIBUSINESS	URBAN & INDUSTRIAL	DOMESTIC AND STOCK (RURAL)	DOMESTIC AND STOCK (URBAN)
Upper	70.4%	16.3%	11.1%	2.2%
Middle	77.5%	16.3%	5.6%	0.6%
Lower	59.0%	37.7%	3.0%	0.3%
Basement	57.8%	15.2%	26.0%	1.0%

Source http://gwhub.srw.com.au/groundwater-use-port-phillip-western-port.

SRW estimates that since 1980 there have been 8408 bores drilled in the Port Phillip and Westernport region and that each use on average 1.3 ML/year in rural areas and 0.2 ML/year in urban areas. Therefore, SRW estimates total average annual use at 6,305 ML.

4.5.3 USAGE OF GROUNDWATER ENTITLEMENTS

Less than half of the licensed groundwater entitlement volume in the region is, on average, used. Unused entitlements may be traded either temporarily or permanently to other users who are seeking additional water or a new water source. But to date trade has been minor. Table 4-10 shows usage for the 2013/14 year for both the Gippsland and Port Phillip-Westernport regions. It shows the licensed groundwater volume in each region and the actual usage during 2013/14 – based on metered data collected by SRW.

The low use relative to the entitlement volume is usually due to individual bores yielding less than the entitlement allocated at the approval. SRW usually suggest 6 ML/ha for the area planned to be developed, but bores frequently are unable to yield the flow required at peak demand periods to service that volume.

Table 4-10: Volumes of groundwater used in Gippsland

	GMU	LICENSED VOLUME (ML) 2013/14	METERED USE (ML) 2013/14
Upper	Denison	18,501.4	5,884.0
	Orbost	1,216.5	257.4
	Tarwin	38.2	21.0
	Wa De Lock	29,285.7	5,546.5
	Wy Yung	7,462	765.1
	Non-GMU	10,857.9	NA
Middle	Giffard	5,688.5	1,436.0
	Rosedale	22,372.0	5,745.6
	Sale	21,217.7	10,036.9
	Non GMU	4,829.4	NA
Lower	Leongatha	1,840.7	208.9
	Moe	3,990.5	797.3
	Stratford	27,645.0	21.3
	Yarram	25,688.8	10,076.5
	Non GMU	2,723.9	NA
Total		**183,358.2**	**11,104**

http://gwhub.srw.com.au/how-much-groundwater-there.

Table 4-11: Volumes of groundwater used in Port Phillip and Westernport

	GMU	LICENSED VOLUME (ML) 2013/14	METERED USE (ML) 2013/14
Upper	Deutgam	5,082.1	801.8
	Nepean	6,109.5	3,003.9
	Merrimu	440.1	123.5
	Lancefield	1,377.5	622.8
	Non-GMU	7,951.7	NA
Middle	Frankston	1,671.4	121.6
	Koo Wee Rup	12,611.8	3,277.2
	Moorabbin	2,623.8	1,131.8
	Non GMU	3,579.6	NA
Lower	Cut Paw Paw	513.5	424.2
	Corinella	662.1	76
	Parwan	371	NA
	Wandin Yallock	3,004.9	366.0
	Non GMU	10,007.8	NA
Total		**56,006.8**	**366**

http://gwhub.srw.com.au/how-much-groundwater-there.

4.6 EMERGENCY WATER SUPPLIES

Emergency water supply points (EWSPs) were built in response to the impact of severe dry seasonal conditions and surface water scarcity in many regions. The EWSPs provide water carting for emergency stock and domestic purposes, during severe dry seasonal conditions and surface water scarcity. Some sites are also equipped to supply water to firefighting vehicles. When the supply is potable, they are sometimes used as a source for water carters filling empty or low rain water tanks.

The Department of Environment, Land, Water and Planning (DELWP) oversees the network of emergency water supply points. While the EWSPs are managed by various state agencies, including local councils and urban and rural water corporations, who undertake maintenance, access and manage use.

There are three main types of EWSPs accessible to the public for water carting:

- Council bores - access groundwater
- Urban standpipes – are connected to reticulated potable water systems. These are managed by urban water corporations and access is subject to water availability. A permit may be needed and costs may apply as they are considered a commercial use.
- Rural standpipes - access channels or reservoirs. These are managed by rural water corporations.

The study region has a network of about 145 EWSPs, which is about half of the States network of 300. The website below provides a map to identify EWSPs and the contact details.

https://www.water.vic.gov.au/groundwater/emergency-water-supply-points

EWSPs have an important function in drought years and for bush fires. However, reliability of some EWSPs can be an issue, especially if they have not been operated for many years and maintenance has been lacking.

This has been an ongoing issue with groundwater bores especially as the maintenance of EWSPs can be outside of Local Government's core business and expertise. What is missing now is a coordinated, strategic, and systematic asset management system for this bore network. Such an approach could provide assurance that these bores would be operational when they are needed and that the beneficiaries of those bores were contributing to their ongoing operations and maintenance. Victoria's Regional Water Monitoring Partnerships provides a model for setting up an appropriate maintenance and assurance framework.

5 Water-Related Challenges for Agriculture

5.1 DECLINING WATER SUPPLY

The draft long term water resource assessment for southern Victoria (DELWP, 2019) found that long-term surface water availability across southern Victoria has declined by up to 21 per cent. The decline in water availability has affected the environment, industry and other water users.

The assessment found that the main cause of declines in surface water availability is drier climatic conditions associated with climate change. The interception of water for storage in domestic and stock dams and plantations may also be contributing to the decline in surface water availability.

Water availability for consumptive uses (by people and industry) has declined in most of southern Victoria, with the percentage declines varying from 1 per cent to 13 per cent.

Long-term groundwater availability has also declined in some areas of southern Victoria. This has had little impact on consumptive uses, and groundwater extraction has had only a very small effect on water availability at the regional level compared to other influences such as climate change.

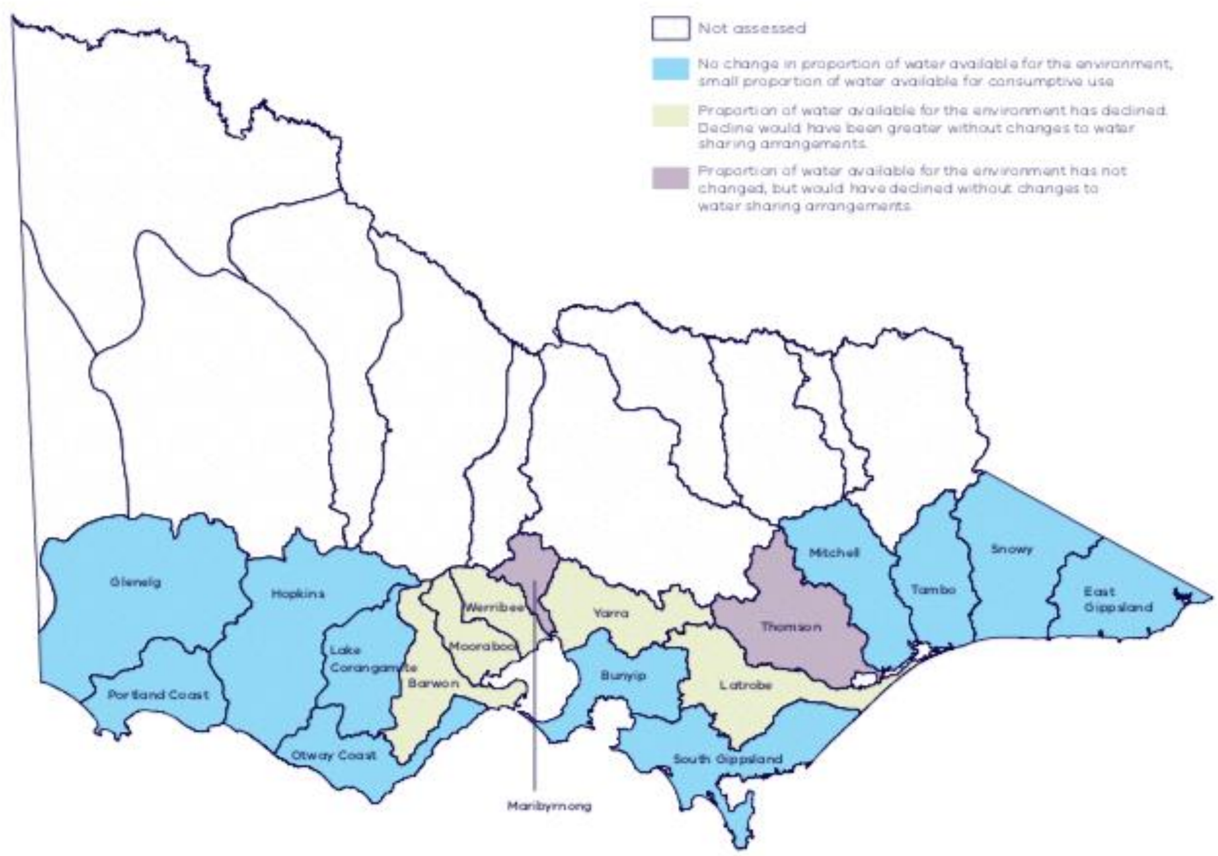

Figure 52: Changes in proportions of water available for the environment and for consumptive uses, by basin

Figure 5-1: Changes in water availability from (DELWP, 2019)

5.2 INCREASING COMPETITION FOR WATER AND LAND WILL LIMIT IRRIGATED AGRICULTURAL GROWTH

Agriculture faces a number of water-related challenges in the Region. Key ones include competition from:

- Power generation, which has required large volumes of water, and probably will continue to do so for 30 years or so after the mines close in order, to the extent possible, to fill the mine voids with water to stabilise the surrounding landscapes. This may also provide the opportunity to harvest high flows and enable the creation of new high reliability water share entitlements for agriculture.
- Population growth and urban demands, Melbourne continues to be one of the fast-expanding cities with growth to the east, north and west, which will impact of agricultural land and water needed for cities.
- Increasing land values and decreasing land supplies close to Melbourne, Geelong, the Bellarine Peninsula, the Surf Coast and the Mornington Peninsula driven by population growth –will further fragment agricultural land uses – however this may also see migration of high value irrigated vegetable and nursery businesses to other parts of the region such as the MID and the Mitchell River flats.
- Water for the environment is being affected by declining availability and water is required to maintain existing ecosystems that support both natural and economic values such as recreation, amenity and tourism. This will reduce potential access for expansion of irrigated agriculture.

There is also a Victorian Government policy commitment to return water entitlements to Traditional Owners and First Peoples in Victoria to support their right to self-determination recognising their deep connection to water and addressing past injustices and dispossession. In November 2020, the Victorian Government made 2 GL of water in the Mitchell River available to the Gunaikurnai Land and Waters Aboriginal Corporation.

5.3 RETICULATED DOMESTIC AND STOCK WATER SUPPLY SYSTEMS ARE NOT FEASIBLE

In Northern Victoria a number of domestic and stock systems have been installed to assist farmers in managing drought.

An examination of the viability of domestic and stock systems in Gippsland (Marsden Jacob Associates, 2019) considered areas with rainfall less than 600 mm and identified there were no feasible options to develop domestic and stock systems in Gippsland.

Their assessment of large to small scale domestic and stock systems found them to be neither efficient nor effective; unless they were part of an expanded irrigation area where complementary domestic and stock systems could be feasible as part of the development. The Study concluded:

"*There are no efficient and effective system options to address domestic and stock needs. Instead, the preferred responses are to improve emergency water access and help address farm practice and landuse change over the longer term."*

Key short term responses identified in the report:

- *"Continue to upgrade emergency water supply points.*
- *Develop farm management plans that recognise and respond more effectively to drought.*
- *Provide farm practice change information*
- *Clarifying accountabilities across jurisdictions and developing greater alignment of emergency jurisdictional approach."*

The report identified a number of longer term responses to enable adaptation and reducing impediments to land use change and farm amalgamation. Including:

- *"Drought management and whole farm planning and grazing management practice change*
- *Development of integrated on farm surface water conservation practices and infrastructure – including deepening of farm dams, farm fencing and grazing management systems*

- *Developing land use change policies and reducing red tape associated with land use change."*

5.4 VARIABILITY IN SUPPLY PLACES A CAP ON IRRIGATION

5.4.1 UNREGULATED SURFACE WATER – DRY MONTHS DETERMINE THE AREA AND VOLUME DEVELOPED

In the long term, irrigation from unregulated surface water systems is limited by the volume of water available in the driest month of the irrigation season. This limits the area of land that can be developed. If irrigation does expand beyond this area, then it will inevitably shrink again the next time water availability is limited in that dry month. Irrigators must make their planting decisions in prospect. That is, because they cannot be sure exactly how an irrigation season will play out, irrigators will usually only plant up the area that they know can be supported through the lowest period of water availability.

Recent experience on the Mitchell River illustrates this point. The Mitchell is the largest unregulated surface water resource in the Region, and SRW has management rules in place to define the way rosters and restrictions will work in the catchment during low flows. Diversions are metered and customers are required to confine their irrigation to the area licensed for irrigation within their properties. Restrictions are triggered by flow levels. There is a complex roster divided into three groups of irrigation licences.

Winter-fill licences are not usually restricted, because, by definition, they only allow diversions in the high-flow winter months, and the diverted water must be stored in off-stream storages until it is used for irrigation in the summer months. Domestic and stock licences, dairy-wash licences and commercial licences are not restricted either since they supply critical needs. There are also a significant number of conditional licences on the Mitchell River, and these cannot be used when restrictions are called; they are excluded from rosters.

Restrictions generally occur between January and April, but can start as early as October. They tend to last for several weeks at a time and sometimes for several months.

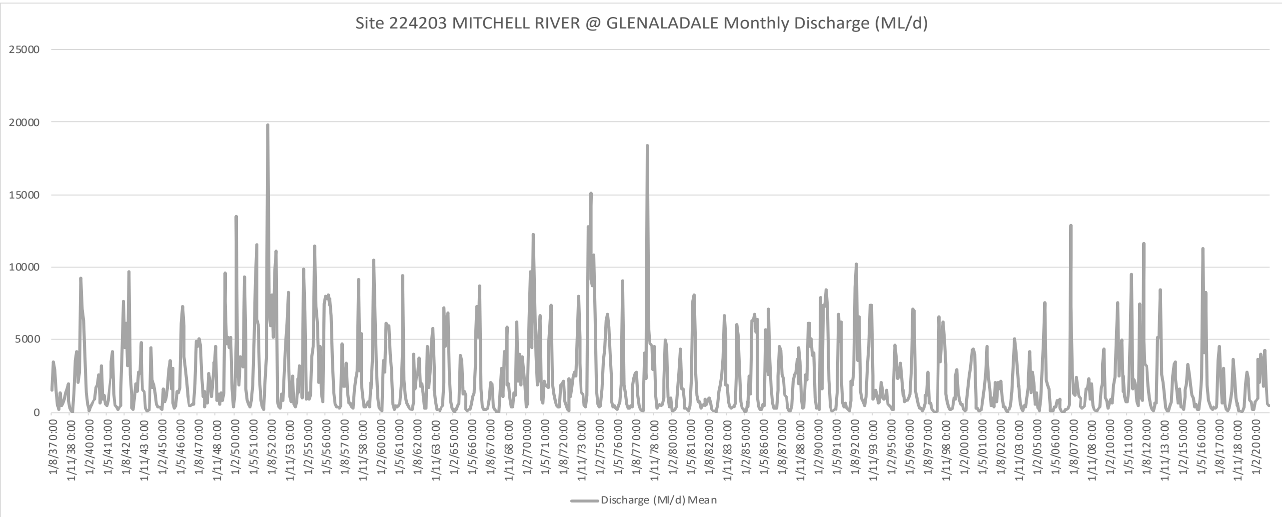

Figure 5-2: Mitchell River flows

The chart shows the variability that is inherent in most of the unregulated surface streams. Important points are that:

- Historically, the Mitchell unregulated flow averages more than 800 GL/y[10]. Streamflow variability is quite high with annual volumes varying from 123 GL in 2006 up to 2,415 GL in 1974. However, it is the

[10] (Source Site 224203 MITCHELL RIVER @ GLENALADALE Victorian Water Management System).

streamflow variability within any one year, as well as the variability of low flows[11] in the summer/autumn period that limits water use.

