SA/VIC Border Groundwaters Review Committee

FIVE YEAR MANAGEMENT REVIEW 1996 – 2000

October 2001

ISSN 1446-1080

Contents

List of Tables

List of Figures

1. Executive Summary

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 centered on the border and extending for its full length. This Designated Area is divided into 22 zones, 11 in each State. See Figure 1.

As part of the Agreement the Committee is required to review certain management prescriptions at periods not exceeding intervals of five years. This review consolidates the Committee's views in respect of the Permissible Annual Volumes, permissible distance and permissible rate of potentiometric surface lowering. There is some comment with respect to salinity and other emerging issues effecting the management of the groundwater resources adjacent to the border. Some recommendations relating to the amendment of the Act as provided for within the Agreement are also documented.

1.1 Review of Permissible Annual Volumes

Under the Agreement the term Permissible Annual Volume can only be applied to a whole zone of the Designated Area. Each zone may only have a single Permissible Annual Volume. This is a deficiency in the Agreement as there are cases where it would be useful to divide a zone into sub zones and apply a Permissible Annual Volume to each sub zone. Likewise there should be provision to set separate Permissible Annual Volumes for each aquifer which are clearly separated from each other such as is the case with the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer. For the time being, the term 'allowable annual volume' is being used for the individual volumes that can be extracted from each aquifer with the sum of these volumes going to form the Permissible Annual Volume for the particular zone.

1.1.1 Tertiary Limestone Aquifer - Unconfined Areas

The allowable annual volume for the Tertiary Limestone Aquifer has been set so as not to exceed vertical recharge. The throughflow is maintained to provide flushing for salinity management. This continues to be the basis for the determination of the allowable annual volume in those zones where the aquifer is unconfined.

Originally the Permissible Annual Volumes for the unconfined portion of the Tertiary Limestone Aquifer were based on a uniform rate of vertical recharge excluding areas of forest and native vegetation. A detailed assessment of the vertical recharge was made for these zones in the 1990-1995 management review by considering the hydrographic response of the aquifer according to the spatial variation in vegetation type, land use, depth to water table and soil type.

In the Five Year Technical Review 1996-2000 it is stated that there are sufficient salinity concerns to warrant holding the allowable annual volume for Zones 8A, 7A, 6A, 5A, 4A, 4B, 3A, 2A & 2B at their present levels.

North of Zones 2A & 2B there are increasing salinity trends. These increases are of concern and should be further investigated. These increases in salinity levels are likely to be due to

either irrigation recycling or vegetation clearance with the resulting mobilisation of salt caused by an increase in vertical recharge.

The areas of concern with respect to salinity within the zones of concern need to be identified and monitoring funding should be focussed there, with a view to having better data to justify or otherwise the retention of the allowable annual volumes at levels less than those obtained under the management prescription.

1.1.2 Tertiary Limestone Aquifer – Confined Areas

The original Permissible Annual Volumes for Zones 8B, 9A, 9B, 10A, 10B, 11A & 11B were set in accordance with the original prescription relating to the Tertiary Limestone Aquifer in this area. These included vertical recharge, a proportion of throughflow and a small annual drawdown of storage of 0.05 m/a. Based on further technical investigations completed by 1990, the hydrogeological conditions were known to vary significantly from zone to zone and the Permissible Annual Volumes were set on an individual basis.

In 1995 investigations in South Australia 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 which resulted in an increase in the Permissible Annual Volume in Zone 10A from 6000 ML/a to 9400 ML/a.

The current understanding of the aquifer's behaviour is that vertical recharge and throughflow are very low and have been taken to be zero in setting the Permissible Annual Volume. The allowable annual volume of extraction for the Tertiary Limestone Aquifer is therefore based on the following relationship:

Allowable annual volume = Proportion of Groundwater Storage[1]

Determination - Allowable Annual Volumes for Sub zones (Tertiary Limestone Aquifer)			
Sub zone	**Calculated volume ML/a**	**Commitment ML/a**	**Allowable Annual Volume ML/a**
Sub zone11A North	11,932*	0	0
Sub zone11A South	5632	6861	6861
Sub zone11B North	1914*	0	0
Sub zone11B North East	1814*	0	0
Sub zone11B South	1823	0	1823
Sub zone 10A	7844	9400	9400
Sub zone 10B	6720	3663	6720
Sub zone 9A North	470	3835	3835
Sub zone 9A South	6496	7760	7760
Sub zone 9B South	2540	5960	5950
Sub zone 8B	6760	2210	6760
* In these sub zones the water quality is greater 3,000 mg/l TDS.			

[1] The current position is that where the Tertiary Limestone Aquifer is confined the vertical recharge and the throughflow are very low and have been taken to be nil for the setting of the Permissible Annual Volume. The allowable annual volume of extraction for the confined areas of the Tertiary Limestone Aquifer is therefore based on the following relationship: Allowable annual volume = Proportion of Groundwater Storage the volume being equivalent to a drawdown of storage under unconfined conditions of 0.05 m/a

1.1.3 Existing Commitments

The allowable annual volumes in Zones 11A, 10A, 9A, 6B & 5B are set at levels to meet existing commitments, which exceed those computed under the revised management prescription. These commitments were made under the Permissible Annual Volume set at the time. In these zones, the licensing agencies need to meter extractions, monitor the levels of drawdown and groundwater quality over the next five year period to determine whether the allowable annual volume should be reduced to the calculated volume. This would have the effect of reducing licence volumes accordingly.

1.1.4 Tertiary Confined Sand Aquifer

Management of the groundwater resources within the Designated Area has to date concentrated on the Tertiary Limestone Aquifer, given the very low level of use of the Tertiary Confined Sand Aquifer. Over the last few years there has been an increased level of interest for individual allocations from the Tertiary Confined Sand Aquifer due to the full allocation of the Permissible Annual Volumes in some zones.

Due to the regional nature of the Tertiary Confined Sand Aquifer and its hydraulic behaviour, it was considered that the determination of the allowable annual volume needed to focus on the whole aquifer system. See Figure 4.

A number of factors are critical in arriving at a management prescription for this aquifer. These are:

- the need to ensure that there is no reversal in the potentiometric levels between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer, which could result in more saline water from the Tertiary Limestone Aquifer adversely effecting the water quality in the Tertiary Confined Sand Aquifer through downward leakage
- computer modelling indicated that there could be a substantial increase in the leakage from the Tertiary Limestone Aquifer following increased extractions from the Tertiary Confined Sand Aquifer. This would have the potential to cause a change in the water balance of the Tertiary Limestone Aquifer resulting in a water level decline in this aquifer as well.
- the increased use of groundwater from the Tertiary Confined Sand Aquifer for irrigation purposes also has the potential to increase the salt accessions to the Tertiary Limestone Aquifer, which could result in adverse water quality deterioration in this aquifer.
- an increase in extractions could reduce discharge with adverse environmental impacts particularly in relation to the marine discharges. Such impacts are difficult to assess given the lack of present understanding of these processes.
- water level decline in response to pumping and to provide existing groundwater users with sufficient time to make changes to pumping infrastructure.
- management areas outside the Designated Area are based on hydraulic flow paths through the aquifer, water quality variations and areas of concentrated usage such as the proposed Kingston Management Area.

The Committee has adopted a precautionary approach to the specification of Allowable Annual Volumes for the Tertiary Confined Sand Aquifer. It has considered the current limited technical understanding of the resource and advice received from the South East Catchment Water Management Board regarding the use of the aquifer and acceptable levels of potentiometric level lowering following consultation with stakeholders in South Australia. The Board advised that declines in potentiometric levels of up to two to four metres across the aquifer would only be acceptable at this time.

Taking the above factors into account the Committee has determined that the management prescription for the Tertiary Confined Sand Aquifer should be as follows: -

Zones	Management Prescription for Allowable Annual Volume
All Designated Area Zones except 3B&4B	= 50% x (0.75 x Throughflow Volume)
Designated Area Zones 3B&4B	= (0.25 x Throughflow Volume)
Zones outside Designated Area except Kingston	= 50% x (0.75 x Throughflow Volume)
Kingston Zone	=25,000 ML/year

The 50% provides for the acceptable regional declines in potentiometric levels of two to four metres as advised by the South East Catchment Water Management Board.

Management areas are recommended for adoption by each of the States outside the Designated Area to provide a consistent approach in the development of this aquifer based on its characteristics. It is recognised that these management boundaries do not coincide with existing management boundaries associated with the Tertiary Limestone Aquifer outside the Designated Area, but nevertheless are recommended for the effective management of the Tertiary Confined Sand Aquifer. (More detailed discussion on these matters is in the body of this review).

Recommendation – Suggested annual volumes for the management areas for the Tertiary Confined Sand Aquifer outside the Designated Area.

That the management areas for the Tertiary Confined Sand Aquifer outside the designated area be those shown in Figure 4. The allowable annual volumes are limited to those suggested in Table 1.

