South Australian – Victorian Border Groundwaters Agreement Review Committee

Management Review
Tertiary Limestone Aquifer
in Province 3 of the Designated Area

Melbourne and Adelaide

January 2010

Foreword

The Border Groundwaters Agreement (the Agreement) was established in 1985 to make provision to protect the groundwater resources adjacent to the South Australia and Victoria border 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. It is divided into 22 zones, 11 in each State. There are three hydrogeological provinces within two sedimentary basins: the Murray Basin to the north and the Otway Basin to the south. The basins are separated in the subsurface along a line between the Padthaway Ridge and the Dundas Plateau as shown in Figure 1.

There are two main aquifer systems comprising the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer. The Tertiary Limestone Aquifer is the principal source of groundwater for existing users. The use of the lower Tertiary Confined Sand Aquifer is generally limited to municipal supply. The Tertiary Limestone Aquifer is as described below:

> Province 1 occurs largely in the Otway Basin and is characterised by Quaternary calcareous sandstone overlying the Gambier Limestone forming one unconfined aquifer system (Figure 2);
>
> Province 2 is located in the Murray Basin where the Murray Group Limestone is unconfined and either outcrops at the surface, or is overlain directly by the Pliocene Sand Aquifer; and
>
> Province 3 is in an area of the Murray Basin where the Murray Group Limestone is confined by the Upper Tertiary Aquitard.

The Border Groundwaters Agreement Review Committee (the Committee) is required to review certain management prescriptions at periods not exceeding intervals of five years. The Committee advised the Ministers of the outcomes of that formal review of Province 3 in 2007 and advised that it would provide further discussion and advice on the significant management issues for this province.

This document consolidates the Committee's understanding of the resources and confirms that the status quo can continue for the time being. In preparing this review the Committee has relied on the report "Consolidated Technical Review of Province 3 of the Designated Area (SKM, January 2010)".

CONTENTS

1. Overview

Groundwater is the only source of water for domestic and stock, town supplies and irrigation in the region.

Province 3 has two prime regional groundwater aquifers with usable water quality, the Tertiary Limestone Aquifer and the underlying Tertiary Confined Sand Aquifer. The Tertiary Limestone Aquifer is the significant aquifer and is the subject of this paper. A brief description of the resource and principle features is found in Appendix A.

The primary objective for the current management arrangements for the groundwater resource of the Tertiary Limestone Aquifer is to provide a quantity of water for irrigation purposes whilst preserving the integrity of the resource for future essential purposes. It is the only water resource in the region suitable for these purposes.

2. Existing prescriptions

At the outset of the Agreement in 1985 the Permissible Annual Volumes for Zones 8B, 9A, 9B, 10A, 10B, 11A & 11B were set in common with all other zones. The Permissible Annual Volumes were based on vertical recharge, a proportion of throughflow and a small annual drawdown of storage of 0.05 m/yr based on the assumption that the aquifers were unconfined.

Investigations in South Australia in 1995 showed that the specific yield of 0.1 used previously for the Tertiary Limestone Aquifer was too conservative. A value of 0.15 was adopted and the Committee determined to increase the Permissible Annual Volume in Zone 10A from 6000 ML/yr to 9400 ML/yr and Zone 9A from 6000 to 11600 ML.

In 2001 the Committee recognised that the aquifer is confined and that the vertical recharge and throughflow of the aquifer were very low and should be taken as zero for water allocation purposes. The Committee revised is management approach and in doing so determined that:

- The primary objective for the management arrangements for the groundwater resource of the Tertiary Limestone Aquifer is to provide a quantity of water for irrigation purposes whilst preserving the integrity of the resource for future essential purposes. It is the only water resource in the region suitable for these purposes. Commercial uses of the resource had developed but the extent of the allocation for these purposes must be consistent with the primary objective for the resource.
- The Permissible Annual Volumes for the Tertiary Limestone Aquifer were amended based on utilising a small proportion of groundwater storage. The volume equivalent to a drawdown of storage under unconfined conditions of 0.05 m/yr for the area of useable resource (i.e. cleared land with groundwater salinity less than 3000 mg/L TDS). The rate of extraction does not significantly diminish the resource given that the aquifer is thick (approximately 100m);
- In Zones 11A, 10A, 9A and 9B allocations had already been made, within the then existing Permissible Annual Volumes, which exceeded the volume calculated under the revised prescription. In these cases the Permissible

Annual Volumes were set to meet the existing commitment. The Committee recommended that the licensing agencies meter extractions and monitor the levels of groundwater drawdown and quality to determine whether the Permissible Annual Volumes needed to be reduced. In that event licensed volumes would have had to be reduced.

The calculations and volumes derived from this management prescription in 2001 are detailed in Appendix B. Table 1 details the Permissible Annual Volumes and allocation for the Tertiary Limestone Aquifer in each zone at 30 June 2009.

South Australia is undertaking a program to convert the current area based water licences for irrigation to volumetric entitlements. The current area unit of groundwater irrigation entitlement is the Irrigation Equivalent (IE). At the time of implementing formal management of groundwater irrigation in the Mallee Prescribed Wells Area, an IE was considered to be the net amount of water required to provide all crop water needs above annual rainfall for a theoretical crop. To enable the irrigation of a range of crops within the IE groundwater allocation, crop area equivalents for alternative crops were established.

