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BIOREGIONAL
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PROVIDING SCIENTIFIC WATER RESOURCE
INFORMATION ASSOCIATED WITH COAL
SEAM GAS AND LARGE COAL MINES

Water balance assessment for the Gippsland Basin bioregion

Product 2.5 from the Gippsland Basin Bioregional Assessment

2018



The Bioregional Assessment Programme

The Bioregional Assessment Programme is a transparent and accessible programme of baseline assessments that increase the available science for decision making associated with coal seam gas and large coal mines. A bioregional assessment is a scientific analysis of the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources. This Programme draws on the best available scientific information and knowledge from many sources, including government, industry and regional communities, to produce bioregional assessments that are independent, scientifically robust, and relevant and meaningful at a regional scale.

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Cover photograph

Lake Victoria, Victoria, 2013

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Contents

- 2.5 Water balance assessment for the Gippsland Basin bioregion 8**
- 2.5.1 Methods 10**
 - 2.5.1.1 Spatial and temporal extent of the water balances 10
 - 2.5.1.2 Water balance uncertainty 11
- 2.5.2 The water balances 12**
 - 2.5.2.1 Reporting unit #1 – the Gippsland Basin 12
 - 2.5.2.2 Reporting unit #2 – BA region 17
 - 2.5.2.3 Reporting unit #3 – The Latrobe River 20
 - 2.5.2.4 Gaps 24
- References 25**
- Datasets 26**

Figures

Figure 1 Water balance reporting regions for (a) the Gippsland Basin (black outline), (b) the bioregional assessment subdomain (green region) and (c) the Latrobe River (purple line).....9

Tables

Table 1	Water balance (GL/yr) in the Gippsland Basin for 2013 to 2042.....	13
Table 2	Water balance (GL/yr) in the Gippsland Basin for 2043 to 2072.....	13
Table 3	Water balance (GL/yr) in the Gippsland Basin for 2073 to 2102.....	13
Table 4	Water balance (mm/yr) in the Gippsland Basin for 2013 to 2042.....	14
Table 5	Water balance (mm/yr) in the Gippsland Basin for 2043 to 2072.....	14
Table 6	Water balance (mm/yr) in the Gippsland Basin for 2073 to 2102.....	15
Table 7	Water balance percentage change (%) in the Gippsland Basin for 2013 to 2042 relative to the baseline 1983 to 2012 period.....	15
Table 8	Water balance percentage change (%) in the Gippsland Basin for 2043 to 2072 relative to the baseline 1983 to 2012 period.....	16
Table 9	Water balance percentage change (%) in the Gippsland Basin for 2073 to 2102 relative to the baseline 1983 to 2012 period.....	16
Table 10	Water balance (GL/yr) in the BA region for 2013 to 2042.....	17
Table 11	Water balance (GL/yr) in the BA region for 2043 to 2072.....	17
Table 12	Water balance (GL/yr) in the BA region for 2073 to 2102.....	18
Table 13	Water balance (mm/yr) in the BA region for 2013 to 2042.....	18
Table 14	Water balance (mm/yr) in the BA region for 2043 to 2072.....	18
Table 15	Water balance (mm/yr) in the BA region for 2073 to 2102.....	19
Table 16	Water balance percentage change (%) in the BA region for 2013 to 2042 relative to the baseline 1983 to 2012 period	19
Table 17	Water balance percentage change (%) in the BA region for 2043 to 2072 relative to the baseline 1983 to 2012 period	19
Table 18	Water balance percentage change (%) in the BA region for 2073 to 2102 relative to the baseline 1983 to 2012 period	20
Table 19	Water balance (GL/yr) in the Latrobe River region for 2013 to 2042.....	20
Table 20	Water balance (GL/yr) in the Latrobe River region for 2043 to 2072.....	21
Table 21	Water balance (GL/yr) in the Latrobe River region for 2073 to 2102.....	21
Table 22	Water balance (mm/yr) in the Latrobe River region for 2013 to 2042	21

Table 23	Water balance (mm/yr) in the Latrobe River region for 2043 to 2072	22
Table 24	Water balance (mm/yr) in the Latrobe River region for 2073 to 2102	22
Table 25	Water balance percentage change (%) in the Latrobe River region for 2013 to 2042 relative to the baseline 1983 to 2012 period	23
Table 26	Water balance percentage change (%) in the Latrobe River region for 2043 to 2072 relative to the baseline 1983 to 2012 period	23
Table 27	Water balance percentage change (%) in the Latrobe River region for 2073 to 2102 relative to the baseline 1983 to 2012 period	24



