

South Australian – Victorian Border Groundwaters Agreement Review Committee



**Management Review
Province 2 of the Designated Area**

Melbourne and Adelaide

March 2023

Foreword

The Border Groundwaters Agreement was established in 1985 to make provision to protect the groundwater resources adjacent to the border between South Australia and Victoria and to provide for the co-operative management and equitable sharing of those resources and to guard against their undue depletion or degradation.

The 'Designated Area' established by the Agreement is a 40 kilometre wide strip centred on the border and extending for its full length. This Designated Area is divided into 22 zones, 11 in each State. In the Designated Area, the main aquifer is the Tertiary Limestone Aquifer, which has been subdivided into three hydrogeological provinces from south to north (Province 1, Province 2 and Province 3) as shown in Figure 1.

In Province 2 (consisting of Zones 4A (part), 5A, 6A, 7A, 8A, Sub-zone 9A South, 3B (part), 4B, 5B, 6B, 7B and 8B) the Tertiary Limestone Aquifer is in the Murray Basin where the aquifer is unconfined and either outcrops at the surface or is overlain directly by the Pliocene Sands Aquifer.

The Review Committee prepared this review in November 2020 and throughout 2021 sought comment and feedback from relevant Ministers and agencies. This document is amended in response to that feedback.

Executive Summary

As part of the Agreement, the Review Committee is required to review certain management prescriptions at periods not exceeding intervals of five years. This review consolidates the Review Committee's views in respect of new understandings of the resource and makes recommendations on the strategic direction and a range of other actions to be undertaken jointly by Governments and the local community through the regional water resource management authorities.¹

In the northern region of Province 2 (comprising Sub-zone 9A South and Zones 8A, 7A, 8B and 7B) the groundwater levels have been stable at the current rates of use.

In the central region of Province 2, (Zones 6A, 5A, 6B and 5B) the observed declines in Tertiary Limestone Aquifer have continued at the rate of about one and a half metres to two metres over the last ten years. If the current rates of extraction observed over the last five years continue, the area affected by declining levels may expand. It is expected that at the rates of current extraction (around 33,000 ML/y), the groundwater levels around Neuarpur and Frances would be one to two metres lower in 10 years.

In southern region of Province 2 (primarily parts of Zones 4A, part of 3B, and Zone 4B) declining groundwater levels in the Mosquito Creek catchment in Zone 4A raise concerns in respect to impacts to water dependent ecosystems and the Ramsar wetlands of Bool and Hacks Lagoons. The region requires a better understanding of recharge, surface water and groundwater interaction and groundwater dependent ecosystems and the impacts of land use change in the southern area of Zone 4A in Province 1. In Zone 4B, which mainly contains the Dundas Tablelands and fringe areas of the Tertiary Limestone Aquifer, the higher salinity and lower yield results in very low extraction, and declines are from reduced recharge, noting that a significant land area has been converted to plantation forest (about 5000 ha) in the last 25 years. The potential for increased extraction is low.

The Review Committee is concerned the continuation of these long-term water level declines in Zones 6A, 5A, 6B and 5B will have an adverse impact on the access to the local groundwater resource, including domestic and stock users. Such impacts could extend beyond the Designated Area.

The Review Committee is proposing:

- that the Permissible Annual Volumes be retained in all zones except where it is significantly greater than allocation, where it will be reduced (applies to Zone 4B and Zone 3B²) following consultation with Victoria; and
- where groundwater extraction is relatively low (at 5-year mean levels) and there is no discernible long term decline to groundwater levels and current use is considered sustainable

¹ For Province 2, these are the Limestone Coast Landscape Board in South Australia and Southern Rural Water Corporation and Grampians Wimmera Mallee Water Corporation in Victoria.

² The boundary between Province 1 and Province 2 bisects Zone 3B, and PAVs are set for an entire Zone. Consultation on changes to Zone 3B will include State agencies in both Provinces. Any reduction will not impact existing users allocations.

(applies to the northern region), undertake a review of the prescribed rates of potentiometric surface lowering following determination of acceptable limits to decline.

- Where groundwater extraction is relatively high, but below Permissible Annual Volumes and there is discernible long term decline to groundwater levels, increasing the use of the resource may not be sustainable over the long term and access to groundwater may be at risk (applies to central region), it is recommended that:
 - The states undertake investigations of risks of further declines to determine whether further groundwater declines will result in unacceptable material impacts on the resource and on groundwater users. (Noting sub-regional groundwater models could provide insights into the likely impacts to the groundwater resource under different extraction and climate scenarios).
 - The states develop management options and a common policy that considers the acceptable level of groundwater decline, mitigates material impacts, and manages the non-renewable resource within the objectives of the Border Groundwaters Agreement in regard to sustainability, equity and interests of future generations.
 - The Review Committee will coordinate and submit the final recommendations for the proposed common policy to each respective Minister seeking their approval to implement this policy.

This report is the review of the Tertiary Limestone Aquifer in Province 2. A preliminary assessment of the Tertiary Confined Sands Aquifer noted there was no extraction of groundwater from this aquifer and further review was not warranted at this time.

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1 Introduction

The Border Groundwaters Agreement was established in 1985 to make provision to protect the groundwater resources adjacent to the border between South Australia and Victoria and to provide for the co-operative management and equitable sharing of those resources and to guard against their undue depletion or degradation.

The 'Designated Area' established by the Agreement is a 40 kilometre wide strip centred on the border and extending for its full length. This Designated Area is divided into 22 zones, 11 in each State. In the Designated Area, the Tertiary Limestone Aquifer has been subdivided into three hydrogeological provinces from south to north (Province 1, Province 2 and Province 3) as shown in Figure 1.

Province 2 has two prime regional groundwater aquifers, the unconfined Tertiary Limestone Aquifer and the underlying Tertiary Confined Sand Aquifer. This report deals with the Tertiary Limestone Aquifer. The report provides a summary of key observations, and technical issues and reviews the management arrangements for the Tertiary Limestone Aquifer in Zones 4A (part), 5A, 6A, 7A, 8A, Sub-zone 9A South, 3B (part), 4B, 5B, 6B, 7B and 8B.

A preliminary assessment of the Tertiary Confined Sands Aquifer noted there was no extraction of groundwater use from this aquifer and further review was not warranted at this time (BGARC, 2019). The condition of the Tertiary Confined Sand Aquifer is not discussed further in this report.

Long term declining water level trends in the Tertiary Limestone Aquifer were first observed in the late 1990s in Zone 5A and parts of Zones 4A, 5B, 6A and 6B. Elsewhere levels were generally stable. Research was undertaken to identify the principal causes of the declines and in 2007 the Review Committee concluded the groundwater in the Tertiary Limestone Aquifer is not being significantly replenished by modern recharge since land clearing (as distinct from ancient recharge) across most of Province 2. As such, the groundwater resource is considered non-renewable for water allocation and management purposes. This represented a shift in management principle, where estimates of aquifer recharge and inflow had previously informed allocation prescriptions. The Review Committee proposed a management strategy based on this understanding, that is Victoria and South Australia develop a common policy for using the non-renewable groundwater resources in Province 2 of the Designated Area. This review contributes to that process.

There have been a range of technical investigations undertaken of which this paper presents a summary. With this in mind the Review Committee has reflected on the current understanding of the groundwater resources and proposes a revised management strategy.

2 Management Framework

The primary objective of the Agreement for the management arrangements for the groundwater of the Tertiary Limestone Aquifer in Province 2 is to protect groundwater from undue depletion (Appendix 4).

While the Agreement does not define 'undue depletion', the Review Committee considers it means to ensure that the groundwater is available for basic human needs (consumptive, domestic and stock purposes) and dependent ecosystems, without compromising the ability of future generation to meet their own needs. Economic development (primarily groundwater for agricultural development) may proceed provided that basic human needs and needs of ecosystems are met. The Review Committee shall act to ensure that there is a program to conserve or improve groundwater resource condition and the economic base dependent on it.

In addition, the Intergovernmental Agreement on a National Water Initiative (CoAG, 2004) states that the term *environmentally sustainable level of extraction* means 'the level of water extraction from a particular system which, if exceeded would compromise key environmental assets, or ecosystem functions and the productive base of the resource'.

Groundwater is the only reliable water resource in the region suitable for stock and domestic use and community water supplies, consequently it is also important to protect water quality for these purposes. Commercial uses of the resource and irrigation have been developed, but the extent of the allocation for these purposes must be consistent with the management objective for the resource.

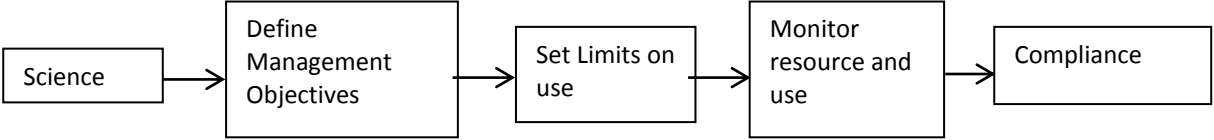
Access to groundwater for purposes other than domestic and stock and community supplies cannot be guaranteed indefinitely as the water allocations are in excess of modern recharge (i.e. since land clearing occurred) and are being drawn from water in storage. The continued use for licensed purposes is only acceptable for such time as the primary management objective for the aquifer continues to be met.

The following principles have been adopted by the Review Committee in implementing the Agreement:

- Principle 1: Equitable sharing and management consistency across borders
- Principle 2: Co-operation among other agencies and organisations
- Principle 3: Protection and conservation of groundwater is for both people and ecosystems dependent on groundwater
- Principle 4: Measurability and adaptability
- Principle 5: Use of best available knowledge – but when knowledge is limited, apply a precautionary approach
- Principle 6: Advance the study of groundwater to address the needs of groundwater resource management.

These principles adopt the powers under the Agreement to conduct investigations (s20), use the information to make recommendations on setting management objectives to respective governments (s 21), set limits on use (Permissible Annual Volumes), monitor the resource and report

on compliance with the Agreement to each Government (s5). Schematically this process is represented below:



3 Key Technical Observations

| Feature | Description |
|--|---|
| Hydrogeology | <p>The Tertiary Limestone Aquifer is typically about 70m thick, generally flat and regionally extensive. Typically, 50-60m of the aquifer thickness is saturated.</p> <p>The Tertiary Limestone Aquifer becomes progressively more confined in the east of Province 2 and a confining layer occurs between the Parilla Sands Aquifer and Tertiary Limestone Aquifer over parts of Zone 8B and Sub-zone 9A South.</p> <p>A groundwater gradient of about 0.0009m/m is low (noting it is higher in the east and lower in the west) and lateral flows are considered to be low (BGARC, 2007). The Tertiary Limestone Aquifer is karstic in some areas (e.g. Zones 4A, 5A and 6A and the western parts of Zones 5B and 6B).</p> <p>The Tertiary Limestone Aquifer is overlain by surficial sediments (Woorinen Formation) and the marine sands of the Parilla Sands Aquifer.</p> <p>The hydraulic gradient between the Parilla Sands and the Tertiary Limestone Aquifer is uniformly downward toward the Tertiary Limestone Aquifer and it is downward from the Tertiary Limestone Aquifer to the Tertiary Confined Sand Aquifer.</p> <p>The Tertiary Confined Sand Aquifer is regionally extensive, being present through western Victoria and in South Australia. It occurs throughout most of the south east of South Australia and extends northwards up to the River Murray through the Mallee region.</p> <p>Aquifer transmissivity for the Tertiary Limestone Aquifer is estimated to be between 200m²/day and 2,000m²/day and specific yield is estimated at 0.1.</p> |
| Age of groundwater | <p>Leaney and Herczeg (1999) undertook an assessment of the origin of fresh groundwater beneath the Mallee region that included Zone 6B in Province 2. They concluded that over the last 20,000 years two recharge regimes have existed. Firstly, significantly higher recharge rates than today resulted from the wetter climatic conditions from approximately 20,000 years ago, and secondly there has been a period with lower recharge rates in semi-arid conditions similar to those experienced today. This investigation suggests that the water recharged close to its current location, probably through the sandy soils of the Big and Little Deserts and has not migrated a significant distance along the groundwater flow path since recharge. This may also have relevance for Zones 6A, 7A, 8A, 7B and 8B.</p> |
| Climate Frances (Zone 6A) (BOM 2019) | <p>Between 1975 and 2014, rainfall averaged 500 mm/y (ranging from 280 – 718 mm/y).</p> <p>During the period from 1975 to 1996, when groundwater levels were stable, the rainfall averaged 528 mm/y.</p> <p>Between July 1997 and June 2009, rainfall averaged 456mm/y, approximately 12% lower than the long term mean (ranging from 396 – 530 mm/y). Only 2 years in this period has reached or exceeded the long term mean rainfall.</p> |

| Feature | Description | | | |
|--|---|---------------------------------------|---------------------------------------|--|
| | <p>Since July 2009, rainfall has averaged 494 mm/y approximately 5% lower than the long term mean (ranging from 299 to 710 mm/y).</p> <p>It is generally agreed that the incidence of rainfall throughout the year is also varying, with some evidence of drier spring periods.</p> | | | |
| Land use | <p>The dominant developed land use is dryland farming and irrigated agriculture. The distribution of land use is illustrated in Figures 2 and 3.</p> <p>There is an extensive tract of native vegetation in the Little Desert National Park in Zone 6B North and southern part of Zone 7B.</p> <p>Agricultural activities have gradually changed over the last 40-50 years and some of these changes include the incorporation of clay to sandy soils and retention of crop stubble in order to maintain soil moisture and nutrients in the root zone. Other changes are the inclusion of deeper rooted harvested crops (such as canola and beans), and a greater use of deeper rooted perennial pasture species. In all, these activities have a net impact of reducing the amount of rainfall passing below the root zone to become groundwater diffuse recharge.</p> <p>While perhaps a combined result of the above changes in land management reducing diffuse groundwater recharge, lower annual rainfall, and perhaps some shift in rainfall seasonality, the earlier practices of diverting surface water off the agricultural land (with heavier soils) to drainage wells and the local creeks has significantly reduced. This is apparent in Zones 7A and 7B, parts of Zones 6A and 6B and in the north of Zones 5A and 5B, with reduced flows in Tatiara, Nalang and Morambro Creeks and the drying of Lake Cadnite at Frances as a result of reduced rainfall affecting surface flows. Tatiara and Nalang Creeks normally discharge into Poocher Swamp where water drains naturally into the Tertiary Limestone Aquifer (which has karstic characteristics in this area). These reductions in surface flows to Poocher is now of concern to SA Water for the public water supplies of Bordertown with reduced recharge into the Tertiary Limestone Aquifer west of the Designated Area.</p> | | | |
| Groundwater allocation and use intensity | | PAV | Allocation | Avg Use 2010-19 |
| | Northern region Zones 9A South, 8A, 7A, 8B and 7B. (~2,677km ²) (Generally stable trends) | 30,422 ML (9 ML/km ²) | 32,647 ML (9 ML/km ²) | 15,811 ML (3.4 ML/km ²) |
| | Central region Zones 6A, 5A, 6B, and 5B (~1,200km ²) (Declining trends) | 50,813 ML (42 ML/km ²) | 57,464 ML (49 ML/km ²) | 30,075 ML (26 ML/km ²) |
| | Southern region Zones 4A, 4B (Some declining trends) | 36,102 ML (32 ML/km ²) | 33,763 ML (30 ML/km ²) | 13,073 ML (12 ML/km ²) |