An element of the volumetric conversion process, the foundation data for the IE system was technically reviewed with respect to its relevance to climate and seasonality. This resulted in a finding that there was deficit in the foundation volume of water embodied in an IE. As part of the volumetric conversion process, there is an expectation that irrigators, within reason, will be able to continue the utilisation of dedicated equipment purchases. The outcome is that in Zone 10A, the proposed aggregate volumetric entitlement is greater than the Permissible Annual Volume for that Zone.

Table 1 Permissible Annual Volumes and allocated volumes for the Tertiary Limestone Aquifer at June 2009

South Australia				**Victoria**			
Tertiary Limestone Aquifer			Zone	Zone	Tertiary Limestone Aquifer		
Permissible Annual Volume (ML/yr)	Licensed Allocations				Permissible Annual Volume (ML/yr)	Licensed Allocations	
	No. of Licences	Volume Allocated (ML)				No. of Licences	Volume Allocated (ML)
6861	17	6627	11A	11B	1823	3	1600
9400	43	9251	10A	10B	6720	23	6358
11595	13	10230	9A*	9B	5960	3	5000
				8B*	6760	7	2538

Note: * Zones 9A and 8B include the unconfined and confined portions of the Tertiary Limestone Aquifer. The unconfined portions were considered in the management review of Province 2 (BGARC 2007). Arising from this review the Committee determined to divide Zone 9A into two sub-zones, one north of the Ngarkat Conservation Park (Sub Zone 9A North) and the other south of the Park (Sub-zone 9A South). An Allowable Annual Volume was set for Sub-zone 9A South at current commitment 7760ML. The Permissible Annual Volume for Zone 8A was reduced to the level of commitment at the time (3500ML). The revised Permissible Annual Volumes take affect on the date they are published in the Government Gazette. The Permissible Annual Volume for Zone 8B was published in the Government Gazette on 15 October 2009. The Allowable Annual Volume for Sub-zone 9A South has not yet been published.

3. Behaviour under existing arrangements

Groundwater volumes extracted

Table 2 details the Permissible Annual Volumes and the volumes extracted since meters were installed on bores. Meters records are available since 2002 in Victoria band 2006 in South Australia. The distribution of allocations in the Zones 10A, 10B 11A and 11B is illustrated in Figures 3 and 4.

Table 2 Permissible Annual Volumes and metered use for the Tertiary Limestone Aquifer from June 2001 to June 2009

Zone	Permissible Annual Volume	Volume extracted (ML)							
		To June 2002	To June 2003	To June 2004	To June 2005	To June 2006	To June 2007	To June 2008	To June 2009
11A	6861	NA	NA	NA	NA	3322	3243	3575	4256
10A	9400	NA	NA	NA	NA	13470	14149	12172	9458
Sub zone 9A North		NA	NA	NA	NA	NA	NA	1436	1927
11B	1823	2515	3378	4868	547	342	225	1062	872
10B	6720				4088	2524	4819	4904	5270
9B	5960	NA	NA	NA	1285	615	1285	630	1332
8B	6760	NA	NA	NA	1829	1994	2218	857	1345

Extraction in Zone 10A has exceeded the Permissible Annual Volume for the zone over a number of years. The total volume extracted in the South Australian portion of Province 3 is less than the total of the Permissible Annual Volumes for the South Australian portion of Province 3.

Groundwater level trends

The Tertiary Limestone Aquifer is confined in Province 3 and is distant from recharge areas. Consequently the aquifer does not respond to seasonal recharge from rainfall. The aquifer response to extraction is that of a confined aquifer.

Groundwater levels have declined and a cone of depression has formed in the region centred at Peebinga which is an area of concentrated irrigation development. The recovered drawdown in Spring 2009 is approximately 9m below initial water levels before the resource was developed for irrigation in the late 1990s. The drawdown is attributed to the intensity of groundwater extraction in the area. The drawdowns are up to 5m deeper that was expected in the 2001 model.

The cone of depression of groundwater levels is continuing to decline, indicating that the system is yet to reach equilibrium (see representative hydrographs in Figure 5). Domestic and stock bores/pumps may be impacted if declines continue. Continued decline may also change the relative balance of interaquifer flows.

Away from areas of concentrated activity the groundwater level trends are stable as there is negligible groundwater extraction either because the groundwater quality is unsuitable or due to land use (e.g. National Parks – Sunset and Big Desert).

A comparison of the observed water level trends with the trends predicted in the numerical model in 2001 indicates that under the current use regime the observed trends are similar to those predicted.

Groundwater salinity trends

There are no discernible salinity trends in Province 3. There is no perceived risk of salinisation of the Tertiary Limestone Aquifer in the short to medium term.

4. Way forward

Overall the Tertiary Limestone Aquifer appears to have responded acceptably to the level of use in terms of drawdowns and salinity.

The full response of the aquifer is yet to be realised as groundwater extraction in Victoria has been less than Permissible Annual Volume. Further drawdowns in groundwater levels are expected as groundwater extractions increase.

Schemes are in place in both South Australia and Victoria to ensure people relying on groundwater bores for domestic and stock purposes can still access the resource. The impacts on domestic and stock bores need to continue to be managed by the States.

There is no immediate risk of increased groundwater salinity due to the lateral movement of saline groundwater or the vertical of leakage of saline water from the Pliocene Sands Aquifer. There is a need to continue to monitor.

There are no environmental assets or ecosystems associated with the confined aquifer which are compromised by the volumes being extracted under these management arrangements.

There is potential for localised “hot spots” of drawdown, which could increase the impact on domestic and stock users, or increase the risks of dewatering the aquifer or accelerating water quality change. It is recommended that States implement measures to prevent uncontrolled localised drawdowns arising from intense groundwater extraction.