2.5 Water balance assessment for the Gippsland Basin bioregion

This product presents the mean annual water balances for the Gippsland Basin bioregion using data based on current water accounts (product 1.5), as well as results from groundwater modelling (product 2.6.2). No surface water modelling was undertaken for the Gippsland Basin bioregion. Surface water flows are available in the Victorian Water Accounts for 2012 (<http://waterregister.vic.gov.au/water-availability-and-use/victorian-water-accounts>). The water balances are reported over three 30-year periods: 2013 to 2042; 2043 to 2072; and 2073 to 2102, during which three global warming scenarios of 1 °C, 1.5 °C and 2 °C have been assumed respectively.

Water balances are reported for the two potential futures considered in a bioregional assessment:

1. Baseline – a future that includes existing coal mines and proposed mines closure as of December 2012.
2. Coal resource development pathway (CRDP) – a future that includes existing coal mines that are considered in the baseline as well as proposed mine expansions that are expected to begin commercial production after December 2012.

This product reports water balance variations between the CRDP and baseline conditions. The primary water balance components describe the inflows, outflows and change in storage for a hydrological domain. Three hydrologic domains have been defined in the Gippsland Basin based on differences in the spatial extents of the surface water and groundwater source areas, proximity to coal resource developments and hydrological connectivity within the surface water domain and the groundwater domain. The three domains are shown in Figure 1 and are:

1. The entire on-shore Gippsland Basin representing an area of 3,639,228 ha
2. The bioregional assessment region representing an area of 1,462,575 ha
3. The Latrobe River and adjacent buffer representing an area of 9,904 ha.

The surface water balance terms only include rainfall, evapotranspiration and surface water inflows. Surface water outflows, licensed extractions from the river, losses and change in surface water



storages were not modelled. Groundwater balance terms include recharge, evapotranspiration, baseflow, licensed extractions and change in groundwater storage. Key terms for quantifying the impacts of additional coal resource development on hydrology in the Gippsland Basin subregions are baseflow and change in groundwater storage. Quantification of climate change impacts are evidenced by variations in rainfall, evapotranspiration, surface water inflows and recharge.

Impacts on the water balance are further considered in the impact and risk analysis (product 3.4).