- Minimum monthly flows have been as low as 2 ML/d, which is unlikely to support any irrigation, but fortunately such events are rare
- The 5th percentile (happens 1 month in 20) is 120 ML/d. This usually occurs in a peak irrigation demand time, usually a hot/dry month and it is this flow rate that limits the area that can be irrigated. Based on a commonly used irrigation design criteria of peak demand being equivalent to approximately 1% of average annual use. (Similar to the design of irrigation channels delivering water right in 100 days plus losses). The 120 ML/d expressed as peak demand (using all the flow) would give an annual extraction for irrigation of around 12 GL/y.
- This matches recent diversions in Mitchell at around 12 GL/y. (But varies from 5 GL to 13 GL/y with a licenced volume of around 15 GL[12])
- This suggests that in unregulated rivers, like the Mitchell, the formula of 100 x 5th percentile monthly stream flow may set the practical limit to annual use available for irrigation
- Areas served by regulated rivers, which have storages (regulated supplies such as that in the irrigation districts), have a higher potential use
- Also, areas where lower value pastures dominate, which can be readily dried off at relatively low cost, may also sustain higher use
- However, perennial plantings such as orchards and vines are likely to have lower utilisation, due to the high cost of not meeting crop requirement.

This reflects the truism that water is highly valuable in a drought and worthless in a flood. Increasing water available in wet periods has little benefit but Increasing water availability in dry periods has a very high benefit.

In southern Victoria's unregulated systems, that is, in those surface water systems where there are no large in-stream storages, irrigators have set up their maximum irrigated area based on dry period availability, and their annual usage is typically 30% of their entitlement volume.

The balance (around 70% of the diversion licence volume) is commonly referred to as 'sleeper' licence. This has utility and value as an insurance policy that would be available in dry years and it helps sustain the security of supply for the 30% commonly used.

Expansion of irrigation from unregulated surface water can only be achieved by increasing the dry period flows. This requires:

- Accessing water from other dry month users,
- Providing new water sources (e.g. recycled water or mine water) that are available in the dry months
- Building storages to convert wet month flows to water that can be made available in the dry months.

The last dot point is exactly what has been achieved in regulated surface water systems that service the irrigation districts. Given that new public storages would take additional water from the environment and environmental water has been identified as being under threat in DELWP's long-term water resource assessment (DELWP, 2019) this is not a feasible solution.

However, there may be opportunities for private storages, where they are cost effective. For example, the Gippsland Sustainable Water Strategy, 2011, identified that there may be additional winter fill water entitlement available for issue in the Mitchell River.

[11] Only 6% of annual flow occurs in the January-March period . (RMCG, 2011).

[12] There is also groundwater use from Wy Yung aquifer, which is sometimes used interchangeably. (RMCG, 2011).

5.4.2 REGULATED SURFACE WATER ALSO HAS VARIABLE USAGE

Regulated supply systems smooth water available by using water storages to achieve a more reliable system that fosters investment in irrigation and underpins each of the irrigation districts and urban users. However, allocations and usage can still be variable.

For example, in the MID, there is:

- 155,000 ML of High Reliability (HR) and 74,000 ML of Low Reliability (LR) water shares or entitlements. The volume of entitlements on issue have increased gradually since 2010 as a result of redistribution of water savings within the district to the consumptive pool (i.e. to irrigators).
- In addition to entitlements on issue, spill water has been made available to irrigators for purchase in most years. Volumes of spill water made available to irrigators are shown in Figure 4-3 below.

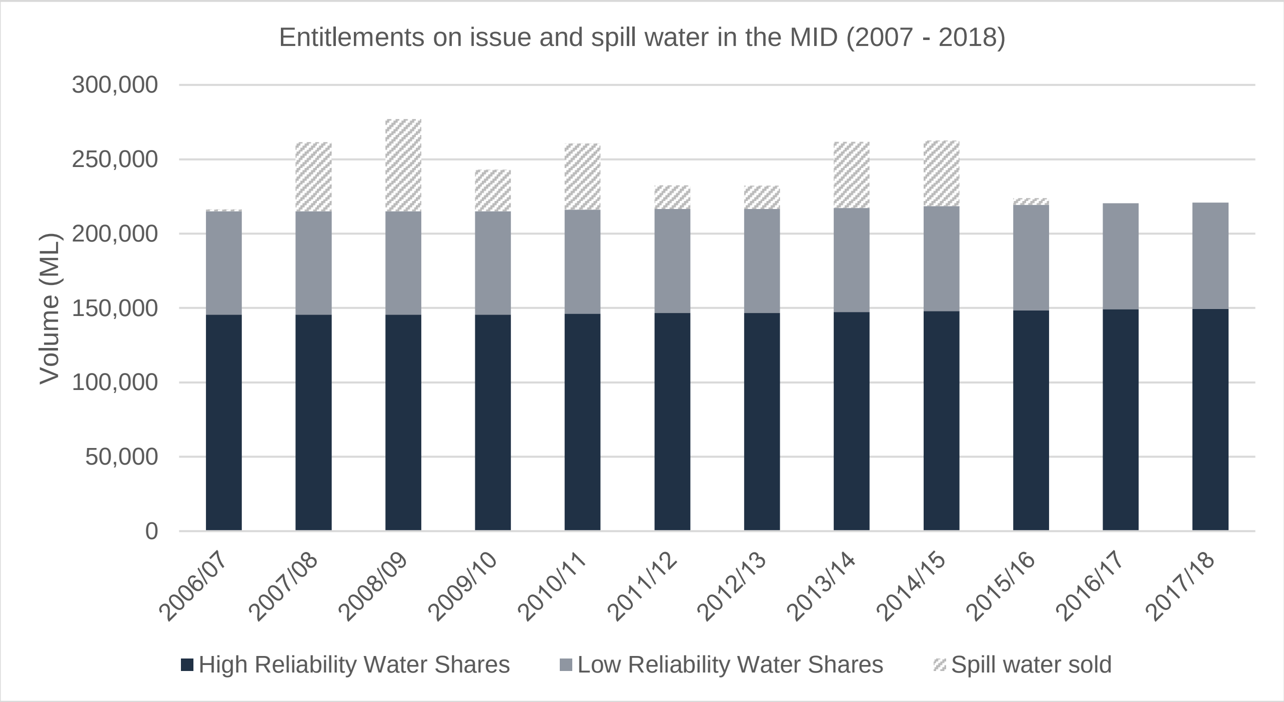

Figure 5-3: MID water products on issue from 2007 to 2018. Note: spill water is made available on a year-to-year basis only (data source: SRW, 2018).

Figure 5-4shows water delivered to the MID as a percentage of water available in a given season. This includes all water products made available in the MID through Announced Allocations (includes both High and Low Reliability water shares) and spill water sold.

As would be expected, this shows an inverse relationship between water available and water delivered. In years of higher rainfall, a lower percentage of the available water resource is delivered. In dry years, including in recent times, allocations are close to fully committed in the district.

There may also be opportunities for optimisation within the regulated systems that could result in the issuing of more water entitlements for agriculture, for example from Blue Rock Dam.

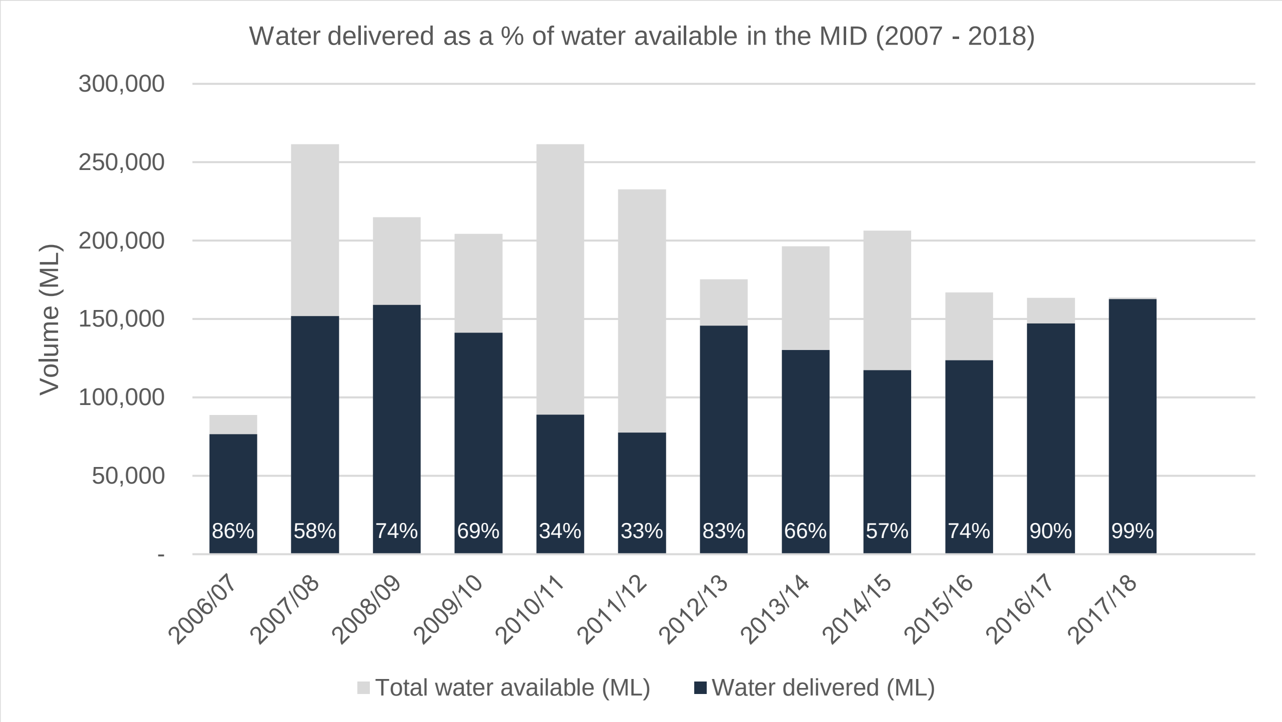

Figure 5-4: Water delivered as a percentage of water available in a given season in the MID from 2007 to 2018 (data source: SRW, 2018)

5.5 LIMITED OPPORTUNITIES FOR WATER TRADE

In some areas water trading is the only option for obtaining or increasing a water licence. This can be done on a temporary basis (for the current season), or on a permanent basis (for the term of the licence). Water trading can only take place within the same Groundwater Management Area (GMA,) or Water Supply Protection Area WSPA for groundwater or surface water river basin, unless there is connecting infrastructure.

If a proposed permanent transfer is within a declared WSPA, it may not be considered for approval until the Minister for Water has determined the Water Management Plan. All applications to transfer water licences must be submitted to Southern Rural Water or Melbourne Water for approval so that the impact of any proposed change to existing extraction or diversion points on other users and the environment can be assessed.

The opportunities for increased water trade are limited by:

- Areas where purchasers can buy water from
- Unreliability of water supply (years with nil or very low allocation); this reduces the demand from potential water buyers
- Rationing and pumping restrictions (reduces both supply and demand)
- High volumes of sleeper licences that are held to mitigate rationing and restrictions (reduces supply)
- High cost of building farm storages (including loss of productive land). This reduces demand through the additional cost of development and reduces supply as the high cost of storage cannot compensate for the loss of sleeper entitlement
- Knowledge of water trading and inability to connect potential buyers and sellers.

When water is traded from an all year round licence to another location then the destination licence only retains the all-year round characteristic if it is traded downstream. If the water moves upstream it is converted to a winter-fill licence. This conversion reduces the value of the licence for purchasers, because additional storage is needed and as a result this discourages trade. The desire to achieve a more active market in unregulated catchments will need to address these constraints.

For example, it may be worth encouraging landholders on suitable sites to construct low cost storages with the aim of becoming a local water supplier for other users. They become active participants in the water market by buying sleeper/winter fill licences and then selling annual allocations. However, this will only work if there is sufficient demand, if it is economic, if it reduces the amount of rationing and if the new regime is practicable and environmentally sustainable.

The results of water trade are reported annually on the Victorian Water Register. The 2018/19 results for Southern Victoria show relatively low volumes of trade, when compared with northern systems. This included:

- Allocation trade in regulated surface water totaled 30 GL:
  - 12 GL commercial, 18 GL non-commercial (zero $)
  - 25 GL in MID median $250/ML (up from $65/ML in 17/18)
  - 2 GL in WID $375/ML
- Entitlement trade in regulated surface water systems 9.8 GL of high reliability water shares (HRWS) and 4.8 GL low reliability water shares (LRWS):
  - MID 8.7 GL HRWS @ $2000/ML and 4.2 GL LRWS @ $200/ML
- Groundwater trade (take and use licences):
  - 13 GL – largest temporary trading GMAs Sale 3 GL, South West Limestone 3 GL (not in the Region) and Denison GMA (3 GL)
  - $1,000/ML permanent and $50/ML for temporary
- Surface water trade (take and use licences):
  - 8 GL- largest temporary trading systems, LaTrobe 5 GL, LaTrobe unreg 0.6 GL, Yarra 0.6 GL
  - $1,000/ML permanent purchases $29/ML temporary.

The main driver of trade in the Region is change in land ownership. The supplementary nature of irrigation combined with the variable/unreliable supply means that the other commercial drivers for water trade are much lower in the Region when compared with Northern Victoria. Low reliability of supply means that achieving a mix of irrigation industries comprising:

- Interruptible crops that can expand in high water availability years, such as annual cropping,
- Partially interruptible, such as dairying for pasture, where feed can be bought in to substitute for lack of water,
- Non-interruptible, such as perennial horticulture,

will be unlikely to develop in unregulated areas.

This is because in wet years, the marginal benefit of irrigation is low or nil, in average years supply systems are partially interruptible, which means that non interruptible crops are at risk. Therefore, it is expected that high value perennial horticulture will be reluctant to develop further, there will be no market driver for trade and the low heterogeneity of industries will remain ‘locked in’.

In conclusion, water trade fuelled by new demands from higher value use is more likely to occur in the regulated supply systems that serve the irrigation districts.

5.6 THE HIGH COST OF USING WINTER-FILL STORAGES TO MAKE WATER RELIABLE

Across all surface water catchments there are limits to water availability in summer. This means that for the most part growth in water demand can only come from winter-fill licences on unregulated systems, which require on-farm storage.