The volumes able to be taken over the next 5 to 10 years will not compromise the quality and availability of this resource.

No amendments are required to the management prescriptions.

5. Recommendations for further technical work

Monitoring

Consideration should be given to enhancing the observation bore network with a bore or bores in the Sunset Country in the south west part of Zone 11B otherwise the water level and salinity monitoring networks are sufficient. Monitoring of extractions, water levels and quality should continue.

Groundwater modelling

The numerical groundwater flow model for the combined Mallee Prescribed Wells Area and Murrayville Water Supply Protection Area was revised in 2006 (DWLBC 2006) and was based on a new conceptualisation of the hydrogeology. The revised conceptualisation is dependent on the lithology of one bore on the border. As such, the model may need to be re-calibrated and updated over time as more data become available.

References

Barnett S. R. & Yan W. (2000). Mallee Region Groundwater Modelling Report No. 1. Report Book 2000/000004

Border Groundwaters Agreement Review Committee (2001a). *Five Year Technical Review 1996 – 2000.*

Border Groundwaters Agreement Review Committee (2001b). *Five Year Management Review Report 1996 – 2000.*

Border Groundwaters Agreement Review Committee (2007). Management Review Report – Tertiary Limestone Aquifer in Province 2 – December 2007.

Department of Water, Land and Biodiversity Conservation (2006) *Mallee PWA – Murrayville WSPA Groundwater Model*. Prepared by K. Osei-Bonsu and S. Barnett. Report 2006/27.

SKM (2009). *Consolidated Technical Review of Province 3 of the Designated Area.* Report prepared by Sinclair Knight Merz for the Border Groundwaters Agreement Review Committee (South Australia – Victoria).