■ **Table 1 - Suggested allowable annual volumes of extraction for the Tertiary Confined Sand Aquifer for Management Areas outside the Designated Area**

South Australian Management Area	Suggested allowable annual volumes of extraction (ML/a)	Victorian Management Area	Suggested allowable annual volumes of extraction (ML/a)
Copeville	940	Dartmoor	18,600
Karoonda	1500	Goroke	2200
Keith	2500	Kaniva	1100
Kingston	25,000	Little Desert	1100
Lameroo	1200	Nhill	1200
Millicent	10,800		
Mindarie	780		
Monbulla	3900		
Naracoorte	3600		
Wirrega	960		

Notes:

1. Where the volume is less than 1000ML, the suggested annual volume has been rounded upwards to the nearest 10ML.
2. Where the volume is greater than 1000ML, the suggested annual volume has been rounded upwards to the nearest 100ML.

1.1.5 Summary

The following Table summarises the position with respect to all zones of all the recommendations that are agreed to.

Permissible Annual Volumes

Determination - Permissible Annual Volumes			
Zone	**Allowable annual volume for Tertiary Confined Sand Aquifer ML/a**	**Allowable annual volume for Tertiary Limestone Aquifer ML/a**	**Permissible Annual Volume ML/a**
11A	0	6861*	6861
11B	0	1823	1823
10A	320	9400*	9720
10B	560	6720	7280
9A	570	11,595*	12,165
9B	630	5960*	6590
8A	340	7700	8040
8B	330	6760	7090
7A	350	7500	7850
7B	350	6600	6950
6A	360	8850	9210
6B	360	9838*	10,198
5A	540	18,500	19,040
5B	570	11,949*	12,519
4A	710	20,000	20,710
4B	300	14,000	14,300
3A	1900	24,000	25,900
3B	1100	16,500	17,500
2A	2900	25,000	27,900
2B	5100	25,000	30,100
1A	9200	30,900	40,100
1B	14,500	45,720	60,220
Note: * These volumes exceed those derived from the application of the revised management prescription and are set to equal the existing commitments made under a previous permissible annual volume of extraction			

1.1.6 Sub zones

In the course of developing these allowable volumes of extraction it has become evident that different circumstances can apply within portions of a zone. These factors are the boundary between the confined and unconfined portions of an aquifer, the areas where the water quality is too poor for productive (irrigation) use, or those areas of national park/forest where groundwater will not be used and to avoid areas of intense allocation and use within a zone, such as in Zones 3A & 6B. For these reasons there is a case to alter the Agreement to provide for sub zones.

Recommendation. – Sub zones

That the Act be amended to provide for sub zones.

1.2 Permissible Distance

The permissible distance is the distance from the border within which all applications must be forwarded to the Committee for approval. To date this has been set at 1 km for all zones. The Committee determines this distance. The Agreement only provides for a single distance to be set for any one zone. It does not allow for separate permissible distances to be set for each individual aquifer.

The radius of interference between pumping bores is greater in a confined aquifer than in an unconfined one for a given discharge.

A permissible distance of 3 km has been adopted in Zones 10A, 10B, 11A & 11B following review of the management prescription for the allowable annual volumes and the confined nature of the Tertiary Limestone Aquifer in these zones.

The permissible distance at 1 km has been retained in all the zones south of Zones 10A &10B. As the Agreement only provides for one permissible distance for a zone the States have been requested to administer any applications in relation to the Tertiary Confined Sand Aquifer as if the permissible distance were 3 km.

Recommendation – Permissible Distance for the Tertiary Confined Sand Aquifer

That as the Agreement only provides for one permissible distance for a zone that the states administer any application with respect to the Tertiary Confined Sand Aquifer as if the permissible distance were three kilometres.

Determination - Permissible Distance
It is recommended that:

I) the Committee sets the permissible distance at three kilometres for Zones 10A, 10B, 11A and11B,

II) the gazettal take effect from a common date with the revision of Permissible Annual Volumes and the revised permissible rate of potentiometric surface lowering ,

III) the need for the Act to be changed to allow for permissible distance to be aquifer specific be included in the five year management report,

IV) the committee ask the Licensing agencies to informally refer any applications to extract water from the Tertiary Confined Sand Aquifer from bores in the range one to three kilometres in Zones 1A,1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6 B, 7A, 7B, 8A, 8B, 9A & 9B until there is power to set a separate permissible distance for each aquifer.

1.3 Permissible Rate of Potentiometric Surface Lowering

Examination of records in Zones 1A, 1B, 2A, 3A, 3B, 4A, 4B, 5A & 5B indicate there may be an average decline in the water level of 0.15– 0.20 m/a in the Tertiary Limestone Aquifer which could be attributed to climate. This then indicates that the net level of decline related to extraction continues to be consistent with the permissible rate of surface lowering of 0.05 m/a. The critical issue here is to obtain an understanding of the actual components of the average annual drawdowns. The significant issue in resolving this is metering of water extractions. In some cases the drawdowns may be due to land use changes or to climatic variations. Further analysis of these parameters is to be undertaken over the next five years.

A single simple rate of decline has meaning in the management of water levels in an unconfined aquifer. In the case of a confined aquifer this simple parameter is inadequate to apply to the behaviour of the aquifer pressure response. Attempts to predict drawdown using modelling are needed in such a case. Metering of extractions is essential for this analysis.

Recommendation – Permissible Rate of Potentiometric Surface Lowering

That, to obtain an understanding of the components of the potentiometric surface lowering, the States implement a program of metering of all groundwater extractions from within the Designated Area.

That as drawdown of the groundwater level may be due to land use change or climate change further analysis of these parameters is undertaken during the next five years.

Determination - Rate of Potentiometric Surface Lowering

It is recommended that:

a) the methodology as set out in Attachment A of the paper "Technical background on the permissible rate of potentiometric surface lowering for the confined portions of the Tertiary Limestone Aquifer – 26 June 2001" for determining the average rate of potentiometric surface lowering for hydrogeological province 3 be adopted;

b) the Committee recommends to the Ministers that the permissible rate of potentiometric surface lowering for Zones 8B, 9A, 9B, 10A, 10B, 11A and 11B be set at 0.65 m/yr and in respect to the unconfined portions of zones 8B and 9A that 0.05 m/yr be the rate of potentiometric surface lowering be the rate for management;

c) a proposal to evaluate the impact of climatic variation on water table movement be included in the technical program for the next five years; and

d) the 1996- 2001 management review incorporate advice that the Act needs to be changed to provide for a more flexible and useful means than at present when specifying the allowable rate of potentiometric surface lowering.

1.4 Emerging Issues

1.4.1 Salinity

There are sufficient salinity concerns to warrant holding the Permissible Annual Volumes for zones in Hydrogeological Provinces 1 and 2 at their present levels. North of Zones 2A & 2B there are increasing salinity trends, which should be further, investigated.

These increases in salinity levels are likely to be due to either irrigation recycling or vegetation clearance with the resulting mobilisation of salt caused by an increase in vertical recharge. The water quality monitoring program suggests that an increasing salinity trend is still sufficiently evident to cause concern especially when experience elsewhere is taken into account. Measures are being taken to ensure that the water quality monitoring program is revised.

> Recommendation – Salinity
>
> *That investigations be undertaken as a matter of priority to assess the salinity risks to the groundwater resources of the Tertiary Limestone Aquifer, especially in Provinces 1 and 2.*

1.4.2 Monitoring

Adequate monitoring is a continuing essential activity relating to salinity, water levels, water chemistry and land use activity to evaluate the performance of the management prescriptions and suitability of Permissible Annual Volumes and management of the aquifers within the Designated Area. All these factors influence the sustainable use of the resource.

> Recommendation – Monitoring
>
> *That adequate monitoring continue relating to salinity, water levels, water chemistry and land use activity*.

1.4.3 Tertiary Confined Sand Aquifer

An adequate monitoring network is required in this aquifer to monitor the response of the aquifer to increased use with the specification of allowable annual volumes of extraction. Declining potentiometric levels around Casterton in Victoria and the lower south east in South Australia have been measured over the last five years and assessment is required to determine whether this is due to reduced recharge from climatic, forestry or hydraulic loading impacts due to declining water levels in the overlying Tertiary Limestone Aquifer. The current monitoring network is not adequate.

> Recommendation – Tertiary Confined Sand Aquifer
>
> *That an adequate monitoring network be established for the Tertiary Confined Sand Aquifer to assess the response to withdrawals and to determine the cause of the decline in potentiometric levels in Victoria and South East of South Australia over the last five years.*

1.4.4 Forestry

Existing areas of plantation forests and native vegetation were taken into account in computing the vertical recharge and hence the quantity of water available. Expansion of forests in the Designated Area needs to be monitored to consider the impact on the current Allowable Annual Volumes for both aquifers. It has the potential to significantly reduce the vertical recharge to the Tertiary Limestone Aquifer and vertical leakage to the Tertiary Confined Sand Aquifer, which may necessitate the need to reduce existing Allowable Annual Volumes and therefore licensed allocations.

