



Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan

Annual Report

For year ending 30 June 2017

Document History and Distribution

Versions

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Foreword

Goulburn-Murray Water (GMW) is pleased to present the annual report for the Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan (the Plan) for the 2016/17 water year.

GMW is responsible for the implementation, administration and enforcement of the Plan which was approved by the Minister administering the *Water Act 1989* (the Minister) in October 2012.

This report has been prepared in accordance with section 32C of the *Water Act 1989* (the Act).

This report provides an overview of the groundwater management activities in the Lower Campaspe Valley Water Supply Protection Area and documents the effective operation of the Plan during the 2016/17 water year.

A copy of this report is available for inspection at the GMW Tatura office, or it can be downloaded from the GMW website.



Pat Lennon

MANAGING DIRECTOR

Date

27. 9. 2017

Executive summary

The Lower Campaspe Valley Water Supply Protection Area (WSPA) Groundwater Management Plan (the Plan) was approved by the Minister for Water in October 2012.

The 2016/17 water year marks the fifth year of operation under the Plan.

Allocations in 2016/17 were 100% of licensed volume in all management zones of the Lower Campaspe Valley WSPA.

Metered use in the Lower Campaspe Valley WSPA was 44% (24,383.2 ML) of licensed volume which is near average use for the area.

There was a decrease in trade activity during 2016/17. There were eight temporary licence transfers for a total of 1,175 ML and two permanent licence transfers for a total of 296 ML/yr.

The use and trade activity is lower than the previous water year and may be attributed to the wetter conditions.

Licence holders in the Lower Campaspe Valley WSPA are entitled to carryover a maximum of 25% of licensed volume. A total 13,776.6 ML has been carried over to 2017/18.

Groundwater level monitoring indicates that seasonal aquifer recovery is strong and levels are generally within observed historical ranges. However, it is noted that there has been a declining trend in groundwater recovery levels in recent years which may be attributed to below average rainfall and groundwater extraction.

Groundwater monitoring and metering programmes continue to be successfully undertaken to support the implementation of the Plan.

The Lower Campaspe WSPA Groundwater Management Plan is continuing to achieve its stated objectives.

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1 Introduction

1.1 Purpose

This annual report has been prepared to meet the requirements of Prescription 7 of the Plan and section 32C of the Act.

This report provides an overview of groundwater management activities undertaken in accordance with the Plan from 1 July 2016 to 30 June 2017.

1.2 Water Supply Protection Area

The Lower Campaspe Valley WSPA was declared in June 2010. It extends from Lake Eppalock in the south to Echuca in the north and includes the towns of Axedale, Goornong, Elmore, Lockington and Rochester.

There are four management zones within the Lower Campaspe Valley WSPA, which are the Barnadown, Elmore-Rochester, Bamawm and Echuca Zones (Figure 1).

The WSPA includes groundwater resources to all depths except where it is overlain by the Campaspe West Salinity Management Plan Area and the region to the north of the Waranga Western Channel including the Shepparton Irrigation Region Groundwater Management Area. In these areas, the Plan only applies to the management of groundwater resources greater than 25 metres (m) depth.

1.3 Groundwater Management Plan

The Plan was approved by the Minister for Water in accordance with section 32A(6) of the Act on 17 October 2012.

The objective of the Plan, as defined in section 32A(1) of the Act, is to make sure that groundwater resources of the WSPA are managed in an equitable manner and so as to ensure the long-term sustainability of those resources. More specifically, the Plan seeks to:

- protect existing groundwater users and the environment by managing groundwater levels and the potential for change in groundwater salinity;
- enable equitable development of groundwater resources to realise the potential for its use in the region; and
- communicate the Plan's objectives, management rules and resource status with stakeholders and the wider community.

GMW is responsible for the implementation, administration and enforcement of the Plan. An assessment summary of GMW's activities in accordance with Plan prescriptions is presented in Appendix A.

A copy of the Plan can be downloaded from the GMW website: www.g-mwater.com.au

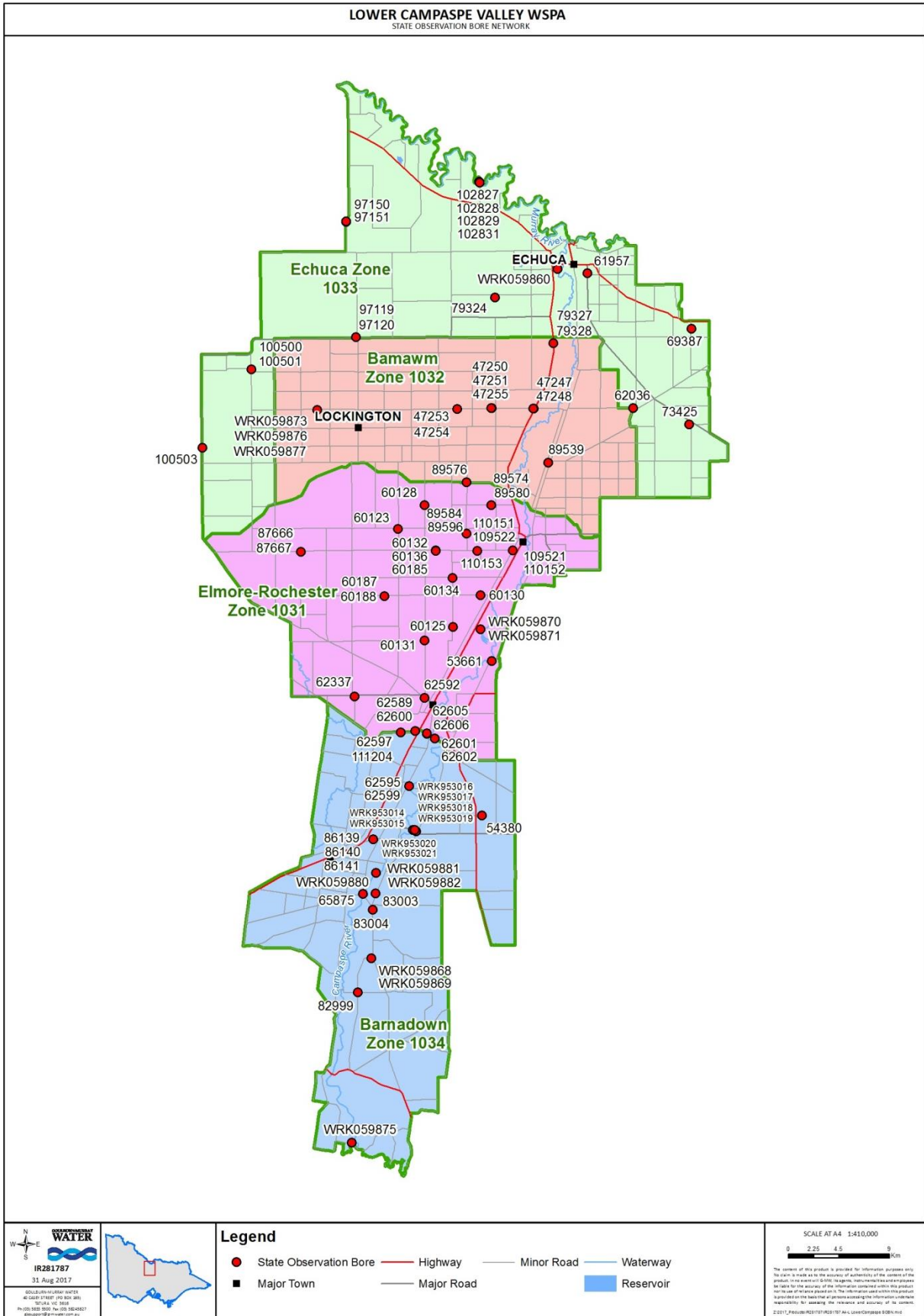


Figure 1 Lower Campaspe Valley Water Supply Protection Area

2 Groundwater Management

2.1 Licence volume

The Minister declared the Permissible Consumptive Volume to be 55,875 megalitres per year (ML/yr) in March 2013 (Victorian Government Gazette, 2013).

The total groundwater licensed volume in the Lower Campaspe Valley WSPA was 55,860 ML/yr on 30 June 2017 (Table 1) which remained unchanged from 30 June 2016.

Table 1 Groundwater license volume in the Lower Campaspe Valley WSPA (2016/17)

Management zone	Licences	Licensed bores	Licensed volume (ML/yr)
Elmore-Rochester Zone – 1031	54	65	16,902.6
Bamawm Zone – 1032	42	47	26,043.3
Echuca Zone – 1033	15	16	4,919.5
Barnadown Zone – 1034	20	57	7,995.0
Total	131	185	55,860.4

Note: Data extracted from the Victorian Water Register 30 June 2017.

2.2 Groundwater allocations

Allocations are a percentage of licensed volume that may be extracted in a given water year. They are determined by comparing the three-year rolling average of the maximum annual groundwater recovery levels in bores 79324 and 62589 with trigger levels stipulated in the Plan (Figure 2 and Figure 3). Annual allocations of 100% were announced on 1 July 2016 for all management zones in the Lower Campaspe Valley WSPA for the 2016/17 water year.