The issues associated with on-farm storages include:

- The large size of storage needed for a substantial enterprise, e.g. 500 ML (enough for 100 ha at 5 ML/ha/a) will take up approximately 17 ha at 3 m depth or 25 ha at 2 m depth. This is a large percentage of the irrigated area and represents a large loss of productive land. At $10,000/ha, this is $250,000 or $500/ML for land purchase/value to start with.
- Earthworks cost $3,000/ML to $10,000/ML (at least $3/m3) depending on storage size, lining and degree of difficulty
- Challenging water pumping regimes for filling. New winter-fill licences are likely to permit pumping only when passing flows are suitable i.e. irrigators cannot count on being able to pump every day in the winter period. And, of course, there can be limits on the daily rate of pumping. These factors limit the viability of winter-fill dams and/or create the need for sophisticated and high-volume pumping arrangements.
- Use of storage represents a double-handling of the water, with pumping into the storage as well as to the irrigation system. This creates additional pumping costs and greenhouse gas emissions
- It can be difficult to find suitable sites for winter-fill dams particularly finding suitable soils for construction
- Construction on the river floodplain may be technically difficult. There are areas where the water table is close to the surface, or highly permeable soils that make construction difficult. Flooding risk may also require the use of turkey-nest style dams
- There are regulatory issues associated with dam construction – a licence is required for farm dams, and there are limits to dam construction on waterways (including those on the flood plain that only fill in floods)
- Evaporation and seepage losses
- Maintenance costs.

It is suggested that the high cost of farm storages is an impediment to further irrigation development in most cases.

The cost of a 17 GL storage was investigated by GHD in 2013 for Lindenow and this cost was reportedly $8,560/ML, but was reviewed by Tasmanian Irrigation to be $3,860/ML. Cited in (Marsden Jacobs, 2014)

The cost of larger dams can be lower, with a recent research paper on dam costs (C. Petheram, 2019) indicating costs in the range of $1,000 to $10,000/ML for storages of 10 GL; with costs declining to around half this once they are above 100 GL.

6 C. Petheram, T.A. McMahon/Journal of Hydrology X 3 (2019) 100026

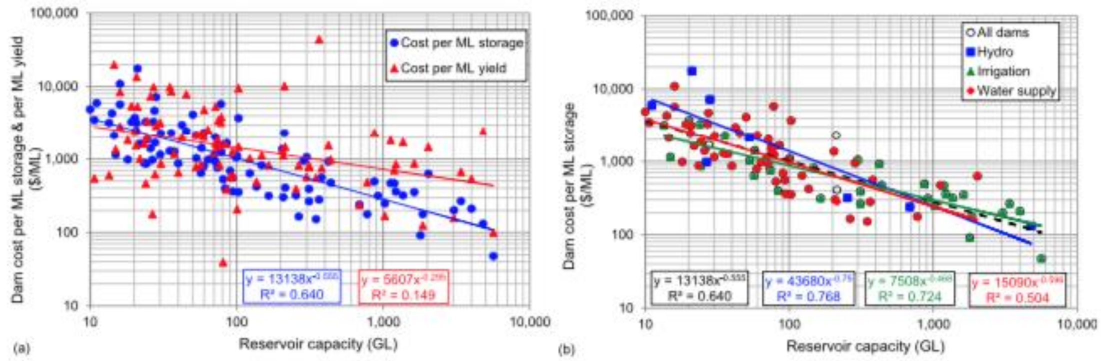

Fig. 6. Relationships between final dam cost (2016AUD) per ML storage and per ML yield related to reservoir capacity (98 and 89 dams respectively) a) Cost per ML storage and per ML yield b) Costs stratified by purpose of dam.

Figure 5-5: Cost of large dams Australia $2016 Source (C. Petheram, 2019)

ttps://www.researchgate.net/publication/331068945_Dams_dam_costs_and_damnable_cost_overruns/link/5c6eb3af299bf1e3a5bb4a04/download

Some properties on regulated supplies may also need small storages to provide a higher level of service (e.g. for drip), but these storages will not increase the total volume of water used each year. Reuse systems are also used on many flood irrigated properties on regulated systems (and possibly for unregulated systems), but these storages are generally designed to capture 15% of one irrigation, which is a fraction of the ten plus irrigations that may need to be stored for a winter-fill licence.

The high private cost of farm storages has been partly addressed by the current Commonwealth funded/ Rural Finance Corporation administered Lindenow Flats irrigation storage grants scheme. In this scheme 50% of the cost of storages and groundwater bores are met by the Commonwealth. This has the objective of supporting the growth of horticulture. To date (February 2021) the $10 M Commonwealth funded program has achieved:

- Over 28 applications for storages and groundwater bores
- $6.5 M matching funding achieving $13 M of works
- $5,600/ML volume weighted average cost per ML of storage (Commonwealth and farmer expenditure). But with a wide range in costs from around $2,000/ML to $12,000/ML.

The scheme largely provides private benefits and progresses regional development. There are no public environmental benefits of the scheme. The Lindenow scheme is unique in that it generates high values per ML and high employment. It is also a system where the major constraint to horticulture are the low unregulated river flows in summer. This constraint is lifted by building farm storage to harvest high flow events into water that is available when river flows are limited.

By contrast, in most other catchments most of the water is used for lower value pastures. The benefits of on-farm storages in those catchments would therefore be expected to be lower than those achieved by Lindenow's high value vegetable enterprises.

Building storage also risks creating ecological harm and may result in reduced availability for downstream users, especially if climate change results in proportionally more of the river flow being harvested. Therefore, a more precautionary approach is not to subsidise storages, especially in catchments that have already experienced declining water availability.

In any case, it is not good public policy to provide subsidies that may result in total costs exceeding the benefits, or subsidising one particular part of the market over others, unless there is an overwhelming public benefit. The Productivity Commission's Draft Report on National Water Reform 2020 (Productivity Commission, 2021) provides high level cost sharing guidelines for water infrastructure, as below:

- *"Investments that are both economically and commercially viable should be undertaken by the relevant water service provider, with full cost recovery from users and generally without government subsidy.[13] This should be the norm.*
  - *The role of government should be limited to project approval, except in cases of substantial public benefits that impose costs best borne by governments.*
  - *Public benefits can include flood mitigation and recreational use of dams, but do not extend to regional development or similar strategic investments.*
- *Major water infrastructure that is not economically viable should not proceed, except where an equity argument supports provision of an essential service.*
- *Government funding should be transparent, and water service provider planning should guide investments. (However, a transparent community service obligation payment is generally preferable to infrastructure expenditure (chapter 11).)*
- *Where governments choose to subsidise infrastructure in pursuit of a strategic objective, including in support of projects that are not commercially viable, additional scrutiny is required to maximise the effectiveness of that investment while minimising the costs and risks to taxpayers.".*

5.7 ECOLOGICAL IMPACTS OF STORAGES

Farm storages change the hydrologic regime of river flows that are associated with unregulated rivers. This can impact on hydrology and ecological cues as well as habitat, connectivity and fish passage. They also reduce water availability for other consumptive users downstream.

On-stream storages have larger impacts than off stream storages, particularly when the storage is large relative to stream flow. Therefore, all new storages are required to be off-stream.

In theory, there may be opportunities to create ecological benefits by improving existing private storages. For example, private on-stream storages which are retrofitted with structures that ensure minimum passing flows and increase the opportunity to reinstate more environmental flows.

But in practice, private storages are relatively small, and it is difficult to demonstrate that:

- increased passing flows would be achieved and quantified
- the additional passing flow created is not captured by another downstream river diverter
- river operational rules and management/compliance systems are sophisticated enough to prevent gaming
- the ecological benefit achieved exceeds the cost.

This means that it is very difficult to capture or quantify the public benefit of investment in changed management of private storages.

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[13] *Economic viability requires a benefit–cost ratio exceeding one, as determined by the business case, whereas commercial viability is determined by whether infrastructure users are willing (and able) to pay the full costs of infrastructure construction and maintenance — simply put, whether the benefits that accrue to infrastructure users are sufficient for them to fund the project without a subsidy, in which case a commercially-focused service provider would have incentive to provide the infrastructure*

6 Water-Related Opportunities for Agriculture

6.1 REGIONAL COMPETITIVE ADVANTAGES

The Region has a number of competitive advantages that will help to encourage agricultural development. Appendix 2 investigates the potential irrigation demand if water was unlimiting and estimates demand as below.

Table 6-1: Estimated water use by industry with expected growth in unlimited water scenario

INDUSTRY	IRRIGATION CURRENT USE ML/Y	D& S USE	TOTAL	GROWTH RATE PER ANNUM IF WATER WAS UNLIMITED	ML GROWTH IF UNLIMITED
Grazing / cropping	10,000	28,000	38,000	Negligible	0
Dairying	220,000	28,000	248,000	1% - 2%	2,480 to 4,960
Horticulture	84,000	0	84,000	2% - 3%	1,680 to 2,520
Intensive animal industries	0	3,000	3,000	2-4%, say 3%	60 to 120
Total	**314,000**	**60,000**	**374,000**		**4,250 to 7,600 around 1% to 2% growth in demand**

Based on the assumptions above, the expected change in water use for a scenario in which water was not limiting growth is shown in Table 6-1. However, it should be noted that the experience has been that there are still a large volume of unused entitlements, because of unreliability of supply which constrains potential growth.

These calculations should be treated with caution as growth in demand depends very much upon the growth in the dairy industry; if milk price were to significantly increase then the potential for increased water demand would be much higher. For example, an increase to 5% growth rate per year would mean an additional annual demand growth of more than 12,000 ML/y for dairying alone.

The Region can be thought of as three distinct zones. The competitive advantages/ characteristics of each of these zones are summarised below – based on notes provided by Terry Flynn, SRW.

Central – Strategic advantage is location

- Main supply of fresh cut vegetables on Melbourne's doorstep
- Export vegetables as close to Melbourne's transport hubs and ports
- Great opportunity to irrigate with recycled water achieving supply reliability and growth, while meeting State objectives and community expectation to minimise waste
- Warm groundwater supply opportunity for aquaculture and heating for greenhouse production
- Good soil
- Coastal location, so few frosts.

West Gippsland – strategic advantage is reliable supply, land affordability, labour force

- Affordable land
- Reliable water supply, particularly MID
- Adjacent to major freight routes
- Established dairy and horticultural industries with processing infrastructure
- Potential target area for “climate refugees”. Apple industry moving to Thorpdale, partly due to climate change
- Significant migration of new agricultural industries (e.g., poultry) is creating critical mass for agricultural services
- Good soil
- Potential to develop agricultural industries as part of long term strategy to rehabilitate Latrobe Valley mines (new water storage)
- Potential to take advantage of major modernisation upgrade to MID
- Latrobe Valley needs replacement industries
- Region has been a backpacker hub (seasonal labour availability)[14]
- Warm groundwater supply opportunity for protected horticulture (e.g., glasshouse heating) and aquaculture.

East Gippsland – Location strategic to supply NSW and Vic markets

- Mitchell River flats ideal for vegetables
- Bengworden plain – affordable land, reliable groundwater
- Warm groundwater supply opportunity for protected horticulture and aquaculture
- Mild climate, few frosts.

A key focus is seen as the opportunity to use existing unused allocated water to expand irrigation and increase value created by agriculture. However, this depends on the ability to provide water in dry months, which usually requires storage.

[14] There have been impacts on seasonal labour availability in the region due to restrictions for COVID-19.

6.2 RECYCLED WATER OPPORTUNITIES

Table 6-2: Volumes of waste water and recycled water

GL IN 2018/19 (FROM VICTORIAN WATER ACCOUNTS 2018/19)	WASTEWATER PRODUCED	TOTAL RECYCLED	VOL RECYCLED FOR AG	POTENTIALLY AVAILABLE?
Barwon	33.8	4.9	1.3	28.9
Bunyip	150.7	21.7	2.7	129.0
East Gippsland	0.1	0.1	0.1	0.0
Latrobe	22.2	0.7	0.1	21.5
Maribyrnong	4.3	1.8	0.7	2.4
Mitchell	1.3	1.3	0.2	0.0
Moorabool	1.4	1.4	0.0	0.0
Otway Coast	1.4	0.4	0.2	1.0
Snowy	0.0	0.0	0.2	0.0
South Gippsland	5.2	0.5	0.4	4.7
Tambo	0.8	0.8	0.8	0.0
Thomson	1.3	1.3	1.3	0.0
Werribee	179.9	39.0	23.7	140.9
Yarra	11.1	3.7	1.0	7.4
Total	**413.5**	**77.6**	**32.6**	**335.9**

The key issues with accessing this potential alternative water source for agriculture are:

- The quality of the recycled water can limit its use. Salinity tends to be moderate to high and pathogen levels are not always appropriate, e.g., for fresh produce crops. Treatment can occur to ensure water quality matches crop needs. However, this is often costly, particularly if salt reduction is required.
- The majority of the recycled water in the region is available from Melbourne's Eastern and Western Treatment Plants. While these locations are suitable for some existing irrigation areas (e.g. the Werribee Irrigation District) they do not necessarily correspond to the preferred locations for irrigation development. As such, there can be a significant cost in pipeline networks and pumping to transfer the water from existing treatment sites.
- Ongoing monitoring is required to meet regulatory requirements, which adds another cost
- Potential agricultural customers may be wary of using recycled water due to concerns about impact on produce quality/safety
- High cost of providing water for agriculture relative to the low cost of current disposal methods. The key costs being treatment, winter storage and distribution infrastructure.

Western Water's Western Irrigation Network (WIN) project, which has established a new irrigation district in Parwan-Balliang, demonstrates how local access to recycled water can support regional agricultural productivity while protecting local waterways and addressing the challenge of increasing volumes of recycled water due to population growth.

6.3 GROUNDWATER OPPORTUNITIES

As demonstrated in Section 4.5, there is the opportunity to further develop groundwater usage. However, the high cost of bores and low aquifer yield are impediments to further development of groundwater.

CSIRO undertook a study on the cost of groundwater bores (D W Robinson, 2002). These figures updated for inflation[15] are:

- Shallow groundwater pump (spearpoint) costs can vary dramatically between locations, the main influences being the cost of geo-technical investigations, system design and power connection, consequently the capital cost of purchasing and installing a spearpoint system to pump a shallow watertable can vary from approximately $29,000 to $113,000 in capital costs.
- Bore costs can vary dramatically depending on and bore depth, bore yield, bore design and power connection costs, consequently the capital cost of purchasing and installing a shallow bore is similar to a spearpoint system and a deep bore from approximately $146,000 to $518,000 in capital costs.
- Annual pumping and other operation and maintenance costs are additional. Pumping costs vary with pumping head. At 10 m costs can be $20/ML while at 60 m it can be $100/ML.

Total capital costs per ML will depend on yield, and may range from $500/ML to $5,000/ML. At the lower end of these costs, there may be opportunity for additional irrigation use. As surface water availability decreases the capital investment and additional operating costs of a groundwater bore may become more economically feasible for irrigators.

6.4 USING OTHER FORMS OF STORAGE TO MAKE WATER MORE RELIABLE

Across surface water catchments there are limits to water availability in summer, which prevents further expansion of irrigated agriculture. This means that, in general, growth in agricultural water demand can only come from storing water to make more available in the dry months. However, as discussed previously (Section 5.6), the high cost of on-farm storage is limiting further growth in winter-fill licences to expand the irrigated area on unregulated systems.

There are, however, other storage options. These include:

- Large-scale in-stream storages on previously unregulated streams
- Large-scale off-stream storages
- Managed aquifer recharge.