Figures

Figure 1 The Designated Area and zones

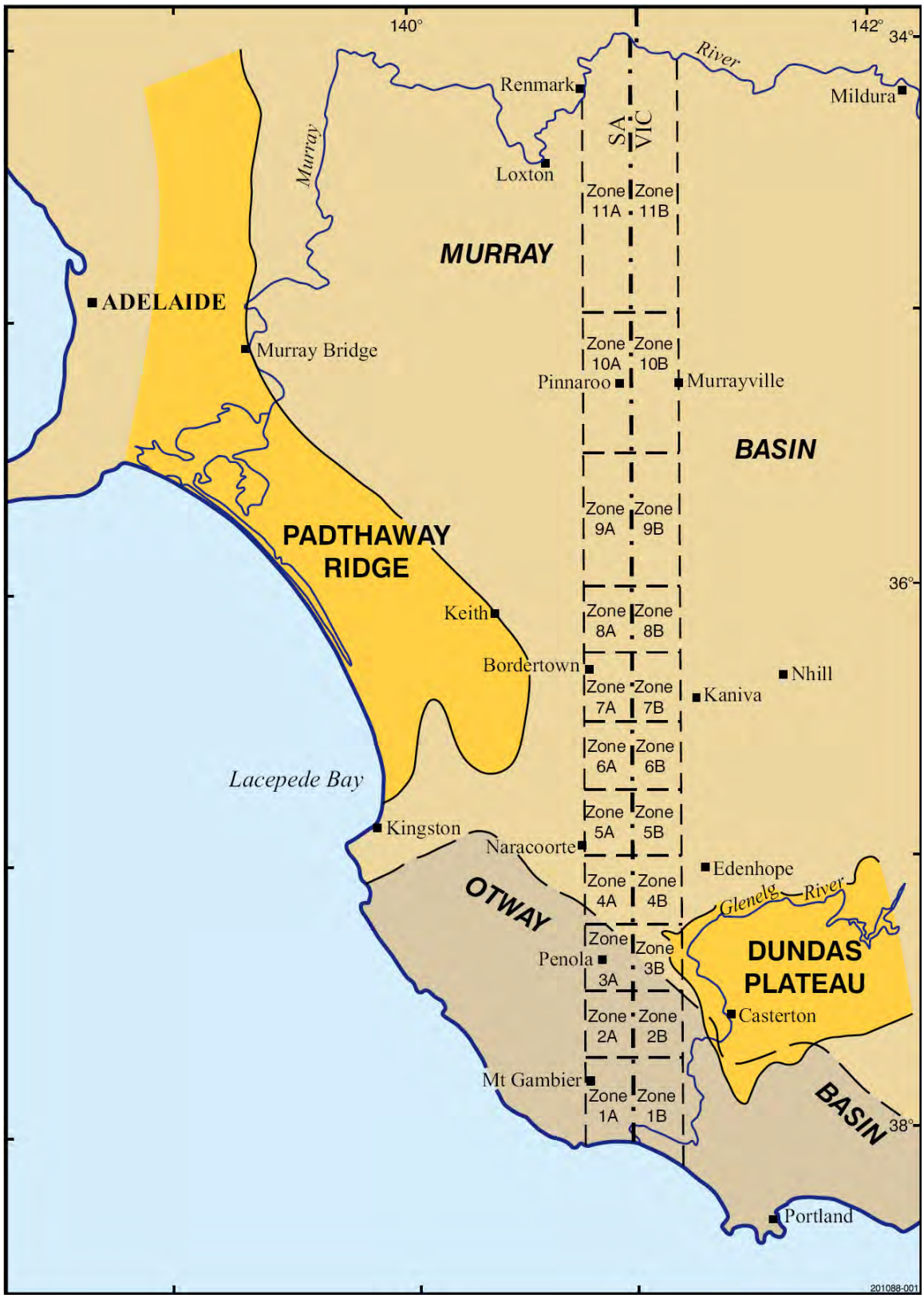


Figure 2 Hydrogeological provinces

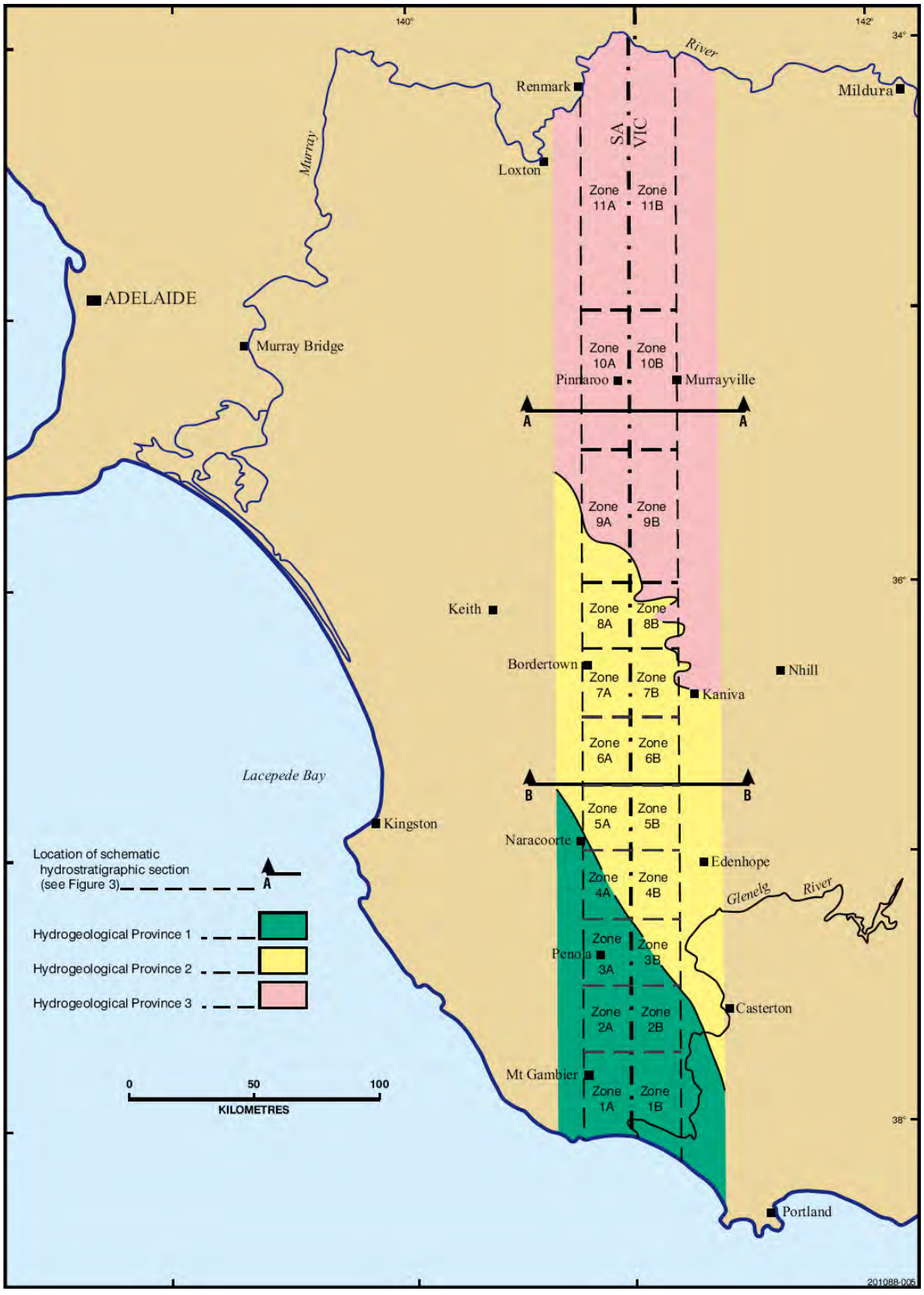