| Feature | Description |
|----------------------------------|--|
| | Extraction in the central region, Zones 5A, Sub-zone 6A South, the north section of 5B and the south section of 6B, during wet periods 2010-2011 and 2016-2017 was ~16,500ML (13 ML/km ²) and 26,500ML (20 ML/km ²) respectively. During these events, groundwater levels were generally stable, suggesting an upper limit to the extraction regime for an equilibrium of the groundwater resources is in the order of approximately 20 ML/km ² in the central area (further discussed in 4.1.2). |
| Water budget | <p>The results of water budget calculation for the area of declining groundwater trends in the central region (Zones 6A, 5A, 6B and 5B) (Figure 2 and 3), indicate that for the volume of groundwater extracted:</p> <ul style="list-style-type: none"> • 16,500 ML - groundwater levels are stable. • 33,000 ML - groundwater levels decline between 0.09 and 0.15m/y. • The reduced rate of groundwater level decline from 2010 to 2019 was due to the combined consequences of higher rainfall and reduced extractions. |
| Groundwater Dependent Ecosystems | <p>The depth to the water table in the Tertiary Limestone Aquifer is regarded as deep (15-25m) throughout Province 2, and hence the potential for ecosystems that are dependent on groundwater is considered to be low. Groundwater dependent ecosystems may occur where the Tertiary Limestone Aquifer is karstic or where the groundwater levels are shallow in South Australia, west of the Designated Area and in the south western area of Zone 4A.</p> <p>Cranswick and Herpich (2018) found the water courses between Bool Lagoon and the border in the south of Province 2 had progressively changed from high likelihood of gaining stream conditions in the 1990s, to a low likelihood by 2009, which had continued to 2017.</p> |
| Groundwater salinisation | <p>Previous studies identified a large salt load in store of up to 10,000-15,000 tonne/km² in Province 2.</p> <p>Earlier studies noted increasing salinity in areas where there had been large tracts of native vegetation clearance or associations with bush fire aftermath however these have now appeared to have stabilised.</p> <p>In general, groundwater salinity levels are stable, except where some increase in salinity (an increase from 1,680mg/L to 3,600mg/L) has been observed in Bore 76898 in Zone 4B. This area has very little groundwater use due to the relatively high natural salinity.</p> |

4 Key Technical Issues

4.1 Groundwater availability

The correlation of drawdown to extraction and information on dating of groundwater continues to support the view that the groundwater resource in the eastern area is ancient and the rate of modern diffuse recharge to the Tertiary Limestone Aquifer is low. In the south-western area, where the water is shallower there is higher percentage of modern recharge. Along with the incremental changes in land management to better utilise rainfall, and the shift in rainfall seasonality, modern diffuse recharge from rainfall is likely to be reducing, in comparison to that occurring in the 1960s to early 1990s, when water tables were relatively stable.

The observations of groundwater trends and water use between 2010 and 2019, coupled with estimates of the water budget have been used to assess impacts of extraction on the water levels in the Tertiary Limestone Aquifer (Appendix 3) over this period.

The technical review for Province 2, as well as selected South Australian studies as part of the 2019 science review of some specific aspects of the Water Allocation Plan for Lower Limestone Coast Prescribed Wells Area, are summarised in Appendix 2.

4.1.1 Northern region

The water level in the northern region is exhibiting a stable to low magnitude declining trend over the last 15-20 years, indicating that whilst extraction volumes are relatively low, water is being removed from storage in the northern region - Zones 7A, 8A, Sub-zone 9A South, 7B and part of 8B. Further allocation in these zones may lead to increased extraction with potential impact on water levels, noting current annual extractions (5-year mean of approximately 17,000 ML) are well below existing allocations (32,647 ML). Modelling in Zones 7A and 8A as part of the Tatiara water allocation plan review indicates that the full extraction of the current allocations would likely result in a water table decline in the order of 0.5 to 2.5 metres by 2030 (Appendix 2).

4.1.2 Central region

Over the last 10 year period, observed groundwater levels in the central region (Zones 5A, 6A, 5B and 6B) range from stable to 0.15 m/y decline although there is some variability with differences noted between shallow versus deeper screened bores. Over this period the average extraction rate is about 30,000 ML/y, increasing to nearly 34,000 ML/y during the last 5-year period. Increased extractions are noticeable in Zones 5B and 6B during the last two years when the annual rainfall was above the long term mean in one year (up 11% in 2017-18) and about the mean annual rate for the other year, suggesting an expansion in irrigation activity. The last 5-year period included two consecutive years where the annual rainfall significantly exceeded the long term mean annual rate by 11 % (2017-18) and 37 % (2016-17), These two years were then followed by a year of mean annual rainfall (2018-19); all contributing to the water level stabilisation and recovery observed at some sites since 2016.

The estimated recharge between 2010 and 2019 is about 4,400 ML/y or 4mm/y (Appendix 3). The rates of water level declines in the previous 10-year period from 2000 to 2009 are significantly greater in all sites, with rates of decline generally being in the order of 0.15 to 0.2 m/y This supports the view the aquifer receives little modern diffuse recharge and the observed change in water levels is the result of groundwater being removed from storage and a regional loss of storage. The variation in the rate of decline may in part be due to the climate influences noted over the last decade and the

aquifer may receive modern episodic recharge from high rainfall events, but there is no clear indication of this and it can't necessarily be relied upon for groundwater resource management. It should also be noted that groundwater extraction is lower in years of high rainfall (Figure A2-4). For example extraction in the central region (Zones 5A, 5B, 6A and 6B combined) ranged from 41,811 ML in 2015-16 to 26,515 ML/y in 2016-17. This large variation in extraction can also be considered as contributing to the observed changes in water level trends. While no metered extraction data is available prior to 2007, it estimated that during the 1990s (based on irrigation bore-hole completed constructions), annual extractions were of an order of 10,000 ML/y increasing to 15,000 ML/y during this 10 year period.

The observed stable groundwater levels that occurred in 2010-11 and 2016-17 coincide with groundwater extraction of between 16,500 to 26,000ML (about 55 to 85% of the mean extractions occurring over the last 10 years). The latest observations (Autumn 2020) indicate a re-emergence of decline across the area following extractions in 2018-19 of 32,814 ML.

The implication of the conceptual model of the water balance is that the groundwater extracted is being taken out of storage from the Tertiary Limestone Aquifer and while there has been some apparent water level stabilisation at some monitoring sites during the last 5-years, groundwater levels are likely to continue to decline, while the current rates of extraction continue (33,862 ML/y is mean extraction observed over the last 5-years, 2015-19), and the area affected by declining levels may expand. It is expected that at the rates of extraction in the order of 33,000 ML/y, the groundwater levels would be 1-2m lower in 10 years. It can be concluded that higher extractions are likely to be from storage in the unconfined aquifer. The extraction intensity for stable water level trends is about 13-20 ML/km² (this is equivalent to about 15,000 to 23,000 ML/y).

The potential impacts of continued water level declines over the long-term may include:

- *Depletion of the aquifer:* The saturated thickness of the aquifer is significant (approximately 50 m) and the volume in store is large, therefore at the current rate of decline (approximately 2m over 10 years) it would take a significant amount of time before the aquifer would be de-saturated to a level restricting water access and the viability of the resource to provide water supplies, assuming the aquifer storativity and transmissivity remains constant at depth.
- *Increased costs for groundwater users:* A decline in groundwater levels can result in groundwater users having to deepen bores and re-configure or purchase new pumps. This results in a cost to individual groundwater users. In the immediate timeframe the rate of decline is small relative to the current head capacities of the pump installations, hence impacts are minimal for existing licensed groundwater users. In the long-term there may be increased capital and operational costs to these licensees.
- *Access for domestic and stock users:* Domestic and stock bores are generally shallower than bores for other commercial purposes. Most of these were constructed prior to irrigation becoming a significant land use. Continuing declines in groundwater levels can result in loss of water supply for domestic and stock bores and users having to deepen bores and re-configure or purchase new pumps. The number of active domestic and stock groundwater users and the bore depths are not known (there are about 1979 domestic and stock bores in TLA G12) although a recent study in South Australia has estimated that about 50% of domestic and stock bores in Province 2 have less than 5m of water head in the bore (Cranswick & Li, 2018). This suggests that these bores are at

risk of losing supply over the next 10 to 20 years, if the declines continue. Information on bore depths for Victorian domestic and stock bores has not been compiled.

- *Groundwater Dependent Ecosystems:* The depth to water table is generally greater than 15-20m throughout Province 2, and hence the potential for groundwater dependent ecosystems is considered to be low. The Tertiary Limestone Aquifer is a large aquifer system and known points of natural discharge are generally remote from areas of intense groundwater extraction in Province 2.

4.1.3 Southern region

Zone 4A is a transition area between Provinces 1 and 2. The divide is the Kanawinka Fault and to the west and south of Zone 4A (part of Province 1) the water table is shallow and rainfall results in more rapid recharge. In the northeast area of Zone 4A, in Province 2, the net declines since 1995 range between 2m and 4m. Some stability and recovery is observed in years of more than average rainfall, which are accompanied by generally reduced groundwater extractions. The falling levels observed are primarily considered to be a result of reduced recharge from lower rainfall, noting there may be some interception from commercial forests in the zone and neighbouring areas. In Zone 4B, which mainly contains the Dundas Tablelands and fringe areas of the Tertiary Limestone Aquifer, the higher salinity and lower yield results in very low extraction. Combined groundwater use over the last 10 years has been 13,073 ML/y, which is about a third of the allocation (33,763ML/y).

Surface and ground water interaction in some areas of Zone 4A in Province 2 may contribute to flows in Mosquito Creek which help to support the Bool Lagoon Ramsar wetlands. The waterways have gone from a high likelihood of gaining to low likelihood of gaining conditions (Cranswick and Herpich, 2018).

Baseflow in Mosquito Creek has declined together with reduced average flows since 1995, resulting in reduced inundations of Bool Lagoon and associated wetlands.

4.2 Groundwater salinisation

Risks for increased salinisation of groundwater in Province 2 have been based on the significant store of salt in the soils that may be mobilised either by rising groundwater levels or by mobilisation from rainfall and irrigation induced recharge infiltration.

There is no overall discernible trend in groundwater salinity. A number of studies undertaken looking at the predicted and observed trends in salinity are inconclusive, possibly due to flaws in the conceptual models and/or flaws in the data (e.g. poorly targeted monitoring or insufficient data on the location of confining layers). A rising salinity trend is noted in a bore in Zone 4B, which is an area where recharge to the shallow water table may be mobilising salt stored in the soil.

4.3 Implications for management

Northern region

- Non-renewable resource. The resource trends are acceptable in terms of current extractions in the area comprising Zones 7A, 8A, 7B, 8B and Sub-zone 9A South. The combined average use over the last 5-years is 17,163 ML/y. No changes to current management prescriptions are proposed.

- As allocations are 32,647 ML or nearly double the current rate of extractions, the potential for increased use from the Tertiary Limestone Aquifer, resulting in undue depletion of groundwater, may require measures to protect existing users.

Central region

- This area of Zones 6A, 5A, 6B and 5B is an area of intensive groundwater extraction and has experienced a net decline in water levels since the mid-1990s (between 2 and 4 m, depending on the monitoring site location).
- Behaves as a connected resource.
- Equitable sharing of the connected resource should be managed under a common policy for acceptable adverse impacts.
- Manage as a non-renewable resource. Long-term water level declines from groundwater extraction for commercial purposes may result in undue depletion. Domestic and stock users are the most likely to be at risk due to shallower bore constructions and equipment choices and in the longer-term, such risks are likely to extend beyond the Designated Area.
- BGARC should collaborate with regional authorities to assess the third party impacts of further water level declines, specifically for domestic and stock bores.
- There is a poor understanding of relationship between surface water and ground water, both in terms of recharge and support of groundwater dependent ecosystems in the southern area of Zone 5A and in Zone 4A.

Southern Region

- The western area of Zone 4A is a renewable resource (part of Province 1). The resource trends have shown declines since the mid-1990s and declining groundwater levels in the Mosquito Creek catchment raise concerns in respect to impacts to water dependent ecosystems and the Ramsar wetlands of Bool and Hacks Lagoons. The region requires a better understanding of surface water and groundwater interaction and the impacts of land use change.
- Mean extractions in Zone 4A for the last 5-years are 14,678 ML/y and 12,828 ML/y for the last 10 years. Using irrigation bore-hole construction data, it is estimated that extractions during the 1990s decade increased from about 8500 ML/y to about 11,500 ML/y by 2000. The observed lowering of water levels has occurred during the period from 1995 to 2010, a period of significantly reduced rainfall and gradually increasing extractions.
- The mean extracted volumes for the last 5-years in Zone 4A are less than 50% of the allocated water, consequently, a mechanism to prevent significant increased activation of currently under-utilised allocations in the Province 2 part of the zone may have to be considered. It should be noted that plantation forests in Zone 4A cover nearly 4000 ha and are managed through a 2696 ML/y water licence (this licence is not accounted for within the PAV as the Agreement applies only to water extracted from licensed bores).
- Groundwater in the south east area in Zone 4B is a renewable resource, however, the resource is declining from reduced recharge, noting that a significant land area has been converted to plantation forest (about 5000 ha) in the last 25 years. The potential for increased extraction for stock and domestic or irrigation use is low due to poor water quality and low yield. The Permissible Annual Volumes, originally based on diffuse recharge from rainfall, are high relative to demands

by land managers. Consideration should be given to reducing the Permissible Annual Volumes while recognising existing entitlement.