Each of these is briefly discussed below.

6.4.1 LARGE-SCALE IN-STREAM STORAGES

Large-scale instream storages are what support the reliability of water entitlements in the existing irrigation districts. In theory, new storages of a similar scale could increase the reliability of irrigation in other parts of southern Victoria, and this could help expand the area of irrigation and make more use of the available water.

15 https://www.rba.gov.au/calculator/annualDecimal.html. $1 in year 200 is worth $1.62 in 2020. The total change in cost is 62.4 per cent, over 20 years, at an average annual inflation rate of 2.5 per cent.

However, as discussed in Section 5.4.1, given that new public storages would take additional water from the environment and environmental water has been identified as being under threat in DELWP's long-term water resource assessment, (DELWP, 2019) new large-scale in-stream storages are not a feasible solution. They are also unlikely to be economic given the high cost of storage (Section 5.6) and generally low economic value of irrigation water (Appendix 2).

6.4.2 LARGE-SCALE OFF-STREAM STORAGES

Large scale off stream storages can be expensive and may have less environmental impact than in stream storages.

Depending on how the different possible climate scenarios play out over the next 30 years, one potential outcome of the Latrobe Valley Regional Rehabilitation Strategy, is that there could be three pit lakes fully/partially occupying the current mine voids. If that were the case, the lakes would require some level of flow through to maintain water quality at desirable levels.

Depending on the feasibility of alternative uses, one option might be to draw water from the lakes for irrigation in order to help maintain water quality. Such an option, while not feasible in the short to medium term, would require further research to determine longer term feasibility.

6.4.3 MANAGED AQUIFER RECHARGE

One storage option is managed aquifer recharge (MAR) in which aquifers are deliberately recharged when water is available, such as in wintertime, and then the aquifer is drawn down by pumping from ground water bores in summer when water is short.

The lower and mid aquifers in the Region have been experiencing gradual decline over time, around 1 m/y in the deep system and 0.5m/year in the mid system. This has created the opportunity for MAR.

There are extensive aquifers suitable for MAR in the Region; and there are examples of MAR being used on the Mitchell for urban supply and also by City West Water. However, to date, capital costs of these schemes are generally well above $10,000/ML plus annual operation and maintenance costs, which precludes agricultural use.

Costs of MAR can be substantial as water for recharging may need filtration to prevent aquifer clogging. Further detail is available in Appendix 5.

At this stage costs would appear to be higher than surface water storage and would be higher than conventional groundwater pumping. But future technology and the identification of low-cost sites may change this.

Therefore, it is suggested that further research and investigations to identify the potential opportunity for low cost MAR that may be affordable for agriculture, be supported.

It is important to note that various urban water corporations are investigating MAR in the Region, City West Water (recycled water for third pipe), South East Water (recycled water for irrigation) and Western Water (for public supply). Melbourne Water were also proposing to undertake a study looking at the potential for stormwater recharge of the Deutgam aquifer.

6.5 IRRIGATION DISTRICT MODERNISATION

Modernisation of irrigation districts enhances water use efficiency, levels of service, system operations and generates water savings that can be shared by consumptive users and the environment. Modernisation has been undertaken in most of the districts and there are ongoing programs, as below.

- Modernisation in the Macalister Irrigation District (MID) under the MID2030 includes[16]:
  - Phase 1 A, 2015 to 2017, $32 M invested with 12 GL of savings
  - Phase 1 B, 2017 to 2020, $65 M invested with 10 GL of savings
  - Phase 2, 2020 to 2024, $63 M invested with 10.3 GL of savings.
- Bacchus Marsh (BMID) modernisation works were completed in 2020[17]. The interim water savings report by Southern Rural Water indicates that nearly 800 ML of water savings has been generated by the project so far and it is on track to generate approximately 1,000 ML in water savings. Half of the water savings will be available to the district's irrigators and the other half will be returned to the flow stressed Werribee River.
- Werribee (WID), Stage 3 modernisation works were completed in September 2019. An interim water savings report by Southern Rural Water indicates that around 3,700 ML of water savings has been generated by the project to date. To fully achieve a modernised system for the WID, funding has been sought from the Commonwealth for stages 4 and 5 of the project to construct a further 16.2 km of pipeline and automation of 70 outlets. Total savings from the WID modernisation works were estimated at 5000 ML (this figure from SRW website). As in the BMID, half of the water savings will be available to the district's irrigators and the other half will be returned to the flow stressed Werribee River.

Modernisation of the remaining older supply delivery systems remain an opportunity.

6.6 ENHANCING TRADE

As discussed in Section 5.5 trade has been limited in the Region. in order to enhance trade it is worth considering the pre-requisites. They include having a willing seller and a willing buyer both satisfied by the agreed water price. For this to occur there generally needs to be:

- A higher value use for the buyer than the seller, so that the costs of trade and water development are exceeded by the benefits; e.g. an area attractive to horticulture needs to exist in the catchment, or dairying in a beef dominated catchment. This means that catchments with soils, climate and infrastructure suitable for higher value irrigation are more likely to have water trade occur.
- High water reliability, so the water is secure enough to be attractive to higher value use
- Low risk of rationing so that potential sellers are willing to sell sleeper water without receiving higher rationing impacts (or have the need to replace sleeper water with farm storages)
- Low cost of irrigation development (e.g. low cost on-farm storages)
- Communication and brokerage between buyers and sellers
- Trust in the market (that sellers will be paid and buyers get the product they seek)
- Metered usage
- There are no more licences available
- A sufficient volume in the catchment, and in reasonable sized parcels that can be traded.

The issues associated with water trade that need to be managed, have been previously discussed (Section 5.5) but key elements limiting the ability to enhance trade are:

- Physical limitations on trade (ability to supply buyer through water delivery system constraints)
- Third party impacts such as less water or increased restrictions on either the environment or other users
- Conversion from all year round licence to winter-fill when trading upstream
- High cost of building storages for buyer to use winter fill (infrastructure, operating, and loss of land)

[16] http://www.srw.com.au/projects/mid-modernisation/.
[17] https://www.water.vic.gov.au/planning/environmental-contributions/fourth-tranche-of-the-environmental-contribution/regional-water-infrastructure.

- Rationing within season deterring high value buyers
- Nil pumping years deterring high value buyers
- Lack of catchments where there are no more licences to be issued and the only means of growth is through trade (In some catchments water is available and can be applied for rather than bought)
- Lack of buyers willing to pay enough to be attractive for those with storages to sell and write off sunk costs
- Lack of buyers willing to pay enough for those with sleeper water to sell, sleeper water has an insurance value to holders through avoid rationing
- Activation of sleeper licenses which reduce reliability and increases rationing in the system
- A small pool of buyers and sellers
- High transaction costs (e.g. fees for water trade, cost of water development and loss of year round license when converted to winter fill).

Therefore, the opportunity to significantly enhance trade will remain limited given the nature of most of the catchments.

Also, under the Ministerial Policies for T&UL 2014 under Clause 27 all year round licences can only be transferred downstream. There are no provisions to enable upstream trade unless an all year round licence is converted to the less valuable winter-fill licence. The result of this trade rule can mean all year round licences at the downstream end of the river can become stranded, and in some cases unused. This is because they cannot be traded upstream to another parcel of land, where they could be activated or used by a higher value user.

It is suggested that this trade rule be reviewed. For example, if an upstream trade has no impacts on third parties including impacts on rosters and restrictions when assuming all licences (including sleeper and dozer) are active then the trade could be allowed. If the impacts are negligible and/or can be adjusted for (e.g. with an exchange rate to account for resource availability changes in locations), then this may be a potential reform that could improve agriculture's accessibility to the water market/resource.

6.7 IMPROVING THE EFFICIENCY OF EXISTING WATER USE

Another opportunity maybe to improve farm irrigation practice or technology so that farm water use efficiency is higher. This includes:

- converting old less efficient surface irrigation/flood or sprinklers to drip,
- converting to more efficient sprinklers such as centre pivots and linear move,
- installing drainage reuse, improving layout, land grades and flow rates for surface irrigation,
- irrigation scheduling tools
- system checks
- Whole Farm Planning programs, for example West Gippsland CMA and the DELWP Sustainable Irrigation Program are currently delivering the "*Newry irrigation farm planning project 2020-21",* as part of Southern Rural Water MID modernisation.

Benefits include yield improvement, crop flexibility and labour efficiency and these benefits are very important drivers of adoption. Another driver is the value of water saved and the value of irrigation water for the Region are estimated in Appendix 2. This shows that the majority of water use is associated with dairy and this has a capital value of around $1,000/ML.

Based on the annual water use in the Region (lower than Northern Victoria) and the experience of farm water savings from new farm technologies (RMCG, 2019) it would be expected that water savings in the study would be typically around 1 ML/ha /year. This compares with a capital cost of upgrade from $3,000/ha to $10,000/ha.

This illustrates that the water savings benefit at 1 ML/ha and $1,000/ML or $1,000/ha are a much less important driver than in Northern Victoria (which typically is 2 ML/ha at $4,000/ML). This means the production benefits, labour efficiency savings and ability to have a more flexible range of irrigation crops must be high to justify the cost of upgrades.

As explained in Section 4.1, the benefit of irrigation water is, on average, lower in southern Victoria, and this means that the drivers for adopting improved farm technology are generally lower. However, this is not to say that irrigation efficiency is already high, it is just that the economic drivers to invest in improved systems are lower. The drivers would be higher if the returns from irrigation are increased by moving to higher value enterprises, but as previously discussed the ability to do this is, in general, constrained by unreliable water flows in summer and the high cost of storages/ bores to overcome the unreliable supply. An important exception is probably in the MID, where regulated / more reliable supplies and the relatively low rainfall mean that the benefits of upgrades are higher.

6.7.1 OPPORTUNITIES TO INCREASE ACCESS TO AVAILABLE WATER FOR AGRICULTURE

Unlike in Northern Victoria, where the vast majority of water resources are fully allocated and governments have actively sought large volumes of water recovery for the environment, there is some unallocated water available to consumptive use in southern Victoria.

Unallocated water volumes are available as winter-fill surface water licences and groundwater licences, which are unlikely to provide scope for significant irrigation development due to the cost limitations to support year-round supply. There may be some opportunities in areas like the Lindenow flats, where existing and/or new businesses can invest in additional water supply for high-value irrigation.

In the Central and Gippsland region, there are also opportunities to increase the access to available water for agriculture in some areas through changes to water sharing in specific areas undergoing transition – like the Latrobe Valley – and capitalising on existing and future investment in large-scale irrigation modernisation projects that secure water savings for agricultural use – like in the Macalister Irrigation District.

Appendix 1: Gross Value of Agricultural Production in the region

Table A1-1: Detailed breakdown of Gross Value of Agricultural Production

State	Victoria													
Sum of Gross value ($)		**SA4**												
Level 1	**Level 2**	**Geelong**	**Latrobe - Gippslan**	**Melbourne - Inner**	**Melbourne - Inner**	**Melbourne - Inner**	**Melbourne - North**	**Melbourne - North**	**Melbourne - Outer**	**Melbourne - South**	**Melbourne - West**	**Mornington Penins**	**Grand Total**	% of Victoria
⊟ **Broadacre crops**	All other crops n.e.c.	41,254	13,065				18,004			615			72,939	0.4%
	Cereal crops	21,976,243	4,721,146				557,222	1,414,749	15,320	204,805	7,666,785	91,802	36,648,073	4.2%
	Non-cereal crops	9,490,842	1,116,426				222,997	426,003	3,249	61,107	936,167		12,256,790	4.8%
⊟ **Fruit and nuts**	Citrus fruit		1,738,801				41,693		2,918,442	886,914		875	5,586,724	6.4%
	Grapes	557,178	196,394				142,687	85,359	5,218,308	3,916	159,686	1,529,049	7,892,577	1.8%
	Nuts	129,495	32,672				2,135,128						2,297,295	0.4%
	Orchard fruit		46,245						16,208			381,710	444,163	3.3%
	Other fruit	238,264	1,242,795	6,956,027			850,575		56,008,595	4,936,639		13,635,851	83,868,745	77.5%
	Pome fruit	191	7,621,033				3,406,041		24,518,013	9,827,326	4,641,376	4,582,210	54,596,190	20.5%
	Stone fruit	11,519	46,794				83,592	140,217	9,480,424	38,708	110,467	400,244	10,311,966	4.7%
⊟ **Hay**	Cereal cut for hay	5,336,869	2,035,391	9,223			115,339	512,207	91,066	26,792	538,707		8,665,594	4.4%
	Lucerne cut for hay	461,397	6,362,109				14,806	4,243	10,935	820,758	51,022	135,837	7,861,106	10.7%
	Other crops cut for hay	275,176	980,007				998	132,522	35,320		36,504	3,098	1,463,625	4.0%
	Other pasture cut for hay	3,237,868	50,379,447				617,740	266,439	1,518,922	34,101,729	53,947	470,517	90,646,609	37.0%
⊟ **Livestock Products**	Eggs	38,622,511	36,633,960			732,929	19,922,800	372,400	4,824,429	37,831,102	6,762,059	712,292	146,414,482	71.4%
	Milk	6,546,405	809,761,030				219,351	757,743	3,580,547	45,502,726			866,367,803	32.8%
	Wool	26,458,274	35,978,665	6,760			146,879	2,716,028	163,534	417,025	909,996	82,922	66,880,082	8.9%
⊟ **Livestock slaughtered and other disposals**	Cattle and calves	19,896,326	629,822,533	683,718			6,865,950	5,603,085	7,661,562	38,328,703	1,950,456	5,077,539	715,889,872	32.0%
	Goats	10,445,443	35,366,149				30,908	120,409	5,151	77,918		63,675	46,109,654	57.0%
	Other n.e.c.	-	-				-	-	-	-	-	-	-	
	Pigs	27,301,716	10,644,834				476,694	243,602		60,198		8,527	38,735,570	12.2%
	Poultry	238,203,058	58,009,985			396,744	20,921,309	2,776,786	9,263,281	89,680,896	21,997,880	98,007,316	539,257,254	79.0%
	Sheep and lambs	43,919,033	61,582,349	89			241,396	4,534,254	464,170	905,354	1,462,447	120,297	113,229,388	8.6%
⊟ **Nurseries, cut flowers or cultivated turf**	Cultivated turf	10,412,893	5,230,904				5,161		955,374	13,131,105	3,942,903	3,978,164	37,656,504	70.2%
	Cut flowers	19,915,451	8,675,034			67,849	1,897,275	392,424	32,906,732	44,275,306		4,513,979	112,644,049	64.5%
	Nurseries	13,168,343	20,750,877	172,604	44,936	4,990,842	14,964,069	3,618,237	99,469,908	31,202,104	7,941,527	17,303,635	213,627,082	78.1%
⊟ **Vegetables for human consumption**	All other vegetables n.e.c.	1,668,057	59,393,806			3,772,427	240,167		1,161,915	133,549,246	19,560,121	34,057,515	253,403,253	85.8%
	Beans (including french and runner)	125	23,595,754				3,997	76	7,331	329,175	301,948	3,091	24,241,498	86.6%
	Broccoli	951,579	13,725,665				1,079,973		17,481	3,620,336	30,113,374	3,651,822	53,160,230	90.6%
	Brussels sprouts		101,719						4,945,032	1,785,387			6,832,137	99.8%
	Cabbages	151,705	22,317,985						2,612	1,651,804	3,204,156		27,328,261	96.4%
	Capsicum	355	8,624,244				11,562		1,128,484	170,015			9,934,660	66.3%
	Carrots	10,411	4,555,159			274,058	2,245		3,915	583,206		1,167,273	6,596,266	10.5%
	Cauliflowers	1,508	2,311,950						9,908	505,519	16,046,901	3,133	18,878,919	99.1%
	Lettuces	8,036,133	33,383,796				2,501		42,091	10,438,471	16,279,249	19,818,617	88,000,857	91.0%
	Melons	8,524											8,524	0.1%
	Mushrooms	350,386					85,891,504	4,377,249					90,619,139	74.4%
	Onions	245,608	4,872,416				95,215			1,179,852		293,830	6,686,920	54.9%
	Peas	662	4,554,197					2,131		9,093		174	4,566,256	84.0%
	Potatoes	50,668	27,457,321				48,428			10,642,836		319,880	38,519,134	39.5%
	Pumpkins	915	229,781				2,590	1,186	6,873	86,686		19,248	347,280	18.6%
	Sweet corn	1,819	22,687,883						4,246	968,638			23,662,586	97.8%
	Tomatoes	890,148	15,650,616		74,471		4,014	130,325	211,097	734,881	227,933	580,888	18,504,372	19.9%
Grand Total		**509,014,352**	**2,032,450,937**	**7,828,421**	**119,408**	**10,234,849**	**161,280,810**	**28,627,672**	**266,670,476**	**518,576,886**	**144,895,609**	**211,015,008**	**3,890,714,427**	**29.7%**

ABS 75030DO005_201516 Value of Agricultural Commodities Produced, Australia 2015-16.