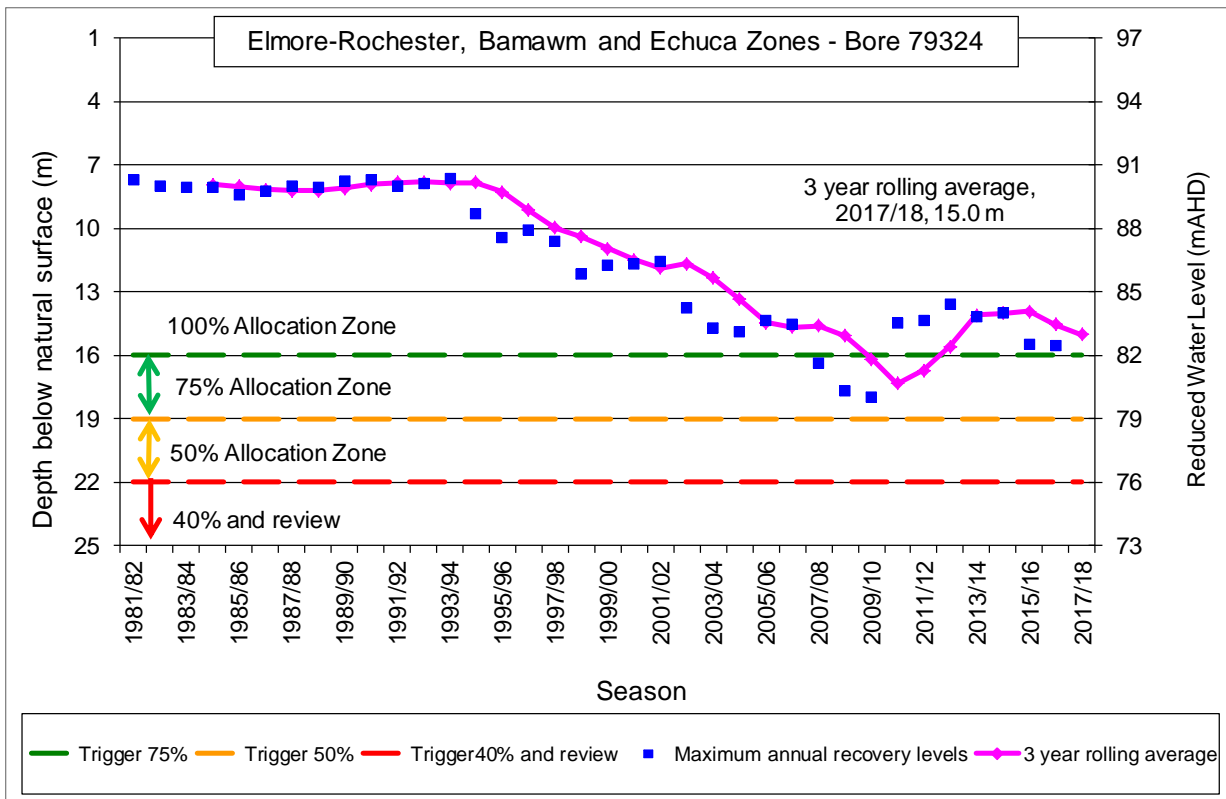


Figure 2 Trigger levels to determine allocations in the Elmore-Rochester, Bamawm and Echuca management zones

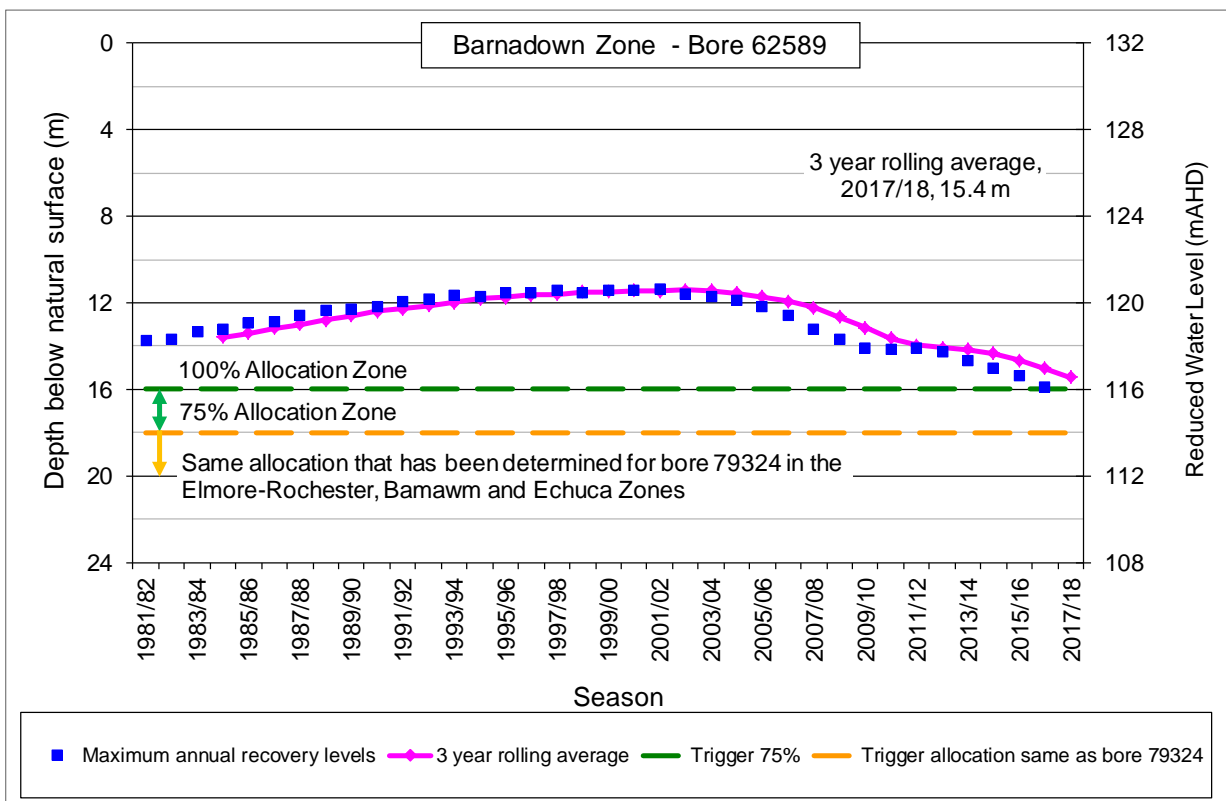


Figure 3 Trigger levels to determine allocations in the Barnadown Zone

2.3 Groundwater use

Metered use in the Lower Campaspe Valley WSPA in 2016/17 was 24,383.2 ML or 44% of total licensed volume. This is significantly less than metered use in 2015/16 which was 81% of licensed volume and more reflective of average use in the area (Figure 4).

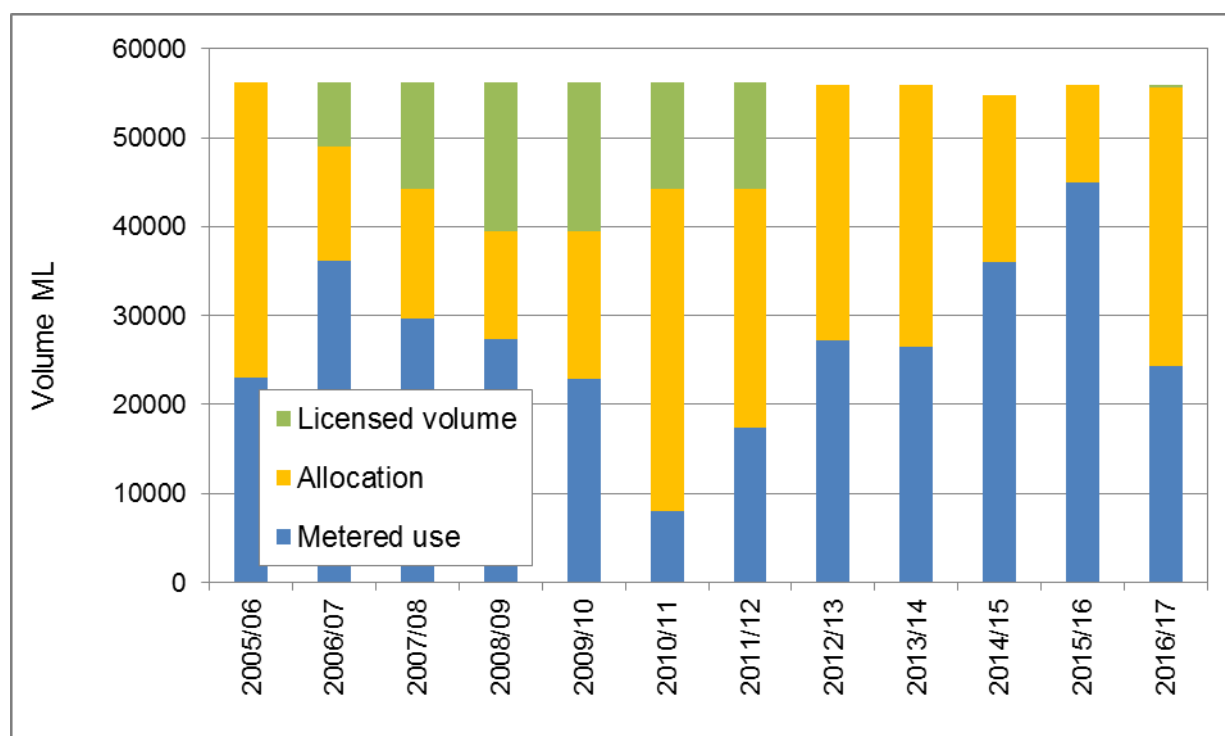


Figure 4 Total licensed volume, allocation and metered use in the Lower Campaspe Valley WSPA

Metered use was greatest in the Bamawm Zone, where a large proportion of the licensed volume is held (Table 2).

Table 2 Metered use by management zone in 2016/17

Management zone	Licence volume (ML/yr)	Total use (ML)	Proportion of total licensed volume used
Elmore-Rochester Zone – 1031	16,902.6	7,848.3	46%
Bamawm Zone – 1032	26,043.3	11,429.1	44%
Echuca Zone – 1033	4,919.5	2,135.1	43%
Barnadown Zone – 1034	7,995.0	2,970.7	37%
Total	55,860.4	24,383.2	44%

Note: Data extracted from Irrigation Planning Module on 1 July 2017.

2.4 Rainfall

Rainfall data from the Bureau of Meteorology (BoM) weather station at Rochester is provided in Figure 5 as an indicator of trends across the WSPA. The data shows that rainfall was high in the early-1970s; was below average in the early-1980s; remained relatively steady to the mid-1990s; and was below average until the high rainfall events in 2010/11. In recent years rainfall has mostly been below average except for 2016/17 where above average rainfall was reported.