All regions

- Water market - Opportunities for trade are mainly limited to within zone, since no trade can occur between zones where allocations equal or exceed the Permissible Annual Volumes. Where groundwater resources are connected and behave similarly across the border, amalgamating zones and PAVs could be considered in order to facilitate groundwater transfers. This will require a consistent approach to assessing the impact of future developments and/or new wells as a result of water transfers, on existing users..
- Salinity – salinity remains a risk due to the significant salt store in the soil profile. Where risks have been identified (Leaney and Herczeg, 1999, Wohling 2007), generally stable salinity levels are observed, other than at one observation bore in 4B (CDMSmith, 2016). This may be in part due to falling groundwater levels, which remain in advance of (lower than) saline pore water reaching the water table. If groundwater levels remain below the salt zone, the likelihood of increasing groundwater salinity over the next 20 years is considered to be low or negligible, however monitoring should continue. The observation network cannot detect saline porewater above the water table and other monitoring options that reflect impacts on users, such as monitoring the salinity in water from pumping bores at risk of rising salinity should be considered. For example, there is a case to be made for irrigators to provide pumped samples from irrigation wells at the beginning and end of the irrigation seasons.

5 Proposed management strategy

Groundwater in Province 2 is the only readily available source of water. It is an ancient resource with some modern replenishment from rainfall. Future management settings need to consider the balance between the existing commitments to the use of the resource and the longer-term need to preserve the resource, noting that the Permissible Annual Volumes were largely based on estimates of diffuse recharge from rainfall with no allowances to permanently remove water from storage or reduce lateral flows.

One of the key objectives of the Agreement is to prevent “undue depletion of the resource”, and that the “resource is equitably shared between the states” (see Appendix 4).

For areas in the northern region where the current level of groundwater extraction is not leading to undue depletion there are essentially no risks for present management, however significant activation of currently under-utilised allocations may increase risks in such areas.

For the central region of Province 2, where water tables are deep and declining, the risk of reduction in access to a water supply may unduly affect all users, including domestic and stock users. Increased use and reduced rainfall may increase this risk. This area will require further studies to determine an acceptable level of groundwater level decline.

In the southern region, declines are evident although extractions are low relative to the current allocations. The risk of further depletion is from increases in extractions from unused allocations and from potential changes to the water balance by an expansion of commercial plantation forests.

To address these risks requires either:

- evidence that depletion in the resource will have no material impacts on users, in particular domestic and stock users, in order to justify further ongoing declines in the resource from commercial groundwater use; or
- restrictions of commercial use of groundwater to stabilise groundwater levels to ensure that there is no undue depletion; or
- approaches that compensate affected stock and domestic users for material impacts.

The following management strategy is proposed in this review:

- that the Permissible Annual Volumes be retained in all zones except where it is significantly greater than allocation, where consideration should be given to reducing the Permissible Annual Volumes (this applies to Zone 4B and Zone 3B³).
- Where groundwater extraction is relatively low (at 5-year mean levels) and there is no discernible long term decline to groundwater levels and current use is considered sustainable (applies to the northern region), undertake a review of the prescribed rates of potentiometric surface lowering following determination of acceptable limits to decline.
- Where groundwater extraction is relatively high, but below Permissible Annual Volumes and there is discernible long term decline to groundwater levels, increasing the use of the resource

³ The boundary between Province 1 and Province 2 bisects Zone 3B, and PAVs are set for an entire Zone. Consultation on changes to Zone 3B will include State agencies in both Provinces. Any reduction will not impact existing user’s allocations.

may not be sustainable over the long term and access to groundwater may be at risk (applies to central region), it is recommended that:

- The states undertake investigations of risks of further declines to determine whether further groundwater declines will result in unacceptable material impacts on the resource and on groundwater users. (Noting sub-regional groundwater models could provide insights into the likely impacts to the groundwater resource under different extraction and climate scenarios).
- The states develop management options and a common policy that considers the acceptable level of groundwater decline, mitigates material impacts, and manages the non-renewable resource within the objectives of the Border Groundwaters Agreement in regard to sustainability, equity and interests of future generations.
- The Review Committee will coordinate and submit the final recommendations for the proposed common policy to each respective Minister seeking their approval to implement this policy.

It is also recommended that the states review the adequacy of the current monitoring. This includes networks for monitoring level and salinity in each state, identify gaps and prioritise upgrades to respective networks (including the consideration of additional monitoring bores in Sub-zone 9A South) and the compliance and consistency in methods for determining water use in both jurisdictions.

6 Review of Management Prescriptions

6.1 Permissible Annual Volumes and Allowable Annual Volumes

The current Permissible Annual Volumes and Allowable Annual Volumes are provided in Table 1 and Table 2 respectively. There are no changes to the Permissible Annual Volumes proposed in Province 2 except for Zones 4B and 3B. The Permissible Annual Volumes for these zones are very high relative to the allocation and use, and reducing the Permissible Annual Volumes to reflect declining levels due to lower recharge may be worthwhile, however it should be noted that there is no evidence of groundwater extractions increasing. This direction will depend on the preferred option for management and agreement on common policy between the Contracting Governments for managing the aquifer as a non-renewable groundwater resource.

| South Australia | | | Victoria | | |
|------------------|-------------------------|-----------------|-----------------|------------------|-------------------------|
| PAV (ML/year) | Allocation (ML/year) | Zone | Zone | PAV (ML/year) | Allocation (ML/year) |
| 5,121 | 6,542 | 8A | 8B ¹ | 3,500 | 3,430 |
| 8,259 | 9,133 | 7A | 7B | 5,782 | 5,782 |
| 8,758 | 10,629 | 6A | 6B | 10,279 | 10,279 |
| 18,943 | 23,723 | 5A | 5B | 12,833 | 12,833 |
| 22,102 | 30,883 | 4A | 4B | 14,000 | 2,880 |
| 24,054 | 32,476 | 3A ² | 3B | 16,500 | 515 |

Table 1 Permissible Annual Volumes for the Tertiary Limestone Aquifer in Province 2

¹ Zone 8B is mostly assigned to Province 3 but is included here for information

² Zone 3A is assigned to Province 1 but is included here for information

| Sub-zone | Allowable Annual Volume (ML/year) | Volume Allocated (ML) |
|-------------------|--------------------------------------|-----------------------|
| Sub-zone 9A South | 7,760 | 7,760 |
| Sub-zone 6A South | 4,658 | 5,321 |

Table 2 Allowable Annual Volumes for the Tertiary Limestone Aquifer in Province 2

These figures are based on BGARC 34th Annual Report and advice from the States

6.2 Permissible potentiometric surface lowering

The original Agreement defined the permissible rate of potentiometric surface lowering as ‘an average annual rate of surface lowering of 0.05 metres, or in relation to a particular zone, such other rate as has been agreed by the Minister of each Contracting Government’ (Groundwater (Border Agreement) Act 1985). It should be noted that as the Permissible Annual Volumes were largely based on groundwater recharge from local rainfall, for Province 1 and 2 the permissible potentiometric surface lowering rates were considered as a mechanism to facilitate temporary ‘borrowing’ of water from storage within the aquifer to counter the impacts of rainfall variability from year to year. It was not considered to be a permanent source of groundwater for beneficial use in Province 1 or Province 2. In the case of Province 3, it was later determined that water could be removed from storage for beneficial use (MESA 1995). The rates were increased in some of the zones to reflect observed trends

in Province 2 in 2001 to enable continued extraction of groundwater while investigations were undertaken to ascertain the cause of the groundwater declines. At that time it was not clear whether the declines were caused by climate, groundwater use or combination of both and whether the refusal to grant new licences or renew groundwater licences in the relevant zones if the permissible rates of potentiometric surface decline were to remain unchanged, would result in stabilising groundwater levels.

There are no changes proposed to the current permissible potentiometric surface lowering rates and the observed rates for the zones in Province 2 as shown in Table 4 below. It is noted that short term variation in some prescribed bores may not represent the long term rate of surface lowering.

This review observes that a section of Sub-zone 9A South is attributed to Province 2, however there are no observation bores prescribed for determining the rate of potentiometric surface lowering for this sub-zone - determining whether this is required should be considered in future technical work.

| South Australia | | | Victoria | | |
|-----------------------|--|------------------|-----------------|--|------------------|
| Zone | Potentiometric surface lowering rate (m/y) | | Zone | Potentiometric surface lowering rate (m/y) | |
| | 2014-2019 Observed rate | Permissible rate | | 2014-2019 Observed rate | Permissible rate |
| 9A South ¹ | - | 0.65 | | | |
| 8A | 0.02 | 0.05 | 8B ² | - | 0.65 |
| 7A | 0.01 | 0.05 | 7B | 0.02 | 0.05 |
| 6A North | 0.05 ³ | 0.05 | 6B | 0.08 | 0.2 |
| 6A South | 0.09 | 0.2 | | | |
| 5A | 0.01 | 0.2 | 5B | 0.03 | 0.2 |
| 4A | 0.11 ⁴ | 0.25 | 4B | 0.08 | 0.25 |
| | | | 3B | 0.13 | 0.25 |

Table 4 Permissible potentiometric surface lowering rates and observed rates 30 June 2019

¹ There is presently no prescribed method for determining the rate of decline in this zone, and Zone 9B is assigned to Province 3.

² The potentiometric lowering in Zone 8B is assigned to Province 3.

³ One of the bores (GGL008) usually used to determine the rate of lowering has had an unusual trend in 2017. If this bore is included the potentiometric surface lowering rate is 0.07 m/y however the bore readings require further investigation.

⁴ This has been determined using those Zone 4A bores in Province 2.

6.3 Permissible distance

The permissible distance is the distance from the border within which all applications for permits such as well construction permits and allocation transfers, must be forwarded to the Review Committee for approval.

Permissible distance is 1 km for the Tertiary Limestone Aquifer and this is to be retained.

The current permissible distances should be maintained.

6.4 Permissible salinity

The Review Committee considers that there are no current technical reasons that warrant setting a permissible salinity rate or level.

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Figures

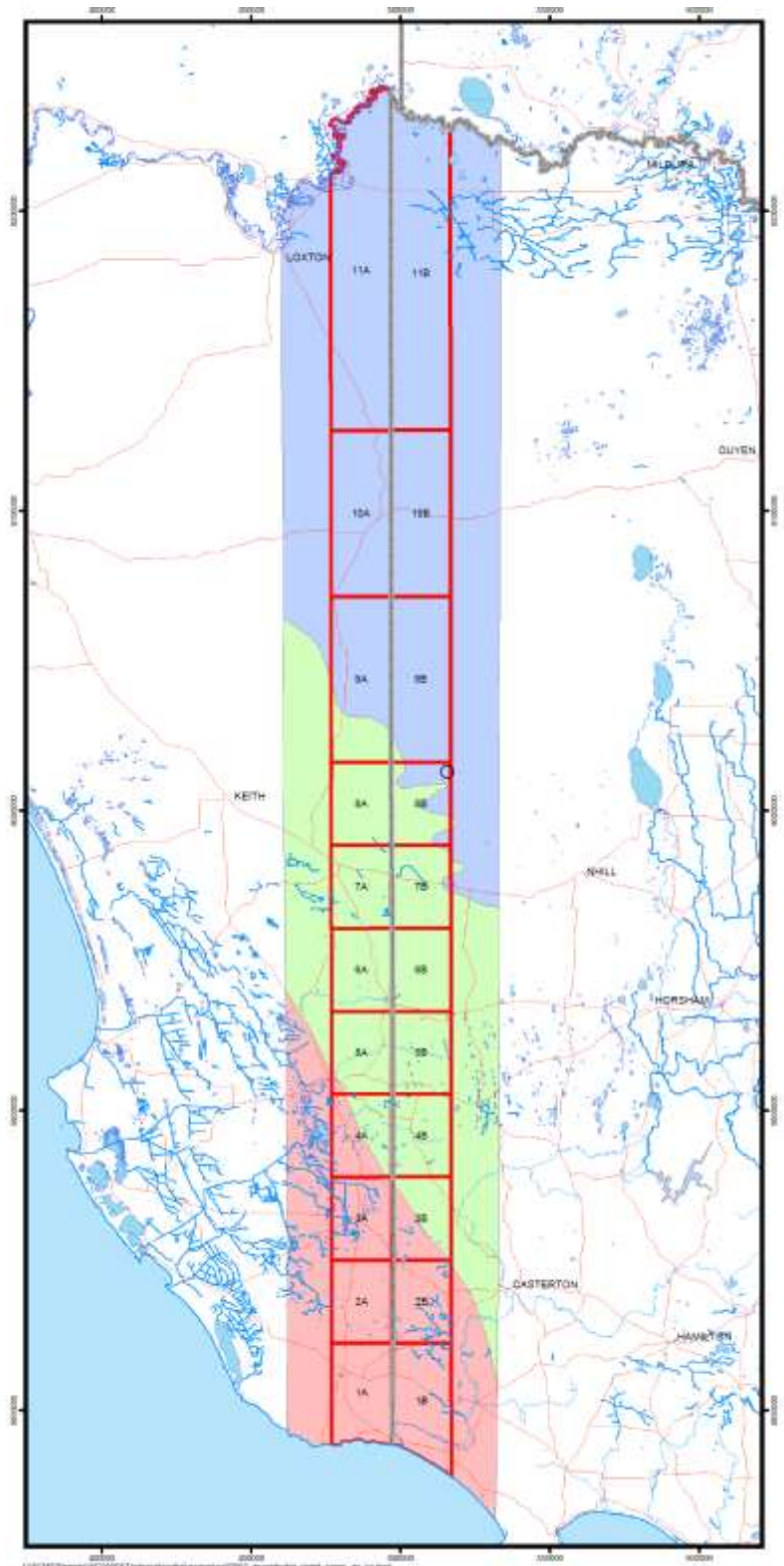


Figure 1 The Designated Area showing zones and the three provinces. Province 1 is shaded red, Province 2 is shaded green and Province 3 is shaded blue