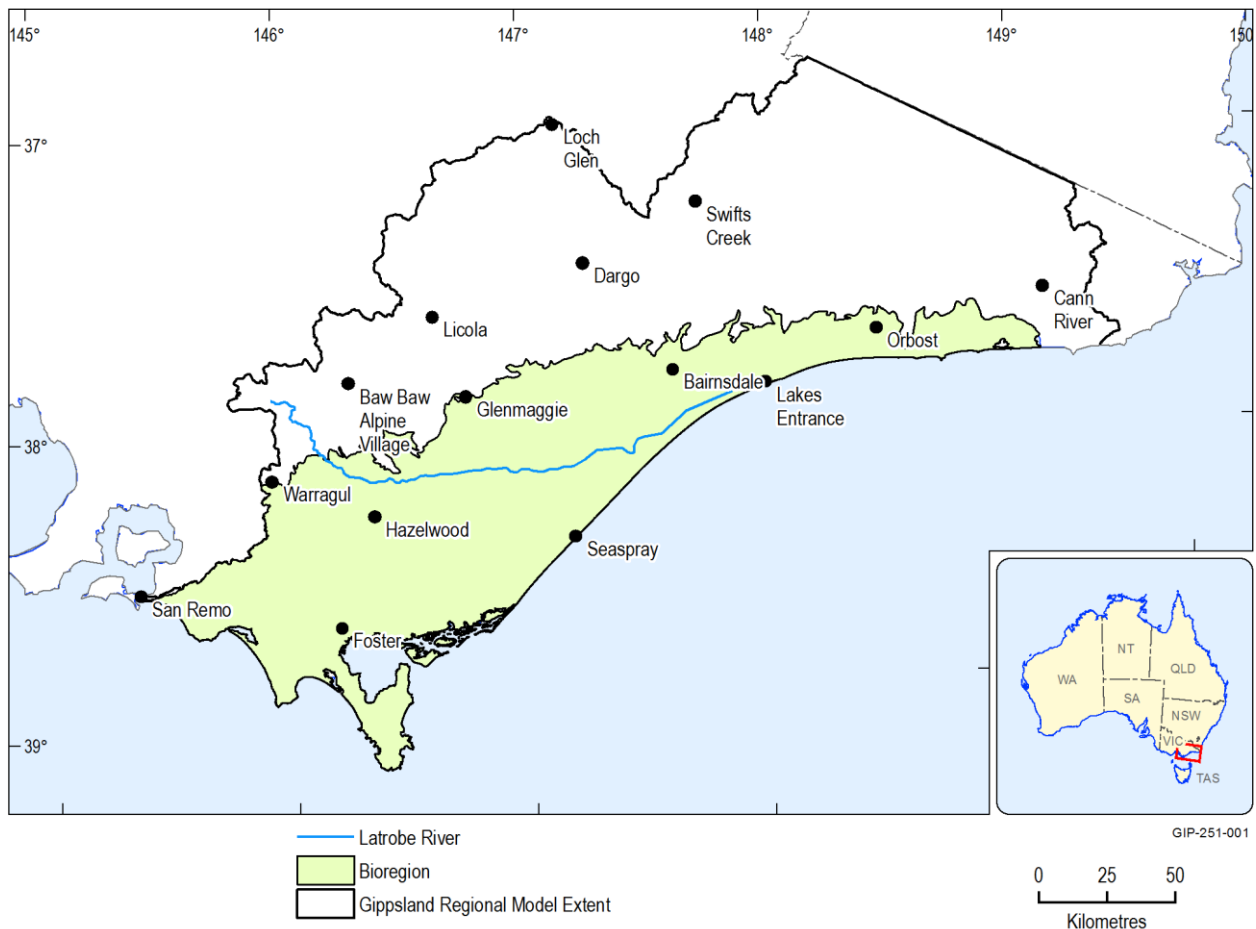


Figure 1 Water balance reporting regions for (a) the Gippsland Basin (black outline), (b) the bioregional assessment subdomain (green region) and (c) the Latrobe River (blue line)

2.5.1 Methods

Summary

Water balances are compiled for three domains of varying extent and hydrological connectivity and complexity.

Three reporting periods are used to summarise water balance terms. These are 2013 to 2042; 2043 to 2072; and 2073 to 2102. They have the same variability as in the 1983–2012 historical sequence, but each of the future 30-year climate blocks assume some level of global warming.

Two possible coal resource development futures have been modelled.

Water balances are presented in volumetric units of giga litres per year (GL/yr), domain averaged millimetres per year (mm/yr) units and as percentage change from the average 1983–2012 historical condition. In all, 27 water balances are generated.

2.5.1.1 Spatial and temporal extent of the water balances

Coal resource development in the Gippsland Basin occur adjacent to the existing Hazelwood, Loy Yang and Yallourn open-pit coal mines. These coal resource developments are detailed in Section 2.3.4 of product 2.3 for the Gippsland Basin bioregion

Water balance reporting domains have been selected to quantify the cumulative hydrologic impacts of coal resource developments over the area that are all hydrologically connected and for which model outputs had been generated. In the case of the Latrobe River reporting region, this domain was selected to assess the maximum hydrologic impacts of coal resource developments on likely aquatic receptors. In contrast, the regional scale reporting domains of the Gippsland Basin and the bioregional assessment subdomain are intended to quantify the ‘maximum’ impact from all hydrologically connected mines, rather than the maximum impact around individual mines or smaller groupings of combinations of some mines.

Surface water balances were derived using the Catchment Analysis Tool (CAT) (Beverly et al., 2005; Beverly, 2009) which simulates soil-water-plant interactions using combinations of farming system models. Future projected climate for three 30-year periods (2013 to 2042; 2043 to 2072; and 2073 to 2102) were constructed assuming temperature increases of 1 °C, 1.5 °C and 2 °C and a climate pattern of change from the Miroc3 global climate model (GCM). These three time periods were generated from the 30-year historical sequence from 1983 to 2012 by modifying the historical sequence to reflect a warming trend. Thus, the variability in the historical sequence is preserved, but the effect of droughts and floods does not confound the comparison between time periods. Daily water balance estimates were subsequently derived from 1970 to 2102 using a combination of historical and future climate conditions from which recharge and potential evapotranspiration were spatially assigned to the groundwater model. Whereas the CAT model accounts for elevated radiation and carbon dioxide impacts on plant performance this was not considered in the current

study. The water balance terms reported here represent the annual averages for each 30-year period.