Low recharge rates under pinus radiata and under blue gums have been assigned in the determination of vertical recharge to the Tertiary Limestone Aquifer. Further research is required to evaluate the impact on recharge. Blue gums and possibly pinus radiata may extract groundwater as well as intercept rainfall where the depth to groundwater is within their rooting depth.

> Recommendation – Forestry
>
> *That research be undertaken to evaluate the impact on recharge from the development of blue gum and pinus radiata forests.*

1.4.5 Groundwater allocation for the environment

The water requirements for groundwater dependent ecosystems are not fully understood. Investigations are needed to establish whether the management prescriptions and water allocations have adequately catered for these needs.

1.4.6 Climate Analysis

Seasonal trends and land use will impact on the water table. Further analysis need to be undertaken to attribute the component of the change in the water table due to these factors.

> Recommendation – Climate Analysis
>
> *That analysis is undertaken of seasonal climate trends to attribute the component of the change in water table levels to these factors.*

1.4.7 Funding

A number of significant issues identified above will require adequate funding to investigate and assess as well as the continuing funding for adequate monitoring and evaluation. This work benefits the management of the total resource in both States outside the Designated Area such as the modelling work on salinity and the Tertiary Confined Sand Aquifer over the last 5 years, as it provides appropriate management for the whole resource and techniques which can be applied to the management of groundwater resources elsewhere.

Recommendation – Funding

That as there are a number of significant issues which will benefit groundwater management in both states adequate funding continue to be provided over the next five years.

1.5 Amendments to the Act

The Agreement provides for the Committee to make recommendations to the Governments relating to any changes to the Agreement that it thinks would improve the management arrangements for the resource adjacent to the border.

In the process of reviewing the various parameters a number of refinements have been identified. These are to provide for;

- a separate Permissible Annual Volume for each aquifer in a Zone,
- sub zones for better detailed management,
- a separate permissible distance for each aquifer, and
- an alternative to a simple permissible rate of potentiometric surface lowering for confined aquifers.

Recommendation – Amendments to the Act

That the Act be amended to provide for;

- *A separate Permissible Annual Volume for each aquifer in a Zone*
- *Sub zones for better detailed management*
- *A separate permissible distance for each aquifer, and*
- *An alternative to a simple permissible rate of potentiometric surface lowering for confined aquifers.*

2. Introduction

The purpose of this report is to provide documentation on the issues effecting groundwater within the Designated Area, to comment on emerging issues and to consolidate the reviews required under the Agreement. This five year management review is the third in a series, the others being released in 1991 and 1996. The Committee produces an annual report in which the progress of the groundwater management activities is reported to both Parliaments.

3. Purpose of the Agreement

Along the Victorian/South Australian border groundwater is the only reliable source of water. In recognition of the need to cooperatively manage this resource the Border Groundwater Agreement was entered into in 1985. Following assent to the *Groundwater (Border Agreement) Act 1985* in each state, the agreement came into force in January 1986.

The Border Groundwaters Agreement operates in both States.

The Agreement establishes the Border Groundwaters Agreement Review Committee with membership from States, as the operating mechanism for jointly managing the groundwater resource of the two States. The Designated Area covered by the Agreement is a 40 kilometre wide strip centered on the border and extending for its full length. This Designated Area is divided into 22 zones, 11 in each State. See Figure 1.

The Agreement provides that the available groundwater shall be shared equitably between the States and that it applies to all existing and future bores within the Designated Area, except domestic and stock bores. Bore construction licences or extraction licences may not be granted or renewed within the Designated Area other than in accordance with the management prescriptions set and provided for by the Agreement. The prescriptions prevent further water extraction in a particular zone if the specified Permissible Annual Volume for total withdrawals or an average rate of lowering of groundwater levels greater than 0.05 meters per year were to be exceeded. The prescriptions also provide that where appropriate a permissible level of salinity can be set for a particular zone. They also provide that where appropriate casing of new bores shall be sealed between aquifers to prevent inter-aquifer contamination.

The Agreement provides that the Review Committee may from time to time coordinate, or cause to be carried out surveys, investigations and studies concerning the use, control protection, management or administration of the groundwater in the Designated Area. The Committee may make recommendations to the Contracting Governments or any authority, agency or tribunal of the Contracting Governments concerning any matter which in the opinion of the Committee, may in any way affect the investigations, use, control, protection, management or administration of groundwater within the Designated Area.

The Agreement further provides that the Review Committee shall from time to time, review the Agreement and if in its opinion any amendments are necessary or desirable recommend accordingly to the Contracting Governments.

At intervals of not more than five years the Committee shall review the permissible distance from the border and the Permissible Annual Volume in relation to each zone and has the power to alter either or both.

The Committee may recommend to the Minister of each Government that a permissible level of salinity is declared for any zone.

The Agreement also provides that at not more then five yearly intervals, a review of the permissible rate of potentiometric surface lowering and the permissible levels of salinity (if set) be carried out and any changes deemed desirable be recommended to the Ministers in both states.

The Committee may declare a period of restriction in any zone whenever it is of the opinion such action is necessary or desirable for the better investigation, use, control, management or administration of the groundwater within the Designated Area.

The Agreement sets out the framework and the Committee develops the management plan for the Designated Area. In each state the individual water allocation polices and licensing arrangements are performed by the state agencies. In Victoria this is done by the Rural Water Authorities under delegation from the Minister; in South Australia by the Department of Water Resources using a water allocation plan developed by the Catchment Water Management Boards, or water resource planning committee.

Under the Agreement the term Permissible Annual Volume can only be applied to a whole zone of the Designated Area. Each zone may only have a single Permissible Annual Volume. This is a deficiency in the Agreement as there are cases where it would be useful to divide a zone into sub zones and apply a Permissible Annual Volume to each sub zone. Likewise, there should be provision to set separate Permissible Annual Volumes for each aquifer which are clearly separated from each other such as is the case with the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer. For the time being, the term 'allowable annual volume' is being used for the individual volumes that can be extracted from each aquifer with the sum of these volumes going to form the Permissible Annual Volume for the particular zone.

4. Tertiary Limestone Aquifer

There are two principal aquifer systems within the Designated Area with generally useable quality water. These are the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer. The Tertiary Confined Sand Aquifer is not used within the Designated Area to any great degree due to the availability of good quality water in the overlying Tertiary Limestone Aquifer.

The Tertiary Limestone Aquifer in the Designated Area has been divided into three hydrogeological provinces as shown in Figure 1. This division has significance in determining the sustainable yield of the aquifer and hence in specifying the Permissible Annual Volume in each zone. These provinces are:

Province 1 Where the Tertiary Limestone Aquifer occurs in Zones 1A, 1B, 2A, 2B & 3A and in parts of Zones 3B, 4A & 5A and where the aquifer is unconfined.

Province 2 Where the Tertiary Limestone Aquifer occurs in Zones 4B, 5B, 6A, 6B, 7A, 7B & 8A and in parts of Zones 3B, 4A, 5A, 8B & 9A and the aquifer is unconfined and partially overlain by the Pliocene Sands Aquifer. This province is characterised by having generally a lower rainfall than Province 1 and the Tertiary Limestone Aquifer is at a greater depth.

Province 3 Where the Tertiary Limestone Aquifer occurs in Zones 9B, 10A, 10B, 11A & 11B and in part of Zones 8B & 9A and the aquifer is confined.

4.1 Management Framework:– Hydrogeological Province 1

4.1.1 Management Prescription

In Hydrogeological Province 1 the allowable annual volume has been set so as not to exceed vertical recharge. The throughflow is maintained to provide flushing for salinity management. This continues to be the basis for the determination of the allowable annual volume in this province.

Originally the Permissible Annual Volumes for hydrogeological provinces 1 and 2 were based on a uniform rate of vertical recharge excluding areas of forest and native vegetation. A detailed assessment of the vertical recharge was made for these provinces in the 1990-1995 management review by considering the hydrographic response of the aquifer according the spatial variation in vegetation type, land use, depth to water table and soil type.

4.1.2 Allowable annual volume for Zone 1A

The 1991 – 1995 Technical Review Report to the committee undertook a detailed analysis of recharge in Zone 1A which identified a lower vertical recharge volume than previously adopted. However, at that time the Permissible Annual Volume was retained as the specific yield was thought to be higher, possibly 0.2 due to the karstic conditions of the aquifer, and therefore the rate of vertical recharge would be underestimated. Subsequent modelling indicated that the regional specific yield is about 0.1 with a lower recharge and the calculated allowable annual volume of 30,900ML/a was more appropriate. The allowable annual volume for the Tertiary Limestone Aquifer for Zone 1A has been reduced to this value.

The reducing water levels in the Mount Gambier area and at the Blue Lake support this action, as does the need to maintain spring discharges along the coast south of Mount Gambier.

4.1.3 Allowable annual volume for Zone 1B

Similar consideration was given to Zone 1B as to Zone 1A following the revision and reduction of the estimated annual vertical recharge. The allowable annual volume has been reduced from 71,000ML/a to 45,720ML/a. In this case the area of forested land is being reviewed which could influence the estimates of available recharge and hence the allowable annual volume for the zone. See further comment under the heading of Forests.