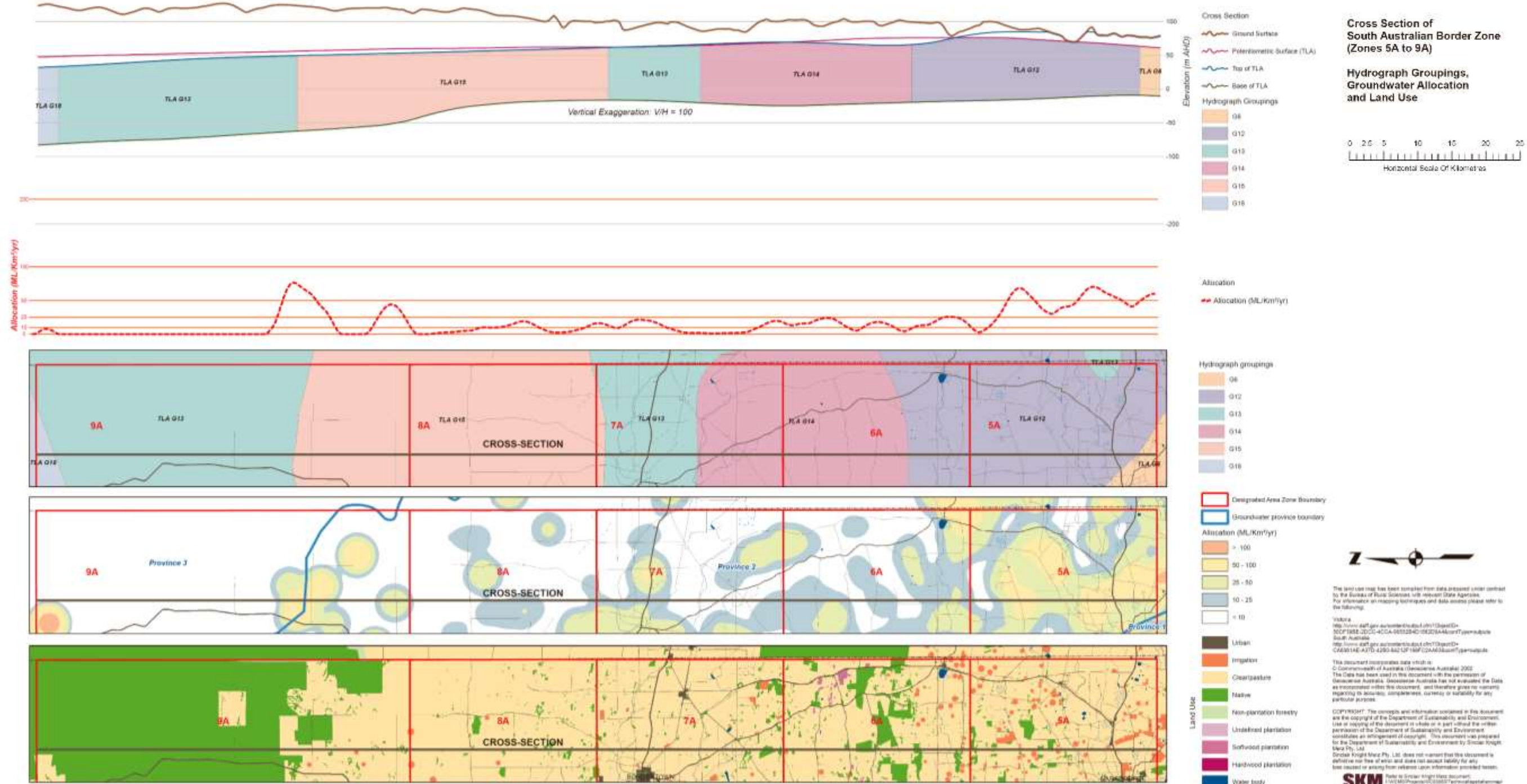


Figure 2 Hydrograph groupings, groundwater allocations and land use, Zones 5A, 6A, 7A, 8A and 9A

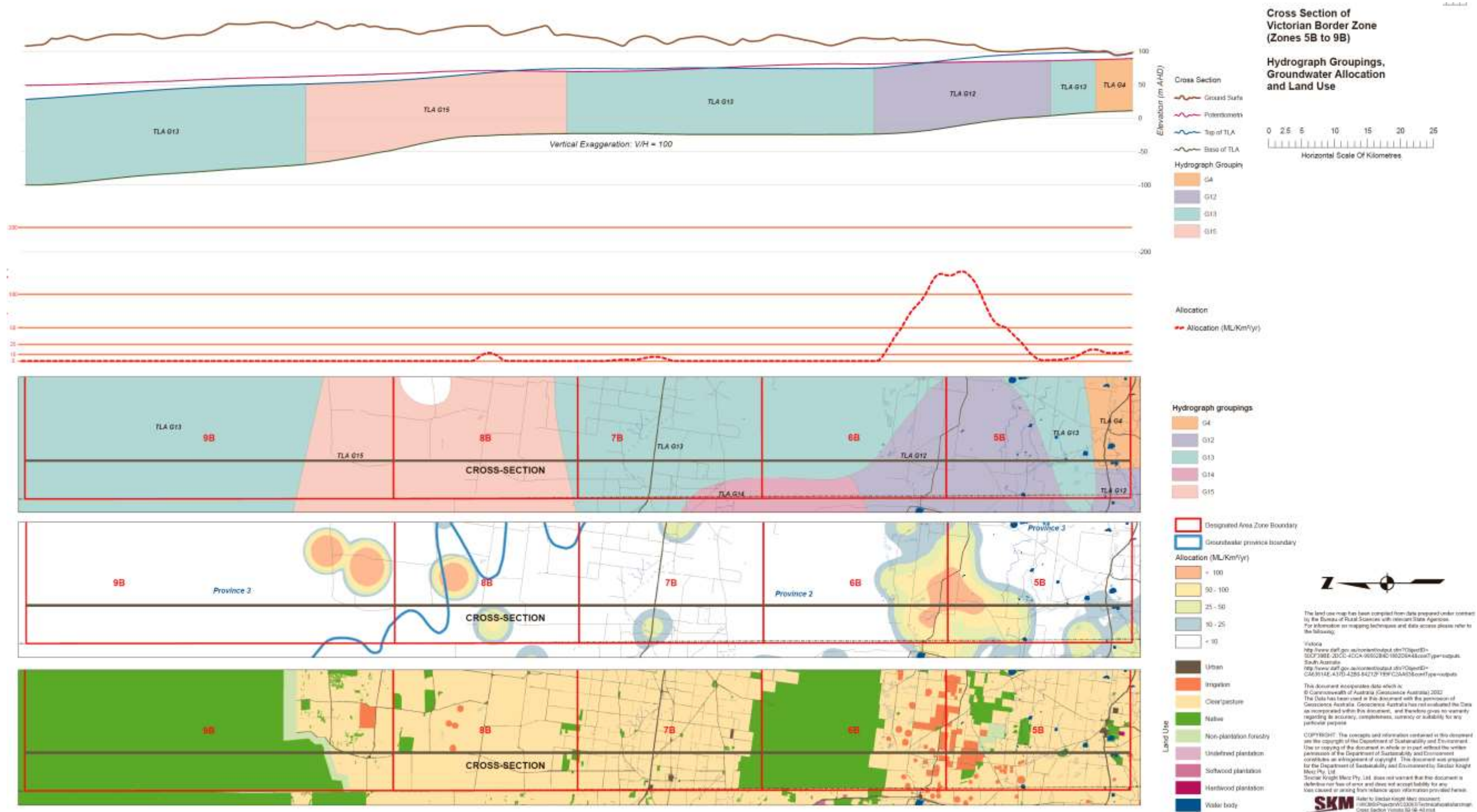


Figure 3 Hydrograph groupings, groundwater allocations and land use, Zones 5B, 6B, 7B, 8B and 9B

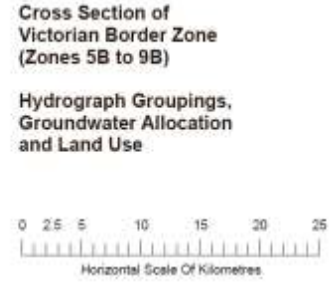
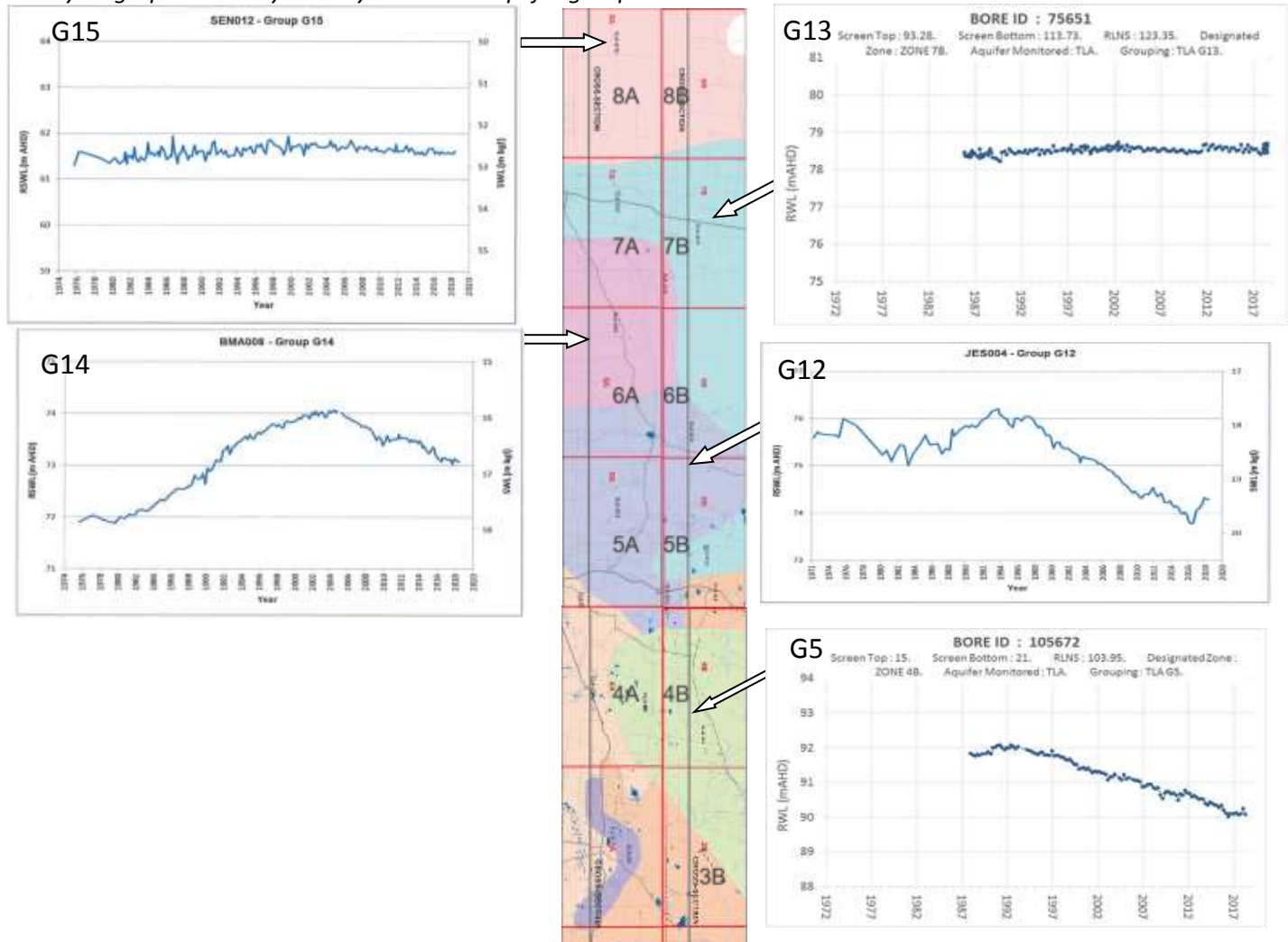


Figure 4 Hydrograph trends by tertiary limestone aquifer group



Appendices

Appendix 1

Groundwater extractions

Metered groundwater extractions for Province 2 have been available since 2006-07 and the mean extractions for the last 5-year and 10-year periods, with the annual and maximum observed zone extractions for the last 10 years (2010-2019), and the allocations applicable for each zone in Province 2 are provided in Table A1-1.

The data is presented in the Province 2 groupings of northern, central and southern regions and also expresses the annual extractions as a percentage of the allocations at June 2019.