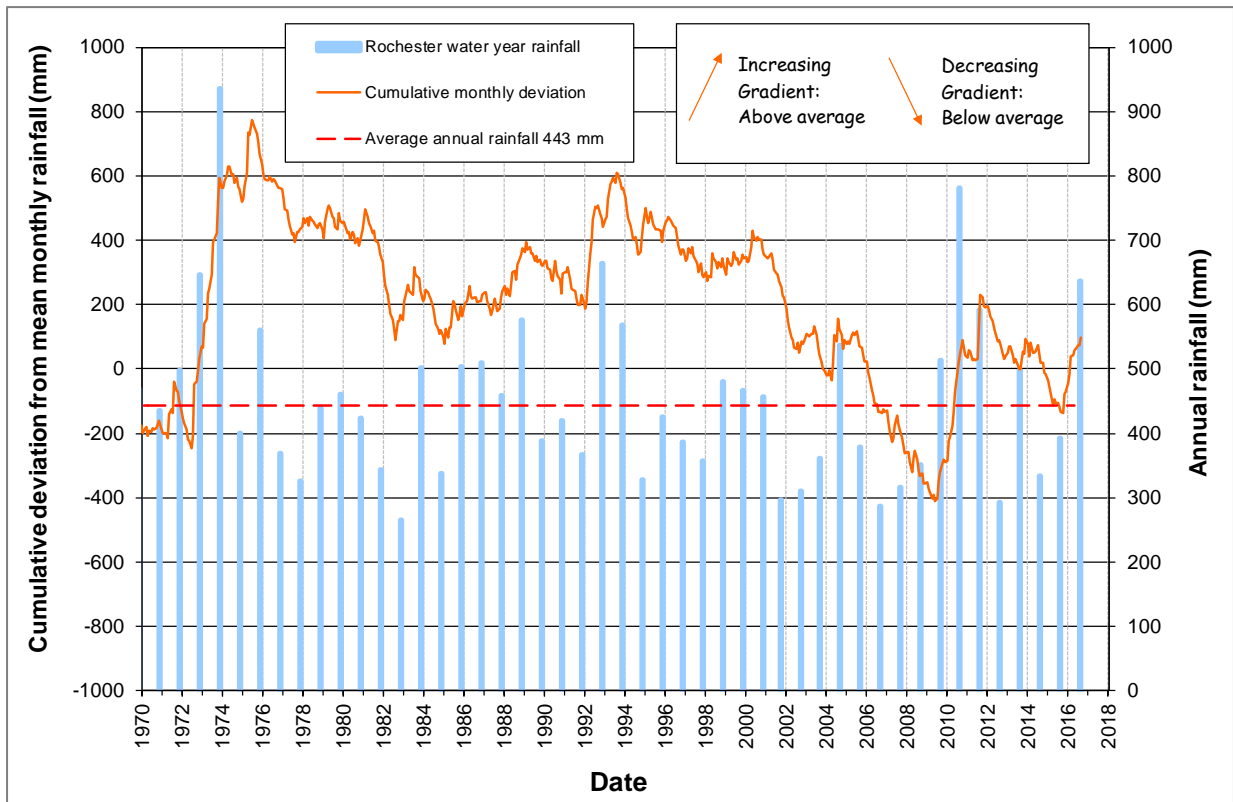


Figure 5 Rainfall at Rochester (BoM station 080049)

2.5 Groundwater licence transfers

The Plan allows groundwater licence holders to temporarily or permanently transfer licensed volume. In 2016/17 there were eight temporary licence transfers for a total of 1,174.8 ML/yr and two permanent transfers for a total of 296 ML/yr. This is a decrease in transfer of licensed volume relative to the previous water year (Figure 6) which may be attributed to reduced demand for groundwater due to wetter conditions (Figure 5).

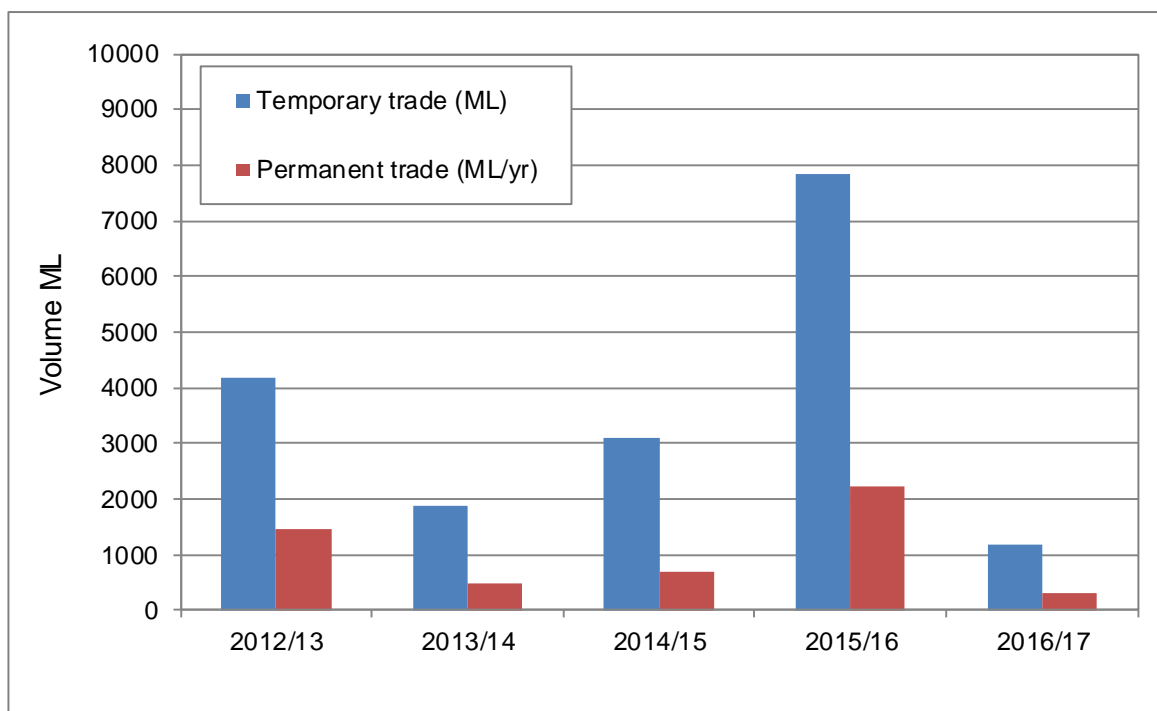


Figure 6 Total licensed volumes transferred in the Lower Campaspe Valley WSPA

The majority of temporary licence transfers occurred within the same management zone (Table 3). There was a transfer from the Bamawm Zone to the Echuca Zone for 2.8 ML/yr of licensed volume.

There was a total of 296 ML/yr transferred permanently out of the Elmore-Rochester Zone and into the Bamawm Zone.

Table 3 Licence transfers in the Lower Campaspe Valley WSPA in 2016/17

Management zone	Temporary				Permanent			
	Transfer from		Transfer to		Transfer from		Transfer to	
	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)
Elmore-Rochester Zone – 1031	1	144.0	1	144.0	2	296.0	0	0.0
Bamawm Zone – 1032	4	610.8	3	608.0	0	0.0	2	296.0
Echuca Zone – 1033	0	0.0	1	2.8	0	0.0	0	0.0
Barnadown Zone – 1034	3	420.0	3	420.0	0	0.0	0	0.0
Total	8	1,174.8	8	1,174.8	2	296.0	2	296.0

2.6 Carryover

The Minister declared that groundwater licence holders in the Lower Campaspe Valley WSPA were authorised to take carryover in November 2012 (Victorian Government Gazette, 2012).

In the Lower Campaspe Valley WSPA licence holders may carryover up to a maximum of 25% of their unused licensed volume for use in the subsequent water year.

In 2016/17 there was a total of 12,707 ML of carryover available to licence holders in the Lower Campaspe Valley WSPA. At the conclusion of the 2016/17 water year, groundwater licence holders in the Lower Campaspe Valley WSPA were able to carryover 13,776.6 ML into the 2017/18 water year.

2.7 Metering

All operational licensed bores in the Lower Campaspe Valley WSPA were metered as of 30 June 2017. There were 64 meter-related activities undertaken in 2016/17, including inspections, maintenance and battery replacements (Table 4).

All meters were read at least twice during the 2016/17 water year.

Table 4 Metering activities in the Lower Campaspe Valley WSPA

Metering activity	Year ending 30 June 2017
Total number of meters	151
Number of meters installed	1
Number of meters replaced	0
Meter maintenance events	64
Total number of meter reads	302

2.8 Domestic and stock bores installed

Domestic and stock use is not required to be licensed as it is a private right under section 8 of the Act.

The installation of a bore for domestic and stock use requires a bore construction licence. Upon completion of a bore, a bore completion report (BCR) is required to be submitted to GMW; details from this report are documented in the Water Measurement Information System at <http://data.water.vic.gov.au/monitoring.htm>.

During the 2016/17 water year in the Lower Campaspe Valley WSPA, 10 domestic and stock bore construction licences were issued by GMW and the Victorian Water Register (combined) and five domestic and stock BCRs were received and processed by GMW.

2.9 Licence compliance

There were no prosecutions or convictions relating to groundwater matters in the Lower Campaspe Valley WSPA in 2016/17.

There were four incidents of unauthorised take and use of groundwater. These incidents have been investigated and GMW has taken action in accordance with the National Framework for Compliance and Enforcement of Systems for Water Resource Management (DSEWPC, 2012). This includes verbal and written notification not to take water without authorisation; a direction to apply to transfer licensed volume to account for use; and providing information on groundwater licence transfer options.

3 Monitoring Program

3.1 Groundwater levels

The Department of Environment, Land, Water and Planning (DELWP) monitored 90 bores from the State Observation Bore Network on a quarterly basis in the Lower Campaspe Valley WSPA (Figure 1). GMW conducted monthly monitoring of 60 key State observation bores identified in Schedule 1 of the Plan (Appendix B) where practicable during the 2016/17 water year.

Monitoring indicates that seasonal groundwater level recovery is strong and observation bore levels are within observed historical ranges. It is also noted that over the period of plan implementation groundwater recovery levels have fallen. This reduction in storage may be attributed to reduced recharge in years of below average rainfall and increased groundwater extraction; e.g. 2015/16.

Groundwater levels recovered well in the Bamawm and Elmore-Rochester management zones where seasonal drawdown of up to 25 m was observed in more intensively pumped areas in 2016/17 (Figure 7).

In the Barnadown and Echuca Zones groundwater recovery levels have remained relatively steady and seasonal drawdown of up to around 5 m is seen (Figure 8).