Groundwater modelling was based on the multi-layered distributed groundwater model MODFLOW-2005 (Harbaugh, 2005) as detailed in Section 2.6.2 of companion product 2.6 for the Gippsland Basin bioregion. The simulation period was 1970 to 2102 with variable time steps ranging from annual for 1970 to 1989 and thereafter 3-monthly. The groundwater balance reported for the bioregional assessment and Latrobe River subdomains were extracted from the regional scale Gippsland Basin groundwater model predictions. Historical groundwater extractions were explicitly modelled with future changes in coal mine extractions post proposed mine closure dates assigned to both the baseline and CRDP modelled scenarios. That is the extractions assigned to existing mine dewatering pumps were assumed not to differ between the two modelled futures. It is noteworthy that the dewatering scenarios adopted post mine closure are hypothetical. The CRDP simulation considered additional groundwater extractions associated with the expansion of open-cut operations. This is based on the coal mine work plans as of 2012.

2.5.1.2 *Water balance uncertainty*

Uncertainty analysis associated with water balance estimates was not undertaken. However, it is possible to present the 10th, 50th and 90th percentiles of the water balance components using the annual estimates within each reporting period.

2.5.2 The water balances

Summary

This report summarises the cumulative impacts of coal development on key water balance components relative to baseline conditions for three regions over three future periods. The three regions assessed were (1) the onshore extent of the Gippsland Basin, (2) the Bioregional Assessment region and (3) the Latrobe River. The reporting periods were 2013 to 2042, 2043 to 2072 and 2073 to 2102. To achieve the CRDP targets requires an increase in licensed extractions to vary from the baseline conditions by on average 124 GL/yr, 116 GL/yr and 108 GL/y for each reporting period respectively. Results suggest that the CRDP has less than a 1% impact on the Gippsland Basin total baseflows relative to baseline conditions, a 4% impact on the Bioregional Assessment regional baseflows and a maximum of 6% impact on the Latrobe River baseflow contribution.

2.5.2.1 Reporting unit #1 – the Gippsland Basin

Water balances for the entire Gippsland Basin are provided in Table 1 for 2013 to 2042, Table 2 for 2043 to 2072 and Table 3 for 2073 to 2102. Corresponding catchment averaged mm/year water balances are presented in Table 4 for 2013 to 2042, Table 5 for 2043 to 2072 and

Table 6 for 2073 to 2102.

Rainfall inputs over the three reporting periods reflect changes due to a varying climate signal.

Within each table, the differences between the baseline and coal resource development pathway scenarios can largely be attributed to the impacts of mining as the climate signal is identical in both scenarios.

The differences between corresponding values over the three reporting periods encompass both the effects of climate and the coal resource development.

The percentage change in volumetric water balance components relative to the average 1983 to 2012 conditions are summarised in Table 7 for 2013 to 2042,

Table 8 for 2043 to 2072 and Table 9 for 2073 to 2102.

Table 1 Water balance (GL/yr) in the Gippsland Basin for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	31,823.72	31,823.72	
	Evapotranspiration	GL/yr	22,353.10	22,353.10	
	Surface water inflow	GL/yr	5,132.73	5,132.73	
Groundwater	Recharge	GL/yr	2,445.40	2,445.40	0
	Evapotranspiration	GL/yr	-2,663.14	-2,618.08	-45.06
	Baseflow (discharge to stream)	GL/yr	-688.93	-684.79	-4.14
	Licensed extractions	GL/yr	-233.23	-356.95	-123.72
	Change in storage	GL/yr	657.58	750.74	-93.16

Table 2 Water balance (GL/yr) in the Gippsland Basin for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	31,279.07	31,279.07	
	Evapotranspiration	GL/yr	22,057.98	22,057.98	
	Surface water inflow	GL/yr	4,987.17	4,987.17	
Groundwater	Recharge	GL/yr	2,348.33	2,348.33	0
	Evapotranspiration	GL/yr	-2,183.23	-2,115.53	-67.71
	Baseflow (discharge to stream)	GL/yr	-476.75	-470.45	-6.31
	Licensed extractions	GL/yr	-228.5	-344.51	-116.01
	Change in storage	GL/yr	313.96	337.47	-23.51