Figure 3 Groundwater allocation, land use & hydrograph groupings Zones 10A & 11A

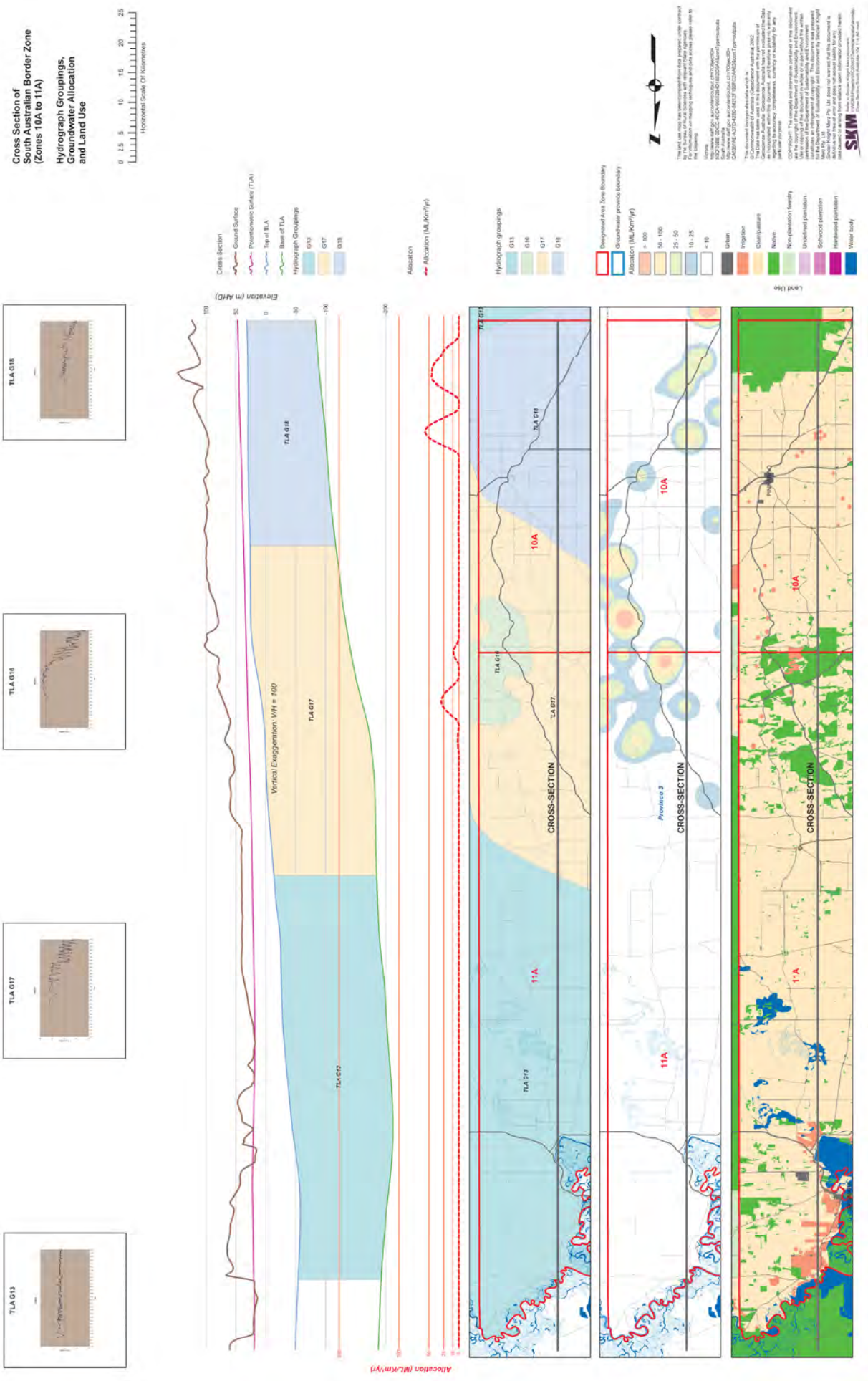
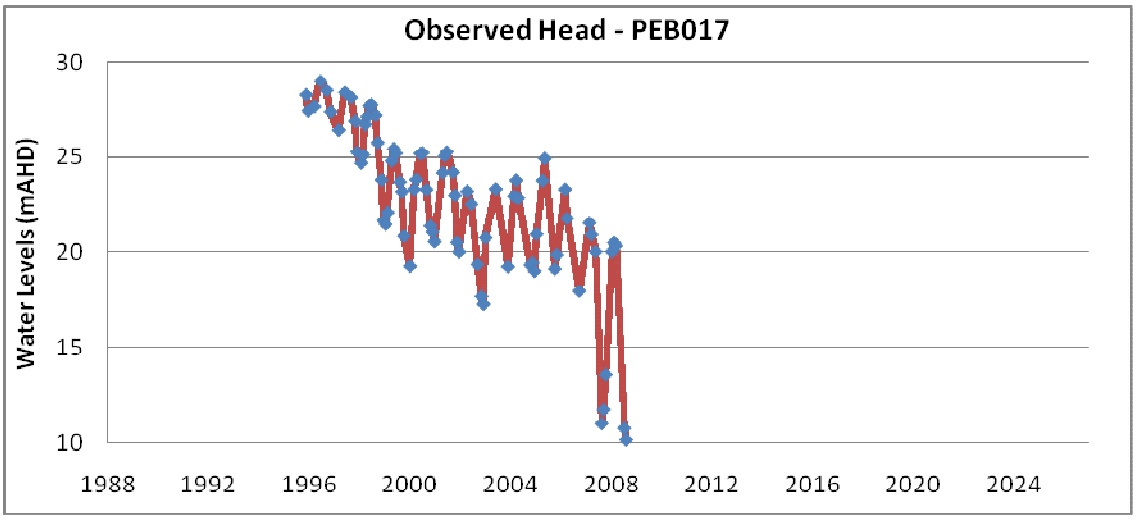
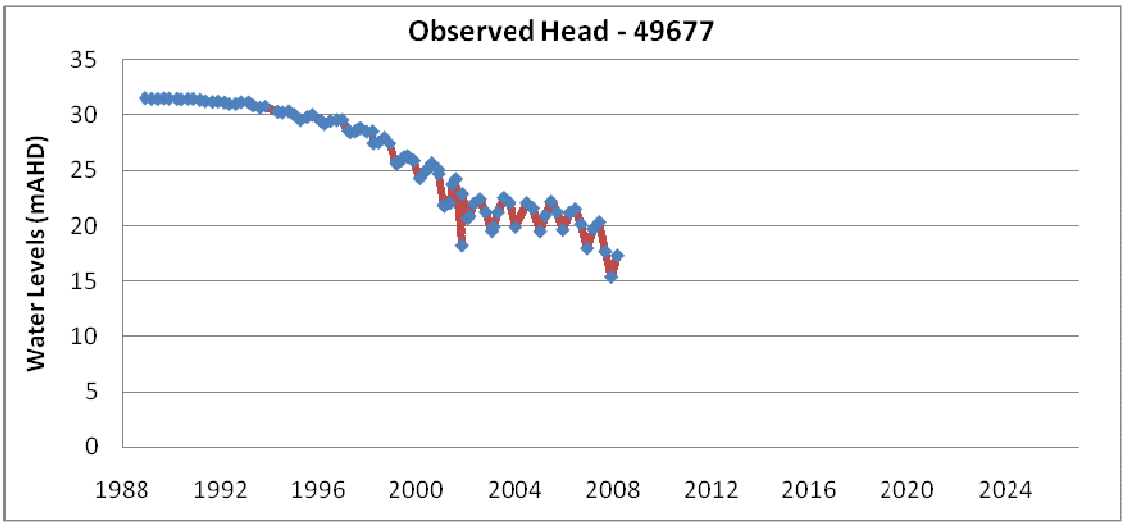