4.1.4 Allowable annual volume for Zones 2A, 2B, 3A, and parts 3B, 4A & 5A

The review of vertical recharge (Bradley 1996) resulted in estimated annual recharge in excess of the existing Permissible Annual Volumes for Zones 2A, 2B, 3A, 3B & 4A. The allowable annual volume for these zones were not increased due to concerns regarding salinity hazards from recycled irrigation water draining to the unconfined aquifer.

North of Zones 2A & 2B there are increasing salinity trends. These increases are of concern and are under investigation. These increases in salinity levels are likely to be due to either irrigation recycling or vegetation clearance with the resulting mobilisation of salt caused by an increase in vertical recharge.

The water quality monitoring program suggests that an increasing salinity trend is still sufficiently evident to cause concern especially when experience elsewhere is taken into account. As well, water levels have declined due to climatic conditions over recent years.

4.1.5 Water Level Trends

The rainfall at Mt Gambier shows an increasing trend from the mid 1880's to 1920, followed by a declining trend. At Naracoorte there has been a rising trend from the 1940's to the mid 1970's with a declining trend since then.

Groundwater level trends have generally reflected rainfall trends. These have resulted in relatively stable levels for the 10 year period up to 1995 but have declined markedly in the order of 0.15 – 0.17 m/a over the last 5 years due to low rainfalls producing low vertical recharge. Intensive areas of irrigation have shown larger declines in groundwater levels of around 0.22 m/a. The portion of water level declines due to extraction is acceptable and complies with the permissible rate of potentiometric surface lowering of 0.05 m/a.

Water levels have shown marked declines within forested areas.

4.1.6 Forestry

Existing areas of plantation forests and native vegetation were taken into account in computing vertical recharge and hence the quantity of water available. Expansion of forests in the Designated Area needs to be monitored to consider the impact on the current Permissible Annual Volumes. It has the potential to significantly reduce the total vertical recharge to the aquifer, which may necessitate the need to reduce existing Allowable Annual Volumes, and therefore licensed allocations.

Low recharge rates under pinus radiata and under blue gums have been assigned in the determination of vertical recharge. Further research is required to evaluate the impacts on recharge. Blue gums and pinus radiata may extract groundwater as well as intercept rainfall where the depth to groundwater is within their rooting depth. A management approach is required to handle further forestry expansion otherwise allowable annual volumes may have to be reduced progressively in response to assessed vertical recharge.

4.1.7 Spring discharges and marine impact

Interest in utilising throughflow to the coast in the region south of Mount Gambier to increase water availability for allocation has arisen as the area has become fully allocated and its discharge along the coast is viewed by some as a waste of good quality water. Modelling undertaken in an area from Mount Gambier to the coast indicates that this is not a viable option due to the potential for the inland migration of the fresh-water /saltwater interface and the potential environmental impacts on the natural discharge springs and dependent ecosystems. This aspect requires detailed investigation.

4.2 Management Framework – Hydrogeological Province 2

4.2.1 Management Prescription

The management prescription for the Zones in Hydrogeological Province 2 is based on the vertical recharge as for Province 1. These are Zones 4B, 5B, 6A, 6B, 7A, 7B & 8A, and part of Zones 3B, 4A, 5A, 8B & 9A

Zones 4B, 5B, 6B & 7B

The Tertiary Limestone Aquifer in Zones 4B, 5B, 6B & 7B was previously assessed to be semi-confined by the upper aquitard as it is overlain by Parilla Sands. Now, however it is assessed to be unconfined and vertical recharge has been recalculated following more detailed work taking into account soil type, vegetation cover and land use.

Zones 4B & 7A and Part Zones 3B, 4A & 5A

In Zones 4B, 5A & 7A the allowable annual volume has not been increased due to salinity concerns as described under sections 4.1.4 and 4.2.3.

Zones 5B &6B

The allowable annual volume for Zones 5B & 6B has been set at the level of the existing commitment, which exceeds the computed volume under the prescription (see section 4.2.4). These commitments were made under the Permissible Annual Volume set at the time. It should be impressed on the licensing agencies of the need to meter extractions and monitor the levels of drawdown over the next five year period to determine whether the Permissible Annual Volume should be reduced to the calculated volume. This would have the effect of reducing the licence volumes accordingly.

Zone 7B

The allowable annual volume for Zone 7B has been reduced from 7000ML/a to 6600 ML/a to equal the computed volume under the management prescription.

Zone 8A

The allowable annual volume for Zone 8A has been retained at 7700ML/a.

4.2.2 Water level trends

Groundwater levels in the 10 year period up to 1995 rose about 0.05 m/a in Zones 4A, 4B, 5A & 5B. Declining water level trends in the order of 0.1m/a have been observed in these zones since 1995. Based on Zone 4B, which has a low level of water allocation, these declines are thought to be due largely to climatic conditions. This is a net change in water level trend of around 0.15 m/a for maximum water level declines up to 0.2 m/a, this suggests the impact of extraction in Zones 4A, 5A & 5B doesn't exceed 0.05 m/a, which would be consistent with the permissible rate under the Agreement.

In Zones 6A, 6B, 7A, 7B, 8A & 8B water levels continued the observed trend of very slight rises. These are attributed to the clearing of native vegetation for a similar overall rainfall pattern experienced since the mid 1970's based on an analysis of rainfall records for Bordertown.

4.2.3 Salinity Trends

There is a continuing trend of increasing salinity levels in Zones 4A, 4B, 5A, 5B, 6A, 6b, 7A, 7B, 8A & 8B which requires further assessment and monitoring.

4.2.4 Neuarpur Groundwater Supply Protection Area

Location The Neuarpur Groundwater Supply Protection Area straddles the boundary between Zone 5B and Zone 6B and also extends to the east of the Designated Area. See Figure 2. The principal irrigation culture is small seed production.

Issue In Victoria a process of assessing the viability of intensely utilised areas of groundwater has been developed. Under this program the Neuarpur locality was identified as having an allocation in excess of the likely sustainable yield. A freeze has been placed on the issue of any further licences pending the development of a detailed management plan for the area.

Management Approach Although the commitment under licence exceeds the likely sustainable yield for the area no significant decline in watertable levels has been discerned to date. The management plan developed for the area provides for all extractions to be metered and extensive water level monitoring is undertaken until the year 2004 when the plan will be reviewed. The plan also provides that there be no new allocations made and that transfers of existing allocations will be limited to entitlements which have a history of use. Any licences without a history of use cannot be activated during this period.

The committee will review the situation over the next 5 years.

4.3 Management Framework – Hydrogeological Province 3

There has been significant drawdowns observed in the Tertiary Limestone Aquifer within Zones 10A and 10B. Whilst the allocations have been within the Permissible Annual Volumes a review of the groundwater behaviour and the availability of water was indicated. It has become apparent that the original assumptions on which the Permissible Annual Volumes were based did not recognise that the Tertiary Limestone Aquifer was confined in these zones. The only way that productive use could continue within this region was if water was to be extracted from storage.

A management prescription has been developed which allows for the extraction of an equivalent volume of water as was originally intended by the Agreement based on a 0.05m/a drawdown in an unconfined aquifer. This is a small volume compared to the quantity of water stored in the aquifer and would be theoretically to depleting the aquifer over 2000 years. The actual allowable annual volume of extraction is to be reviewed at five yearly intervals as provided for in the Agreement.

It must be recognised that this is a management decision to allow for higher consumptive use of the resource over a given timeframe. This is not sustainable in the long term but needs to maintained under active review.

4.3.1 Management Prescription

The original Permissible Annual Volumes for Zones 8B, 9A, 9B, 10A, 10B, 11A & 11B were set in accordance with the original prescription relating to the Tertiary Limestone Aquifer which included vertical recharge, a proportion of throughflow and a small annual drawdown of storage of 0.05m/a. By 1990 based on further technical investigations the hydrogeological conditions were known to vary significantly from zone to zone and the Permissible Annual Volumes were set on an individual zone basis in accordance with the hydrogeological conditions.

In 1995 investigations in South Australia showed that the specific yield of 0.1 used previously for the Tertiary Limestone Aquifer was too conservative and a value of 0.15 was adopted which resulted in an increase in the Permissible Annual Volume in Zone 10A from 6000 ML/a to 9400 ML/a.

The current position is that vertical recharge where the Tertiary Limestone Aquifer is confined and throughflow are very low and have been taken to be nil for the setting of the Permissible Annual Volume. The allowable annual volume of extraction for the confined areas of the Tertiary Limestone Aquifer is therefore based on the following relationship:

Allowable annual volume = Proportion of Groundwater Storage

(Volume equivalent to a drawdown of storage under unconfined conditions of 0.05 m/a)

The zones have been subdivided into sub-zones based on the following 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 useable water quality taken as = 3000 mg/L Total dissolved Solids (TDS). See Figure 3.