Table 3 Water balance (GL/yr) in the Gippsland Basin for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	30,698.53	30,698.53	
	Evapotranspiration	GL/yr	21,874.92	21,874.92	
	Surface water inflow	GL/yr	4,702.29	4,702.29	
Groundwater	Recharge	GL/yr	2,227.12	2,227.12	0
	Evapotranspiration	GL/yr	-1,952.29	-1,875.25	-77.04
	Baseflow (discharge to stream)	GL/yr	-391.03	-387.56	-3.46
	Licensed extractions	GL/yr	-221.24	-328.90	-107.66
	Change in storage	GL/yr	191.83	205.23	-13.4

Table 4 Water balance (mm/yr) in the Gippsland Basin for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	874.46	874.46	0
	Evapotranspiration	mm/yr	614.23	614.23	0
	Surface water inflow	mm/yr	141.04	141.04	0
Groundwater	Recharge	mm/yr	67.20	67.20	0
	Evapotranspiration	mm/yr	-73.18	-71.94	-1.24
	Baseflow (discharge to stream)	mm/yr	-18.93	-18.82	-0.11
	Licensed extractions	mm/yr	-6.41	-9.81	3.40
	Change in storage	mm/yr	18.07	20.63	-2.56

Table 5 Water balance (mm/yr) in the Gippsland Basin for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	859.50	859.50	0
	Evapotranspiration	mm/yr	606.12	606.12	0
	Surface water inflow	mm/yr	137.04	137.04	0
Groundwater	Recharge	mm/yr	64.53	64.53	0
	Evapotranspiration	mm/yr	-59.99	-58.13	-1.86
	Baseflow (discharge to stream)	mm/yr	-13.10	-12.93	-0.17
	Licensed extractions	mm/yr	-6.28	-9.47	3.19
	Change in storage	mm/yr	8.63	9.27	-0.65

Table 6 Water balance (mm/yr) in the Gippsland Basin for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	843.55	843.55	0
	Evapotranspiration	mm/yr	601.09	601.09	0
	Surface water inflow	mm/yr	129.21	129.21	0
Groundwater	Recharge	mm/yr	61.20	61.20	0
	Evapotranspiration	mm/yr	-53.65	-51.53	-2.12
	Baseflow (discharge to stream)	mm/yr	-10.74	-10.65	-0.10
	Licensed extractions	mm/yr	-6.08	-9.04	2.96
	Change in storage	mm/yr	5.27	5.64	-0.37

Table 7 Water balance percentage change (%) in the Gippsland Basin for 2013 to 2042 relative to the baseline 1983 to 2012 period.

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-3.41	-3.41	0
	Evapotranspiration	%	-2.66	-2.66	0
	Surface water inflow	%	-3.83	-3.83	0
Groundwater	Recharge	%	-5.98	-5.98	0
	Evapotranspiration	%	-35.56	-36.65	-1.09
	Baseflow (discharge to stream)	%	-56.04	-56.31	-0.27
	Licensed extractions	%	32.99	103.54	70.55
	Change in storage	%	-64.03	-64.03	0.01

Table 8 Water balance percentage change (%) in the Gippsland Basin for 2043 to 2072 relative to the baseline 1983 to 2012 period.

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-5.06	-5.06	0
	Evapotranspiration	%	-3.95	-3.95	0
	Surface water inflow	%	-6.56	-6.56	0
Groundwater	Recharge	%	-9.71	-9.71	0
	Evapotranspiration	%	-47.17	-48.81	-1.64
	Baseflow (discharge to stream)	%	-69.58	-69.98	-0.4
	Licensed extractions	%	30.30	96.45	66.15
	Change in storage	%	-58.93	-81.54	-22.61

Table 9 Water balance percentage change (%) in the Gippsland Basin for 2073 to 2102 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-6.82	-6.82	0
	Evapotranspiration	%	-4.74	-4.74	0
	Surface water inflow	%	-11.90	-11.90	0
Groundwater	Recharge	%	-14.37	-14.37	0
	Evapotranspiration	%	-52.76	-54.62	-1.86
	Baseflow (discharge to stream)	%	-75.05	-75.27	-0.22
	Licensed extractions	%	26.16	87.55	61.39
	Change in storage	%	-81.54	-88.77	-7.23

2.5.2.2 Reporting unit #2 – BA region

Water balances for the entire Bioregional reporting region are summarised in Table 10 for 2013 to 2042, Table 11 for 2043 to 2072 and

Table 12 for 2073 to 2102. The corresponding spatially averaged mm/year water balances are presented in Table 13 for 2013 to 2042, Table 14 for 2043 to 2072 and Table 15 for 2073 to 2102. As a comparison to the calibration period the percentage change in volumetric water balance components relative to the average 1983 to 2012 conditions are summarised in

Table 16 for 2013 to 2042, Table 17 for 2043 to 2072 and Table 18 for 2073 to 2102.