Figure 4 Groundwater allocation, land use & hydrograph groupings Zones 10B & 11B

Figure 5 Hydrographs





Appendix A - Description of the resource

Province 3 is located in the Mallee region of the Murray Basin in South Australia and Victoria. There are five main hydrogeological units (aquifers and confining layers). The units are, in order of increasing depth below the surface:

- the **Pliocene Sands Aquifer**; generally an unconfined aquifer which is saturated on the east in Victoria. The unit comprises unconsolidated to weakly cemented fine to course sand and is generally 50m in thickness. The groundwater gradients are low (0.0001) and in the general direction towards the north. Groundwater salinity ranges between 1000mg/L TDS to 35000mg/L TDS;

- the **Upper Tertiary Aquitard**, consisting the Bookpurnong Beds, this boundary of this unit defines the boundary between Province 2 and Province 3. The unit dips gradually to the east and increases in thickness. It is a low permeability unit between the Pliocene Sands Aquifer and the underlying Tertiary Limestone Aquifer. It comprises poorly consolidated plastic silts, clays and sands up to 30m in thickness.

- the **Tertiary Limestone Aquifer**, consisting the Murray Group Limestone in the Murray Basin: occurs as a confined aquifer in Province 3. It comprises a consolidated, highly fossiliferous, fine to coarse bioclastic limestone. The thickness is of the unit is generally 100m. Groundwater gradients are low (0.0001) in the north west direction. Salinity of the groundwater ranges from 500mg/L TDS to 3000mg/L TDS.

- the **Lower Tertiary Aquitard**, consisting the Ettrick Formation: occurs between the Murray Group Limestone and the underlying Tertiary Confined Sand Aquifer. The unit is around 15m in thickness and comprises a glauconitic marl and clay;

- the **Tertiary Confined Sand Aquifer**, consisting the Renmark Group a confined aquifer underlying the Lower Tertiary Aquitard. The unit comprises unconsolidated carbonaceous sands, silts and clay around 150m in thickness. Groundwater gradients are low in the direction north-west and west. The salinity of the groundwater ranges from 500mg/L TDS to 3000mg/L TDS.

Appendix B - Revised management prescription calculations, 2001

(Based on source: Border Groundwaters Review Committee minutes March 2001)

Vertical recharge and throughflow are very low and have been taken to be negligible for the setting of the Permissible Annual Volume. The Permissible Annual Volume is therefore based on the following relationship:

> Permissible Annual Volume = Proportion of Groundwater Storage (Volume equivalent to a drawdown of storage under unconfined conditions of 0.05m/year)

The zones have been subdivided into sub-zones[1] based on the criteria:

(a) land in public ownership reserved as parks from which groundwater will not be extracted, and
(b) private land separated as to the likely usable water quality taken as 3000mg/L TDS.

As the water in storage beneath areas of native vegetation is not directly assessable and drawdown associated with extractions will extend into these areas a portion of this water in storage has been included in the Permissible Annual Volume for the neighbouring sub-area. The approach will not adversely impact on the areas of native vegetation, as they are not dependent on the groundwater in the Tertiary Limestone Aquifer.

The Tertiary Limestone Aquifer is confined in the Designated Area in Zones 11A, 11B, 10A and 10B, and in parts of Zones 9A, 9B and 8B. The revised management prescription provides for a volume of water to be extracted which is equivalent to that which would be available from reduction in storage of 0.05m/year if the aquifer were unconfined. This prescription has been divide up into sub-zones based on suitable water quality and areas of native vegetation.

It is recognised that where the aquifer is confined the actual drawdowns will be substantially greater than would occur if the aquifer were unconfined. The principle concern that might occur here is the loss of water in existing stock and domestic bores.

In the northern parts of Zones 11A and 11B the water quality exceeds 3000mg/L TDS which is generally taken as being too saline for irrigation use. The Permissible Annual Volumes for these portions of the zones have been set at zero. The Committee recognizes that there will always be a potential for an alternative use for this water, perhaps associated with an extractive industry. In the event that such a proposal is advanced the Committee is prepared to consider the proposal and the Permissible Annual Volume taking into account criteria appropriate to the proposal.

In Zones 11A south,10A, 9A north & south and 9B the existing commitments made within the framework of the framework of the existing Permissible Annual Volumes, exceeds the computed volumes using the new prescription. The Committee in recognition that these allocations were made correctly is to set the new Permissible Annual Volumes in these cases to the volumes that equal the commitment. In doing so the

[1] "Sub-zones" means part of a zone for the purpose of reviewing the Permissible Annual Volumes. None of these areas were declared sub-zones in 2001.