| Zone (sub-zone) | Volume extracted for year ending June (ML): Province 2 Northern | | | | | | | | | | Zone PAV/AAV | Allocation at 2019 | Zone 10-yr mean annual extraction | Zone 5-yr mean annual extraction | Maximum extraction | Maximum extraction as % of allocation | Number of licences at 2019 |
|-------------------------|---|-------|-------|-------|-------|--------|-------|--------|-------|-------|--------------------------|-----------------------|--|---|-----------------------|--|-------------------------------------|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | | | | | | | |
| 9A south | | 4772 | 7091 | 8147 | 7279 | 8146 | 7340 | 6311 | 6573 | 6294 | 7760 | 7760 | 6884 | 6933 | 8147 | 105% | 5 |
| 8A | 1142 | 574 | 918 | 1303 | 1058 | 1480 | 2052 | 714 | 1342 | 1587 | 5121 | 6542 | 1217 | 1435 | 2052 | 31% | 25 |
| 7A | 6265 | 3029 | 5075 | 4839 | 3318 | 4581 | 5614 | 3076 | 3684 | 4202 | 8259 | 9133 | 4368 | 4231 | 6265 | 69% | 76 |
| 8B | 1768 | 125 | 0 | 18 | 14 | 1.144 | 365 | 261.15 | 603 | 1092 | 3500 | 3430 | 425 | 464 | 1768 | 52% | 8 |
| 7B | 670 | 1388 | 1957 | 2217 | 2444 | 2846.9 | 3196 | 5159.8 | 5291 | 4001 | 5782 | 5782 | 2917 | 4099 | 5291 | 92% | 13 |
| total | | 9888 | 15041 | 16524 | 14113 | 17055 | 18567 | 15522 | 17493 | 17176 | 30422 | 32647 | 15811 | 17163 | 23523 | 72% | 127 |
| total as% of allocation | | 30% | 46% | 51% | 43% | 52% | 57% | 48% | 54% | 53% | mean as % of allocations | | 48% | 53% | | | |
| Zone | Volume extracted for year ending June (ML): Province 2 Central | | | | | | | | | | Zone PAV | Allocation at 2019 | Zone 10-yr mean annual extraction | Zone 5-yr mean annual extraction | Maximum extraction | Maximum extraction as % of allocation | Number of licences at 2019 |
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | | | | | | | |
| 6A | 5955 | 3898 | 5581 | 5290 | 4353 | 5925 | 8346 | 4024 | 3970 | 5551 | 8758 | 10629 | 5289 | 5563 | 8346 | 31% | 40 |
| 5A | 12716 | 6970 | 15101 | 14372 | 10274 | 18516 | 18314 | 9318 | 10791 | 12021 | 18943 | 23723 | 12839 | 13792 | 18516 | 78% | 130 |
| 6B | 4217 | 739 | 3234 | 5028 | 5196 | 7203 | 7812 | 7501 | 7164 | 6325 | 10279 | 10279 | 5442 | 7201 | 7812 | 76% | 16 |
| 5B | 6455 | 4940 | 5808 | 5652 | 5662 | 6000 | 7339 | 5673 | 8606 | 8912 | 12833 | 12833 | 6505 | 7306 | 8912 | 69% | 39 |
| total | 29343 | 16547 | 29724 | 30342 | 25485 | 37644 | 41811 | 26516 | 30531 | 32809 | 50813 | 57464 | 30075 | 33862 | 43586 | 76% | 225 |
| % of alloc | 51% | 29% | 52% | 53% | 44% | 66% | 73% | 46% | 53% | 57% | mean as % of allocations | | 52% | 59% | | | |
| Zone | Volume extracted for year ending June (ML): Province 2 Southern | | | | | | | | | | Zone PAV | Allocation at 2019 | Zone 10-yr mean annual extraction | Zone 5-yr mean annual extraction | Maximum extraction | Maximum extraction as % of allocation | Number of licences at 2019 |
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | | | | | | | |
| 4A | 12641 | 6874 | 12780 | 13264 | 9332 | 14605 | 21594 | 15164 | 10145 | 11884 | 22102 | 30883 | 12828 | 14678 | 21594 | 70% | 177 |
| % of alloc | 41% | 22% | 41% | 43% | 30% | 47% | 70% | 49% | 33% | 38% | mean as % of allocations | | 42% | 48% | | | |
| 4B | 78 | 114 | 164 | 386 | 330 | 315 | 289 | 300 | 358 | 115 | 14000 | 2880 | 245 | 275 | 386 | 13% | 22 |
| % of alloc | 3% | 4% | 6% | 13% | 11% | 11% | 10% | 10% | 12% | 4% | mean as % of allocations | | 9% | 10% | | | |

Table A1-1 PAV, allocation, extraction and mean use 2010 to 2019 in Province 2

Groundwater extraction relationship with rainfall variability – Zone 5A

In the central zones of Province 2, a strong relationship is apparent between the annual extractions and the annual rainfall. In drier rainfall years, extractions are above the mean extractions (of the last 10-year and 5-year periods), while in years with above average rainfall, extractions are lower than the mean extractions.

There are some anomalies and these include the last two years in Zone 5B where annual rainfall was at the mean level in 2018-19 and above the long term mean in 2017-18, although these two years present the two highest observed extractions in the last 10-years of the zone. Even in higher rainfall years, the distinct lack of rainfall during the irrigation season can lead to an increase in extraction due to the timing of the rainfall recorded in those years, for example in Jan-April in 2017-18 and Jan-May in 2018-19 when virtually no rain fell.

An example of the relationship between annual rainfall and groundwater extractions is presented in Figure A1-1 for Zone 5A, with this zone having the greatest number of licences in the central area (130 out of a total of 225) the highest volume of allocated water (about 40 per cent of the Province 2 central total) and highest average annual use (between 35 and 50 per cent of the central area total extractions). Figure A1-1 (A and B) illustrates the inverse relationship between annual rainfall and groundwater extractions, with an r^2 correlation of 0.83.

The observed annual rainfall at Frances BOM26007 for the years ending in June is presented in Table A1-2, with the percentage deviation from the long term mean annual rainfall.

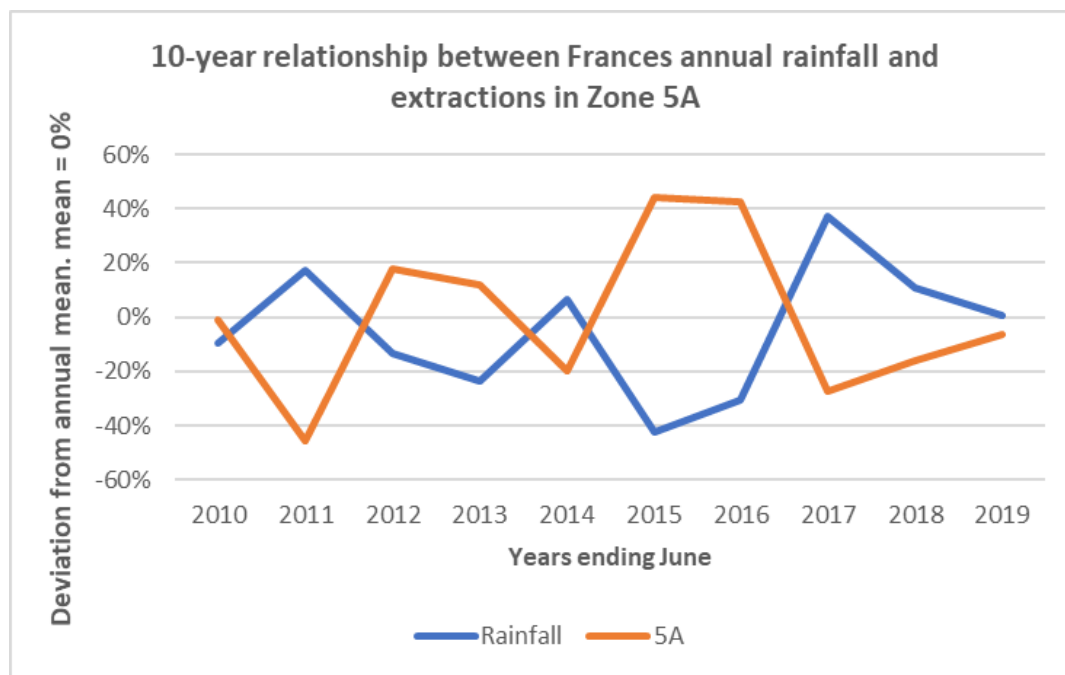


Figure A1-1 (A) Relationship between annual rainfall and extractions in Zone 5A, 2010-2019

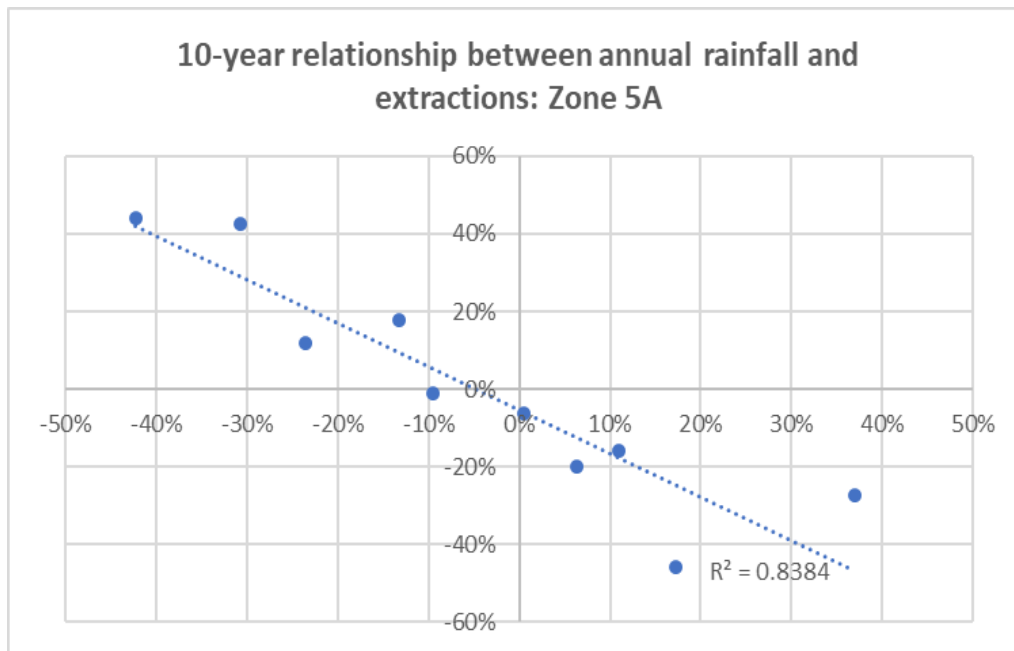


Figure A1-1 (B) Relationship between annual rainfall and extractions in Zone 5A, 2010-2019

| Rainfall at Frances (BOM 26007) | | | | | | | | | | | | | | | | | | | | |
|---------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--|
| Yr ending June | 2000-01 | 2001-02 | 2002-03 | 2003-04 | 2004-05 | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | |
| year rain mm | 519.8 | 440.6 | 478.4 | 480.4 | 398.6 | 467.4 | 396.0 | 425.4 | 409.4 | 469.0 | 607.6 | 449.8 | 396.0 | 551.4 | 299.2 | 358.8 | 710.0 | 575.6 | 520.8 | |
| deviation from mean % | 0% | -15% | -8% | -7% | -23% | -10% | -24% | -18% | -21% | -10% | 17% | -13% | -24% | 6% | -42% | -31% | 37% | 11% | 0% | |

Table A1-2 Annual rainfall at Frances (BOM 26007) 2000-01 to 2018-19

Estimating groundwater extractions in the pre-metered period

While metered groundwater extraction data has been available since the 2006-07 year in South Australia, an important missing element is an understanding of extractions in the period from the mid-1970s (when groundwater level monitoring commenced) to the early 2000s, when the groundwater level decline had commenced. Understanding the relationship between the extraction history and the observed changes in groundwater levels would assist in formulating groundwater management policy for the present and future.

The South Australian Department of Mines and Energy in its technical report 95/22, titled, *Five Year Technical Review 1991-1995 Border (Groundwater Agreement) ACT, 1985*, has provided estimates of pumped groundwater extractions (excluding stock and domestic uses) for each South Australian zone in the Designated Area for the period 1985-86 to 1993-94. It is understood that the published data is the result of assessing irrigation activities from aerial assessment of irrigation activity and estimated crop water needs. While the estimates are for each of the nine years, the overall trend is one of reducing extractions for zones 5A and 6A. In aggregate, extractions for zones 5A and 6A in 1985-86 total 18864 ML with a gradual decline to 14159 ML in 1991-92. It is noted that data for 1992-93 and 1993-94 is not complete.

With a need for a broad perspective of extractions for a longer period for groundwater modelling purposes, a study was undertaken by Harrington and Li (2015). The Harrington and Li study was based on the analysis of bore hole data and associated licence details for over 4000 irrigation bores across the south east of South Australia. The resulting information from that work is presented as decadal extractions for the different groundwater management areas, including those in the South Australian part of the Designated Area.

Another separate study, using the borehole construction history for each 5-year period from the 1961 to 2010 was undertaken by Harvey (2020 Draft). Using the average metered extraction data for the period 2006-07 to 2009-10 as a base line for extractions in each zone, extraction estimates based on the percentage expansion of irrigation borehole population from 1961 to 2010 was undertaken for each 5-year period for Province 1 and 2 of the Designated Area.

This approach was based on the principle that as irrigation activities in the period prior to 1960 were at a very low level, an increase in irrigation borehole population indicated an intent to irrigate. An important aspect of the irrigation bore-hole population approach was that expansion of the irrigation bore-hole population appeared to almost cease in the 2006-10 period. This provided support for using the metered extractions between 2007 and 2010 as an extraction baseline against which to estimate extractions, using the borehole population increase percentage factor. That is, past extraction is estimated using a multiplier (based on irrigation borehole population increase) applied to the mean metered extractions between 2007 and 2010.

Table A1-3 is preliminary work by South Australia which provides a summary of estimates of extractions from Harvey (2020 Draft) for the South Australian Province 1 and Province 2 areas. Bore-hole population expansion is also presented for the border land division hundreds. This indicates a consistent trend in irrigation borehole population expansion from the 1960s to 2010.

Given the land use similarities between the neighbouring South Australian and Victorian central zones, similar approaches to estimating extractions in the pre-metered period could be applied to Zones 5B and 6B.