Table 10 Water balance (GL/yr) in the BA region for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	16,655.78	16,655.78	0
	Evapotranspiration	GL/yr	12,721.84	12,721.84	0
	Surface water inflow	GL/yr	2,156.18	2,156.18	0
Groundwater	Recharge	GL/yr	1,092.03	1,092.03	0
	Evapotranspiration	GL/yr	-1,250.24	-1,205.84	-44.4
	Baseflow (discharge to stream)	GL/yr	-95.28	-91.41	-3.87
	Licensed extractions	GL/yr	-135.79	-259.51	123.72
	Change in storage	GL/yr	141.03	232.61	-91.58

Table 11 Water balance (GL/yr) in the BA region for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	16,378.43	16,378.43	0
	Evapotranspiration	GL/yr	12,512.93	12,512.93	0
	Surface water inflow	GL/yr	2,127.42	2,127.42	0
Groundwater	Recharge	GL/yr	1,065.22	1,065.22	0
	Evapotranspiration	GL/yr	-1,123.47	-1,057.30	-66.17
	Baseflow (discharge to stream)	GL/yr	-86.39	-80.70	-5.69
	Licensed extractions	GL/yr	-131.07	-247.08	116.01
	Change in storage	GL/yr	68.28	90.14	-21.86

Table 12 Water balance (GL/yr) in the BA region for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	16,270.54	16,270.54	0
	Evapotranspiration	GL/yr	12,526.63	12,526.63	0
	Surface water inflow	GL/yr	2,037.91	2,037.91	0
Groundwater	Recharge	GL/yr	1,023.21	1,023.21	0
	Evapotranspiration	GL/yr	-1,051.85	-977.19	-74.66
	Baseflow (discharge to stream)	GL/yr	-80.80	-77.97	-2.82
	Licensed extractions	GL/yr	-123.80	-231.45	107.65
	Change in storage	GL/yr	43.04	55.47	-12.43

Table 13 Water balance (mm/yr) in the BA region for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	770.69	770.69	0
	Evapotranspiration	mm/yr	588.66	588.66	0
	Surface water inflow	mm/yr	147.42	147.42	0
Groundwater	Recharge	mm/yr	74.66	74.66	0
	Evapotranspiration	mm/yr	-85.48	-82.45	-3.04
	Baseflow (discharge to stream)	mm/yr	-6.51	-6.25	-0.26
	Licensed extractions	mm/yr	-9.28	-17.74	8.46
	Change in storage	mm/yr	9.64	15.90	-6.26

Table 14 Water balance (mm/yr) in the BA region for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	758.48	758.48	0
	Evapotranspiration	mm/yr	579.47	579.47	0
	Surface water inflow	mm/yr	145.46	145.46	0
Groundwater	Recharge	mm/yr	72.83	72.83	0
	Evapotranspiration	mm/yr	-76.81	-72.29	-4.52
	Baseflow (discharge to stream)	mm/yr	-5.91	-5.52	-0.39
	Licensed extractions	mm/yr	-8.96	-16.89	7.93
	Change in storage	mm/yr	4.67	6.16	-1.49

Table 15 Water balance (mm/yr) in the BA region for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	745.62	745.62	0
	Evapotranspiration	mm/yr	574.05	574.05	0
	Surface water inflow	mm/yr	139.34	139.34	0
Groundwater	Recharge	mm/yr	69.96	69.96	0
	Evapotranspiration	mm/yr	-71.92	-66.81	-5.10
	Baseflow (discharge to stream)	mm/yr	-5.52	-5.33	-0.19
	Licensed extractions	mm/yr	-8.46	-15.82	7.36
	Change in storage	mm/yr	2.94	3.79	-0.85

Table 16 Water balance percentage change (%) in the BA region for 2013 to 2042 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-2.58	-2.58	0
	Evapotranspiration	%	-2.39	-2.39	0
	Surface water inflow	%	-0.46	-0.46	0
Groundwater	Recharge	%	-2.54	-2.54	0
	Evapotranspiration	%	-22.72	-25.46	-2.74
	Baseflow (discharge to stream)	%	-25.70	-28.72	-3.02
	Licensed extractions	%	73.00	230.63	157.63
	Change in storage	%	-60.42	-34.72	25.7