Committee encourages the licensing agencies to arrange metering of extractions and the monitoring of the drawdowns as a high priority within these sub-zones to evaluate the longer term viability of these extraction levels.

Figure A1 shows the location of the zones, sub-zones and elements used in determining the calculations. Table A1 shows the calculated volumes. Table A2 details the calculated volumes and the commitments as at March 2001. The details for each zone are explained below.

Zone 8B

Zone 8B has been divided into two sub-zones:

- 8B confined
- 8B unconfined

Sub-zone 8B confined comprises generally the northern and eastern portions of the zone, the calculated volume of which is 1558ML/a.

Sub-zone 8B unconfined comprises generally the western and southern portions of the zone, the calculated volume of which is 5202ML/a.

Zone 9A

Zone 9A has been divided into sub-zones as follows:-

- 9A North
- 9A (South and central confined) and,
- 9A south unconfined.

Sub – Zone 9A North is the cleared portion in the north which has a calculated volume of 470ML/a. The existing commitment for this sub-zone is 3835ML/a. The Permissible Annual Volume will be set at 3835ML/a.

Sub – Zone 9A (South and Central Confined) covers the portion of the native vegetation adjacent to the cleared southern portion of the zone in the Hundred of Shaugh which is confined. The area of Hundred of Shaugh within Zone 9A which is unconfined is included in the PAV for a sub – area covering both unconfined and confined portions. The computed volume for these areas is 6495ML/a.

The existing commitment for this sub-zone is 7760ML/a. The Permissible Annual Volume will be set at 7760ML/a.

Zone 9B

The major portion of this zone is covered by native vegetation. A management sub area which is confined has been defined as 9B South. The computed volume is 2539 ML/a.

The existing commitment for this sub-zone 5960ML/a. The Permissible Annual Volume will be set at 5960ML/a.

Zone 10A

Zone 10A is confined with small portions of the zones covered by native vegetation. The computed volume is 7844 ML/a.

The existing commitment for this sub-zone is 9400ML/a. The Permissible Annual Volume will be set at 9400ML/a.

Zone 10B

Zone 10B is confined with small portions of the zones covered by native vegetation. The revised management prescription specifies an increased Permissible Annual Volume for Zone 10B from 6000 to 6720 ML/a. This is due to the adoption of a revised specific yield of 0.15 as opposed to 0.10 that has been previously adopted for Zone 10B.

Zone 11A

Zone 11A is confined with the northern portion of the zone having a water quality in excess of 3000mg/l. Zone 11A has been divided into two sub-zones.

Sub Zone 11A North - The computed volume for this sub – zone of poor water quality exceeding 3000 mg/l TDS is 11,932ML/a. The volume will be set at zero for this sub-zone.

Sub Zone 11A south - The revised management prescriptions specifies a reduced PAV for the useable quality water even after the adjustment has been made for increasing the specific yield from 0.1 to 0.15. The computed volume is 5632ML/a, whilst the commitment is 6861ML/a.

The existing commitment is 6861ML/a. The Permissible Annual Volume will be set at 6861ML/a.

Zone 11B

Zone 11B is confined with the majority of the zone covered by native vegetation and with a water quality in excess of 3000mg/l TDS. Zone 11B has been divided into three sub-zones.

Two sub- zones are in the north, 11B North and 11B North East where the computed volumes are 1914 ML/a and 1814 ML/a respectively. In both of these areas the water quality is in excess of 3000mg/l TDS and therefore the volume assigned will be zero.

The southern portion of the zone, sub zone 11B South, has a water quality less than 3000 mg/l. The computed volume for this sub- zone is 1823 ML/a.

The Permissible Annual Volume for this zone will be set at 1823ML/a.