Table A1-2 Change in value of Production of major commodities produced in the Region (ABS)

COMMODITY	VALUE OF AGRICULTURAL COMMODITIES PRODUCED, AUSTRALIA, 2007-08 (% OF VICTORIA) $	VALUE OF AGRICULTURAL COMMODITIES PRODUCED, AUSTRALIA, 2018-19 (% OF VICTORIA) $
Horticulture - Nurseries, cut flowers and cultivated turf - Total value ($)	245,326,212 (46%)	417,152,004 (65%)
Horticulture - Vegetables for human consumption - Total value ($)	503,657,879 (66%)	672,295,482 (62%)
Horticulture - Fruit - Fruit (excluding grapes) - Total value ($)	132,468,990 (19%)	152,817,648 (11%)
Horticulture - Fruit - Grapes - Total value ($)	21,654,114 (5%)	25,875,693 (5%)
Livestock - Livestock products - Milk - value ($)	1,249,232,439 (41%)	973,133,390 (36%)
Total crops	1,344,346,894 (25%)	1,467,309,076 (23%)
Total Agriculture	3,724,933,176 (32%)	4,182,420,247 (26%)

The above table suggests that the value and contribution of most agricultural products has remained relatively stable. The exception would be nurseries, cut flowers and turf which has increased in value.

THE GROSS VALUE OF IRRIGATED AGRICULTURAL PRODUCTION

The ABS Gross Value of Irrigated Agricultural Production (GVIAP) and Gross Agricultural Production for 2017/18 for the Region and the State is below.

Table A1-2: Central Gippsland Region GVIAP as a % of gross value of irrigated production for each commodity

	Column Labels										GVIAP as	Study area GVIAP
	Corangamite		East Gippsland		Port Phillip and Western Port		West Gippsland		Total Sum of Gross	Total Sum of Gross	% of gross value	% of Victoria
Row Labels	Sum of Gross Valu	Sum of Gross Valu	Sum of Gross Valu	Sum of Gross Valu	Sum of Gross Value of	Sum of Gross Valu	Sum of Gross Valu	Sum of Gross Value of Irrigated Production ($)			in Study Area	GVIAP
Cereals for grain and seed (a)	$ 88,222,152	$ 1,486,668	$ -	$ -	$ 20,212,210	$ 11,380,254	$ 3,263,776	$ 192,164	$ 111,698,139	$ 13,059,086	12%	42%
Dairy production (d)	$ 423,262,180	$ 110,111,086	$ 31,095,267	$ 6,474,825	$ 208,376,992	$ 10,501,960	$ 605,701,923	$ 236,756,093	$ 1,268,436,362	$ 363,843,964	29%	28%
Fruit and nuts (excluding grapes)	$ 1,585,182	$ 1,462,273	$ 2,449,521	$ 2,449,521	$ 141,684,038	$ 138,207,475	$ 1,137,108	$ 1,137,108	$ 146,855,849	$ 143,256,376	98%	13%
Grapes	$ 335,174	$ 271,564	$ 110,216	$ 110,216	$ 25,002,508	$ 24,967,579	$ 125,453	$ -	$ 25,573,350	$ 25,349,359	99%	7%
Hay	$ 35,310,270	$ 482,625	$ 3,587,096	$ 690,873	$ 10,326,780	$ -	$ 16,810,054	$ 3,002,703	$ 66,034,200	$ 4,176,200	6%	7%
Nurseries, cut flowers and cultivated turf	$ 66,133,693	$ 48,342,843	$ -	$ -	$ 321,293,020	$ 250,968,694	$ 16,614,689	$ 13,758,393	$ 404,041,403	$ 313,069,930	77%	82%
Other broadacre crops	$ 38,255,527	$ 385,049	$ 444,853	$ -	$ 8,960,287	$ 1,827,712	$ 1,746,402	$ 147,697	$ 49,407,069	$ 2,360,457	5%	13%
Production from meat cattle	$ 255,640,040	$ 8,098,886	$ 59,744,023	$ 3,870,584	$ 140,677,536	$ 3,885,110	$ 389,081,043	$ 59,900,125	$ 845,142,642	$ 75,754,704	9%	21%
Production from sheep and other livestock (e)	$ 529,766,690	$ 12,527,464	$ 43,442,678	$ 2,302,636	$ 386,135,950	$ 620,118	$ 114,388,460	$ 6,071,825	$ 1,073,733,778	$ 21,522,042	2%	8%
Total	$ 1,472,472,411	$ 210,672,220	$ 244,407,162	$ 89,948,378	$ 1,735,756,755	$ 769,940,226	$ 1,278,997,925	$ 445,996,699	$ 4,731,634,252	$ 1,516,557,523	32%	31%
Vegetables (c)	$ 33,961,501	$ 27,503,762	$ 92,624,379	$ 65,991,853	$ 473,087,434	$ 327,581,325	$ 130,129,017	$ 125,030,593	$ 729,802,331	$ 546,107,533	75%	68%

4610055008do001_201718 gross value of irrigated agricultural production–2017-18.

Table A1-3: State GVIAP for each commodity

Sum of Gross Value of Irrigated Production ($)	Column Labels										
Row Labels	Corangamite	East Gippsland	Glenelg Hopkins	Goulburn Broken	Mallee	North Central	North East	Port Phillip and Western Port	West Gippsland	Wimmera	Grand Total
Cereals for grain and seed (a)	$ 1,486,668	$ -	$ 936,284	$ 11,883,838	$ -	$ -	$ -	$ 11,380,254	$ 192,164	$ 5,215,641	$ 31,094,850
Dairy production (d)	$ 110,111,086	$ 6,474,825	$ 136,385,028	$ 496,764,207		$ 236,722,274	$ 49,857,654	$ 10,501,960	$ 236,756,093	$ -	$ 1,283,573,126
Fruit and nuts (excluding grapes)	$ 1,462,273	$ 2,449,521	$ 828,631	$ 392,699,199	$ 475,533,577	$ 101,177,391	$ 31,561,634	$ 138,207,475	$ 1,137,108	$ 656,980	$ 1,145,713,787
Grapes	$ 271,564	$ 110,216	$ 1,005,056	$ 9,186,829	$ 333,858,606	$ 12,350,497	$ 5,958,998	$ 24,967,579	$ -	$ 1,269,216	$ 388,978,560
Hay	$ 482,625	$ 690,873	$ 42,653	$ 34,125,206	$ 2,003,910	$ 18,131,744	$ 633,448	$ -	$ 3,002,703	$ 451,220	$ 59,564,381
Nurseries, cut flowers and cultivated turf	$ 48,342,843	$ -	$ 121,260	$ 41,613,727	$ -	$ -	$ 2,459,627	$ 250,968,694	$ 13,758,393	$ 22,728,025	$ 379,992,569
Other broadacre crops	$ 385,049	$ -	$ -	$ 3,110,845	$ 990,315	$ 10,421,439	$ -	$ 1,827,712	$ 147,697	$ 932,767	$ 17,815,823
Production from meat cattle	$ 8,098,886	$ 3,870,584	$ 40,088,650	$ 145,940,731	$ 47,233	$ 71,533,644	$ 28,253,649	$ 3,885,110	$ 59,900,125	$ -	$ 361,618,611
Production from sheep and other livestock (e)	$ 12,527,464	$ 2,302,636	$ 13,461,516	$ 52,235,498	$ 789,918	$ 176,105,482	$ 3,121,739	$ 620,118	$ 6,071,825	$ 4,444,598	$ 271,680,795
Total	$ 210,672,220	$ 89,948,378	$ 199,059,336	$ 1,328,067,225	$ 964,455,426	$ 776,770,745	$ 124,034,924	$ 769,940,226	$ 445,996,699	$ 35,698,447	$ 4,944,643,627
Vegetables (c)	$ 27,503,762	$ 65,991,853	$ 6,190,259	$ 140,507,146	$ 57,293,866	$ 55,040,178	$ 2,188,176	$ 327,581,325	$ 125,030,593	$ -	$ 807,327,157

4610055008do001_201718 gross value of irrigated agricultural production–2017-18.

Note: Corangamite NRM Region is only partly in the Region.

Appendix 2: Irrigation water demand and cost thresholds

This Appendix includes:

- A description of the perceived demands for water (using the best available data/knowledge) for agriculture currently and into the future along with comparison to available water supplies
- Analysis and reporting of the perceived cost thresholds, or willingness to pay, for viable agricultural water use (using best available data/knowledge) for different industries in terms of unregulated, groundwater, regulated and alternative (recycled and/or stormwater) supplies.

EXISTING AGRICULTURAL DEMANDS FOR WATER

Irrigation demands change with locational differences in rainfall, evapotranspiration and canopy size. The table below provides an estimate of the regional demands for the main enterprise types. As effective rainfall increases, irrigation demand falls. But total demand, which is ET x canopy area (crop coefficient) is relatively uniform from season to season.

Table A2-1: Estimated irrigated crop water requirements in study area

ENTERPRISE	EFFECTIVE RAINFALL	IRRIGATION DEMAND	TOTAL	AREA	IRRIGATED WATER USE
Unit	ML/ha	ML/ha	ML/ha	ha	ML/y
nurseries	5	5	10	2,000	10,000
orchards	5	4	9	2,000	8,000
wine grapes	5	2	7	5,000	10,000
vegetables	5	4	9	14,000	56,000
crops	5	2	7	5,000	10,000
Pastures (mostly dairy)	5	4	9	55,000	220,000
Total					**314,000**

Stock demands are estimated below using Agriculture Victoria values[18]. However, these are estimated to be double southern Victorian values as water requirements are substantially reduced when grazing green moist pastures, when compared to dried pastures.

[18] (https://agriculture.vic.gov.au/farm-management/water/farm-water-solutions/how-much-water-does-my-farm-need) and also (Williams J., DPI VIctoria, 2010).

Table A2-2: Estimated stock water requirements in study area (approx. double actual due to moist pastures)

LIVESTOCK	DRINKING WATER REQUIREMENTS L/HEAD/YEAR
dairy cows	36,500
beef	29,200
pigs	7,300
poultry	120
sheep	2,555

These have been applied to stock numbers for ABS data produced for 2018/19[19], which generates the total drinking water demands below.

Table A2-3: Estimated stock water requirements in study area based on ABS stock numbers (approx. double actual requirement due to moist pastures)

Sum of Estimate	Region label				
Commodity description	Corangamite	East Gippsland	Port Phillip and Western Port	West Gippsland	Grand Total
Livestock - All other livestock n.e.c. (no.) (s)	3,878	868	7,208	17,376	29,330
Livestock - Cattle - Total cattle (no.)	430,326	97,145	246,468	761,504	1,535,443
Livestock - Dairy cattle - All other dairy cattle n.e.c. (no.) (p)	8,850	719	2,325	13,624	25,518
Livestock - Dairy cattle - Calves less than 1 year (no.)	41,107	1,763	12,670	63,646	119,186
Livestock - Dairy cattle - Cows in milk and dry (no.)	144,670	7,430	50,961	267,213	470,273
Livestock - Dairy cattle - Heifers 1 to 2 years (no.)	41,805	1,269	19,678	63,882	126,634
Livestock - Dairy cattle - Heifers over 2 years (no.)	8,990	338	5,398	16,013	30,740
Livestock - Dairy cattle - Proportion dairy cattle to total cattle (%)	57	12	37	56	162
Livestock - Dairy cattle - Total (no.)	245,422	11,519	91,032	424,379	772,351
Livestock - Meat cattle - All other meat cattle (no.) (p)	31,455	11,430	39,839	102,116	184,841
Livestock - Meat cattle - Calves less than 1 year (no.)	60,646	26,418	44,247	91,640	222,951
Livestock - Meat cattle - Cows and heifers 1 year and over (no.)	92,802	47,778	71,350	143,370	355,300
Livestock - Meat cattle - Proportion of meat cattle to total cattle (%)	43	88	63	44	238
Livestock - Meat cattle - Total (no.)	184,903	85,627	155,437	337,126	763,092
Livestock - Pigs - All other pigs (no.) (q)	48,309	3	27,967	12,344	88,623
Livestock - Pigs - Breeding sows (no.)	8,313		2,656	1,475	12,444
Livestock - Pigs - Total (no.)	56,622	3	30,623	13,818	101,066
Livestock - Poultry and eggs - All other chickens (including pullets and replacement stock) (no.)	428,024	281	205,773	11	634,090
Livestock - Poultry and eggs - Hen egg production for human consumption - Total (dozens)	18,517,218	90,977	40,126,540	369,856	59,104,592
Livestock - Poultry and eggs - Live poultry - All other poultry (no.)	3,050		41,344	22	44,416
Livestock - Poultry and eggs - Live poultry - Meat chickens (no.)	12,262,819		9,765,556	394,353	22,422,728
Livestock - Poultry and eggs - Live poultry - Total layers (excluding pullets) (no.) (r)	967,221	4,619	1,773,603	22,028	2,767,471
Livestock - Sheep and lambs - All other (no.)	270,648	36,137	36,891	42,942	386,619
Livestock - Sheep and lambs - Breeding ewes 1 year and over - Merinos (no.)	425,453	65,618	21,606	106,026	618,703
Livestock - Sheep and lambs - Breeding ewes 1 year and over - Other breeding ewes n.e.c. (no.)	389,813	35,959	56,294	87,656	569,721
Livestock - Sheep and lambs - Breeding ewes 1 year and over (merino and all other) - Total (no.)	815,266	101,577	77,900	193,681	1,188,424
Livestock - Sheep and lambs - Ewes mated to produce lambs - Total (no.) (o)	690,170	77,330	62,123	185,116	1,014,740
Livestock - Sheep and lambs - Ewes mated to produce lambs to Merino rams (no.) (o)	283,565	45,743	8,092	56,596	393,995
Livestock - Sheep and lambs - Ewes mated to produce lambs to other rams (no.) (o)	406,605	31,588	54,031	128,521	620,745
Livestock - Sheep and lambs - Lambs marked - All other breeds (no.) (o)	483,700	44,085	77,439	128,513	733,737
Livestock - Sheep and lambs - Lambs marked - Merino lambs (no.) (o)	179,511	29,271	6,189	23,753	238,724
Livestock - Sheep and lambs - Lambs marked - Total (no.) (o)	663,211	73,356	83,627	152,267	972,461
Livestock - Sheep and lambs - Lambs under 1 year - Total (no.)	311,851	26,252	38,785	77,676	454,564
Livestock - Sheep and lambs - Total (no.)	1,397,765	163,966	153,576	314,300	2,029,607
Grand Total	39,904,091	1,119,168	53,397,328	4,612,942	99,033,529

		ML/y				
	L/hd/y	Corangamite	East Gippsland	Port Phillip and Western Port	West Gippsland	Total
Consumption livestock nos nec	25,550	99	22	184	444	749
consumption dairy	36,500	8,958	420	3,323	15,490	28,191
consumption beef	29,200	5,399	2,500	4,539	9,844	22,282
consumption pigs	7,300	413	0	224	101	738
consumption poultry	120	1,588	1	1,390	50	3,028
consumption sheep	2,555	3,571	419	392	803	5,186
Total stock demand		20,029	3,362	10,051	26,732	60,174

It is suggested the 60,000 ML/y demand in actuality is closer to 30,000 ML/y due to moist pastures, this excludes household domestic usage. However, it is worth noting that this compares with the 49 GL/y harvested in catchment dams (see Table A3-1) and 11 GL/y pumped from groundwater bores (see 4.5.2) for domestic and stock purposes.