Table 17 Water balance percentage change (%) in the BA region for 2043 to 2072 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-4.21	-4.21	0
	Evapotranspiration	%	-4.00	-4.00	0
	Surface water inflow	%	-1.79	-1.79	0
Groundwater	Recharge	%	-4.93	-4.93	0
	Evapotranspiration	%	-30.56	-34.65	-4.09
	Baseflow (discharge to stream)	%	-32.63	-37.07	-4.44
	Licensed extractions	%	66.99	214.79	147.8
	Change in storage	%	-80.84	-74.70	6.14

Table 18 Water balance percentage change (%) in the BA region for 2073 to 2102 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-4.84	-4.84	0
	Evapotranspiration	%	-3.89	-3.89	0
	Surface water inflow	%	-5.92	-5.92	0
Groundwater	Recharge	%	-8.68	-8.68	0
	Evapotranspiration	%	-34.98	-39.60	-4.62
	Baseflow (discharge to stream)	%	-36.99	-39.20	-2.21
	Licensed extractions	%	57.73	194.88	137.15
	Change in storage	%	-87.92	-84.43	3.49

2.5.2.3 Reporting unit #3 – The Latrobe River

The impact of the CRDP on the Latrobe River streamflow was evaluated by consideration of the change in surface water inflows and baseflow contributions. Water balances for the region defined by a 100 m buffer either side of the Latrobe River are summarised in Table 19 for 2013 to 2042, Table 20 for 2043 to 2072 and Table 21 for 2073 to 2102. The corresponding spatially averaged mm/year water balances are presented in Table 4 and Table 22 for 2013 to 2042, Table 23 for 2043 to 2072 and Table 24 for 2073 to 2102. As a comparison to the calibration period, the percentage change in volumetric water balance components relative to the average 1983 to 2012 conditions are summarised in Table 7 and Table 25 for 2013 to 2042, Table 26 for 2043 to 2072 and Table 27 for 2073 to 2102.

Table 19 Water balance (GL/yr) in the Latrobe River region for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	104.89	104.89	0
	Evapotranspiration	GL/yr	79.72	79.72	0
	Surface water inflow	GL/yr	15.07	15.07	0
Groundwater	Recharge	GL/yr	8.82	8.82	0
	Evapotranspiration	GL/yr	-49.89	-46.9	-2.99
	Baseflow (discharge to stream)	GL/yr	-11.32	-10.66	-0.66
	Licensed extractions	GL/yr	0	0	0
	Change in storage	GL/yr	0.06	1.49	-1.43

Table 20 Water balance (GL/yr) in the Latrobe River region for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	102.49	102.49	0
	Evapotranspiration	GL/yr	77.76	77.76	0
	Surface water inflow	GL/yr	15.12	15.12	0
Groundwater	Recharge	GL/yr	8.64	8.64	0
	Evapotranspiration	GL/yr	-48.06	-43.76	-4.3
	Baseflow (discharge to stream)	GL/yr	-10.18	-9.34	-0.84
	Licensed extractions	GL/yr	0	0	0
	Change in storage	GL/yr	0.02	0.04	-0.01

Table 21 Water balance (GL/yr) in the Latrobe River region for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	GL/yr	102.56	102.56	0
	Evapotranspiration	GL/yr	78.40	78.40	0
	Surface water inflow	GL/yr	14.75	14.75	0
Groundwater	Recharge	GL/yr	8.48	8.48	0
	Evapotranspiration	GL/yr	-47.04	-42.29	-4.75
	Baseflow (discharge to stream)	GL/yr	-9.74	-8.86	-0.88
	Licensed extractions	GL/yr	0	0	0
	Change in storage	GL/yr	0.01	0.02	-0.01

Table 22 Water balance (mm/yr) in the Latrobe River region for 2013 to 2042

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	758.36	758.36	0
	Evapotranspiration	mm/yr	576.37	576.37	0
	Surface water inflow	mm/yr	152.16	152.16	0
Groundwater	Recharge	mm/yr	89.05	89.05	0
	Evapotranspiration	mm/yr	-503.74	-473.55	-30.19
	Baseflow (discharge to stream)	mm/yr	-114.30	-107.63	-6.66
	Licensed extractions	mm/yr	0.00	0.00	0.00
	Change in storage	mm/yr	0.61	15.04	-14.44