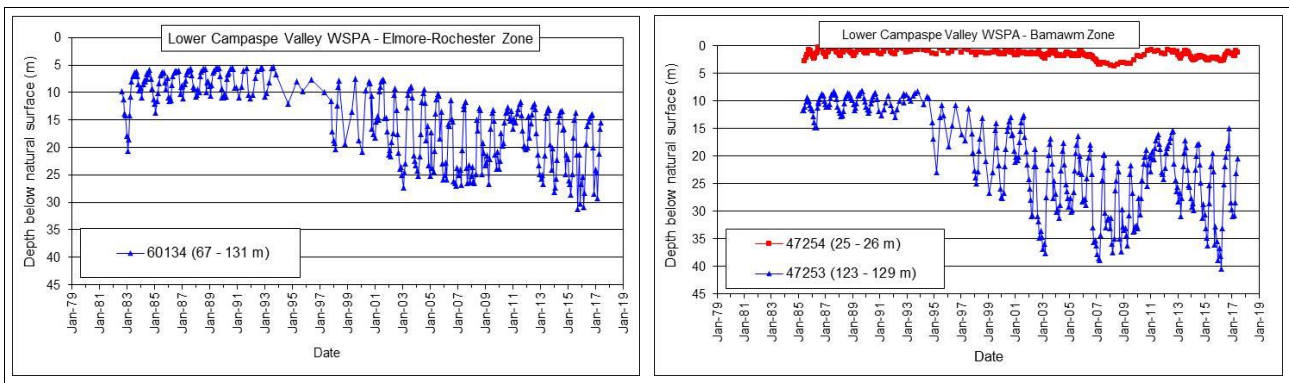


Figure 7 Groundwater levels in the Elmore-Rochester and Bamawm management zones

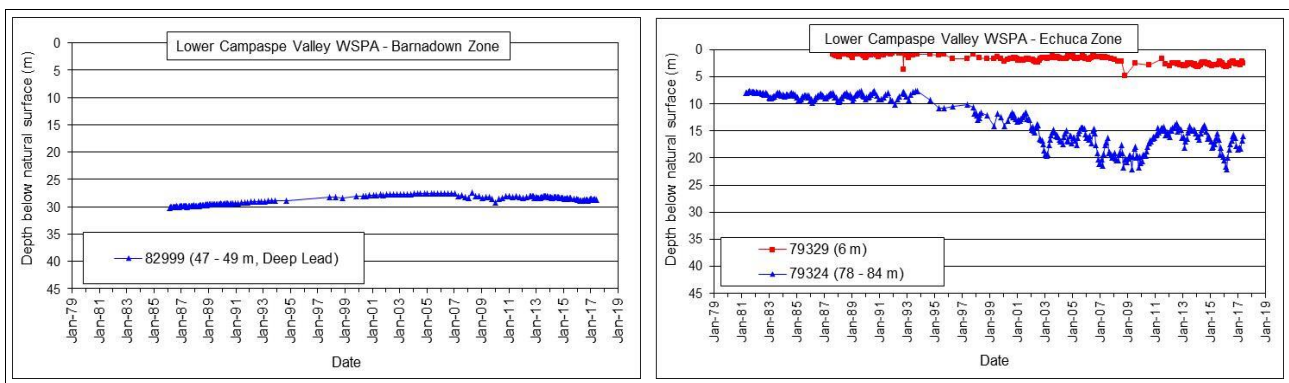


Figure 8 Groundwater levels in the Barnadown and Echuca management zones

3.2 Groundwater quality

Groundwater user salinity sampling

GMW sent 174 sample bottles and a reply paid envelope to licence holders, and domestic and stock users upon request, to collect a groundwater sample from their bore for analysis. There were 35 samples returned for analysis (a return rate of 20%).

GMW measured the groundwater salinity, advised each bore owner of the result and recorded the data in the State groundwater database. The results are shown spatially in Figure 9 and show more saline groundwater in the northern parts of the Lower Campaspe Valley WSPA. Higher groundwater salinity levels west of the Campaspe River in the Barnadown Zone may be influenced by groundwater contributions from the Huntly Deep Lead.

A higher and more consistent sample return rate would assist with spatially assessing any changes in groundwater salinity over time. Groundwater users are strongly encouraged to participate in this program so that they can identify any changes in groundwater salinity, which in turn enables a greater understanding of how using groundwater from their bore might impact on their business.

Targeted sampling of licensed bores

GMW has enlisted six licence holders to participate in the targeted groundwater salinity monitoring program. The purpose of the program is to ensure that samples are consistently collected each year from private bores in strategic locations that will provide a reliable data set to aid in understanding any changes in groundwater salinity over time. The results are presented in Appendix C. Groundwater salinity varies between seasons, although there appears to be a rising trend in groundwater from some bores. Continued monitoring will enable trends to be better understood and inform Plan review.

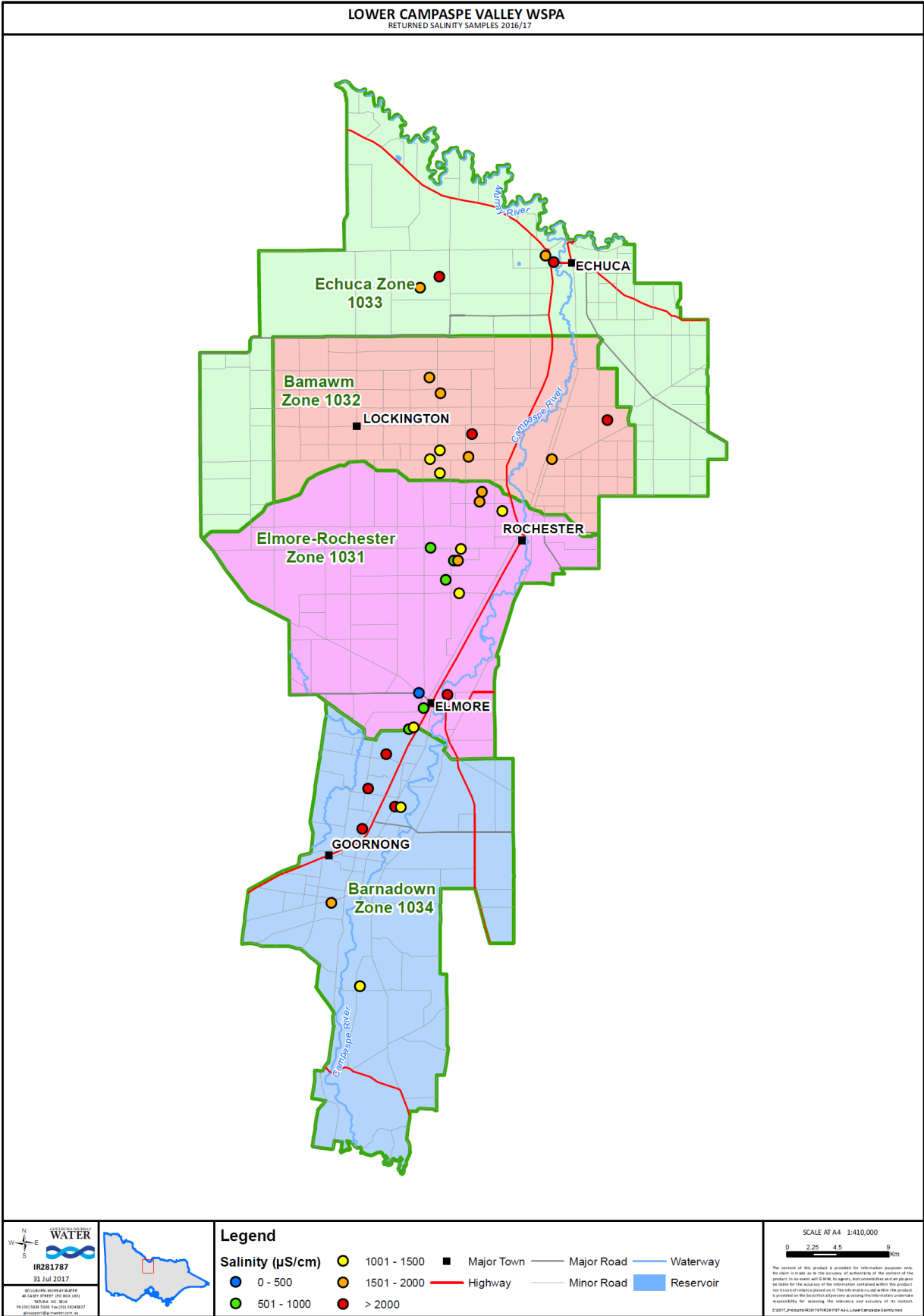


Figure 9 Location of returned samples analysed for groundwater salinity

Sampling from State observation bores

Groundwater samples from nested State observation bores were sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis. Nested sites feature two or more monitoring bores in close proximity, each monitoring a different aquifer. The State observation bores used for water quality testing are located in the areas of intensive groundwater pumping west of Rochester and at the northern margins of the Lower Campaspe Valley WSPA.

Groundwater salinity results are presented in Table 5. The results have been compared to earlier measurements of groundwater salinity (Appendix C). Groundwater salinity varies between seasons but no strong trends are identified. Continued monitoring of groundwater quality will enable any trends to be identified to inform Plan review.

Table 5 Groundwater salinity results for key monitoring bores sampled in October and November 2016

Bore number	Management zone	Bore screened interval (m below natural surface)	Groundwater salinity – EC
102827	Echuca Zone – 1033	108 – 114	4,685
102828	Echuca Zone – 1033	160 – 167	3,718
102829	Echuca Zone – 1033	70 – 74	4,026
73425	Echuca Zone – 1033	87 – 89	10,474
73426	*Echuca Zone – 1033	6 – 18	9,165
WRK059873	Bamawm Zone – 1032	82 – 87	3,873
WRK059876	Bamawm Zone – 1032	91 – 97	2,999
WRK059877	Bamawm Zone – 1032	34 – 37	4,173
47250	Bamawm Zone – 1032	73 – 85	1,717
47251	Bamawm Zone – 1032	22 – 27	3,954
89584	Elmore-Rochester Zone – 1031	84 – 88	3,416
89596	Elmore-Rochester Zone – 1031	2 – 14	Bore dry

*Bore screened in shallow aquifer above the Echuca Zone.

Note: EC is the electrical conductivity @ 25°C measured in $\mu\text{S}/\text{cm}$

4 Future Management Considerations

4.1 Groundwater Reference Committee

The Groundwater Reference Committee (GRC), appointed in accordance with Prescription 7(c) of the Plan, met on 5 October 2016.

Key points of discussion included:

- Resource update
- Plan implementation including
 - Metered use
 - Trading
 - Carryover
 - Groundwater level response
 - Groundwater salinity
- Technical investigations
- Policy development
- Watermatch

Actions from the meeting included:

- 1) Avoid holding GRC meetings on a Wednesday and avoid clash with Elmore Field Days.
- 2) Send link to flow and level data on Campaspe River to members – <https://waterline.gmwater.com.au/waterstatus/>
- 3) The review of the Plan should look to simplify temporary trading, particularly with regard to the intensity rule, while continuing to protect existing users.
- 4) Let Fosterville Gold Mine know about community concern regarding proposal to pump mine water back into the aquifer.
- 5) Monitor levels in Barnadown Zone and consider need for increased communications with customers in if levels continue to fall.
- 6) Let the Diversions Inspectors know when the mail out occurs so that they can encourage irrigators to respond.