As the water in storage beneath areas of native vegetation is not directly accessible and drawdown associated with extractions will extend into these areas, a portion of this water in storage has been included in the allowable 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 a confined aquifer in Zones 11A, 11B, 10A & 10B and in portions of Zones 9A, 9B & 8B. The revised management prescription provides for a volume of water to be extracted which is equivalent to that which would be available from a reduction in storage of 0.05 m/a, if the aquifer were unconfined. This prescription has been divided into sub-zones based on the suitability of the water for irrigation use, taken as 3000 mg/L TDS and on the areas of national parks in which no extractions will take place.

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

> Recommendation. – Sub zones
>
> *That the Act be amended to provide for sub zones.*

4.3.2 Allowable annual volume for 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, based on vertical recharge, is 1558 ML/a.

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

4.3.3 Allowable annual volume for Zone 9A

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

- 9A North (confined)
- 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.

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 allowable annual volume for a sub area covering both unconfined and confined portions. The computed volume for these areas is 6,495ML/a.

4.3.4 Permissible Annual Volume for 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 3,052 ML/a.

4.3.5 Allowable annual volume for Zone 10A

Zone 10A is confined with small portions of the Zone covered by native vegetation. The revised allowable annual volume has been calculated in accordance with the revised management prescription.

This prescription would specify a reduced allowable annual volume for Zone 10A from 9400 ML/a to 7844 ML/a. As the revised prescription is based on computations rather than observation on the ground, detailed monitoring of behaviour (metering of extraction and monitoring of water levels and salinity) is to be carried out so as to enable appropriate future reviews of the allowable annual volume to be undertaken.

The current allocation and commitment is 9400 ML/a. The allowable annual volume will be maintained at 9400 ML/a to recognise these commitments.

4.3.6 Allowable annual volume for Zone 10B

Zone 10B is confined with small portions of the zones covered by native vegetation. The revised management prescription specifies an increased allowable 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 10A.

4.3.7 Allowable annual volume for Zone 11A

Zone 11A is confined with the northern portion of the Zone having a water quality in excess of 3000mg/l. A volume of 5632 ML/a is available in the southern sub zone where the water quality is less than 3000 mg/l TDS.

The revised management prescription specifies a reduced allowable annual volume for the useable quality water even after the adjustment has been made for increasing the specific yield from 0.1 to 0.15. The useable volume is computed to be 5632 ML/a, whilst the commitment is 6861 ML/a. In the northern sub zone where the water quality is in excess of 3000 mg/l TDS the allowable annual volume is assigned as zero.

4.3.8 Allowable annual volume for 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 allowable annual volume is 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 and allowable annual volume for this sub- zone is 1823 ML/a.

■ **Table 2 – Proposed Sub-Zones (Tertiary Limestone Aquifer)**

Sub zone	Calculated volume ML/a	Commitment ML/a	Allowable Annual Volume ML/a
Sub zone11A North	11,932*	0	0
Sub zone11A South	5632	6861	6861
Sub zone11B North	1914*	0	0
Sub zone11B North East	1814*	0	0
Sub zone11B South	1823	0	1823
Sub zone 10A	7844	9400	9400
Sub zone 10B	6720	3663	6720
Sub zone 9A North	470	3835	3835
Sub zone 9A South	6496	7760	7760
Sub zone 9B South	2540	5960	5950
Sub zone 8B	6760	2210	6760

* In these sub zones the water quality is greater 3,000 mg/l TDS.

4.3.9 Water Level Trends

Away from areas of concentrated activity there are no regional trends. The aquifer response to extraction is that of a confined aquifer. Comparisons of drawdown can only be made with those predicted in the groundwater numerical model.

4.3.10 Salinity Trends

There has been no discernible change in salinity in this province. Monitoring is in place to check for the possibility of lateral movement of saline groundwater and work is continuing to ascertain the potential for vertical leakage from the overlying Parilla Sand Aquifer that is considered a low risk.

4.3.11 Murrayville Groundwater Supply Protection Area

Location The Murrayville Groundwater Supply Protection Area is located in and to the east of Zone 10B and in the south west corner of Zone 11B. See Figure 2. The principle irrigated culture is potatoes.

Issue Although the water allocations were within the Permissible Annual Volume for the zone rapid drawdowns were observed causing difficulties in maintaining domestic and stock water on adjacent properties. A similar phenomenon occurred across the border near Pinnaroo in South Australia.

Management approach An immediate program was implemented by Wimmera Mallee Water and the Victorian Farmers Federation to address the domestic and stock issue. A Groundwater Supply Protection Area was established with the key element of the management plan being the division of the area into a number of sub zones. The maximum allocation in any sub zone is limited to that which it is predicted will result in a drawdown of acceptable limits for domestic and stock purposes. All irrigation supplies are being metered and monitoring is being carried out. A review will be undertaken in five years.

Interstate issues A groundwater model was developed in South Australia and applied to make predictions of the behaviour of the aquifer to various pumping patterns in both states and to show the consequent likely drawdowns. These predictions are to be used to compare with the actual results observed in the future.

4.3.12 Mallee Prescribed Wells Area

A water allocation plan was prepared for the Mallee Prescribed Wells Area under the *Water Resources Act 1997* in South Australia consistent with the requirement of the Border Groundwaters Agreement. There has been cross representation on the Mallee and Murrayville planning committees to prepare complimentary water allocation and management plans.

5. Tertiary Confined Sand Aquifer

5.1 Background

Management of the groundwater resources within the Designated Area has to date concentrated on the Tertiary Limestone Aquifer, given the very low level of use of the Tertiary Confined Sand Aquifer. However, over the last few years there has been an increased level of interest in groundwater from the Tertiary Confined Sand Aquifer. As a result, an assessment of the available resource for this deeper aquifer has been carried out.

Due to the regional nature of the Tertiary Confined Sand Aquifer and its hydraulic behaviour, it was considered that the determination needed to focus on the whole aquifer system, not just be limited to the Designated Area. See Figure 4.

5.2 Nature of the Resource

The Tertiary Confined Sand Aquifer system is regionally extensive; being present through western Victoria and in South Australia occurs throughout most of the South East and extends northwards up to the River Murray through the Mallee region.

Groundwater flow in the aquifer is generally from Victoria to South Australia across the border. The direction of flow varies from north to south in the southern part of the region, east to west in the central part of the region, and south east to north west in the northern part of the region.

In most areas the Tertiary Confined Sand Aquifer yields good to excellent quality groundwater, the exceptions being in the vicinity of a basement high in the upper parts of the South East in South Australia and near the end of the flow paths in the north west, where the salinity can exceed 10,000 mg/L.

Artesian groundwater conditions occur in the upper South East and along a coastal zone from Kingston in South Australia to Portland in Victoria.

Current recharge rates to the Tertiary Confined Sand Aquifer are considered to be low, being a few millimeters per year.

Discharge from the Tertiary Confined Sand Aquifer occurs westwards and southwards of the zero head difference in potentiometric (water) levels between the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer via upward leakage to the Tertiary Limestone Aquifer. The mechanism of discharge to the marine environment is largely unknown.

Proposed allowable annual volumes for the Tertiary Confined Sand Aquifer were developed from a combination of throughflow determinations and computer flow modelling.

Throughflow was determined from a flow net analysis undertaken for the area where the groundwater is of useable quality. Management areas were defined in addition to the zones of the Designated Area based on the flow net. The resource was then divided between the zones of the Designated Area and the new management zones by sharing the throughflow along flow paths.

A groundwater flow model was used to assess the throughflow values in the southern part of the Designated Area and including adjoining areas in Victoria and South Australia. The model established that there was a reasonable match between modeled inflows to the Tertiary Confined Sand Aquifer under current extraction conditions and the throughflow calculated from the flow net analysis, and that the throughflow volumes could therefore be used as a starting point for modelling future extraction scenarios.

Various extraction scenarios were modeled to examine the longer term change in aquifer pressure and changes in leakage between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer.

The main limitations with the modelling were recognised to be the uncertainty in the levels of extraction from the aquifer, particularly in the artesian area in the South East of South Australia, and a lower level of reliability of the model results in the areas where there is limited current extraction from the Tertiary Confined Sand Aquifer. This made calibration of the model difficult in these areas.

5.3 Management Issues

The magnitude of the water level decline in the Tertiary Confined Sand Aquifer in response to increased withdrawals needs to be managed so as to reduce the impact on existing groundwater users.

Another important consideration is to limit any reversal in the potentiometric levels between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer, which could result in the more saline water from the Tertiary Limestone Aquifer in the western areas adversely effecting the water quality in the Tertiary Confined Sand Aquifer through downward leakage.

The computer modelling indicated that there could be a substantial increase in the leakage from the Tertiary Limestone Aquifer following increased extractions from the Tertiary Confined Sand Aquifer. This would have the potential to cause a change in the water balance of the Tertiary Limestone Aquifer resulting in a potentiometric level decline in this aquifer as well.

The increased use of groundwater from the Tertiary Confined Sand Aquifer for irrigation purposes also has the potential to increase the salt accessions to the Tertiary Limestone Aquifer, which could result in adverse water quality deterioration in this aquifer.