As previously discussed (Section 5.3), an evaluation of piped domestic and stock system in low rainfall areas in Gippsland by Marsden Jacobs in 2020[20] indicated that they were not economically viable.

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[19] 71210DO002_201819 Agricultural Commodities, Australia–2018-19 Released at 11:30 am (Canberra time) 28 May 2020.

[20] Report unpublished - Factsheet available for download at http://www.srw.com.au/wp-content/uploads/2021/05/Improving-DS-access.pdf

FUTURE AGRICULTURAL DEMANDS FOR WATER

Assuming water was unlimited in peak demand periods then, in theory irrigation could expand to most of the agricultural area, provided it was profitable.

However, the marginal benefit of irrigation is variable due to:

- The high proportion of ET being met by rainfall.
- Lack of supply in high demand periods
- High cost of storages to store water for high demand periods.

It is suggested that future demands will not change due to the lack of available affordable supply in peak periods.

If this barrier were to be overcome then it is suggested that over a ten-year period the main constraints on growth would be market demand (at sustainable price), labour and skills development, but irrigation production could grow as per the commentary below.

The following section draws upon previous work on future water demands undertaken by RMCG in 2011. (RMCG, 2011) and updated for contemporary market conditions.

Dairy

General:

- Production has remained relatively constant over the last decade with changes in production responding to price signals and seasonal conditions.
- Access to dairy wash-down water is as important as access to irrigation water – much of the area has sufficient rainfall to support dairy without access to irrigation water. But if there is no access to water for dairy wash-down and stock requirements then no development is possible.
- Labour for dairy operations is a constraint to growth
- New rye grasses are increasing productivity and stocking rates
- Other limitations are the availability of cleared land
- No major water use efficiency improvements expected

Gippsland:

- Most of the dairy production in Gippsland is in the Wellington, Baw Baw and South Gippsland shires
- Areas close to larger towns and along the coast, like South Gippsland, are pressured by other land uses (urban, lifestyle)
- Irrigation in the unregulated systems tends to be a small part of the whole farming system with most feed generated from natural rainfall
- Milk production is expanding in Gippsland following retraction from drought and shortage of stock
- There are multiple milk processors in Gippsland providing choice for farmers
- Horticulturalists are seeking land in the MID, sometimes replacing dairy
- Potential growth in lower Macalister, Thomson, and Latrobe catchments (Traralgon to Maffra area) – mostly regulated catchments
- Dairying is constrained by poorer access to grain growing areas. Gippsland generally uses 1 Mt/y of grain as a feed supplement, but it only grows 0.2 Mt/y. Other areas (South West and North Vic) have advantage of being closer to grain growing areas and therefore have lower feed prices
- Yarram and Alberton groundwater levels are falling and under threat

- Generally, not a lot of growth potential in North (east) Gippsland –
- Other areas such as West of Warragul getting squeezed with other demands on land.

Central:

- Growth in the West will be adjacent to and within existing dairying areas and some movement North of these. Not likely much growth to the east due to rain shadows
- Expansion in West is limited by more waterlogging prone soils especially in wet winters
- Price of water plus irrigation costs must be less than cost of feed, otherwise irrigation will be substituted by feed
- 600 mm annual rainfall start to become marginal to support a dairy operation.

Conclusion:

- Growth of production – lower rate would be expected in Gippsland, as it has less access to grain and more competition from housing and horticulture, which leads to higher land prices
- Dairying expansion is more likely in areas where it is already established
- Water use efficiency changes – likely to be small
- Industry growth is made up of expansion of existing farms (majority), relocation from other areas (e.g. from Northern Victoria) and new entrants
- Water unreliability is managed through substitution (feed).

Based on the continuation of existing trends, which was largely stable production, large increases in dairy production and hence water use are not expected. If water were unlimited then growth of perhaps 10% to 20% may occur in the next ten years, (1% to 2% per annum) depending on milk price (global demand and supply) and seasonal conditions.

Horticulture

General:

- Production is likely to remain stable but the number of growers is likely to decline – rationalisation of industry is already occurring (e.g. in potatoes)
- Efficient users of water – approximately 2 ML/ha/crop (potatoes) in Gippsland
- The cost of irrigation can be high due to the high energy input costs
- Warragul area and MID growing in horticultural production as growers relocated from city fringe
- Potato growers e.g. Thorpdale relatively stable industry, has been some retraction due to potato cyst nematode
- Generally, across Australia production of vegetables is stabilising or declining, but is increasing in Gippsland due to relocation of growers particularly from the city fringe, but also large enterprises spreading risk with production across multiple climates (and therefore multiple regions/states)
- Potential for wine grape growers to relocate to Gippsland due to climate change if market oversupply is addressed (very long term)
- Mitchell River area is the main area for vegetable production. Mitchell River constrained by water available had restrictions 1 in 5 year historically, this has more recently been 3 to 4 years in 5 with restrictions. Some growers have installed winter-fill storages at major cost to provide water security
- Mitchell River also constrained by land available. Although land available is probably double existing horticultural area. This would need to move from grazing. So water is the more immediate constraint.
- Ground water and surface water is generally of adequate quality

- Main competitive advantages for Gippsland are consistent climate (few extreme days), potential to spread production risk (multiple locations), plenty of suitable soils
- East of Lakes Entrance is generally too isolated and lacking services, infrastructure etc., and land available (majority public land) to have much potential for growth
- Environmental constraints for intensive growing e.g. potatoes, vegetables and chemical runoff may become a constraint
- Many existing growers seem reluctant to relocate their total operation, but some will relocate parts to assist their overall management. Often labour is seen to be a major impediment in regional areas – proximity to Melbourne is good for access to immigrant communities.

Conclusion:

- Growth of production – Global outlook for horticultural growth is related to population and domestic market growth
- Growth of urban Melbourne is significant and this is expected to increase relocation of vegetable production to Gippsland
- Large scale vegetable producers are looking at having production centres in a number of regions to spread production risk. This may also increase growth in Gippsland from interstate companies.
- Water availability/reliability is a constraint to growth. The Mitchell River valley has enough suitable soil to significantly increase the existing horticultural area. However, the high cost of building private dams to harvest winter flows is an impediment. At present the Macalister Irrigation District is the target for growth due to reliable water supplies.
- Water use efficiency changes –while interviewees believed these to be insignificant, because drought has prompted all practical efficiency measures. There is potential gain in some areas and technologies, e.g. subsurface drip. It is expected that these water savings will be retained on-farm for individual production growth.

Water unreliability cannot be managed through substitution and there are significant interruptions in supply which limits growth. If water was unlimited horticultural production would be expected to match population growth, which in 2018/19 was 2.3%, most of this was overseas migration. In 2020 population growth declined during the pandemic.

With unlimited water it would be reasonable to assume 2% growth in horticulture per annum.

Beef/sheep/ cropping/mixed grazing

General:

- Mostly stable in broad acre areas and in the upper catchments e.g. Omeo/Tambo valley
- Profitability has improved in recent years for meat production
- Some being converted to rural residential in south Gippsland
- Beef and sheep meat consumption per capita has been declining in Australia, but prices are improving.

Conclusion:

- Very stable or decline over time, although decline recently slowed due to improvement in profitability
- Water use efficiency changes – small. The potential for new technology is limited by low value of production per ML.

With unlimited water it would be reasonable to assume no change in beef/sheep/cropping mixed operations demand per annum.

Intensive animal Industries

- Growth potential in poultry close to processing facilities, within 2 hours of Frankston and Geelong
- Expect to match population growth and consumption per capita is expanding for chicken meat and pork
- Trend to free range which needs 25% more water and feed
- Biosecurity requirements mean that water quality is a key requirement. Needs treating. Preferred source is town water, then ground water then river water. Capture from shed roofs is also a significant source given moderate to high rainfall.
- Substantial costs in storing and treating water
- Can only use low salinity water
- Water requirements are 100% reliability in 100% of years
- Relatively minor water user compared to other agricultural industries.

Conclusion:

- Market outlook for high growth
- Growth of urban Melbourne is expected to increase relocation to Gippsland and the South West within 2 hours of processing plants located in eastern suburbs and Geelong. This is especially true for poultry industries.
- Pork industry is also expected to expand, but is more inclined to head north to be close to grain centres
- Water use efficiency changes – not likely to have a major impact on reducing water demand. Except shift to free range may actually increase water demand slightly.

The impact of restrictions/rationing and water quality treatment may limit growth, because these industries require 100% reliability. Therefore, we expect the demand to be a 2-5% increase per annum. This will have a negligible impact on total water demand as it is of a low base.

The table below estimates change in water use growth prospects, if water was unlimited.

Table A2-4: Estimated water use by industry with expected growth in unlimited water scenario

INDUSTRY	IRRIGATION CURRENT USE ML/Y	D& S USE	TOTAL	GROWTH RATE PER ANNUM IF WATER WAS UNLIMITED	ML GROWTH IF UNLIMITED
Grazing / cropping	10,000	28,000	38,000	Negligible	0
Dairying	220,000	28,000	248,000	1%-2%	2,480 to 4,960
Horticulture	84,000	0	84,000	2%-3%	1,680 to 2,520
Intensive animal industries	0	3,000	3,000	2-4%, say 3%	60 to 120
Total	**314,000**	**60,000**	**374,000**		**4,250 to 7,600 around 1% to 2% growth in demand**

Based on the assumptions above, the expected change in water use is shown above for a scenario in which water was not limiting growth. However, it should be noted that the experience has been that there are still a large volume of unused entitlements, because of unreliability of supply which constrains potential growth.

This should be treated with caution as growth in demand depends very much upon the growth of dairy; and if milk price were to significantly increase then the potential for increased water demand is much higher. An increase to 5% growth rate per year would mean an additional annual demand growth of more than 12,000 ML/y for dairying alone.

RETURNS PER MEGALITRE AND WILLINGNESS TO PAY

The table below provides an estimate of returns and gross margins per ML and per ha for irrigation in the Region.

Table A2-5: Estimated gross value of production and gross margins from irrigation in the Region

ENTERPRISE	ESTIMATED GROSS VALUE	AREA	GVIAP /HA	WATER USE INCLUDING EFFECTIVE RAIN	VALUE PER ML (INCLUDING EFFECTIVE RAINFALL)	GROSS MARGIN	
Unit	$/y	ha	$	ML/ha	$	Per ha	Per ML
Nurseries	300,000,000	2,000	150,000	10	15,000	75,000	7,500
Orchards	144,000,000	2,000	72,000	9	8,000	36,000	4,000
Wine grapes	45,000,000	5,000	9,000	7	1,286	4,500	643
Vegetables	560,000,000	14,000	40,000	9	4,444	20,000	2,222
Crops	15,000,000	5,000	3,000	7	429	1,500	214
Pastures (dairy)	467,500,000	55,000	8,500	9	944	4,250	472
Total	**1,531,500,000**						

As a rule of thumb irrigators are not able to pay more than the profit per ML for water. Farm profit typically sits between zero to 20% of gross income depending on the cost structure of the business. Adopting a typical value of 10% would suggest the values in Table A2-6.

However, if there is spare capital and labour capacity within the farm (there usually is), then some additional production can be afforded by paying more per ML. Theoretically irrigators can pay up to the gross margin value per ML if capital and labour is not limiting. However, there is usually some additional capital or labour required and a value of 50% of the gross margin per ML is suggested as the marginal value that most farmers might consider valuing water at.

The range in affordable water values are estimated below.

Table A2-6: Estimated affordable annual water values for each industry

ENTERPRISE	GVIAP/HA	GROSS MARGIN	LOW RANGE WATER VALUE	HIGH RANGE WATER VALUE
Unit	$	Per ML	10% of GVIAP $/ML	50% of gross margin $/ML
nurseries	15,000	7,500	1,500	3,750
orchards	8,000	4,000	800	2,000
wine grapes	1,286	643	129	321
vegetables	4,444	2,222	444	1,111
crops	429	214	43	107
Pastures (dairy)	944	472	94	236

Given that the majority of water use is dairy (220 GL out of approx. 314 GL/y) it will be dairy/pastures that sets the value of water.

At $94/ML to $236/ML capitalised at 5% this is $1,889/ML to $4,722/ML capital value of water. But this is assuming 100% reliability and utilisation. In reality, reliability is less than 100% and utilisation, especially in wet years when the marginal value of water is nil is also less than 100%.

Adjusting for 50% of use due to low reliability and lower utilisation in wet years, this would indicate water values around $1,000/ML to $2,400/ML, which matches recent auction results that are reported below.

It is worth noting that auctions in the MID have sold water at a higher end of the value, this is due to higher utilisation in the regulated system due to the lower rainfall, ability to carry forward and more reliable regulated supply.

The results from Parwan GMU and Tarwin winterfill sales are shown below. Parwan underlies Bacchus Marsh Irrigation District. The 2016 sale was during a dry season. The 2018 sale was returned water from a customer who defaulted on payment from the 2016 sale. Tarwin was triggered by interest from an applicant who sought a large volume to set up a vegetable farm.