4.2 Management plan review

Prescription 7(d) of the Plan states that the Corporation will undertake a comprehensive review of the Plan after 5 years from approval. Accordingly, GMW will commence with a comprehensive review of the Plan in 2017/18.

5 References

Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012. National Framework for Compliance and Enforcement of Systems for Water Resource Management. Viewed 28 August 2014, <http://www.environment.gov.au/system/files/resources/d4367a3b-28a9-430d-a869-2effbda8a447/files/ris-water-compliance-enforcement.pdf>

Department of Sustainability and Environment, 2012. Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan October 2013. Department of Environment and Primary Industries, Melbourne

Goulburn-Murray Water, 2013. Lower Campaspe Valley Water Supply Protection Area Groundwater Targeted licensed bore sampling. Unpublished report by Goulburn-Murray Water, Tatura. Document reference number 3503975.

Victorian Government, 2012. Victorian Government Gazette No. G43 25 October 2012. Victoria Government, Melbourne

Victorian Government, 2013. Victorian Government Gazette No. G10 7 March 2013. Victoria Government, Melbourne

Appendix A – Assessment of activities against Plan prescriptions

RESOURCE MANAGEMENT

Prescription	Activity	Compliant
<p>Prescription 1: Triggers and Restrictions</p> <p>By 1 July each year the Corporation will:</p> <ul style="list-style-type: none"> (a) Determine the rolling average of the maximum annual groundwater recovery levels from the preceding three seasons for the relevant bore, or its replacement, and announce a corresponding allocation for the subsequent season for zones as detailed in the Plan. (b) Announce seasonal allocations by listing them on its website; sending letters to all licence holders and placing public notices in local newspapers. (c) Not apply restrictions to any water authorised to be taken in a subsequent water season (carryover). 	<p>GMW determined the rolling average of the maximum annual groundwater recovery levels from the preceding three water years and announced allocations of 100% in all management zones on 1 July 2016.</p> <p>GMW announced allocations by listing them on their website, sending letters to all licence holders and placing public notices in local newspapers.</p>	Yes
<p>Prescription 2: Trading rules</p> <p>The Corporation may approve a transfer of a groundwater licence under section 62 of the <i>Water Act 1989</i> provided section 53 matters have been considered and it accords with the following:</p> <ul style="list-style-type: none"> (a) Transfer of licence entitlement can occur between zones as specified in the Plan (b) Despite (a) above, if the groundwater level falls to a depth of 18 metres below the natural surface in bore 62589 a licence may be transferred between the Barnadown Zone and other zones (c) Limits on the maximum licence volume in each zone as specified in the Plan are not exceeded. 	<p>GMW processed 8 temporary transfer transactions for a total of 1,174.8 ML; and 2 permanent transfer transactions for a total of 296 ML in 2016/17.</p> <p>GMW processed all groundwater licence applications in accordance with Prescription 2(a) and (c).</p>	Yes
<p>Prescription 3: Intensive groundwater pumping</p> <p>The Corporation may approve an application to take and use groundwater under section 51 or a transfer under section 62 of the <i>Water Act 1989</i> provided that section 53 matters have been considered and the following conditions are satisfied:</p> <ul style="list-style-type: none"> (a) For a permanent transfer, the total licence entitlement of bores within a 4 km radius of an applicant's bore is less than 7.5 GL/yr. (b) Where summed licence entitlement exceed the limits specified in (a) above, then a licence holder's usage is to be limited to 125% of entitlement in one water season whether it occurs through either temporary transfer of entitlement or carryover. (c) Usage may exceed 125% of entitlement as specified in (b) above through temporary or permanent transfer of entitlement from others within the 4 km radius. 	<p>GMW processed all groundwater licence applications in accordance with Prescription 3.</p>	Yes

MONITORING PROGRAM

Prescription	Activity	Compliant
<p>Prescription 4: Monitoring groundwater levels</p> <p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Obtain monthly groundwater level readings (up to 480 readings per season) from key State observation bores from the list in Schedule 1, or their replacement, where practicable. (b) Install at least one new observation bore in the Coonambidgal Formation to better inform groundwater interaction with the Campaspe River. 	<p>GMW obtained monthly groundwater level readings from bores listed in Schedule 1 of the Plan where practicable.</p> <p>A new observation bore is still to be installed in the Coonambidgal Formation. Consideration will be given to the installation of this bore now that the Department of Environment, Land, Water and Planning have completed the review of the State Observation Bore Network.</p>	<p>Yes</p>
<p>Prescription 5: Monitoring groundwater salinity</p> <p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Support annual groundwater user salinity sampling by: <ul style="list-style-type: none"> (i) Providing a sample bottle and a reply paid envelope to each groundwater licence holder and request that they collect a groundwater sample from all their licensed bores and return the samples to the Corporation for salinity analysis. (ii) Providing a sample bottle and a reply paid envelope to any domestic and stock groundwater user upon their request for them to provide a sample for salinity analysis. (iii) Measuring groundwater salinity in all returned sample bottles and providing the bore owner with the results. (iv) Entering the groundwater salinity results into the State groundwater database. (b) Establish a targeted groundwater salinity monitoring program to collect and analyse groundwater samples from selected licensed bores each year. (c) Collect groundwater samples from selected State observation bores identified in Schedule 1 where practicable, or their replacement. 	<p>GMW provided a sample bottle to licence holders and domestic and stock users upon request. GMW measured the groundwater salinity in returned samples, advised bore owners of the result and entered the results into the State groundwater database.</p> <p>GMW engaged with the six land holders participating in the target sampling of licensed bores. A total of 9 bores were sampled in 2016/17.</p> <p>GMW collected groundwater samples from nested State observation bores identified in Schedule 1 where practicable and sent them to a NATA accredited laboratory for analysis.</p>	<p>Yes</p>
<p>Prescription 6: Metered licensed use</p> <p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Ensure that a meter is fitted to all operational licensed bores. (b) Read each meter at least once a year and enter readings into the Water Register. 	<p>All operational licensed bores are metered. Meters were read in February/March and May/June 2017 and data entered into the Water Register.</p>	<p>Yes</p>

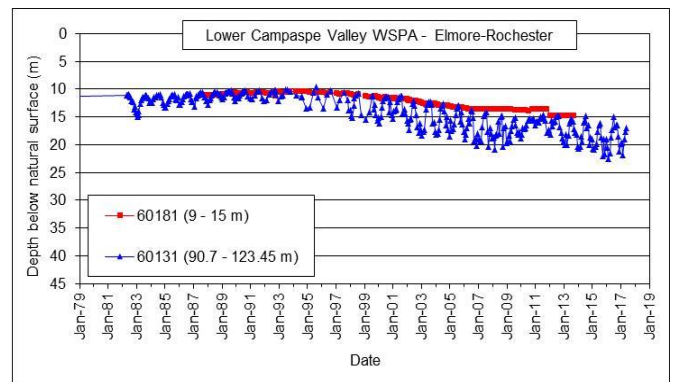
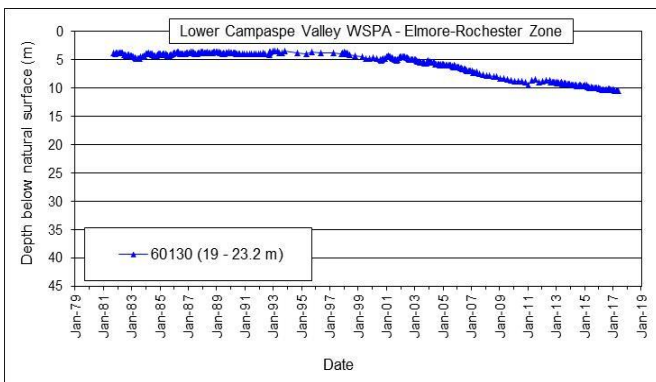
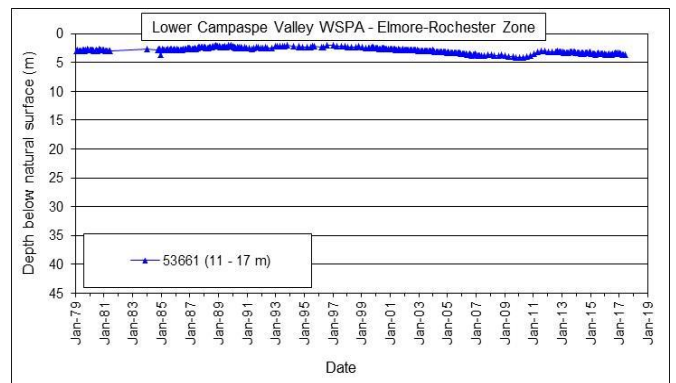
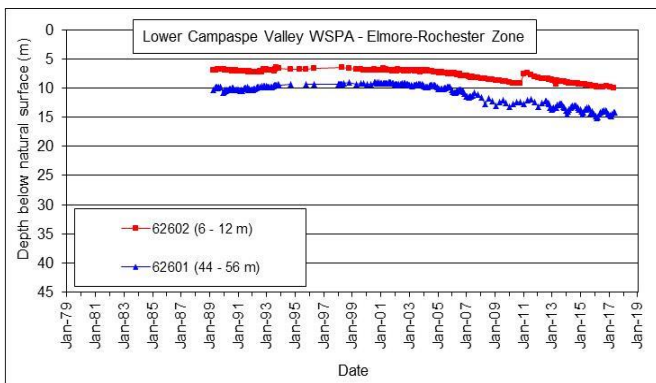
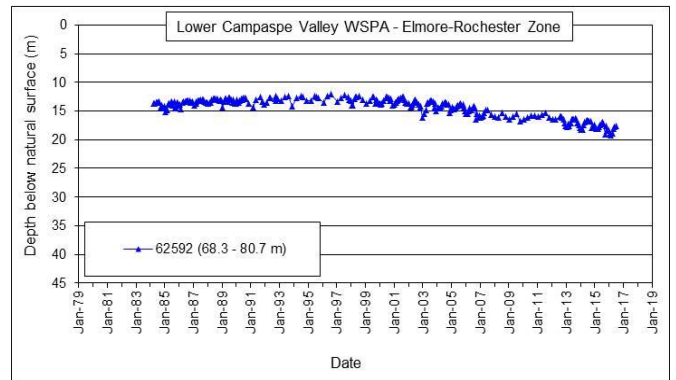
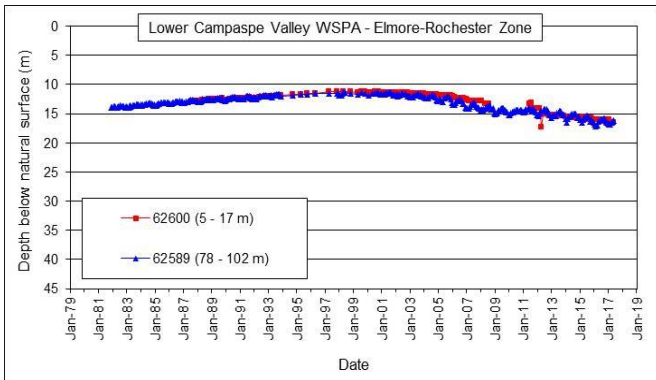
PLAN IMPLEMENTATION