With an increase in extractions from the Tertiary Confined Sand Aquifer, a reduction in the natural discharge would occur which could have some adverse environmental impacts particularly in relation to the marine discharges. Such impacts are difficult to assess given the lack of present understanding of these processes.

The management areas outside the Designated Area are based on hydraulic flow paths through the aquifer, water quality variations and areas of concentrated usage such as the proposed Kingston Management Area. See Figure 4.

These management areas are recommended for adoption by each of the States to provide a consistent approach in the development of this aquifer based on its characteristics. It is recognised that these management boundaries do not coincide

with existing management boundaries associated with the Tertiary Limestone Aquifer outside the Designated Area, but nevertheless are recommended for the effective management of the Tertiary Confined Sand Aquifer.

5.4 Management Prescription

Taking the above factors into account and given the relatively limited understanding of the characteristics of this aquifer the Committee has determined that the management prescription for the Tertiary Confined Sand Aquifer should be as follows: -

Zones	Management Prescription for allowable annual volume
All Designated Area Zones except 3B&4B	= 50% x (0.75 x Throughflow Volume)
Designated Area Zones 3B&4B	= (0.25 x Throughflow Volume)
Zones outside designated Area except Kingston	= 50% x (0.75 x Throughflow Volume)
Kingston Zone	=25,000 ML/year

The Committee has adopted a precautionary approach to the specification of these Permissible Annual Volumes (note: allowable annual volumes for the zones in the Designated Area). It has considered the current limited technical understanding of the resource and advice received from the South East Catchment Water Management Board regarding the use of the aquifer and acceptable levels of potentiometric level drawdown following consultation with stakeholders in South Australia. The Board advised that declines in potentiometric levels of 2 to 4 metres across the aquifer would only be acceptable at this time.

In response to this advice, the committee determined that the management prescription should be 50% of the original proportion (0.75) of the throughflow to maintain recovered seasonal potentiometric levels within this recommended range.

Adopting a cautious approach for the setting of the Allowable Annual Volumes also allows for the lack of knowledge of the environmental significance of the marine discharges from the aquifer.

The specific management prescription for Zones 3B and 4B is due to the proximity of these Zones to the Dundas Highland and the limited throughflow from the east.

Best management practice would suggest that the Tertiary Confined Sand Aquifer be managed as a whole resource unit due to the regional effects of drawdowns of potentiometric levels associated with water extraction. These are more extensive than drawdowns in the Tertiary Limestone Aquifer for similar extraction rates. To provide a consistent approach within this criteria, the recommended management prescription for the management areas outside the Designated Area are similar to the management prescription for the Designated Area.

The management prescription recommended for the Kingston Management Area sets the “suggested allowable annual volume of extraction” at the current level of allocation in this area. However, the Committee considers that this is too high based on the current level of assessment and understanding of the resource. It is recommended therefore that the South Australian Government and the South East Catchment Water

Management Board review groundwater usage and implement metering and bore rehabilitation programs to reduce water usage over the next five years.

If the review indicates that the level of allocation and use is not sustainable, then the suggested annual volume of extraction for the Kingston Management Area should be reduced and management strategies introduced to decrease allocations and usage to a sustainable level over the following five years.

5.5 Allowable annual volumes of extraction

In accordance with the management prescriptions specified above, the allowable annual volume of extraction for the Tertiary Confined Sand Aquifer for zones within the Designated Area is listed in Table 3. The suggested allowable volume of extraction for the Tertiary Confined Sand Aquifer for management areas outside the Designated Area is listed in Table 4.

■ **Table 3 – Allowable annual volume of extraction for the Tertiary Confined Sand Aquifer for Zones within the Designated Area**

South Australian Zone	Allowable annual volume of extraction (ML/a)	Victorian Zones	Allowable annual volume of extraction (ML/a)
1A	9200	1B	14,500
2A	2900	2B	5100
3A	1900	3B	1100
4A	710	4B	300
5A	540	5B	570
6A	360	6B	360
7A	350	7B	350
8A	340	8B	330
9A	570	9B	630
10A	320	10B	560
11A	0	11B	0

Notes:
1. Where the volume is less than 1000ML, the allowable annual volume has been rounded upwards to the nearest 10ML.
2. Where the volume is greater than 1000ML, the allowable annual volume has been rounded upwards to the nearest 100ML.
3. The northern parts of Zones 11A and 11B contain saline groundwater with salinity greater than 3000 mg/L. The determined volumes for the areas where the TDS is less than 3000 mg/L are insignificant (less than 100ML).

■ **Table 4 – Suggested allowable annual volumes of extraction for the Tertiary Confined Sand Aquifer for Management Areas outside the Designated Area**

South Australian Management Area	Suggested allowable annual volumes of extraction (ML/a)	Victorian Management Area	Suggested allowable annual volumes of extraction (ML/a)
Copeville	940	Dartmoor	18,600
Karoonda	1500	Goroke	2200
Keith	2500	Kaniva	1100
Kingston	25,000	Little Desert	1100
Lameroo	1200	Nhill	1200
Millicent	10,800		
Mindarie	780		
Monbulla	3900		
Naracoorte	3600		
Wirrega	960		

Notes:
3. Where the volume is less than 1000ML, the suggested annual volume has been rounded upwards to the nearest 10ML.
4. Where the volume is greater than 1000ML, the suggested annual volume has been rounded upwards to the nearest 100ML.

Recommendation – Suggested allowable annual volumes for the Tertiary Confined Sand Aquifer outside the Designated Area.

That the management areas for the Tertiary Confined Sand Aquifer outside the designated area be those shown in Figure 4 and that the allowable annual volumes are limited to those suggested in Table 4*.*

5.6 Drilling protocol to authorities

All bores constructed within the Designated area may only be drilled by licensed driller holding the class of licence appropriate to the nature of the bore to be constructed in respect to depth, strata and nature of the water to be encountered.

In respect of the Tertiary Confined Sand Aquifer the committee has developed a protocol for the guidance of the bore construction supervising authorities to ensure that all data with respect to strata encountered is reported and that special conditions apply if the bore is artesian.

6. Management Prescriptions required in the Agreement

The committee has reviewed the Permissible Annual Volume for all zones for both the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer. In accordance with the provisions of the Agreement a single Permissible Annual Volume has been set for each Zone with an allowable annual volume for each aquifer. The Permissible Annual Volumes so established are set out in Table 5.

■ **Table 5 – Permissible Annual Volumes**

Zone	Allowable annual volume for Tertiary Confined Sand Aquifer ML/a	Allowable annual volume for Tertiary Limestone Aquifer ML/a	Permissible Annual Volume ML/a
11A	0	6861*	6861
11B	0	1823	1823
10A	320	9400*	9720
10B	560	6720	7280
9A	570	11,595*	12,165
9B	630	5960*	6590
8A	340	7700	8040
8B	330	6760	7090
7A	350	7500	7850
7B	350	6600	6950
6A	360	8850	9210
6B	360	9838*	10,198
5A	540	18,500	19,040
5B	570	11,949*	12,519
4A	710	20,000	20,710
4B	300	14,000	14,300
3A	1900	24,000	25,900
3B	1100	16,500	17,500
2A	2900	25,000	27,900
2B	5100	25,000	30,100
1A	9200	30,900	40,100
1B	14,500	45,720	60,220

✸ Note: These volumes exceed those derived from the application of the revised management prescription and are set to equal the existing commitments made under a previous permissible annual volume of extraction

6.1 Review of Permissible Distance

The Agreement defines Permissible Distance as:

The "Permissible distance from the border between the State of South Australia and the State of Victoria" means the distance of 1km from the border, or in relation to a particular zone such other distance as has been determined by the Committee.

The Agreement only provides for a single distance to be set for any one Zone. It does not allow for separate permissible distances to be set for each individual aquifer.

The Committee has adopted a permissible distance of 3 km in Zones 10A, 10B, 11A & 11B following review of the management prescription for the Permissible Annual Volumes in these zones.

The Agreement provides that all applications within this distance must be forwarded to the Committee for approval. In order to administer this requirement the Committee has adopted a protocol to streamline this process, as the 3 km permissible distance will apply to a larger number of applications.

The committee has determined to retain the permissible distance at 1 km in all the zones south of Zones 10A &10B. As the Agreement only provides for one Permissible Distance for a zone the Committee has determined to request the States to administer any applications within 3 km of the border in the Tertiary Confined Sand Aquifer as if the Permissible Distance were 3 km.

Recommendation – Permissible Distance Tertiary Confined Sand Aquifer

That as the Agreement only provides for one permissible distance for a zone that the States administer any application with respect to the Tertiary Confined Sand Aquifer as if the permissible distance were three kilometres.

Determination - Permissible Distance
It is recommended that:

V) the Committee sets the permissible distance at three kilometres for Zones 10A, 10B, 11A and11B,

VI) the gazettal take effect from a common date with the revision of Permissible Annual Volumes and the revised permissible rate of potentiometric surface lowering ,

VII) the need for the Act to be changed to allow for permissible distance to be aquifer specific be included in the five year management report,

VIII) the committee ask the Licensing agencies to informally refer any applications to extract water from the Tertiary Confined Sand Aquifer from bores in the range one to three kilometres in Zones 1A,1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6 B, 7A, 7B, 8A, 8B, 9A & 9B until there is power to set a separate permissible distance for each aquifer.