Figure A1 Province 3 Revised Management Prescription 2001 – Zones and sub-zones

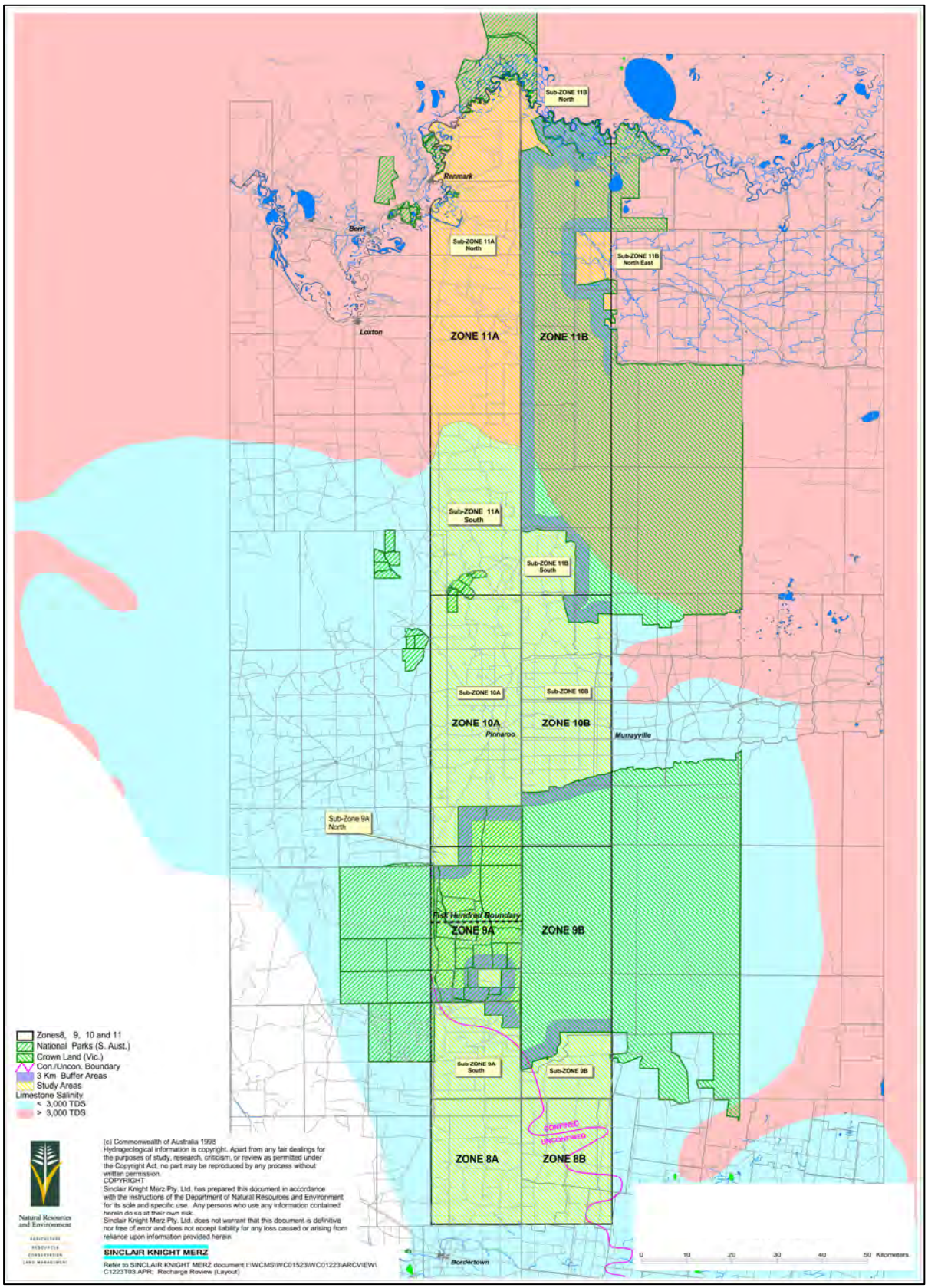


Table A1 Calculated volumes

Zones and Sub - Zones	Sub-Areas of Zones and Sub-Zones	Sub-Zone Area <3000 mg/L km^2	Sub-Zone Area >3000 mg/L km^2	Area 3km Into Park km^2	Total Area km^2	Current Zone PAV ML/yr	Confined Volume of Sub-Zone Sy = 0.15 ML/yr	Confined Volume 3km into Park Sy = 0.15 ML/yr	Total Confined Volume ML/yr	Unconfined Recharge Rate mm/yr	Unconfined Volume ML/yr	Total Zone/ Sub-Zone Volume ML/yr
Zone 11A					2146.00	12000.00						
Sub-Zone 11A North			1421.70	169.25	1590.95		10662.75	1269.38	11932.13			**11932.13**
Sub-Zone 11A South		707.60		43.30	750.90		5307.00	324.75	5631.75			**5631.75**
Zone 11B					2115.00	12000.00						
Sub-Zone 11B North			163.72	91.42	255.14		1227.90	685.65	1913.55			**1913.55**
Sub-Zone 11B North-East			102.43	139.39	241.82		768.23	1045.43	1813.65			**1813.65**
Sub-Zone 11B South		168.79		74.30	243.09		1265.93	557.25	1823.18			**1823.18**
Zone 10A					1110.00	9400.00						
Sub-Zone 10A		986.73		59.10	1045.83		7400.48	443.25	7843.73			**7843.73**
Zone 10B					1110.00	6000.00						
Sub-Zone 10B		789.20		106.90	896.10		5919.00	801.75	6720.75			**6720.75**
Zone 9A					1110.00	11600.00						
Sub-Zone 9A North		24.85		37.80	62.65		186.38	283.50	469.88			**469.88**
Sub-Zone 9A South	9A South (Confined)	89.97		136.93	226.90		674.78	1026.98	1701.75			
	9A South (Unconfined)	319.60			319.60					15	4794	**6495.75**
Zone 9B					1110.00	6000.00						
Sub-Zone 9B South	9B South (Confined)	221.24		68.75	289.99		1659.30	515.63	2174.93			
	9B South (Unconfined)	24.30			24.30					15	364.5	**2539.43**
Zone 8B					555.00	3500.00						
	8B (Confined)	207.76			207.76		1558.20		1558.20			
	8B (Unconfined - 1)	334.83			334.83					15	5022.45	
	8B (Unconfined - 2)	12.00			12.00					12	180	**6760.65**

Notes:

Volume calculation (ML/yr) for confined areas is - Area (km^2) x 0.15 x 0.05 x1000

Volume calculation (ML/yr) for unconfined areas is - Area (km^2) x recharge rate in meters x1000

The two sub-areas of 8B (unconfined) relate to areas of different land use with different vertical recharge rates

Table A2 Comparison of calculated volumes and commitment

Sub-zone	Calculated volume ML/a	Commitment ML/a (March 2001)
Sub-zone11A North	11,932*	0
Sub-zone11A South	5632	6861
Sub-zone11B North	1914*	0
Sub-zone11B North East	1814*	0
Sub-zone11B South	1823	0
Sub-zone 10A	7844	9400
Sub-zone 10B	6720	3663
Sub-zone 9A North	470	3835
Sub-zone 9A South	6495	7760
Sub-zone 9B South	2540	5960
Sub-zone 8B	6760	2930

* In these Sub-zones the water quality is greater 3,000mg/lL TDS.