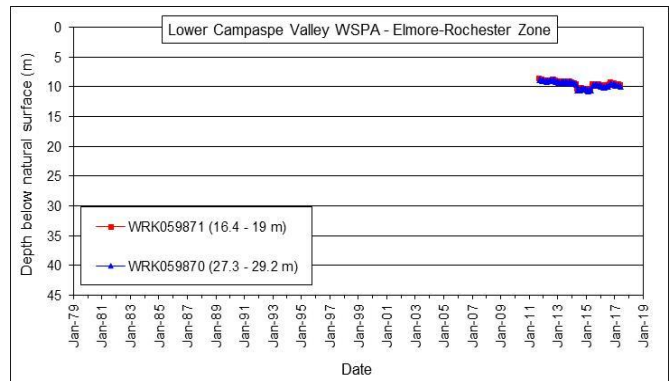
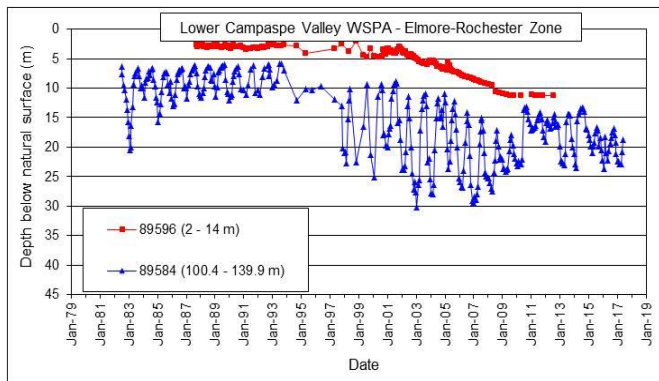
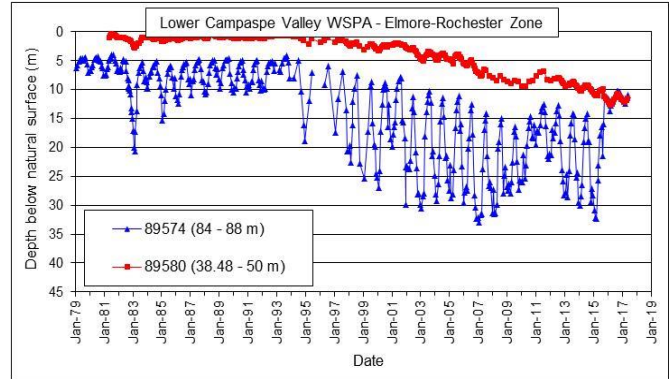
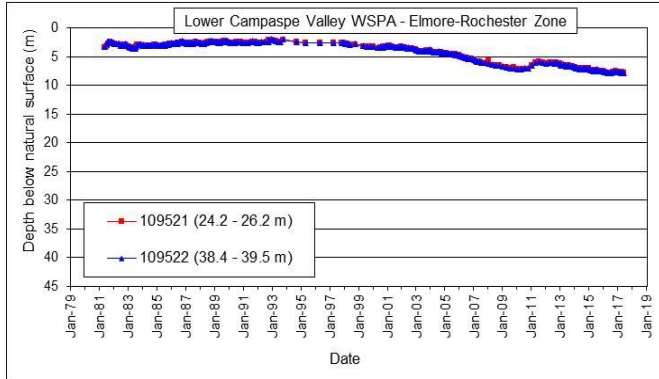
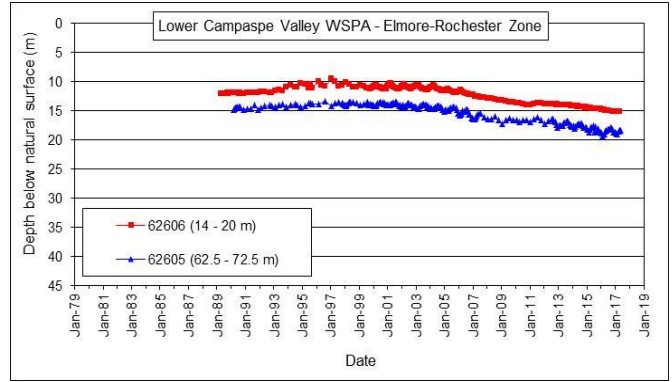
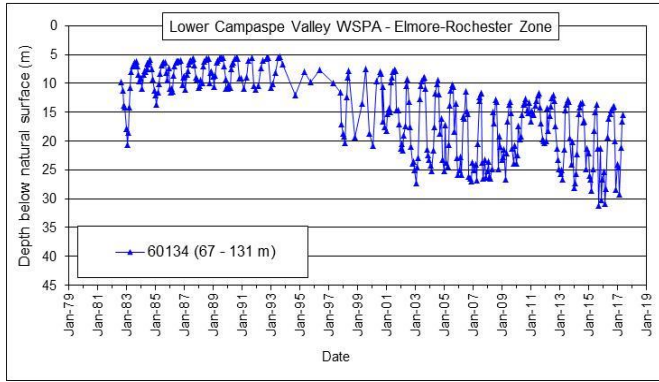
Prescription	Activity	Compliant
<p>Prescription 7: Plan implementation</p> <p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Post on its website the Plan; annual reports and newsletters; groundwater levels; and rolling average for trigger bores. (b) Mail a newsletter in October each year to groundwater licence holders, and domestic and stock users upon request, in the Lower Campaspe Valley WSPA and relevant agencies stating the resource position and summarising outcomes in the annual report. (c) Meet with the Groundwater Reference Committee at least once each year to report on the groundwater resource status and implementation of the Plan and consider the need to review the Plan. (d) Undertake a comprehensive review of the Plan after five years from 	<p>GMW has posted on its website the Plan, annual reports, groundwater level and rolling average for trigger bores.</p> <p>Newsletters reporting on resource status and implementation of the Plan were provided in September 2016.</p> <p>GMW met with the Groundwater Reference Committee in October 2016 to discuss Plan implementation.</p>	<p>Yes</p>

Appendix B – Hydrographs for key monitoring bores listed in the Plan (Schedule 1)

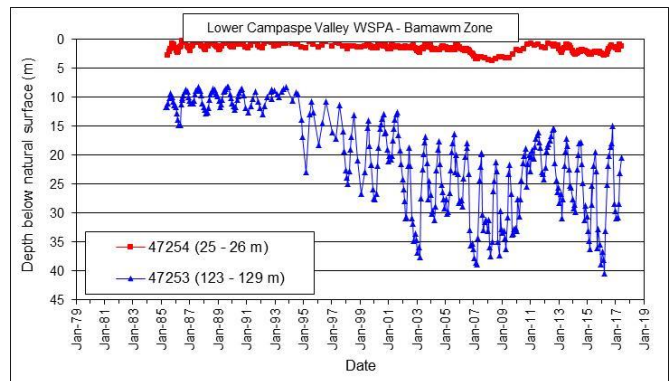
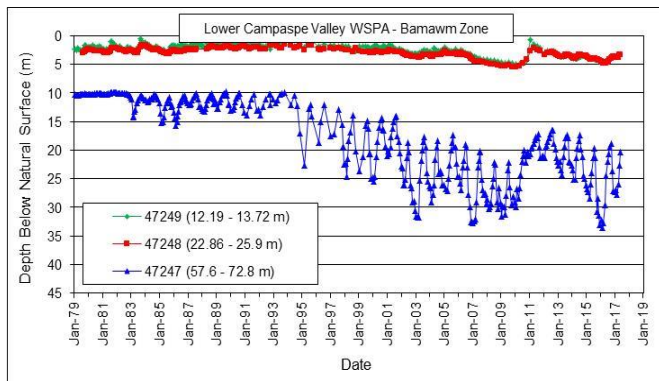
Further groundwater level information from other State observation bores is available on the Water Measurement Information System at <http://data.water.vic.gov.au/monitoring.htm>

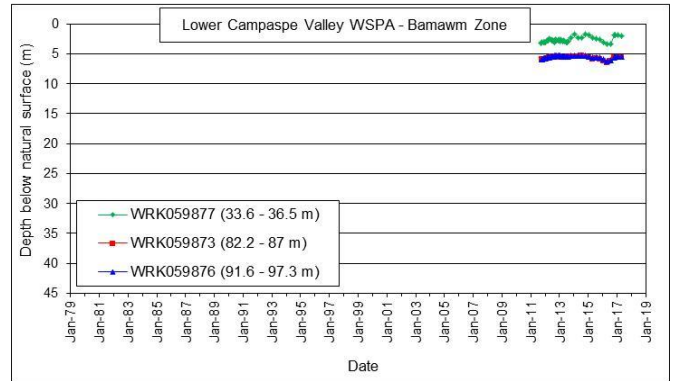
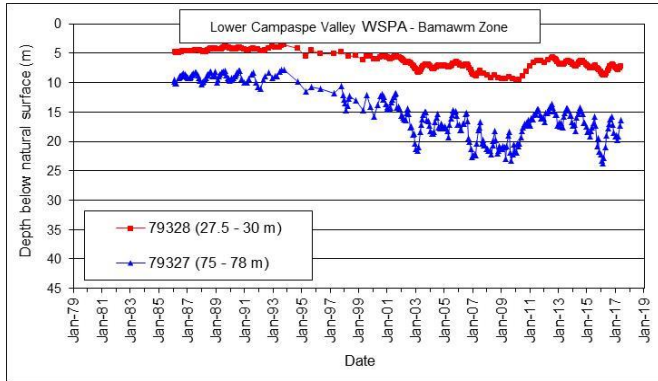
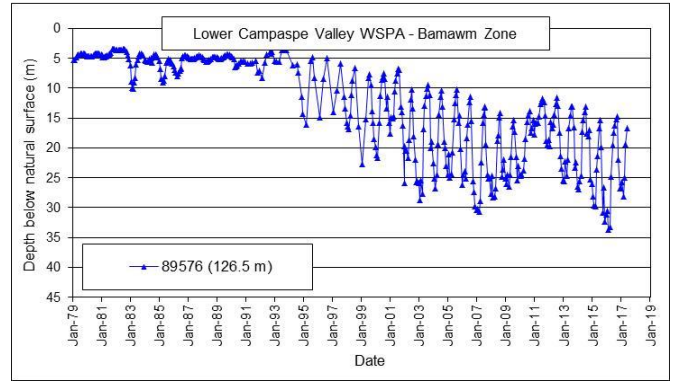
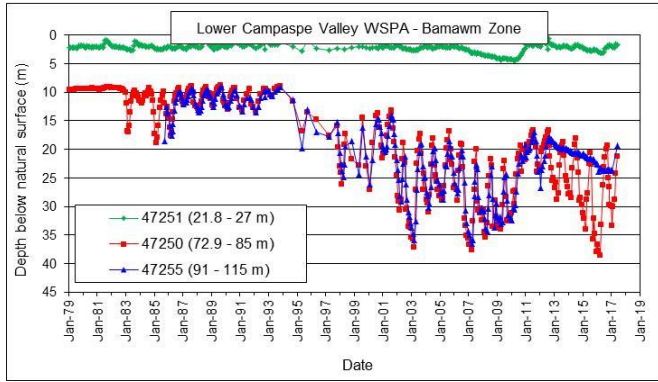
Elmore-Rochester Zone – 1031