Estimates of extractions in the Province 2 central area for the 5-year periods of 1991-95, 1996-00 and 2001-05 are important for helping to determine the contribution of groundwater extractions in the overall water account, and the resulting observed decline in the depth to groundwater which is considered as the removal of water from storage.

| Summary of irrigation well construction | | <1960 | 1961-65 | 1966-70 | 1971-75 | 1976-80 | 1981-85 | 1986-90 | 1991-95 | 1996-00 | 2001-05 | 2006-10 | 2011-15 | 2016-19 |
|---|-------------------|-----------|-----------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
| Province 2 North aggregate | Senior | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 2 | 2 | 1 | 0 |
| | Tatiara | 5 | 2 | 20 | 6 | 6 | 5 | 0 | 2 | 6 | 5 | 6 | 3 | 4 |
| | Geegeela | 2 | 1 | 3 | 2 | 3 | 7 | 1 | 1 | 1 | 7 | 5 | 5 | 3 |
| | Total | 7 | 3 | 23 | 10 | 9 | 12 | 1 | 3 | 11 | 14 | 13 | 9 | 7 |
| | Prog total | 7 | 10 | 33 | 43 | 52 | 64 | 65 | 68 | 79 | 93 | 106 | 115 | 122 |
| Province 2 Central aggregate | Binnun | 4 | 1 | 5 | 21 | 31 | 29 | 58 | 47 | 110 | 36 | 33 | 0 | 2 |
| | Jessie | 14 | 1 | 8 | 7 | 6 | 9 | 7 | 15 | 35 | 6 | 11 | 0 | 1 |
| | Total | 18 | 2 | 13 | 28 | 37 | 38 | 65 | 62 | 145 | 42 | 44 | 0 | 3 |
| | Prog total | 18 | 20 | 33 | 61 | 98 | 136 | 201 | 263 | 408 | 450 | 494 | 494 | 497 |
| Transition Zone 4 | Joanna | 3 | 4 | 8 | 6 | 13 | 16 | 4 | 26 | 26 | 14 | 4 | 1 | 5 |
| | Prog total | 3 | 7 | 15 | 21 | 34 | 50 | 54 | 80 | 106 | 120 | 124 | 125 | 130 |
| Province 1 Aggregate | Comaum | 4 | 1 | 12 | 19 | 31 | 29 | 58 | 47 | 108 | 36 | 33 | 0 | 0 |
| | Penola | 0 | 1 | 2 | 9 | 21 | 24 | 23 | 35 | 63 | 7 | 17 | 1 | 4 |
| | Nangwarry | 0 | 0 | 0 | 0 | 3 | 3 | 6 | 7 | 6 | 2 | 1 | 0 | 1 |
| | Mingbool | 5 | 1 | 10 | 25 | 17 | 27 | 33 | 36 | 70 | 48 | 24 | 0 | 4 |
| | Gambier | 0 | 0 | 6 | 14 | 10 | 14 | 16 | 10 | 18 | 11 | 7 | 0 | 3 |
| | Caroline | 1 | 0 | 0 | 2 | 0 | 1 | 5 | 1 | 22 | 2 | 4 | 0 | 5 |
| | Total | 10 | 3 | 30 | 69 | 82 | 98 | 141 | 136 | 287 | 106 | 86 | 1 | 17 |
| Prog total | 10 | 13 | 43 | 112 | 194 | 292 | 433 | 569 | 856 | 962 | 1048 | 1049 | 1066 | |
| All Hundreds | Total | 38 | 12 | 74 | 113 | 141 | 164 | 211 | 227 | 469 | 176 | 147 | 11 | 32 |
| | Prog total | 38 | 50 | 124 | 237 | 378 | 542 | 753 | 980 | 1449 | 1625 | 1772 | 1783 | 1815 |
| 5-yr periods | | <1960 | 1961-65 | 1966-70 | 1971-75 | 1976-80 | 1981-85 | 1986-90 | 1991-95 | 1996-00 | 2001-05 | 2006-10 | 2011-15 | 2016-19 |

New irrigation bore holes constructed from 1961 to 2019 in Province 1 and 2. Parameter for an irrigations bore-hole is a minimum diameter of 200 mm

| Region | as at 1960 | 1961-1965 | 1966-1970 | 1971-1975 | 1976-1980 | 1981-1985 | 1986-1990 | 1991-1995 | 1996-2000 | 2001-2005 | 2006-2010 |
|----------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Prov 2 North | 415 | 580 | 2239 | 2902 | 3400 | 3815 | 3815 | 3981 | 4810 | 5390 | 6054 |
| Prov 2 Central | 699 | 803 | 1362 | 2410 | 3807 | 5379 | 7684 | 9885 | 14985 | 16696 | 18408 |
| Zone 4A | 320 | 746 | 1598 | 2237 | 3621 | 5326 | 5752 | 8521 | 11291 | 12782 | 13208 |
| Prov 1 | 457 | 594 | 1965 | 5118 | 8866 | 13344 | 19788 | 26003 | 39119 | 43963 | 47894 |
| Total | 1890 | 2724 | 7164 | 12668 | 19695 | 27864 | 37039 | 48390 | 70204 | 78832 | 85563 |

Table A1-3 Estimated extractions (ML) in the South Australian Province 1 and Province 2 areas from 1960s to 2000s

Appendix 2

Technical Review

This document aims to support the Management Review of Province 2 of the Designated Area (the Management Review) by providing a summary of relevant technical work and reviews for the Province 2 part of the Border Designated Area. Consistent with the Management Review, information is presented for sub-regions of Province 2 grouped into the northern, central and southern regions of Province 2 (see Figure A2-1). The document pertains exclusively to groundwater resources in the unconfined Tertiary Limestone Aquifer (TLA).

A numerical groundwater model for the entire Province 2 region was developed as part of this review, however the poor calibration to observed groundwater trends resulted in the model not being fit for the purpose of predicting resource behaviour under increasing groundwater use or changing climate. Data in the water budget were not consistent with the conceptual understanding of the system indicating some of the modelling inputs need further study (particularly recharge and through flow values). It is likely that this model may be improved with additional years of metered groundwater use and calibration of recharge data resulting in better conceptual understanding.

Additional modelling in the northern region of Province 2 in relation to the Tatiara Water Allocation Plan review has also been completed separately from this review. Model scenarios simulating the impact of increased extraction in Zones 7A and 8A are relevant to this review, and are referred to further.

Supplementary work based on observed groundwater level behaviour over the period of metered use since 2007 was also used to provide input to this review and presented in Appendix 3. While this considered all zones in Province 2, there was particular consideration given to the area of long term decline, which is characterised by a group of hydrographs referred to below as Tertiary Limestone Aquifer - Group 12 (TLA G12) in Zones 5A, 6A, 5B and 6B.

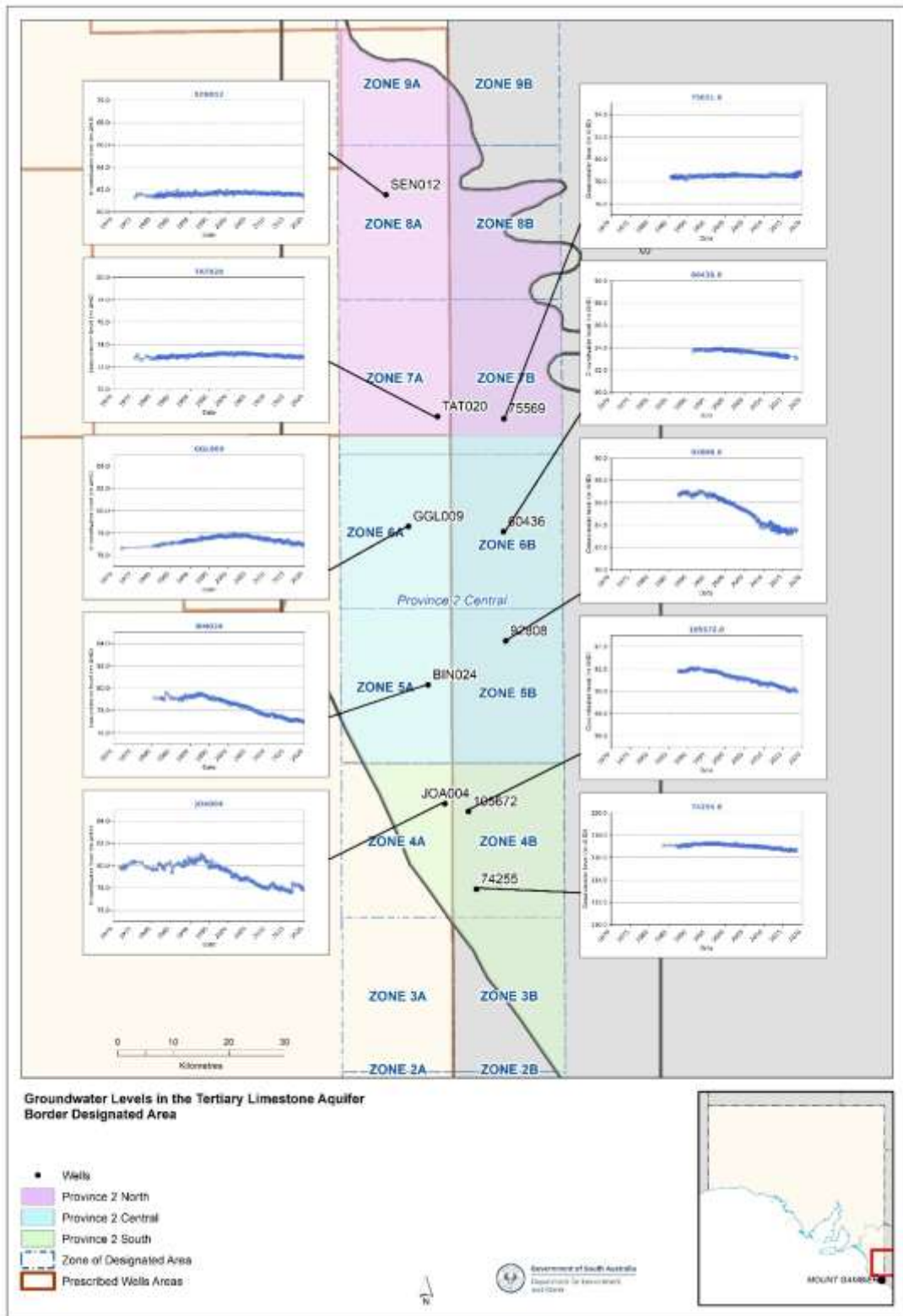


Figure A2-1 showing Province 2 regions and characteristic hydrographs for Province 2

Province 2 northern region

Province 2 northern region encompasses the main part of Zones 7A (aligning with the boundary between Lower Limestone Coast and Tatiara Prescribed Wells Areas in SA), Zone 8A and Sub-zone 9A South to the northern extent of the Tatiara Prescribed Wells Area, and Zones 7B and 8B which are part of the West Wimmera Groundwater Management Area. These include hydrograph groups TLA G13, TLA G14 and TLA G15. The water table in the Tertiary Limestone Aquifer is generally deep (30 to 50 m below ground level), recharge is considered to be low or negligible and groundwater levels are considered stable, but a consistent small declining trend can be observed over the last 15 years (Figure A2-1).

The stability in groundwater levels in Zones 7A, 8A and Sub-zone 9A South and in Zones 7B and 8B indicates the current level of extractions is acceptable. However, if groundwater use were to increase towards full allocation (Table A1-1), declines that exceed the current permissible rates of decline may be expected. This was observed in modelling presented by Cranswick and Li (2018) for the Tatiara Water Allocation Plan review, who demonstrated that declines of 0.5 to 2.5 m could be expected in Zones 7A, 8A and Sub-zone 9A South by 2030 under a scenario where the full allocation is extracted. Further work is needed to understand the link between extraction and groundwater levels across this part of the Designated Area and in particular to assess risks of increased extraction in Zone 7A on Bordertown's town water supply in the neighbouring management area of Wirrega.

Annual extractions including the mean and maximum extraction are available in Table A1-1 and are also expressed as a percentage of total allocations as at 2019.

As discussed earlier, a model for the entire Province 2 region was constructed as part of this review, however further work is needed to develop the model into a tool that can assist with scenario analysis, similar to that done with the Tatiara modelling (Cranswick and Li, 2018). If the Province 2 model were to be refined, management scenario options for future modelling could include:

- test extractions at full Permissible Annual Volume
- test extractions at current mean rate of annual extraction.

Province 2 central region

Province 2 central region encompasses Zones 5A, 5B, 6A and 6B (Figure A2-2) and includes most of the area which corresponds to TLAG12. In Zone 6A groundwater levels showed rising trends through the 1970s and 1980s, most likely from increased recharge in response to large scale land clearance of native vegetation on sandy soils.

In Zones 5A, 6A, 5B and 6B, groundwater levels have been declining since the 1990s. These declines are thought to be due to low rates of recharge and increased extraction for irrigation, which is concentrated in the Frances-Neuarpur area of Zones 5B and 6B, Zone 5A and Sub-zone 6A South.

While groundwater levels have declined by 2m to 4 m in the central region since the mid to late 1990s, reduced rates of decline and periods of stabilisation have been observed between 2010 and 2019 (Figure A2-3). This is a period during which rates of groundwater extraction has varied between 16,500 ML and 42,000 ML/y (Appendix Table A1-1), with variation in extraction from year to year linked to variations in rainfall (Figure A2-4). The mean annual extractions during the last 5 years, compared to the mean extractions of the last 10 years is about 10 per cent higher at 33,862 ML. This indicates some variation to the water balance before 2010, compared to the years following, which is discussed in Appendix 3. The most recent water level observations in autumn 2020 indicate a re-emergence of declining trends.

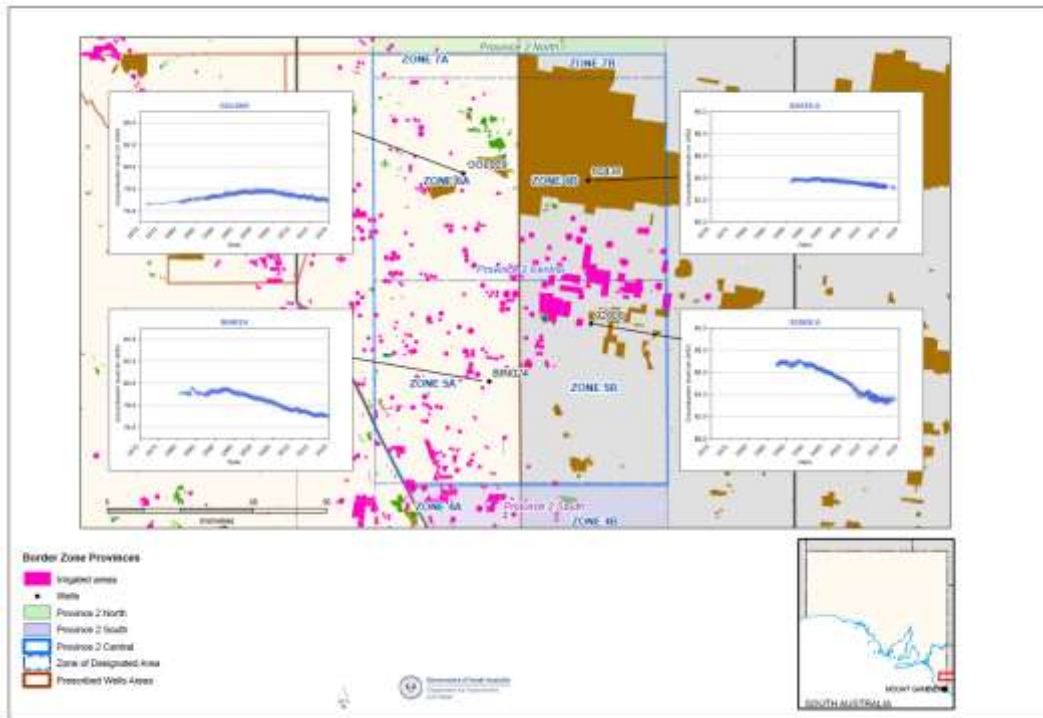


Figure A2-2. Groundwater level trends and land use in Province 2 central region

Allocations in Zone 5A was reduced by 8.5 per cent under the Lower Limestone Coast Water Allocation Plan in 2016 to 23,723 ML, but allocations at 2019 still exceed the Permissible Annual Volume for Zone 5A by 4,780 ML. Restrictions of licensed allocation volume in Neuarpur Zone 1 (which includes parts of Zone 6B and 5B in Victoria) reached the maximum of 20 per cent reduction under the West Wimmera Groundwater Management Area plan. As peak use is around 70 per cent of allocation, it is uncertain if these reductions have had any material effect on reducing actual extractions, with the highest observed extractions in Zone 5B occurring in the last two years (2017-18 and 2018-19), years of average and above average rainfall at Frances.