6.2 Review of Permissible Rate of Potentiometric Surface Lowering

The agreement defines the permissible rate of potentiometric surface lowering as “an average annual rate of surface lowering of 0.05 m/a or, in relation to a particular Zone some other rate as has been agreed by the Minister of each Contracting Government”.

A single simple rate of decline such as this may have some value in the management of water levels in an unconfined aquifer. In the case of a confined aquifer this simple

parameter is not adequate to apply to the behaviour of a pressure response in a confined aquifer. Not only is the hydraulic behaviour of confined and unconfined aquifers dissimilar but the analysis and prediction of water level responses is far more complicated for confined aquifers.

As a consequence, the committee has developed methodologies to apply this parameter in a meaningful way.

The proposed rates for confined conditions in the Tertiary Limestone Aquifer strike a balance between realistic values that are not likely to be exceeded by the extraction of the allowable annual volumes and the level of uncertainty attached to predicting water level responses under confined conditions at this time.

The actual rates of potentiometric surface lowering measured are to be reviewed at five yearly intervals as provided for in the Agreement.

6.2.1 Tertiary Limestone Aquifer Confined in Zones 8B, 9A, 9B, 10A, 10B, 11A & 11B

A method for calculating the average annual rate of potentiometric surface lowering in areas where the Tertiary Limestone Aquifer is confined has been developed. The method entails:

(i) reviewing the potentiometric levels from a representative set of observation bores that monitor the confined parts of the Tertiary Limestone Aquifer where the water quality is useable (i.e. TDS less that 3000 mg/L); and for Zones 10A, 10B, 11A, and 11B comprise those bores in which predictions on the rate of potentiometric surface lowering has been made through groundwater flow modelling.

(ii) calculating the average rate of potentiometric surface lowering for a zone by determining the observed change in potentiometric surface level in each bore in the network at seasonal recovery over the preceding five year period (i.e. bore trend); and calculating the arithmetic average of the bore trends in a zone.

The purpose of the calculations is to check on the reasonableness of the Allowable Annual Volumes. The methodology is not designed to deal with short term, seasonal and very localised drawdowns associated with groundwater extraction that may be experienced within the Tertiary Limestone Aquifer.

6.2.2 Tertiary Limestone Aquifer in Zones 1A, 1B, 2A, 2B, 3A,3B, 4A, 4B, 5A, 5B, 6A, 6B, 7A, 7B & 8A

Seasonal trends and land use will impact on the water table levels. Further analysis need to be undertaken to attribute the component of the change in the water table due to these factors. The permissible rate of surface lowering is 0.05 m/a and it is not proposed to change this in these zones.

Examination of records in Zones 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A & 5B indicates there may be an average decline of 0.15– 0.20 m/a which could be attributed to climate. This then indicates that the net level of decline related to extraction continues to be consistent with the permissible rate of surface lowering of 0.05 m/a. The critical issue is to understand

the actual components of the average annual drawdowns. A significant issue to resolve this is metering of all water extractions.

Recommendation – Permissible Rate of Potentiometric Surface Lowering

That, to obtain an understanding of the components of the potentiometric surface lowering, the States implement a program of metering of all groundwater extractions from within the Designated Area.

That as drawdown of the groundwater level may be due to land use change or climate change further analysis of these parameters is undertaken during the next five years.

Determination - Rate of Potentiometric Surface Lowering
It is recommended that:

e) the methodology as set out in Attachment A of the paper "Technical background on the permissible rate of potentiometric surface lowering for the confined portions of the Tertiary Limestone Aquifer – 26 June 2001" for determining the average rate of potentiometric surface lowering for hydrogeological province 3 be adopted;

f) the Committee recommends to the Ministers that the permissible rate of potentiometric surface lowering for Zones 8B, 9A, 9B, 10A, 10B, 11A and 11B be set at 0.65 m/yr and in respect to the unconfined portions of zones 8B and 9A that 0.05 m/yr be the rate of potentiometric surface lowering be the rate for management;

g) a proposal to evaluate the impact of climatic variation on water table movement be included in the technical program for the next five years; and

h) the 1996- 2001 management review incorporate advice that the Act needs to be changed to provide for a more flexible and useful means than at present when specifying the allowable rate of potentiometric surface lowering.

6.2.3 Tertiary Confined Sand Aquifer

There are insufficient monitoring points in this aquifer to monitor actual behaviour with modeled predictions. It is not proposed to set separate rates for potentiometric surface lowering for the Tertiary Confined Sand Aquifer at this time. The management prescription adopted to determine the proposed allowable annual volumes of extraction for this aquifer have been set to limit regional declines in levels.

The concept of a rate of potentiometric surface lowering and the value as provide for in the agreement of 0.05m/a has meaning for an unconfined aquifer, as such, is applicable to the Tertiary Limestone Aquifer in Zones 1 to part 9. The management prescription adopted for the Tertiary Limestone Aquifer with no modern vertical recharge in Zones 10 and 11 is to allow for a rate of extraction equivalent to a decline of aquifer storage of 0.05m/a. The concept of specifying an annual rate of potentiometric surface lowering in a confined aquifer is not applicable. It is not proposed to alter the existing prescription.

7. Emerging Issues

7.1 Salinity

Salinity was identified as a critical issue for this five year management review period in the 1991 – 1995 five year review. It is particularly applicable to Hydrogeological Provinces 1 and 2 where it was considered to be a critical issue for the future specification of permissible annual volumes.

In the Five Technical Review 1996-2000 it is stated that there is sufficient salinity concerns to warrant holding the Permissible Annual Volumes for these zones at their present levels.

North of Zones 2A & 2B there are increasing salinity trends. These increases are of concern and should be further investigated. These increases in salinity levels are likely to be due to either irrigation recycling or vegetation clearance with the resulting mobilisation of salt caused by an increase in vertical recharge.

The water quality monitoring program suggests that an increasing salinity trend is still sufficiently evident to cause concern especially when experience elsewhere is taken into account. Measures are being taken to ensure that the water quality monitoring program is revised.

The areas of concern with respect to salinity within the zones of concern need to be identified and monitoring funding should be focussed there, with a view to having better data to justify or otherwise the retention of the Permissible Annual Volumes at levels less than the present prescriptions.

The Committee has had groundwater modelling studies undertaken to develop predictive models for salinity. These have been constrained by the lack of field investigations to calibrate the models. Further work is continuing to develop the models and field surveys are proposed to obtain soil salinity data down to the water table.

> Recommendation – Salinity
>
> *That investigations be undertaken as a matter of priority to assess the salinity risks to the groundwater resources of the Tertiary Limestone Aquifer, especially in Provinces 1 and 2.*

7.2 Forestry

Existing areas of plantation forests and native vegetation were taken into account in the computing the vertical recharge and hence the quantity of water available. Expansion of the areas planted to forests in the Designated Area needs to be monitored to consider the impact on the current Permissible Annual Volumes. It has the potential to significantly reduce the vertical recharge to the aquifer, which may necessitate the need to reduce existing Allowable Annual Volumes and therefore licensed allocations.

Low recharge rates under pinus radiata and under blue gums have been assigned in the determination of vertical recharge. Further research is required to evaluate the impact on recharge. Blue gums and pinus radiata may extract groundwater as well as intercept rainfall where the depth to groundwater is within their rooting depth.

After clearance some evidence of salinity increase has been observed. There are some ramifications for both water allocations and water quality associated with these large plantations.

> Recommendation – Forestry
>
> *That research be undertaken to evaluate the impact on recharge from the development of blue gum and pinus radiata forests.*

7.3 Monitoring

Adequate monitoring is a continuing essential activity relating to salinity, water levels, water chemistry and land use activity to evaluate the performance of the management prescriptions and suitability of PAV's and management of the aquifers. All these factors influence the sustainable use of the resource.

> Recommendation – Monitoring
>
> *That adequate monitoring continue relating to salinity, water levels, water chemistry and land use activity*.

7.4 Climate Analysis

Seasonal trends and land use will have an impact on the water table levels. Further analysis need to be undertaken to attribute the component of the change in the water table levels due to these factors.

Examination of records in Zones 1 to 5 indicates there maybe an average decline of 0.15 to 0.20 m/a, which could be attributed to climate. This then indicates that the net level of decline related to extraction continues to be consistent with the permissible rate of surface lowering of 0.05 m/a. The critical issue is to understand the actual components of the average drawdowns. The significant issue to resolve this is metering of water extraction.

The committee will further investigate and assess this matter.