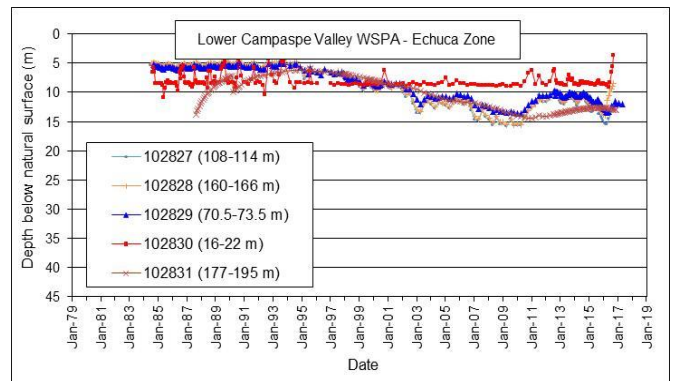
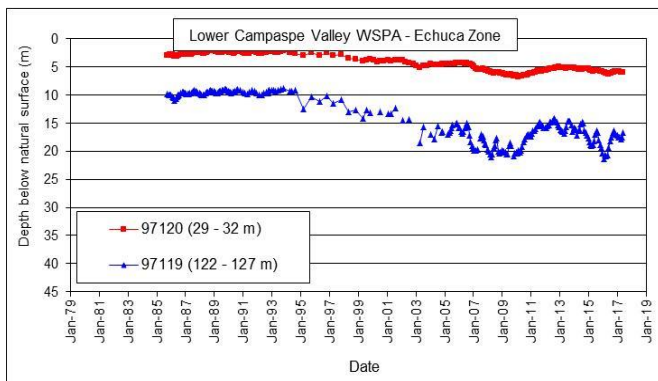
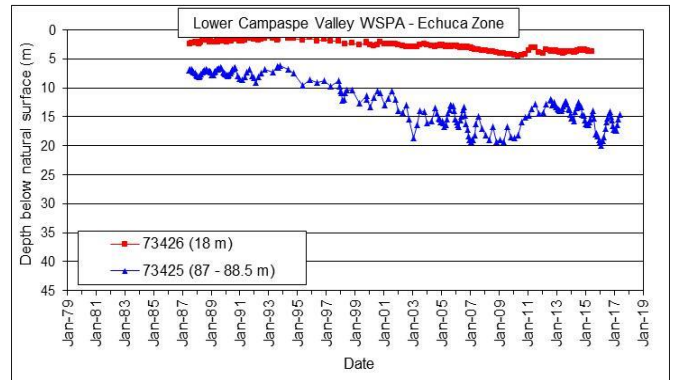
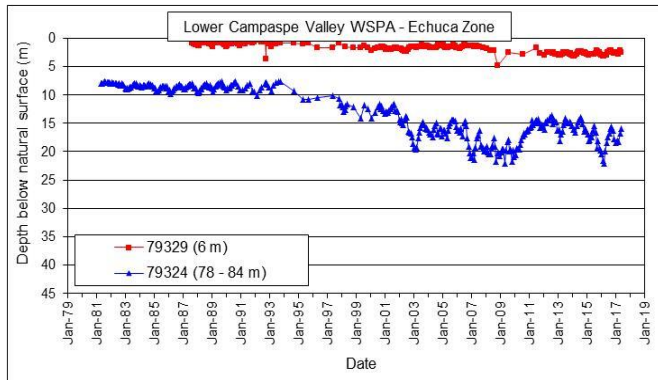


Bamawm Zone – 1032

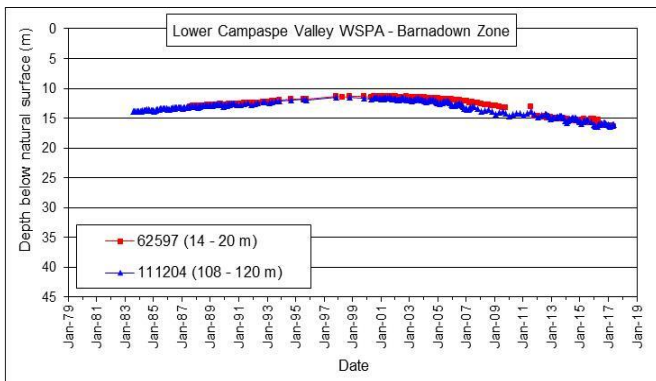
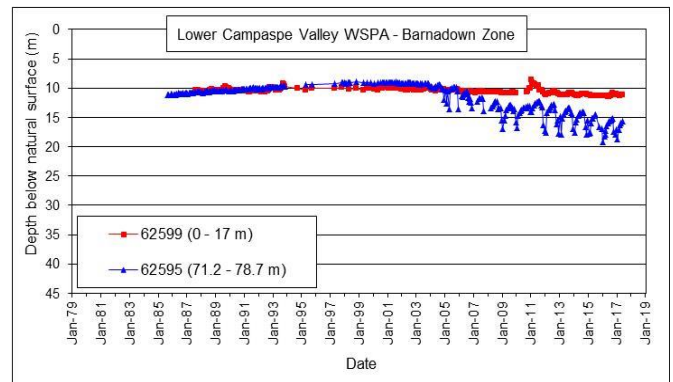
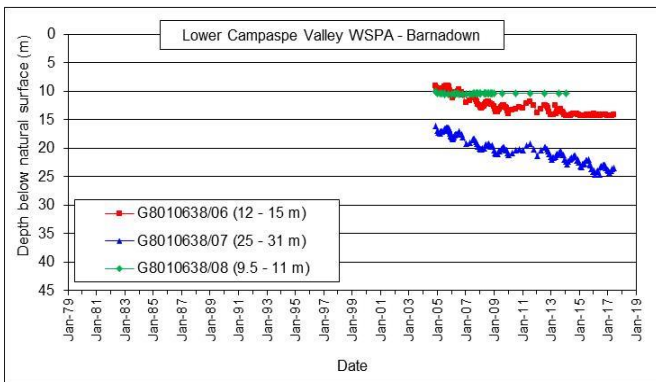
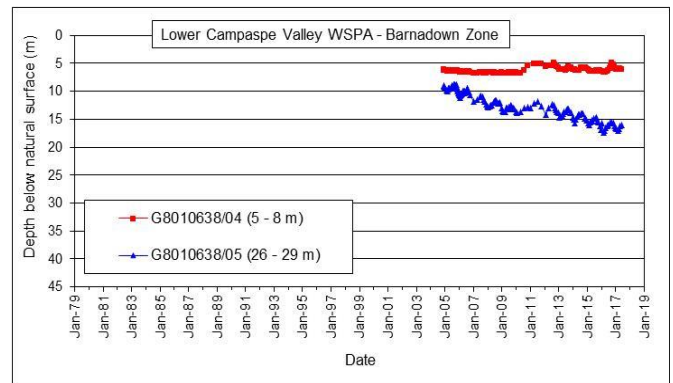
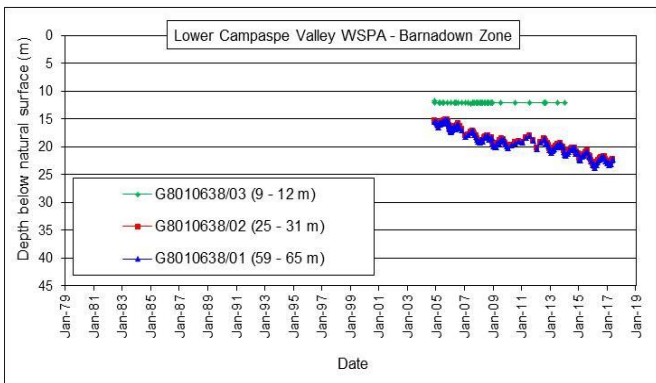
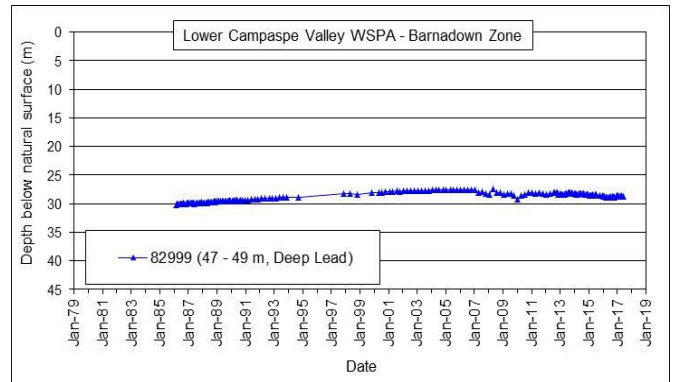
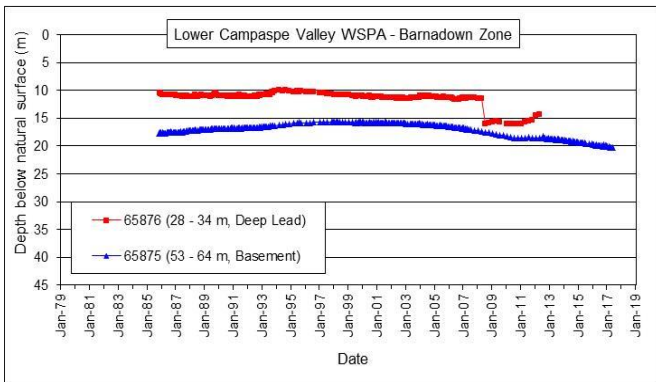