The relationship between annual rainfall and extractions in Zone 5A for the 10-year period 2009-10 to 2018-19 is compared in Appendix Figure A1-1 (A and B), with a correlation r^2 value of 0.83.

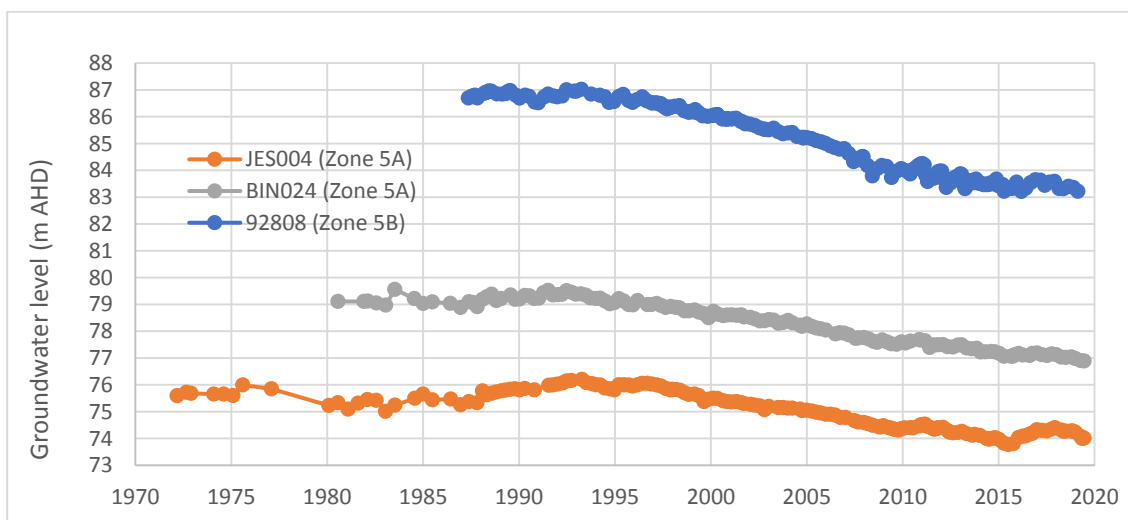


Figure A2-3. Groundwater levels in Province 2 central region

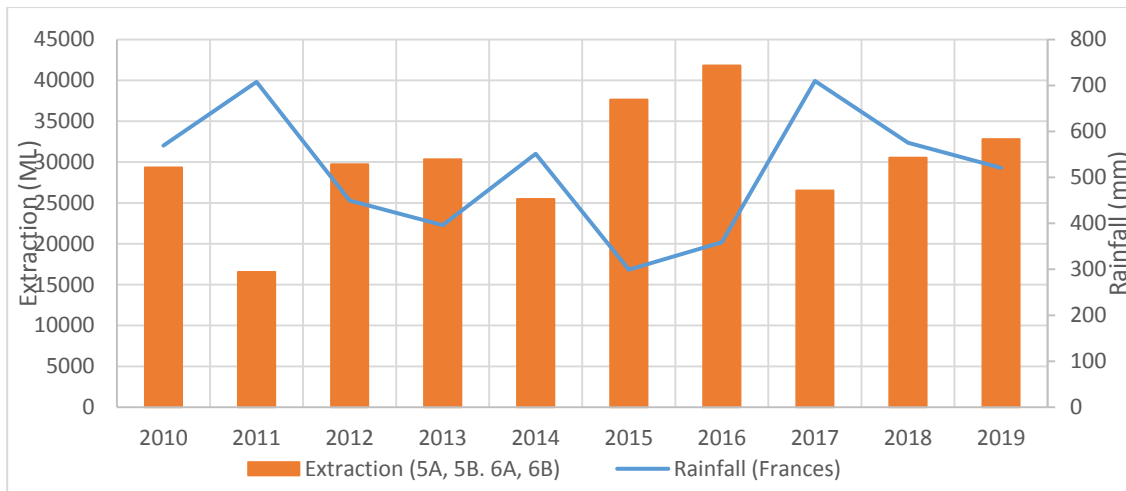


Figure A2-4. Combined annual extraction in Zones 5A, 5B, 6A and 6B and rainfall (at Frances) since 2007

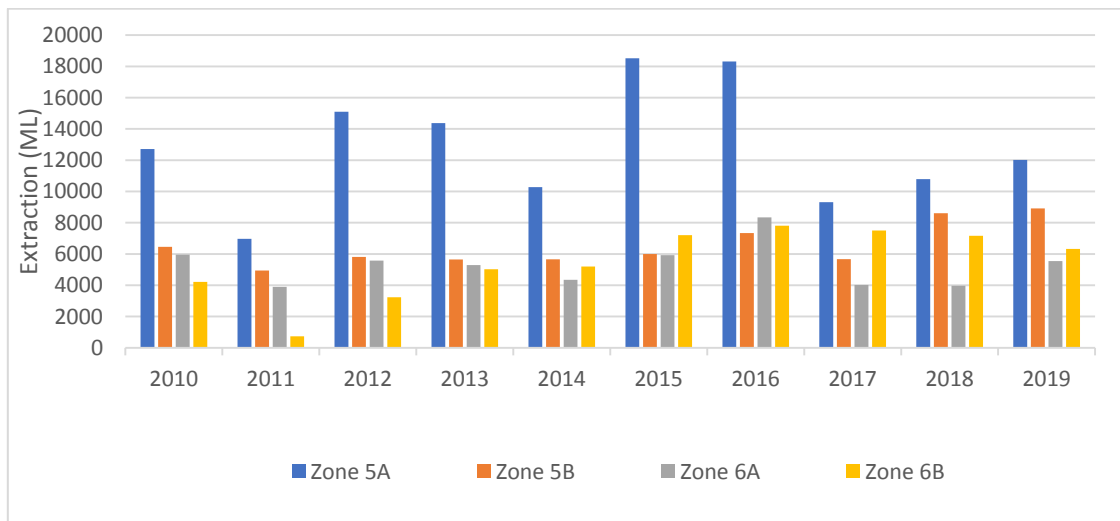


Figure A2-5. Annual extractions by zone for Zones 5A, 5B, 6A and 6B

It is not currently clear what impact increased extraction up to full allocation (or the Permissible Annual Volume) or sustained high rates of extraction would have on the productive use of the aquifer and the material impact on users. While increased extractions in the future will result in further declines, a strong scientific evidence base with groundwater modelling is required to determine the potential magnitude and risk of further declines posed by different extraction regimes. Given the dependence on the regional groundwater resource for stock and domestic supplies, impacts beyond the Designated Area may also be relevant in any risk assessment.

The recent science review conducted by the independent Goyder expert panel (Simmons *et al*, 2019) noted the current water declines and the risks to stock and domestic water supplies, particularly where the declines are in the order of 2-3 metres and more.

The relative lack of groundwater dependent ecosystems in Province 2 (except in the southern region, as noted below) means the most likely impact of declines in the central region is a material impact to domestic and stock users. Further work is needed to assess the risks of material impacts to domestic and stock users in the central region of Province 2.

Management implications

The material impacts of declines in groundwater levels, particularly to domestic and stock users, depends on the depth of existing bores and rate of decline. Bore depths have been surveyed in South Australia (Cranswick and Li, 2018) but not in Victoria.

An updated version of the Province 2 model could be used to simulate the impact of future extraction, and develop potential Resource Condition Limits (RCLs) to assess impacts and provide a warning system for review of the ongoing risks to the resource.

South Australia advised this type of approach is being considered in the Tatiara PWA (Cranswick and Li, 2018) and has been endorsed by a recent independent review of the science underpinning groundwater management in the Lower Limestone Coast (Simmons *et al*, 2019).

The similarity in the hydrographs trends in these zones suggest the central region is generally behaving as a connected resource across Zones 5A, 6A, 5B and 6B in South Australia and Victoria.

Province 2 southern region

The Province 2 southern region includes Zone 4B and part of Zones 4A and 3B. Land use is a mix of dryland pasture, viticulture, plantation forest and native vegetation (predominantly Victoria) and irrigation (predominantly South Australia). In the southern region, the water table is shallower (approximately 5 metres below ground level) and higher rainfall results in more rapid recharge responses.

In Zone 4B, in the Dundas Tablelands and fringe area, higher salinity and lower yield results in very low use and the declining groundwater levels observed is primarily a result of reduced recharge from rainfall and some interception from commercial forests. Management of groundwater use by commercial forests does not fall within the terms of the Agreement.

The Permissible Annual Volume in Zone 4B is high relative to allocation and extraction, and reducing the Permissible Annual Volume to be more closely aligned with the allocations is an appropriate action.

Groundwater levels have declined about 2 m since the 1990s, although this increases to about 4m in the west of the Province 2 region. There is some stabilisation in recent years, similar to trends in the central region (Figure A2-6), although here it is likely to be from rainfall as the water table is shallower (e.g. 10 m below ground level at JOA005, Figure A2-6) and groundwater extraction is much lower in the southern region (Figure A2-7).

Plantation forests are present in Zones 3B and 4B with a combined area of 24,600 ha, although their impact on groundwater resources has not been studied to the same extent as in South Australia where commercial plantation requires an entitlement to be issued. In Zone 4A, plantation forests occupy nearly 4,000 ha with much of it being in place for over 30 years and is offset with licensed water allocations of about 2,700 ML.

Mosquito Creek flows from east to west through the southern region of Province 2, and is the main source of water for the Ramsar-listed Bool and Hacks Lagoons just west of Zone 4A. Surface water monitoring for Mosquito Creek (at Struan gauging station to the west of Zone 4A) indicates changes in creek flow and level in the period between 1995 and 2005 (period of reduced rainfall), with a loss

of baseflow and reduced frequency and magnitude of flow events. The relationship between declining groundwater levels and declining flows in Mosquito Creek is not fully understood.

Following the South East Science Review, South Australian Department for Environment and Water has a project in 2020 to develop a sub-regional model for part of the Lower Limestone Coast, including the southern region of Province 2. The current project plan is scoped to include Zones 4B and 3B and the Mosquito Creek catchment.

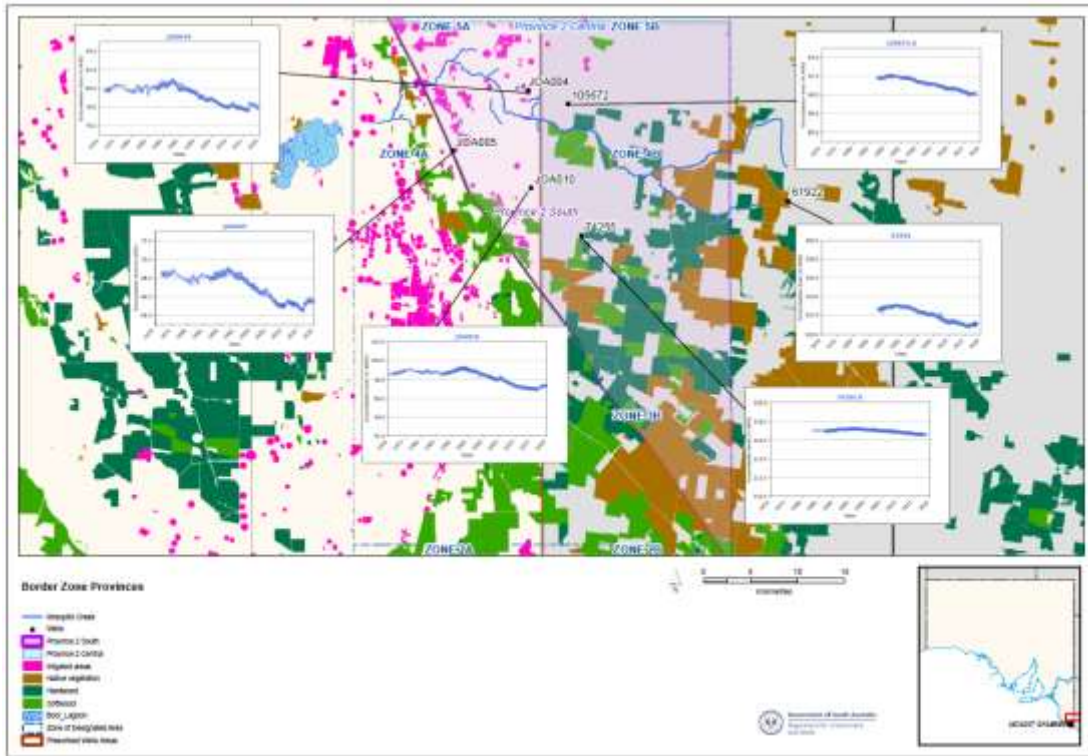


Figure A2-6. Groundwater levels in Province 2 South

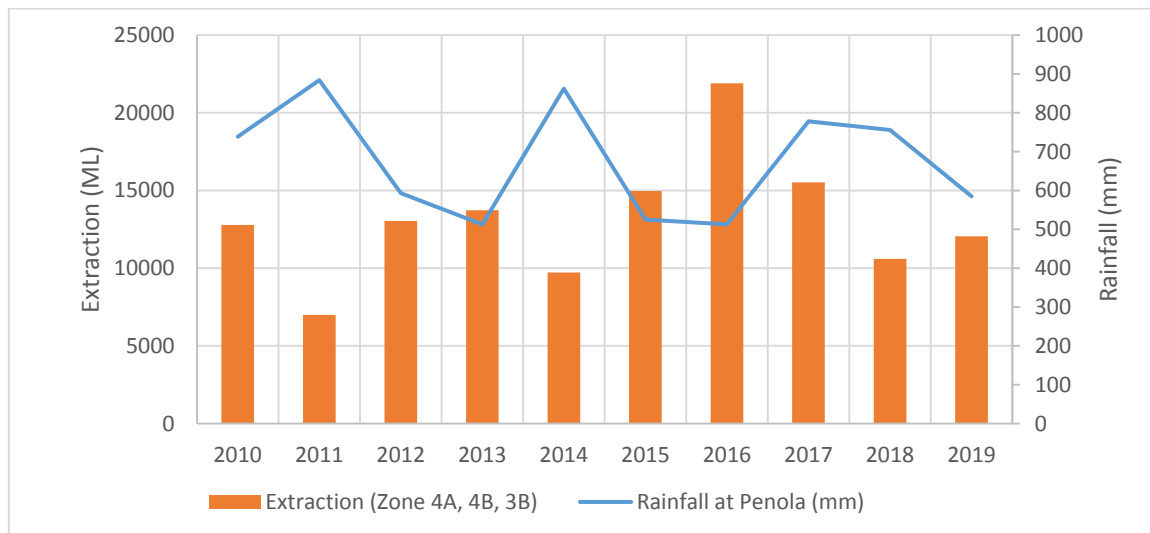


Figure A2-7. Groundwater extraction in Zones 4A, 4B and 3B (noting that Zone 4A is split between Province 1 and 2).