Table A2-7: Parwan 2016 sale

LOT #	VOLUME (ML)	WHOLE LOT	SALE PRICE PER MEGALITRE
1	10	$11,025	$1,103
2	90	$120,550	$1,339
3	30	$44,925	$1,498
4	30	$45,075	$1,503
5	40	$60,076	$1,502
6	90	$201,025	$2,234
7	30	$52,025	$1,734
8	30	$52,545	$1,752
9	10	$17,559	$1,756
10	90	$72,025	$800
11	30	$25,025	$834
12	10	$16,025	$1,603
Pre sale*	110	$16,060	$146
Average			$1,465
Auction Total	490	$717,880	
Total	**600**	**$733,940**	
***Shared between 11 customers**			

Table A2-8: Parwan 2018 sales

		SALE PRICE			
Lot #	**Volume (ML)**	**Whole lot**	**Per Megalitre**	**Bidders**	**Bids**
1	5	$3,525	$705	4	38
2	5	$10,025	$2,005	3	15
3	5	$5,032	$1,006	3	11
4	5	$7,655	$1,531	4	12
5	8	$6,025	$753	3	12
6	10	$12,025	$1,203	4	16
7	10	$12,025	$1,203	4	16
Average			$1,201	4	17
Total	**48**	**$56,312**		**25**	**120**

Table A2-9: TARWIN sales

VOLUME	# OF LOTS	TOTAL PRICE
2.5	1	$740
2.5	1	$740
220	2	$180,050
200	1	$135,025
1340	12	$1,709,950
300	4	$441,200
100	1	$171,025
100	2	$150,550
50	1	$75,125
120	8	$192,811
20	1	$35,525
10	1	$17,575
10	1	$17,375
10	1	$17,775
5	1	$8,780
10	2	$15,300
2,500	40	$3,169,546 Average = $1,268/ML.

Latrobe River temporary water sale – results 27 Nov 2020:

- In November, tenders were called for 800ML of temporary water from the Blue Rock Drought Reserve. The water was made available for sale by tender to customers on the Latrobe River system. One lot of 50ML sold for $40 per megalitre.

Macalister Irrigation District (MID) permanent water share auction – 3 April 2020:

- An annual auction of permanent water shares in the Macalister Irrigation District (MID) was conducted successfully online Friday 3 April 2020, through WaterBid
- A total of 92.8 megalitres (ML) high reliability water shares and 48.5 ML low reliability water shares were offered across 15 lots, all with allocation
- Buyers were predominantly dairy, beef and fodder businesses in the MID
- Winning bids ranged from $2,672.50 to $2,805 per megalitre for the high and low reliability bundled lots, with an average of $2,734.44 per megalitre
- The lots comprising only high reliability shares sold between $2,555 to $2,658.92 per megalitre, with an average of $2621.28 per megalitre
- Based on the results for the day the market is valuing low reliability water shares at an average of $113 per megalitre.

Dilwyn aquifer allocation auction – December 2019:

- An auction of section 51 licences for a total allocation of 5,000 ML from the Dilwyn (deep) aquifer, near Warrnambool, were offered to registered bidders over the period from Tuesday 3 December 2019 to Wednesday 11 December 2019. The 15 lots offered ranged in size from 200ML to 500ML. The auction was open for seven days and all lots were passed in after a total of 74 bids were placed, failing to meet the reserve.

Tarwin River winterfill auction – results 26-27 June 2019:

- An auction of Section 51 take and use licences for Tarwin River winterfill was completed 26-27 June. A total volume of 2,495ML was sold in 38 lots, ranging from 200ML to 5ML. All lots had multiple bidders, with some receiving over 40 bids. Prices ranged from $675 to $1,784 per ML. The average price was $1,494 per ML.

Latrobe River auction – results May 2019:

- A further auction of temporary water from the Blue Rock Drought Reserve was made available for auction to customers on the Latrobe River system. The auction offered 285 ML in 8 lots ranging in size from 10ML to 50 ML. Three lots totalling 200ML sold at auction, with one further lot of 50ML sold off-the-shelf. The water sold for an average of $31 per megalitre.

Bacchus Marsh and Werribee Irrigation District auction – results May 2019:

- An auction for 230 megalitres (ML) of high reliability and 115 ML of low reliability water shares in the Bacchus Marsh and Werribee Irrigation Districts was conducted online between Tuesday 14 and Thursday 16 May 2019. The lots were offered as: 26 lots of 5ML of HRWS with 2.5ML LRWS; and 5 lots of 20ML of HRWS with 10ML LRWS. At the completion of the auction:
  - 26 lots were sold, ranging in size from 5ML high-reliability with 2.5 low-reliability water shares, to 20ML high reliability with 10ML low reliability water shares
  - The results ranged between $1,000 and $1,405 per high and low combined megalitre
  - 5 lots did not meet the reserve and were passed in.

Latrobe River auction – results April 2019:

- A further auction of temporary water from the Blue Rock Dought Reserve was made available for auction to customers on the Latrobe River system. The auction offered 900 ML in 14 lots ranging in size from 10ML to 150 ML. The water sold for an average of $55.57 per megalitre.

Latrobe River auction – results February 2019:

- In response to drought conditions, temporary water from the Blue Rock Dought Reserve was made available for auction to customers on the Latrobe River system. The auction offered 900 ML in 12 lots ranging in size from 25ML to 100 ML. The water sold for an average of $87.42 per megalitre.

MID Permanent water share auction – results 20 February 2019:

- The auction for 269 megalitres (ML) of permanent water shares in the Macalister Irrigation District was completed successfully yesterday (19 Feb) at Southern Rural Water's office in Johnson Street, Maffra
- The lots were offered as high and low reliability bundles. There were successful bidders from dairy, beef and fodder enterprises in the district.
- Prices ranged from a high of $2,200 per ML to $1,850 per ML
- The average was $2,035 per ML.

MID online auction – results 20 December 2018:

- Irrigation customers paid an average of $282.29 per megalitre for water in the MID seasonal water online auction, which ended on 20 December
- The unreserved auction was for a total 134 ML of 2018-19 season water, sold in 10 lots between 5ML and 20ML. All lots sold with prices ranging from $251 to $310 per ML.

Moorabbin auction – results December 2018:

- Section 51 licences for an allocation of 42.7 ML from the Moorabbin Groundwater Management Unit were auctioned to eligible bidders. Four lots were offered as: 4 x 10.6 ML and were successfully sold. The lots sold at an average of $1,343 per megalitre (ML), with a total of 117 bids placed.

MID online auction – results November 2018:

- MID customers paid an average of $263.75 per megalitre for water in the November MID seasonal water online auction
- The unreserved auction was for a total 40 ML of 2018-19 season water, sold in four lots of 10 ML. All lots sold with prices ranging from $252.50 to $277.50 per ML.

Parwan GMU auction – results June 2018:

- Section 51 licences for an allocation of 48 ML from the Parwan Groundwater Management Unit were auctioned to eligible bidders when the auction closed on Thursday 28 June 2018. The seven lots were offered as: 4 x 5ML, 1 x 8ML and 2 x 10ML. The auction was open for four days and all lots were successfully sold. The lots sold at an average of $1,201 per megalitre (ML), with a total of 120 bids placed.

WID and BMID auction – results April 2018:

- The final online allocation auction for the 2017-18 Werribee/Bacchus Marsh Irrigation District season closed Thursday 12 April with all lots sold to bidders registered on WaterBid
- The 155L seasonal allocation was offered in 14 lots, 5x5ML, 5x10ML, and 4 x 20ML. The auction was open for three days and all lots were successfully sold.

MID auction – results February 2018:

- The results from SRW's recent online auction of water from the Macalister Irrigation District include:
  - Auction prices ranged from $44.25 and $14.31 per ML depending on the lot size.

MID auction – results January 2018:

- The results from SRW's recent online auction of water from the Macalister Irrigation District include:
  - Auction prices ranged from $80.50 and $20.10 per ML depending on the lot size.

MID auction – results 21 December 2017:

- The results from SRW's recent online auction of water from the Macalister Irrigation District include:
  - Auction prices ranged from $92.10 and $112.50 per ML depending on the lot size.

MID auction – results 27 February 2017:

- The results from SRW's recent online auction of water from the Macalister Irrigation District include:
  - Auction prices ranged from $117.50 to $161.25 per ML depending on the lot size.

MID auction – results 23 January 2017:

- The results from SRW's recent online auction of water from the Macalister Irrigation District include:
  - Auction prices ranged from $82.75 – 182.50 per ML depending on the lot size.

Parwan GMU auction –results 24 June 2016

- The results from SRW's recent online auction of water from the Parwan GMU include:
  - Because of concerns about the high demand for water, Southern Rural Water offered 10ML lots to 11 customers who expressed interest before the auction at the reserve price
  - There were 10 registered bidders and four winning buyers (all market gardeners)
  - 8 out of 10 of the registered bidders actively participated in the auction
  - 490ML (all that was available at the auction) was sold
  - With the 110ML being sold beforehand, this makes a total of 600ML now in customer hands for use
  - Auction prices ranged from $800 to $2,234 per ML.

Appendix 3: 2018/19 Water Use on Australian Farms data for the Region

Table A3-1: Study Area Water use on Australian Farms

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Area of holding - Total area (ha) (a)	743,995	271,096	325,439	579,582	1,920,112	17%	11,464,631
Irrigation expenditure - Annual irrigation water volumetric/usage charges - Total cost ($)	1,253,794	408,404	5,228,028	5,822,910	12,713,136	13%	95,258,084
Irrigation expenditure - Purchases of extra water on a permanent basis - Total cost ($)	13,982	31,203	257,916	552,205	855,306	9%	9,974,189
Irrigation expenditure - Purchases of extra water on a permanent basis - Total volume purchased (ML)	135	-	2,186	1,248	3,569	26%	13,851
Irrigation expenditure - Purchases of extra water on	375,631	83,196	1,465,917	1,439,437	3,364,181	3%	127,624,217

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
a temporary basis - Total cost ($)							
Irrigation expenditure - Purchases of extra water on a temporary basis - Total volume purchased (ML)	1,041	4,230	2,447	14,893	22,611	6%	387,543
Number of agricultural businesses (no.)	2,199	521	2,364	2,452	7,537	34%	21,856
Number of agricultural businesses irrigating (no.)	461	125	770	410	1,765	30%	5,840
Water source - Groundwater (e.g. bores, springs, wells) - Total volume used (ML)	20,521	12,274	9,388	40,342	82,525	26%	314,130
Water source - Other sources of water (excluding rainfall) - Total volume used (ML)	71	1	460	1	533	54%	981
Water source - Recycled/re-used water from off-farm sources (e.g. re-use schemes, mines) - Total volume used (ML)	830	367	36,710	5,422	43,329	71%	61,134
Water source - Total volume of water from all sources (ML)	46,953	29,262	79,217	151,208	306,641	16%	1,869,554
Water source - Town or reticulated mains supply - Total volume used (ML)	5,659	208	1,910	1,060	8,837	67%	13,205

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water source - Water taken from irrigation channels or irrigation pipelines - Total volume used (ML)	1,577	1,127	4,858	71,270	78,832	8%	956,951
Water source - Water taken from on-farm dams or tanks - Total volume used (ML)	15,539	2,246	17,241	14,232	49,258	52%	94,026
Water source - Water taken from rivers, creeks, lakes, etc. - Total volume used (ML)	2,756	13,038	8,651	18,881	43,326	10%	429,127
Water source - Water taken from rivers, creeks, lakes, etc. - Where a volumetric/usage charge occurs - Total volume used (ML)	2,248	9,185	6,200	15,808	33,440	8%	404,307
Water source - Water taken from rivers, creeks, lakes, etc. - Where there is no volumetric/usage charge - Total volume used (ML)	509	3,853	2,451	3,073	9,886	40%	24,820
Water use - Fruit trees, nut trees, plantation or berry fruits - Application rate (ML/ha)	1	1	2	4			8
Water use - Fruit trees, nut trees, plantation or berry fruits - Area watered (ha)	53	70	2,093	88	2,304	5%	50,404
Water use - Fruit trees, nut trees, plantation or berry fruits - Total area grown (ha)	182	70	2,290	257	2,798	5%	53,737

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water use - Fruit trees, nut trees, plantation or berry fruits - Volume applied (ML)	29	58	4,272	378	4,737	1%	403,216
Water use - Grapevines - Application rate (ML/ha)	3	1	2	0			5
Water use - Grapevines - Area watered (ha)	268	27	4,612	29	4,936	20%	24,270
Water use - Grapevines - Total area grown (ha)	281	69	4,848	73	5,270	19%	27,395
Water use - Grapevines - Volume applied (ML)	820	38	6,985	14	7,857	7%	112,260
Water use - Nurseries, cut flowers and cultivated turf - Application rate (ML/ha)	6	4	3	1			4
Water use - Nurseries, cut flowers and cultivated turf - Area watered (ha)	141	176	1,399	105	1,820	53%	3,421
Water use - Nurseries, cut flowers and cultivated turf - Total area grown (ha)	593	180	1,879	138	2,791	47%	5,877
Water use - Nurseries, cut flowers and cultivated turf - Volume applied (ML)	911	616	4,821	102	6,449	48%	13,424
Water use - Other agricultural water use - Volume used (ML) (b)	19,025	5,330	8,614	20,367	53,335	36%	147,715
Water use - Other broadacre crops - Application rate (ML/ha)	2		4	1			1

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water use - Other broadacre crops - Area watered (ha)	247		402	51	700	4%	17,040
Water use - Other broadacre crops - Total area grown (ha)	46,490	193	6,303	1,520	54,506	6%	906,997
Water use - Other broadacre crops - Volume applied (ML)	407		1,552	38	1,997	9%	21,772
Water use - Other cereals for grain or seed (e.g. wheat, oats, maize) - Application rate (ML/ha)	2	2	7				2
Water use - Other cereals for grain or seed (e.g. wheat, oats, maize) - Area watered (ha)	474	617	2,835		3,926	8%	50,650
Water use - Other cereals for grain or seed (e.g. wheat, oats, maize) - Total area grown (ha)	93,027	1,695	13,646	6,201	114,568	5%	2,487,331
Water use - Other cereals for grain or seed (e.g. wheat, oats, maize) - Volume applied (ML)	778	939	18,449		20,166	20%	100,618
Water use - Other crops n.e.c. - Application rate (ML/ha)	2			2			3
Water use - Other crops n.e.c. - Area watered (ha)	279			95	374	13%	2,911
Water use - Other crops n.e.c. - Volume applied (ML)	543			209	752	9%	8,440

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water use - Pastures (including lucerne) and cereal crops cut for hay - Application rate (ML/ha) (c)	2	2	0	2			3
Water use - Pastures (including lucerne) and cereal crops cut for hay - Area watered (ha) (c)	1,465	1,533	32	1,857	4,887	8%	60,924
Water use - Pastures (including lucerne) and cereal crops cut for hay - Volume applied (ML) (c)	3,336	2,853	11	4,049	10,249	6%	163,048
Water use - Pastures (including lucerne) and cereal crops cut for silage - Application rate (ML/ha) (d)	4	2	2	3			2
Water use - Pastures (including lucerne) and cereal crops cut for silage - Area watered (ha) (d)	1,313	587	455	1,958	4,313	10%	45,249
Water use - Pastures (including lucerne) and cereal crops cut for silage - Volume applied (ML) (d)	5,219	999	1,035	5,771	13,023	14%	94,220
Water use - Pastures (including lucerne) and cereal crops used for grazing or fed off - Application rate (ML/ha)	2	2	4	3			3
Water use - Pastures (including lucerne) and cereal crops used for grazing or fed off - Area watered (ha)	6,506	4,297	2,512	32,111	45,425	19%	236,792

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water use - Pastures (including lucerne) and cereal crops used for grazing or fed off - Total area grown (ha)	518,887	235,685	233,827	510,453	1,498,850	24%	6,162,930
Water use - Pastures (including lucerne) and cereal crops used for grazing or fed off - Volume applied (ML)	13,611	10,426	10,227	106,651	140,916	20%	711,108
Water use - Pastures (including lucerne) cereal and other crops cut for hay - Total area grown (ha)	62,615	3,077	25,704	38,965	130,361	17%	788,492
Water use - Pastures (including lucerne) cereal and other crops cut for silage - Total area grown (ha)	24,942	1,939	10,549	46,876	84,306	47%	179,839
Water use - Total application rate (ML/ha)	2	2	3	3			3
Water use - Total area watered (ha)	11,600	9,762	21,384	40,337	83,083	16%	513,706
Water use - Total volume applied (ML)	27,929	23,932	70,603	130,841	253,305	15%	1,721,839
Water use - Total volume applied/used (including other agricultural water) (ML)	46,953	29,262	79,217	151,208	306,641	16%	1,869,554
Water use - Vegetables for human consumption - Application rate (ML/ha)	3	3	3	3			4
Water use - Vegetables for human consumption - Area watered (ha)	855	2,457	7,044	4,042	14,398	65%	22,046

COMMODITY DESCRIPTION	CORANGAMITE	EAST GIPPSLAND	PORT PHILLIP AND WESTERN PORT	WEST GIPPSLAND	GRAND TOTAL	% OF VICTORIA	VICTORIA
Water use - Vegetables for human consumption - Total area grown (ha)	1,207	3,308	10,443	5,310	20,269	65%	31,172
Water use - Vegetables for human consumption - Volume applied (ML)	2,275	8,002	23,251	13,630	47,158	50%	93,734

ABS 46180DO001_201819 Water use on Australian Farms–2018-19.