Echuca Zone – 1033

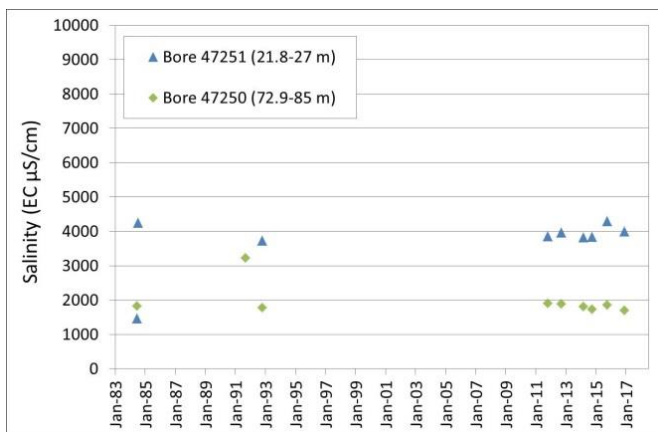
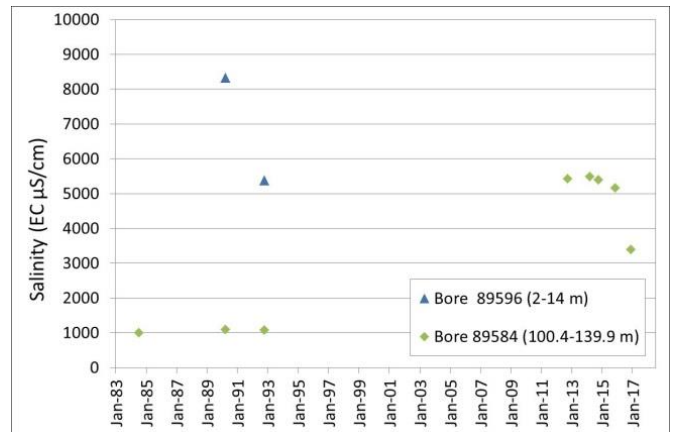
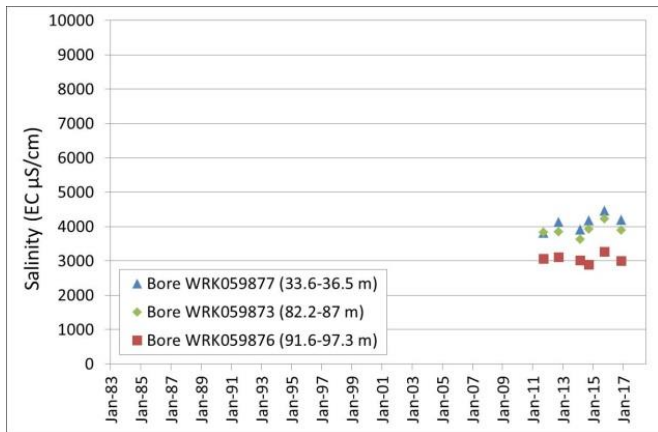
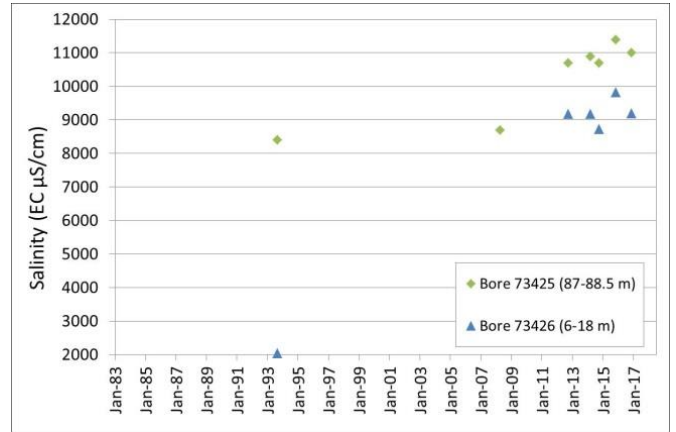
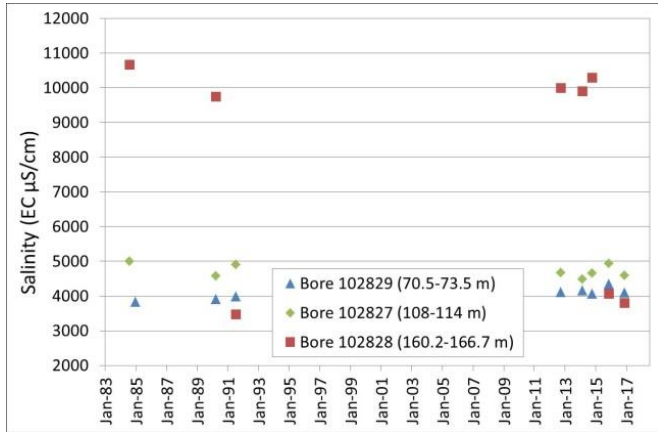


Barnadown Zone – 1034



Appendix C – Groundwater quality results

Historical groundwater salinity results from key monitoring bores listed in the Plan (Schedule 1)



Groundwater chemistry results from key monitoring bores listed in the Plan (Schedule 1)

Analyte	Unit	Bore:	102828	102827	102829	WRK059873	WRK059876	WRK059877
		Date:	29/11/2016	29/11/2016	29/11/2016	30/11/2016	30/11/2016	30/11/2016
Electrical Conductivity @ 25°C	µS/cm		3800	4600	4100	3900	3000	4200
pH	Units		8.7	9.1	7.6	6.9	6.9	7.1
Sulphate as SO4 - Turbidimetric	mg/L		280	230	280	230	< 10	310
Ionic Balance	%		3.96	4.7	1.77	11.5	6.24	0.26
Total Anions	meq/L		37	48	40	39	29	40
Total Cations	meq/L		35	44	39	31	25	40
Total Alkalinity, as CaCO3	mg/L		230	180	180	140	170	150
Bicarbonate Alkalinity as CaCO3	mg/L		210	120	180	140	170	150
Calcium	mg/L		25	7	37	64	44	55
Carbonate Alkalinity as CaCO3	mg/L		17	59	< 2	< 2	< 2	< 2
Chloride	mg/L		950	1400	1100	1100	900	1100
Hydroxide Alkalinity as CaCO3	mg/L		< 2	< 2	< 2	< 2	< 2	< 2
Potassium	mg/L		6	9	7	9	8	11
Sodium	mg/L		630	780	690	440	400	680
Ammonia	mg/L		< 0.1	< 0.1	< 0.1	0.087	0.15	< 0.002
Nitrate	mg/L		< 0.01	< 0.01	< 0.01	< 0.003	0.007	0.79
Total Kjeldahl Nitrogen as N	mg/L		< 0.1	< 0.1	< 0.1	0.11	0.2	0.16
Total Nitrogen as N	mg/L					0.11	0.21	0.95
Arsenic	mg/L		< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001
Iron	mg/L		0.06	< 0.01	0.1	5.1	0.51	< 0.01
Mercury	mg/L		< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Magnesium	mg/L		70	110	85	98	68	93
Manganese	mg/L		0.3	0.086	0.032	0.15	0.089	0.001
Total Dissolved Solids @ 180°C	mg/L		1800	2300	2000	2200	1600	1800
Turbidity	NTU		21	51	36	15	17	0.4
Total Phosphorus as P	mg/L		< 0.05	< 0.05	0.05	0.097	0.13	0.02
Total Organic Carbon (TOC)	mg/L		< 0.5	< 0.5	< 0.5	0.8	3	< 0.5
Lead	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L		< 0.001	< 0.001	0.073	0.009	0.007	< 0.001
Cadmium	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004
Copper	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L		0.002	0.001	0.007	0.003	0.002	0.003

		Bore:	47251	47250	73425	73426	89584
		Date:	30/11/2016	30/11/2016	29/11/2016	29/11/2016	30/11/2016
Analyte	Unit						
Electrical Conductivity @ 25°C	µS/cm		4000	1700	11000	9200	3400
pH	Units		9	9.5	7.3	6.9	5.6
Sulphate as SO4 - Turbidmetric	mg/L		190	25	530	920	< 1
Ionic Balance	%		1.44	-2.09	3.94	4.03	5.9
Total Anions	meq/L		39	15	105	93	31
Total Cations	meq/L		37	16	97	86	28
Total Alkalinity, as CaCO3	mg/L		180	83	200	38	< 2
Bicarbonate Alkalinity as CaCO3	mg/L		150	50	200	38	< 2
Calcium	mg/L		17	7	120	120	38
Carbonate Alkalinity as CaCO3	mg/L		34	33	< 2	< 2	< 2
Chloride	mg/L		1100	450	3200	2600	1100
Hydroxide Alkalinity as CaCO3	mg/L		< 2	< 2	< 2	< 2	< 2
Potassium	mg/L		13	6	12	7	7
Sodium	mg/L		700	290	1600	1400	340
Ammonia	mg/L			0.27			< 0.002
Nitrate	mg/L		0.004	< 0.003	< 0.01	2.4	0.011
Total Kjeldahl Nitrogen as N	mg/L		1.6	0.32	0.1	0.2	0.05
Total Nitrogen as N	mg/L		1.6	0.32			0.06
Arsenic	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L		0.01	0.01	0.64	0.01	23
Mercury	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Magnesium	mg/L		71	29	260	230	130
Manganese	mg/L		0.093	0.026	0.099	0.002	3.4
Total Dissolved Solids @ 180°C	mg/L		2200	850	6000	5100	2100
Turbidity	NTU		22	40	8	6.4	3.8
Total Phosphorus as P	mg/L		0.055	0.061	0.08	0.06	0.008
Total Organic Carbon (TOC)	mg/L		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L		< 0.001	< 0.001	0.001	0.004	< 0.001
Cadmium	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L		< 0.001	< 0.001	< 0.001	0.004	0.003
Zinc	mg/L		0.004	< 0.001	0.003	0.006	0.019

Groundwater salinity results from targeted sampling program with historical data (where available)