Key messages:

- Northern region: Groundwater levels in the region are stable at current levels of use. Groundwater modelling as part of the Tatiara water allocation plan review has demonstrated that extraction of full allocations is likely to cause drawdowns that would exceed the permissible rate of potentiometric surface lowering in Zones 7A and 8A. Further work may be required to assess the impacts of drawdown in Zone 7A on neighbouring management areas and Bordertown's town water supply. Further advice for the Review Committee on this can be prepared through the Technical Working Group. The resource trends are acceptable in terms of current use. There is no need to alter management prescriptions for this region, however consideration needs to be given to reducing or restricting allocations to the Permissible Annual Volumes.
- Central region: Long term declines appear to be related to rainfall trends and these impacts on extractions with periods of higher rainfall resulting in lower extractions and probably providing higher rates of recharge. Groundwater level stabilisation can be observed in recent years during these periods of reduced extraction in high rainfall years. There is annual variability in extractions and it is unclear if declines will continue or increase in future without some mechanism to ensure there is no expansion in irrigation activities (as observed in Zone 5B during the last two years of average and above average rainfall). Material impacts on users from further decline in levels are uncertain without better information on users' bore depths and equipment. A stronger evidence base for assessing the risk of future groundwater extraction could be developed through revising the Province 2 groundwater model. Further work is needed to assess the risks of material impacts to users, particularly domestic and stock users in the central region.
- Southern region: Declining groundwater levels in the Mosquito Creek catchment have raised concerns in South Australia about impacts to water dependent ecosystems identified in the Lower Limestone Coast Risk Assessment.

Groundwater extraction is low, relative to the allocations, creating the potential to increase extractions in the southern region. The interception of recharge by forests in Zones 4A and 4B, and possibly groundwater extraction by plantation forest from shallow water tables, can also be contributing to the long term declines.

The risks of impact from declining flows in Mosquito Creek on the ecological character of the Ramsar-listed Bool and Hacks Lagoons is considered high and the South Australian Department for Environment and Water are planning further modelling work for this region, however additional information is needed for assessing the forest impact on recharge particularly in the catchment area of Mosquito Creek in Zone 4B. A separation of the zones into Province 1 and 2 should be considered in Zone 4A, allowing the Province 1 part to be managed as a renewable resource.

An attempt to stabilise water table trends in the Province 2 area needs to be considered by ensuring that under-utilised allocations are not overly activated whilst further studies are undertaken to better understand the Mosquito Creek relationship and the consequences for the Ramsar sites of Bool and Hacks Lagoons.

Note on South Australian independent expert review

South Australia's volumetric conversion program, through water allocation plans and involving about 4000 volumetric irrigation licenses, resulted in the aggregated allocations exceeding the Permissible Annual Volume and Allowable Annual Volume in all zones in the Lower Limestone Coast Prescribed Wells Area. Effective July 2016, a program of staged reductions was incorporated in the current water allocation plan. This program consisted of percentage reductions in individual allocation every two years through to 2022, however this program was placed on hold by the Minister for Environment and Water, following the current Government's election in March 2018, to enable an independent expert review of the science underpinning the reductions and a revised risk assessment for the management zones.

The science review was carried out by an independent panel of scientists commissioned by the Goyder Institute for Water Research (Simmons *et al*, 2019).

The main points from the science review, relative to the South Australian portion of the Designated Area, are summarised as:

- The amount of science available for the groundwater and groundwater dependent ecosystems is extensive and well above average compared to other parts of Australia and the world.
- There has been some recovery of water levels since 2012 and stabilisation of water levels over the last two years in most areas.
- The panel has also made various recommendations to increase scientific understanding of the resource and groundwater dependent ecosystems, including maintaining and expanding the existing monitoring network (including salinity monitoring), updating and expanding groundwater models, and expanding monitoring activities associated with groundwater dependent ecosystems.

The South Australian independent science review noted above, identified the most significant risks are to groundwater dependent ecosystems and access for domestic and stock users, as both tend to rely on access to shallower water tables.

References

- Cranswick RH & Li C (2018). *Science support for the Tatiara PWA WAP review: 2017–18 Volume 1*, DEW Technical report 2018/06, Government of South Australia, Department for Environment and Water, Adelaide.
- Simmons C, Cook P, Boulton AJ & L Zhang (2019) *Independent review of science underpinning reductions to licensed water allocation volumes in the Lower Limestone Coast water allocation plan*. Goyder Institute for Water Research Technical Report Series No. 19/01.

Appendix 3

Observed groundwater use and trends in Province 2 central (2007-2019)

A key task for the review of Province 2 is to:

- Identify the level of groundwater extraction that does not result in unacceptable declines
- Investigate the potential impact of extracting the full PAV
- Investigate the potential impact of climate variability on extraction.

Since 2000, groundwater levels have fallen by 2 to 4 m in the central region. The observed extractions and trends, since metering was introduced in 2006, allows changes in extraction to be compared to variations in observed trends.

Stable levels were observed during the period 2010-11 and again in 2016-17, both periods of below average extraction during above average annual rainfall periods (Figure A3-1). There is also a reduction in the rate of decline after 2010 despite average extraction remaining approximately the same. Either lateral inflows have contributed to stabilisation or there is some (delayed) contribution from rainfall or both. Another explanation could be the significant year to year variation in extraction. For example extraction in the central region (Zones 5A, 5B, 6A and 6B combined) ranged from 41,811 ML in 2015-16 to 26,515 ML/y in 2016-17. As there is no significant change to the hydraulic gradient (i.e. change in lateral flows), the reduced decline may be due to the effect of episodic recharge.

While this approach does not predict future behaviour, the observed behaviour forms a useful basis for revising the conceptual model required to revise the numerical model previously developed.

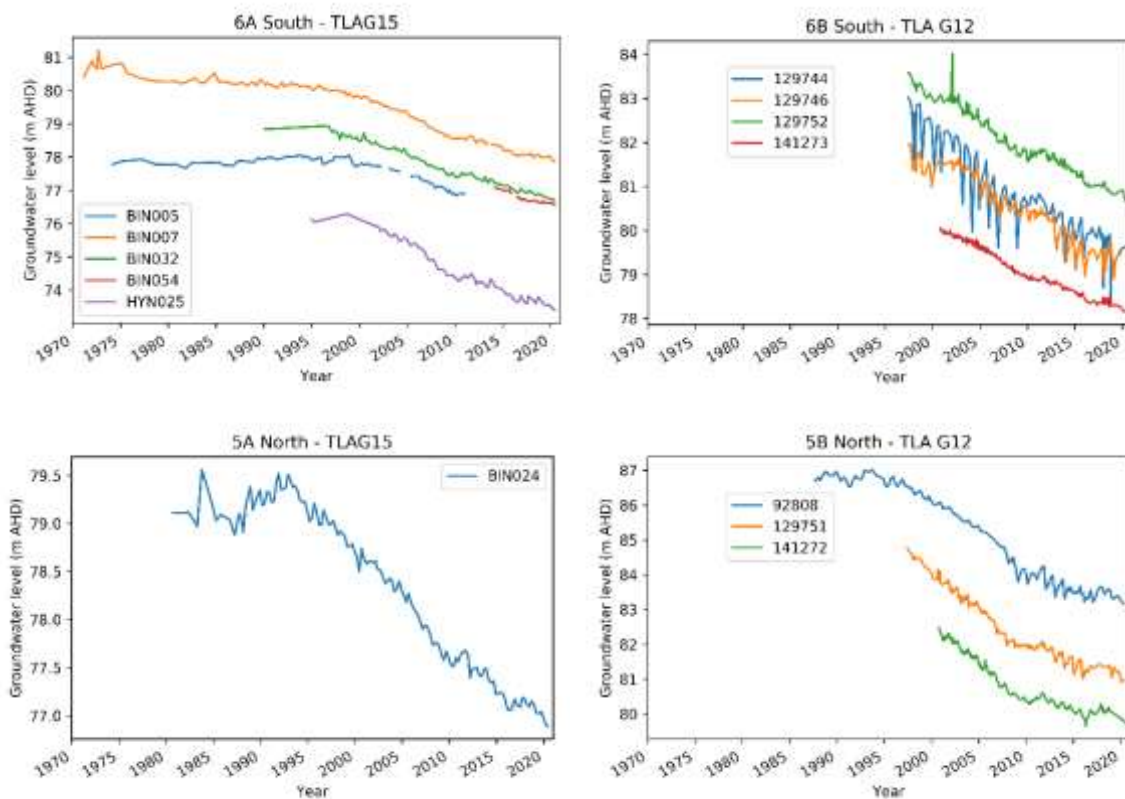


Figure A3-1 Representative hydrographs in the central region of Province 2 by zone.

Province 2 central region water balance (2007-2019)

Considering the metered use data from 2010-2019 (Appendix 1) and the hydrograph responses, an estimate of the water balance for the period from 2010 to 2019 (the period of metered use) has been prepared.

This water balance is based on the following assumptions:

- The Tertiary Limestone Aquifer in the central region is behaving as a connected resource.
- No effective recharge (from rainfall or irrigation drainage) occurs between 1995 and 2010 (the period of below average rainfall).
- Above average rainfall events (in 2010-11 and 2016) results in some episodic recharge but is delayed by depth to water table and occurs over extended period.
- This recharge (reduced irrigation extractions plus rainfall) produced a reduced rate of decline between 2011 and 2018.
- Lateral inflow less outflow is constant, based on a constant hydraulic gradient.

Table A3-2 presents the observed use and trends for characteristic periods, and the estimated groundwater balance, over the period from 2006 to 2018.

| | Decline | Extraction | Recharge | Net inflow | Change in storage | Sy | Recharge |
|-----------|---------|------------|--------------------|---------------------|---------------------|--------------------|------------------|
| | mm/y | ML/y | ML/y | ML/y | ML/y | | mm/y |
| 2010-11 | 0.0 | 16,500 | 0 | 16,500 ¹ | 0 | - | 0 |
| 2006-2009 | 0.15 | 33,893 | 0 | 16,500 | 17,400 ² | 0.097 ³ | 0 |
| 2011-2018 | 0.09 | 31,721 | 4,412 ⁴ | 16,500 | 10,800 | 0.1 | 3.7 ⁴ |

Table A3-2 Province 2 central region water balance 2006-2018

Notes:

1 Stable level, no recharge - lateral flow=extraction

2 No recharge, known decline, change in storage with constant inflow,

3 Sy = decline/change in storage

4 Recharge based on water balance using change in storage from Sy, and estimated area of 1201km² (SKM, 2007b)

The lateral outflow is low as the potentiometric surface is relatively flat to the west of the TLA G12 area. The specific yield (Sy) estimated above (~0.1) is consistent with previous work for the Tertiary Limestone Aquifer in Province 2. The estimated recharge of 4,400ML/y is low which reflects the low rainfall and depth to the water table and is consistent with the current policy to manage the resource as non-renewable. Most of the recharge between 2010 and 2018 is likely from the two significant above average rainfall events in 2016-17 and 2017-18 (Figure A2-4).

An estimate of the groundwater level trends based on two climate scenarios - "dry" (no recharge) and "average" (4mm/y recharge) and groundwater use (extrapolated up to the Permissible Annual Volume) is provided in Table A3-3.

| | | | | | | | |
|-----------------------|---------|--------|--------|--------|--------|--------|--------|
| Long term average use | ML/y | 16,500 | 26,500 | 29,000 | 31,721 | 33,893 | 50,000 |
| As % PAV | | 33% | 53% | 58% | 63% | 68% | 100% |
| Rainfall | Decline | | | | | | |
| Dry (<490mm/y) | mm/y | 0 | 83 | 100 | 130 | 145 | 280 |
| Average (~520mm/y) | mm/y | -37 | 50 | 70 | 90 | 110 | 240 |

Table A3-3 Observed and estimated groundwater level trends in the central region and estimated rate of decline, based on the water balance for 2010-19 for use up to the Permissible Annual Volume

Based on this work, stabilised groundwater levels since 2009-10 occurred when use was approximately 33-45% of the Permissible Annual Volume.

Significant uncertainties remain to this analysis, particularly the magnitude of the 'net' inflow and the potential for this to come from storage further to the east, affecting groundwater users east of the Designated Area, and the increased decline to the west of the Designated Area. This conceptual understanding may provide input to the revision of the numerical groundwater model previously developed.

Appendix 4

The Agreement

The objectives of the Agreement are to ensure:

- **No undue depletion of the resource**

The Agreement does not define undue depletion. The Review Committee applies the following principle:

“(to) ensure that the basic human needs of all are met (water for consumptive, domestic and stock purposes) and ecosystems dependent on groundwater, without compromising the ability of future generations to meet their own needs. That economic development (primarily groundwater for agricultural development) may proceed provided that basic human needs and needs of ecosystems are met. The Review Committee shall act to ensure that there is a program to conserve or improve groundwater resource condition and the economic base dependent on it.”

- **Equitable sharing of the resource**

“Equitable sharing” means the Review Committee will act to “to divide, portion or allocate the groundwater resources between the states and zones and to ensure consistency across the border.” In this context any management prescriptions reducing allocation should be consistent in relation to the proportional impacts use has on the shared resource.

The Review Committee could recommend to respective Ministers the proposed volume allocated to achieve the required groundwater trend or maximum depth to water table. If both Ministers agreed, each State would implement through their groundwater plans