> Recommendation – Climate Analysis
>
> *That analysis is undertaken of seasonal climate trends to attribute the component of the change in water table levels to these factors.*

7.5 Tertiary Confined Sand Aquifer

An adequate monitoring network is required in this aquifer to monitor the response of the aquifer to increased use with the specification of allowable annual volumes of extraction. Declining potentiometric levels around Casterton in Victoria and the lower south east in South Australia have been measured over the last five years and assessment is required to determine whether this is due to reduced recharge from climatic, forestry or hydraulic loading impacts due to declining water levels in the overlying Tertiary Limestone Aquifer. The current monitoring network is not adequate.

> Recommendation – Tertiary Confined Sand Aquifer
>
> *That an adequate monitoring network be established for the Tertiary Confined Sand Aquifer to assess the response to withdrawals and to determine the cause of the decline in potentiometric levels in Victoria and South East of South Australia over the last five years.*

7.6 Metering

The metering of all extractions is a high priority, particularly from those zones where the Permissible Annual Volume has been set at a level in excess of that which would apply if the management prescriptions were strictly adhered to. To this end it is noted that significant progress has been made in metering in the Murrayville (Zones 11B & 10B) and Neuarpur (Zones 6B & 5B) Groundwater Supply Protection Areas. As well the majority of extractions in Zones 7B, 8B & 9B are metered. South Australia has instituted metering trials in the Mallee.

7.7 Funding

A number of significant issues identified above will require adequate funding to investigate and assess as well as the continuing funding for adequate monitoring and evaluation. This work benefits the management of the total resource in both States outside the Designated Area such as the modelling work on salinity and the Tertiary Confined Sand Aquifer over the last 5 years, as it provides appropriate management for the whole resource and the techniques can be applicable to management of other resources elsewhere.

> Recommendation – Funding
>
> *That as there are a number of significant issues which will benefit groundwater management in both states adequate funding continue to be provided over the next five years.*

7.8 Hydraulic Parameters and Leakage

Field testing to improve estimates of hydraulic parameters, specifically in Zones 1B & 2B, but also elsewhere in Hydrogeological Provinces 1 and 2 for the Tertiary Limestone Aquifer are required to improves estimates of vertical recharge.

Field testing to improve estimates of leakage from the Tertiary Limestone Aquifer to the Tertiary Confined Sand aquifer in the southern part of the Designated Area is required. Leakage from the Tertiary Limestone Aquifer was indicated as a significant source of recharge to the Tertiary Confined Sand Aquifer in the modelling studies.

Similarly in Zones 10A, 10B, 11A &11B in the Mallee modelling indicated that upward leakage from the Tertiary Confined Sand Aquifer to the Tertiary Limestone Aquifer was potentially a significant source of recharge. This needs to be validated.

7.9 Groundwater Allocations for the Environment:

There is an emerging concern that the current management prescriptions and allocation of groundwater have not adequately considered the water requirements of groundwater dependant ecosystems. Investigations need to be undertaken to identify and define the water requirements of such ecosystems.

8. Institutional Arrangements

8.1 Amendments to the Act

The agreement provides for the committee to make recommendations to the Governments relating to any changes to the Agreement that it thinks would improve the management arrangements for the resource adjacent to the border.

In the process of reviewing the various parameters a number of refinements have been identified. These are to provide for;

- a separate Permissible Annual Volume for each aquifer in a Zone,
- sub zones for better detailed management,
- a separate permissible distance for each aquifer, and
- an alternative to a simple permissible rate of potentiometric surface lowering for confined aquifers.

> Recommendation – Amendments to the Act
>
> *That the Act be amended to provide for;*
> - *A separate Permissible Annual Volume for each aquifer in a Zone*
> - *Sub zones for better detailed management*
> - *A separate permissible distance for each aquifer, and*
> - *An alternative to a simple permissible rate of potentiometric surface lowering for confined aquifers.*

8.2 Full Cost Identification of Management

The committee has attempted to identify the full groundwater management costs associated with technical investigations and management of the agreement and the resource management for the resources in the border designated area in its annual reports. A multiplier of 3 has been applied in SA to allow direct comparison with Victoria, which has identified the full on-costs in its management costs. This complies with recommendation 9 of the National Framework for Improving Groundwater Management in Australia (Allocation and Use of Groundwater) December 1996.

To allow for the orderly operation of interstate transfer of water entitlements to be considered both States would need to adhere to full cost recovery principle to avoid a skewing of trade due to artificial cost structures.

8.3 Interstate TWE

Committee is developing discussion papers to explore the concept and feasibility of interstate TWE under the Border Agreement.

Appendix A Figures

- **Figure 1 – Hydrogeological Provinces in the Designated Area**

■ **Figure 2 – Relationship of other Management Areas in Victoria and South Australia to the Designated Area**

- **Figure 3 – Sub-Zones for the Confined Tertiary Limestone Aquifer**

- **Figure 4 – Tertiary Confined Sand Aquifer – Groundwater Management Zones**

Appendix B Terminology

"Allowable Annual Volume of Extraction" means the allowable volume of extraction, which is specified, for each aquifer within a zone of the Designated Area, which is a component of the Permissible Annual Volume for the zone.

"Aquifer" means a geological structure or formation or an artificial landfill permeated or capable of being permeated permanently or intermittently with water.

"Designated Area" means an area 40 kilometres wide and centred on the South Australia - Victoria Border and is the area to which the Management Plan applies.

"Permissible Annual Volume" means the permissible annual volume of extraction, which is specified, for each zone of the Designated Area. It is the maximum volume that may be authorised for extraction within the zone.

"Permissible distance from the border between the State of South Australia and the State of Victoria" is the distance, currently one kilometre either side of the border, within which all applications for licences must be referred to the Committee to determine where the licence should be issued.

"Permissible rate of potentiometric surface lowering" means an average annual rate of lowering within a zone of 0.05 metres or in relation to a particular zone, such other rate as has been agreed by the Minister for each Contracting Government.

"Permissible level of salinity" means such level of salinity as results in electrical conductivity not in excess of so many micro siemens per centimetre at twenty five degrees Celsius as may be agreed upon by the Minister of each Contracting Government for any zone pursuant to Clause 28 (6), or in relation to a particular zone, such other level as has been agreed upon by the Minister of each Contracting Government under Clause 28 (4).

"Suggested Allowable Volume of Extraction" means the allowable annual volume of extraction, which is specified, for the Tertiary Confined Sand Aquifer within a management area outside the Designated Area.

"The Tertiary Limestone Aquifer" comprises aquifers in the Murray Group, Heytesbury Group, Coomandook Formation, Bridgewater Formation and Padthaway Formation, called collectively the Tertiary Limestone Aquifer, the base of which is identified as marl or black carbonaceous silt, sand or clay.

"The Tertiary Confined Sand Aquifer" comprises aquifers in the Wangerrip Group and Renmark Group, below the Tertiary Limestone Aquifer.

Appendix C Reports

Barnett S R and Yan W (2000) Mallee Region Groundwater Modelling Report No1. Report Book 2000/00004, Primary Industry and Resources SA, February 2000.

Bradley J, De Silva J, Foley G, Robinson M, Stadter F, (1995) Five Year Technical Review 1991 – 1995. Report for SA/Vic Border Groundwater Agreement Review Committee, HydroTechnology Report No MC/44057.050, February 1995.

Brown K (2000) A Groundwater Flow Model of the Tertiary Confined Sand Aquifer in South East South Australia and South West Victoria. Report book 2000/00016 Primary Industries and Resources SA.

Brown K & SKM (1998) The Hydrochemistry of Groundwaters in the South Australian – Victorian Designated Area. Groundwater Border Agreement Act. Report Book 98/00025 Primary Industries and Resources SA. Joint Report by SA Department for Primary Industries and Resources and Sinclair Knight Merz, June 1998.

Leaney F.W.J. and Herczeg A.L. (1999) The Origin of Fresh Groundwater in the SW Murray Basin and its Potential for Salinisation, CSIRO Land and Water Technical Report # 7/99, April 1999.

SKM (1996a) Border Zone Groundwater Monitoring Review. Report to DCNR, February 1996.

SKM (1996b) Trends in Groundwater Use in the Border Zone. Report to DNRE, March 1996.

SKM (1997b) Border Groundwater Agreement - Review of the Upper Tertiary Aquitard Distribution and PAVs for Designated Zones 5B to 8B. Report to DNRE, November 1997

SKM (1997d) Border Groundwater Agreement - Development and Application of a One Dimensional Hydraulic Soil Column Model (SUS1D), Report to DNRE, November 1997.

SKM (1998d) Review of Transmissivity and Storage Co-efficient Values from Pumping Test Data for the Victoria Portion of the Border Designated Area. Report to DNRE, November 1998.

SKM (1998f) SA/Vic Border Groundwater Agreement - Assessment of Groundwater Throughflow for the Tertiary Confined Sand Aquifer. Report to DNRE, December 1998.

SKM (1998g) Development of an Investigation Program to Determine the Feasibility of Artificial Recharge in Designated Zones 5B and 6B. Report to DNRE, 1998.

Stadter F and Yan W (2000). Assessment of the Potential Use of the Groundwater Resources in the area south of Mount Gambier. Report book 2000/00040 Primary Industries and Resources SA.