Table 23 Water balance (mm/yr) in the Latrobe River region for 2043 to 2072

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	746.96	746.96	0
	Evapotranspiration	mm/yr	566.70	566.70	0
	Surface water inflow	mm/yr	152.67	152.67	0
Groundwater	Recharge	mm/yr	87.24	87.24	0
	Evapotranspiration	mm/yr	-485.26	-441.84	-43.42
	Baseflow (discharge to stream)	mm/yr	-102.79	-94.31	-8.48
	Licensed extractions	mm/yr	0.00	0.00	0.00
	Change in storage	mm/yr	0.20	0.40	-0.20

Table 24 Water balance (mm/yr) in the Latrobe River region for 2073 to 2102

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	mm/yr	735.43	735.43	0
	Evapotranspiration	mm/yr	562.24	562.24	0
	Surface water inflow	mm/yr	148.93	148.93	0
Groundwater	Recharge	mm/yr	85.62	85.62	0.00
	Evapotranspiration	mm/yr	-474.96	-427.00	-47.96
	Baseflow (discharge to stream)	mm/yr	-98.34	-89.46	-8.89
	Licensed extractions	mm/yr	0.00	0.00	0.00
	Change in storage	mm/yr	0.10	0.20	-0.10

Table 25 Water balance percentage change (%) in the Latrobe River region for 2013 to 2042 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-5.71	-5.71	0
	Evapotranspiration	%	-6.25	-6.25	0
	Surface water inflow	%	0.41	0.41	0
Groundwater	Recharge	%	-4.13	-4.13	0
	Evapotranspiration	%	-6.59	-12.19	-5.6
	Baseflow (discharge to stream)	%	-25.67	-30.01	-4.34
	Licensed extractions	%	0	0	0
	Change in storage	%	-66.67	-727.78	794.45

Table 26 Water balance percentage change (%) in the Latrobe River region for 2043 to 2072 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-7.87	-7.87	0
	Evapotranspiration	%	-8.56	-8.56	0
	Surface water inflow	%	0.75	0.75	0
Groundwater	Recharge	%	-6.09	-6.09	0
	Evapotranspiration	%	-10.02	-18.07	-8.05
	Baseflow (discharge to stream)	%	-33.16	-38.67	-5.51
	Licensed extractions	%	0.00	0.00	0
	Change in storage	%	-88.89	-77.78	11.11

Table 27 Water balance percentage change (%) in the Latrobe River region for 2073 to 2102 relative to the baseline 1983 to 2012 period

	Water balance term	Units	Under the baseline	Under the coal resource development pathway	Difference
Surface water	Rainfall	%	-7.80	-7.80	0
	Evapotranspiration	%	-7.80	-7.80	0
	Surface water inflow	%	-1.72	-1.72	0
Groundwater	Recharge	%	-7.83	-7.83	0
	Evapotranspiration	%	-11.93	-20.82	-8.89
	Baseflow (discharge to stream)	%	-36.05	-41.83	-5.78
	Licensed extractions	%	0.00	0.00	0
	Change in storage	%	-94.44	-88.89	5.55

2.5.2.4 Gaps

The limitations in the water balance estimates reported above are a result of the limitations in the numerical modelling and the absence of surface water modelling. Specific limitations in the numerical modelling relate to the spatial and temporal scales underpinning the distributed groundwater modelling which is detailed in Section 2.6.2 of product 2.6 for the Gippsland Basin bioregion. The assumptions attributed to the implementation of the CRDP in the configuration and application of the groundwater modelling should also be considered when interpreting the water balance estimates.

The most uncertain component of the predicted water balance is the licensed extractions associated with the CRDP. The increased extractions relative to the baseline were based on matching both hydraulic head and broad volumetric dewatering targets. These targets were met with the exception of those associated with the Yallourn coal mine. The high correlation between mine dewatering extractions and the characteristics of the aquifer beneath the coal seam of interest suggest that the targets used to constrain dewatering drain cells in the numerical groundwater model are inadequate to provide a precise estimate of this component of the water balance.

References

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- Beverly C, Bari M, Christy B, Hocking M and Smettem, K (2005) Predicted salinity impacts from land use change: a comparison between rapid assessment approaches and a detailed modelling framework. *Australian Journal of Experimental Agriculture* 45, 1453–1469.
- Harbaugh AW (2005) MODFLOW-2005, The U.S. Geological Survey modular ground-water model—the ground-water flow process. Techniques and Methods Report 6-A16. U.S. Geological Survey.

Datasets

Dataset 1: Gippsland Basin Bioregional Assessment Groundwater Model (2016)