Appendix 4: Recycled water use – Victorian Water Accounts 2018/19

Table A4-1: Volumes of recycled water for agriculture

GL IN 2018/19 (FROM VICTORIAN WATER ACCOUNTS 2018/19)	VOL RECYCLED FOR AGRICULTURE
Barwon	1.3
Bunyip	2.7
East Gippsland	0.1
Latrobe	0.1
Maribyrnong	0.7
Mitchell	0.2
Moorabool	0.0
Otway Coast	0.2
Snowy	0.2
South Gippsland	0.4
Tambo	0.8
Thomson	1.3
Werribee	23.7
Yarra	1.0
Total	**32.6**

Appendix 5: Previous Work on Managed Aquifer Recharge

Examples of previous work on Managed Aquifer Recharge (MAR) include:

1. The Yarram Artificial Recharge Study (SKM, 2004). This study evaluated MAR to support irrigation in the Yarram area. The irrigation in this area has a high degree of dependence on groundwater stored in the Latrobe Group and Balook Formation aquifers, which experienced increasing costs of extracting groundwater due to the decline in groundwater level (1.1m/year in the Latrobe Gp and approx. 0.5m/year in the Balook Fm) .The study identified in 2004 that:
   - Artificial recharge of 4,000 ML/y and 10,000 ML/y using injection wells would be required to stabilise the declining levels; as artificial recharge using spreading basins would be unlikely to provide more than 500 ML/y recharge
   - The conceptual layout for artificial recharge and preliminary costing was undertaken assuming the winter flow were available for artificial recharge. But noted a detailed evaluation of the environmental impact would need to be undertaken before that volume could be considered available.
   - The injection of 4,000 ML/y and 10,000 ML/y was estimated to cost between $27 M and $51 M for winter only operation, and $37 M and $71 M for continuous operation
   - An economic evaluation conservatively estimated the impact of the declining levels (to the Yarram region) in terms of on farm costs and structural change (i.e. losses due to changes in the type of agricultural activity) to be in the order of $240,000/year or $12/ML. This excluded broader environmental impacts of declining water levels, subsidence, river flows, water quality, coastal impacts etc.
   - The costs related to agriculture are far too low to justify an artificial recharge scheme that would have a capital cost between $5,000/ML and $9,000/ML. ($2004).
2. Work undertaken by Agriculture Victoria , “Optimising groundwater - MAR potential in Victoria”. (Michael Adelana, 2016), and found:
   - Augmentation of groundwater resources through MAR has become widespread around the globe, in recent decades in response to groundwater shortages. In Australia, MAR has mostly occurred in urban settings to augment water supply for domestic or industrial needs, with minimal application to agriculture.
   - Example case studies to illustrate a range of scales under which MAR could be applied. These range from individual, farmer-led management in the Philippines or village scale in India, to co-operative farming or broad-scale, larger agency schemes in the USA, Spain and South Australia.
   - The main challenges in implementing MAR are related to source water quality-aquifer chemistry, technical issues (e.g. infrastructure installation) and economics of MAR for agriculture (e.g. capital cost for re-injection and recovery)
   - Identifying potential MAR sites include the vast majority of irrigation water supply bores in the state. They indicate regions with potentially conducive aquifer conditions, available infrastructure for groundwater pumping and are associated with irrigation and proven demand for water.
   - Victorian aquifers identified as having best potential for MAR storage are near surface aquifers that can most easily allow passive or active recharge methods. The overlay of these suitable aquifers with irrigation districts provides a first-step to narrow the focus for locating potentially viable MAR schemes. Existing surface irrigation districts potentially provide suitable quantities and quality of recharge water to support MAR.

- That investigations that are more detailed are required at the sub-regional and farm scale within the prospective areas identified in this report to properly assess specific MAR viability in these contexts for Victorian agriculture. These intensive investigations will need to focus on matters such as irrigation water demand, MAR substitution benefits and costs, farm economics, recharge water supply, operating costs, salinity management implications and assess social impacts (acceptability).
- Several areas in Gippsland were retained as potential MAR locations because water is available from rivers or mine dewatering and because PCVs were set at low levels to prevent saltwater intrusion to the aquifers. MAR thus could allow for groundwater use without allowing excessive drawdown, preventing saltwater intrusion.
- Urban or semi-urban areas that are near irrigation districts (e.g. the Werribee Irrigation district) may be found suitable or have the greater potential for broad scale MAR projects for agriculture, if costs can be kept to the minimum through the use of existing infrastructure
- The irrigation districts or parts of irrigation districts determined as being potentially favourable for MAR include Shepparton, Central Goulburn, Werribee, Macalister, Horsham and Torrumbarry
- The largest identified area is around the Shepparton Irrigation District and the target suitable aquifers are the Tertiary aquifers (Shepparton and Calivil formations). Other potential areas include the area around and near Traralgon (e.g. Macalister Irrigation District), Horsham, Geelong and Swan Hill. However, more detailed screening of the areas is required before any investment in the MAR scheme.
- It is also clear from the figures that the high rainfall zones (e.g. around Traralgon, Morwell and Rosedale, in Gippsland) that harvested rainwater can be an additional water source for MAR scheme. Harvesting rainwater for MAR has been seen in many parts of the world as a means to considerably lower the cost of MAR for agriculture. Rainwater is an important source of water for MAR elsewhere in the world especially in India and Bangladesh (Rahman et al., 2003; UNESCO-IHP, 2005; IWM, 2011) and offers advantages with respect to water quality. Rainwater is naturally soft (unlike well water), contains almost no dissolved minerals or salts, is virtually free of chemical compounds, and thus requires minimal costs for treatment (IWM, 2011). There are two potential approaches to implement MAR using rainwater. The approaches are: (a) Collection of storm water run-off from public land like Parks and gardens, (b) Roof top rainwater harvesting combined with MAR. This provides opportunity for MAR across the state, even in low rainfall areas, to harvest and store rainwater during winter and spring.

Table 4.2.1. Screening of Groundwater Management Areas for potential MAR locations

Name	Rural Water Corporations	Depth included in GMA (m)	PCV (ML)	Target Aquifers (Appendix A.1)	Fully allocated?	Possible Freshwater Source?	Exclude Reason	Retain Reason
Central Victorian Mineral Springs	GMW*	ALL	6024	UTB	Yes	rivers		MAR may help maintain baseflow in basalt
South West Limestone	SRW*		85000	UMTA	Nearly	rivers		Large significant resource limited by GDEs and other management considerations
Denison	SRW	0-25	18502	QA	No, but nearly full allocation	rivers	possibly too shallow	Still to be determined
Glenormiston	SRW	0-60	2698	QA; UTB; UTAM	Yes	unknown		Still to be determined
Mid Loddon	GMW	ALL	34037		Yes - fully allocated	Lancoorie Reservoir		Still to be determined
Wa De Lock	SRW	0-25	30795	QA	Yes	rivers	possibly too shallow	Still to be determined
Wy Yung	SRW	0-25	7463	QA	Yes	rivers	possibly too shallow	Still to be determined
Barnawartha	GMW	ALL	1111				In North-East CMA	
Broken							Plan not in place yet	
Cardigan	SRW	ALL	3967	QA; UTB; UTAF	Yes	rivers?	near top of catchment? Uncertain water source; mainly urban use	
Colongulac	SRW	0-60	4695	QA; UTB; UTAM	Nearly	rivers?	In Corangamite CMA	
Corinella	SRW	ALL	2550	LTB, LTA	No		Small; no obvious water source; not fully allocated	
Cut Paw Paw	SRW	>50	3650	LTA	No	rivers	Deep/Urban/not fully allocated	
Eildon							Plan not in place yet	
Frankston	SRW	ALL	3200	UTAF			Urban	
Gellibrand	SRW	ALL	NA	LMTA; LTA; LTB		unlikely	In Corangamite CMA; PCV of 0	
Gerangamete	SRW	>60	20000	LMTA; LTA			Deep/Corangamite/ urban use	
Giffard	SRW	50-200	5689	UTAF			Deep	
Hawkesdale	SRW	All	16161				Superceded by SW Limestone GMA	
Heywood	SRW	0-70	8500				Superceded by SW Limestone GMA	
Jan Juc	SRW	ALL	39250				In Corangamite CMA	
Kiewa	GMW	ALL	3852				In North-East CMA	
Kinglake	SRW			BSE			Basement likely hard to recharge	
Lancefield	SRW	ALL	1485	UTB	No	river?	not fully allocated. Uncertain water source	
Leongatha	SRW	ALL	6500	LTB, LTA	No	rivers?	not fully allocated	
Lower Ovens	GMW	ALL	25200				In North-East CMA	
Merrimu	SRW	0-30	451	QA	Nearly	river?	Aquifer area likely too small for storage	
Mid Goulburn	GMW	All	12470				Usage far below entitlement/deep	
Moe	SRW	>25	8200	UTQA; UMTA; LTB	No		Deep; not fully allocated	
Moorabbin	SRW	ALL	2700	UTAF; UMTA; LMTA	Yes		Urban	
Nepean	SRW	ALL	6110	QA	Yes	unlikely	lack of water source	
Newlingrook	SRW	ALL	1977	LTA	Yes	rivers	In Corangamite CMA/mainly urban use	
Orbost	SRW	20-45	1217				Deep/small/isolated	
Paaratte	SRW	>120	4606	LTA	No		Deep/Corangamite/mainly urban	
Portland	SRW	>200	15295	LTA	No		Deep/urban/not fully allocated	
Rosedale	SRW	25 - 350	22372				Deep	
Shepparton Irrigation	GMW	0-25	NA		No - wl control desireable		Identified as possible in GIS but consideration needed of salinity control	Possible (GIS) but see "remove" comment.
Stratford	SRW	> 150	27645	LTA	Yes		Deep	
Strathbogie	GMW	ALL	1660		Yes		low yield. Low groundwater demand	
Tarwin	SRW	0-25	1300	QA	No	not likely	lack of water source	
Upper Goulburn	GMW	ALL	8568				Fractured granite has low yield; alluvium has high stream connectivity	
Upper Murray	GMW	ALL	7674				In North-East CMA	
West Wimmera	GWMW***	ALL	55659				Border with South Australia	

Table 4.2.2. Screening of Water Supply Protection Areas for potential MAR locations

Name	Rural Water Corporations	Depth (m)	PCV (ML)	Target Aquifers	Fully allocated?	Possible Freshwater Source?	Exclude Reason	Retain Reason
Deutgam	SRW	0-30	5100	QA	Nearly	rivers; wastewater?		No new licenses due to saltwater intrusion risk
Koo wee rup	SRW	ALL	12915	QA, UTAF, UMTA	Yes	Bunyip River; Lang Lang River		Prevention of saltwater intrusion?
Lower Campaspe Valley	GMW	N/A	56381		Yes	Campaspe River Waranga W Channel		Water availability; salinity management
Sale	SRW	25-200	21238	UTAF	Yes	rivers/dewatering		Prevention of saltwater intrusion; water availability; cap on water usage
Yarram	SRW	All	25690		Yes	rivers/dewatering		Prevention of saltwater intrusion; water availability; minimisation of impacts of extractive industry
Wandin Yallock	SRW	ALL	3008	LTB	Yes	Yes		Uncertain
Bungaree	SRW	ALL	5334	QA; UTB; UTAF	Yes	rivers?	Small, near top of catchment	
Condah	SRW	70-200	7475	LMTA	Yes	unlikely - gw discharge area	GDEs/lack of water source	
Glenelg	SRW	ALL	33262	QA		river	high ecological value of river system/border with SA	
Katunga	GMW	>25	60577			Irrigation; Murray River	Sufficient water volume exists for trading; Complications of proximity to Murray River	
Loddon Highlands	GMW	ALL	20697		Yes	Limited	Limited water source	
Murrayville	GWMW		10883				Mallee border area	
Upper Ovens	GMW	ALL	NA				North East CMA	
Warrion	SRW	ALL	14086	QA; UTB; UTAM	Yes	unknown	Corangamite CMA	

Table 4.2.2. Screening of Water Supply Protection Areas for potential MAR locations

Name	Rural Water Corporations	Depth (m)	PCV (ML)	Target Aquifers	Fully allocated?	Possible Freshwater Source?	Exclude Reason	Retain Reason
Deutgam	SRW	0-30	5100	QA	Nearly	rivers; wastewater?		No new licenses due to saltwater intrusion risk
Koo wee rup	SRW	ALL	12915	QA, UTAF, UMTA	Yes	Bunyip River; Lang Lang River		Prevention of saltwater intrusion?
Lower Campaspe Valley	GMW	N/A	56381		Yes	Campaspe River Waranga W Channel		Water availability; salinity management
Sale	SRW	25-200	21238	UTAF	Yes	rivers/dewatering		Prevention of saltwater intrusion; water availability; cap on water usage
Yarram	SRW	All	25690		Yes	rivers/dewatering		Prevention of saltwater intrusion; water availability; minimisation of impacts of extractive industry
Wandin Yallock	SRW	ALL	3008	LTB	Yes	Yes		Uncertain
Bungaree	SRW	ALL	5334	QA; UTB; UTAF	Yes	rivers?	Small, near top of catchment	
Condah	SRW	70-200	7475	LMTA	Yes	unlikely - gw discharge area	GDEs/lack of water source	
Glenelg	SRW	ALL	33262	QA		river	high ecological value of river system/border with SA	
Katunga	GMW	>25	60577			Irrigation; Murray River	Sufficient water volume exists for trading; Complications of proximity to Murray River	
Loddon Highlands	GMW	ALL	20697		Yes	Limited	Limited water source	
Murrayville	GWMW		10883				Mallee border area	
Upper Ovens	GMW	ALL	NA				North East CMA	
Warrion	SRW	ALL	14086	QA; UTB; UTAM	Yes	unknown	Corangamite CMA	

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