Water Quality in the Victorian Murray Darling Basin

A Basin Plan Report: Matter 12 Progress towards targets of Chapter 9, 2020

VICTORIA State Government

Environment, Land, Water and Planning

Acknowledgements

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Vale David Buck McPhee

Water quality management is critical to looking after our environment now and into the future for ecological and human outcomes. This is not possible without information. The ability to monitor and report on the chemical and physical water quality properties of waterways across the state is only possible through the installation of robust and reliable gauging and monitoring stations, and regular site visits and sampling at the remotest of locations. Victoria is able to deliver this through a cooperative partnership and contract. Making this contract work, in the field, for the last 10 years, has been the dedicated, passionate and effective approach of David Buck McPhee. David loved this job, and he was a well-loved member of the team and of the broader water community, and the community in which he lived. David passed away, too young, on Thursday 24 September 2020. He will be greatly missed by colleagues, friends, and family.

Contents

1. Introduction

1.1 Water Quality Management in Victoria

Since the commencement of the Murray Darling Basin Plan (the Basin Plan), Victoria has actively delivered on its water quality requirements. Victoria has:

- developed and had accredited Water Quality Management Plans for each of its five water resource plan areas;
- considered water quality targets for dissolved oxygen, salinity, and blue-green algae when making decisions for water releases and planning environmental water;
- applied the end-of-valley targets of Schedule B to the Basin Plan Agreement.

This 5-yearly report, the first addressing Matter 12 of Schedule 12 of the Basin Plan, brings together for the first time information on:

- blue-green algae blooms that affect recreational water use;
- how Victoria's water quality has tracked against the Basin target for dissolved oxygen;
- salinity in the Victorian rivers of the Basin Plan through reporting against end-of-valley targets; and
- updates on the measures Victoria is taking to contribute to water quality objectives of the Basin Plan – as described in the Wimmera-Mallee and the North and Murray Water Quality Management Plans.

The report also identifies future opportunities for 2025 Matter 12 report against the Water Resource Plan Targets, and opportunities for future data collection and analysis.

The Murray-Darling Basin Authority's (MDBA's) review of the Chapter 9 targets during 2020 may lead to changes in reporting approaches and aims going forward.

Victoria looks forward to working collectively and collaboratively with all the Basin States, the Commonwealth and the Murray Darling Basin Authority to build a shared framework for contributing to, and reporting on water quality actions and outcomes.

1.2 Approach to this report

1.2.1 Basin Plan Obligation and Murray Darling Basin Authority Guidance

The Basin Plan sets out the obligations for this reporting:

- Clause 13.14 of the Basin Plan requires reporting as specified in Schedule 12 – including by the identified reporter and within set timeframes
- Schedule 12 specifies matters to be reported, the timeframes, and the reporting parties.
- Matter 12 of Schedule 12 is identified as follows:

Matter	Reporter	Category	Relevant Chapter
Progress towards the water quality targets in Chapter 9	Basin States, Authority	A (which indicates 5 yearly reporting)	Chapter 9

Chapter 9, the Basin Plan's 'water quality and salinity plan', includes three groups of water quality targets incorporating subsets of targets. They are:

- Targets for managing flows (cl 9.14):
  - salinity at set sites on the Murray and Darling Rivers,
  - dissolved oxygen; and

−targets for recreational waters – blue-green algae

- Targets for Water Resource Plans (cl 9.15-9.18)
  - − Irrigation target,
  - − targets for fresh water-dependent ecosystems,
  - − targets for recreational waters – blue-green algae
- Targets for long term salinity planning and management (cl 9.19) which reference the End-of-Valley salinity targets of Basin Salinity Management Strategy (BSM2030).

In January 2020, the Murray Darling Basin Authority (MDBA) wrote to Victoria's Basin Officials Committee (BOC) Alternate member to advise that Basin states may determine how to synthesise information about achievement and progress in their state and will not prescribe reporting requirements for Matter 12.

Earlier, the MDBA with Basin States, developed the 'Basin Plan Schedule 12 Reporting Guidelines' which were signed off in 2013, and updated in 2015. The Guidelines presented indicators and detail for reporting on Matter 12. Groundwater salinity is not a requirement of this report.

1.2.2 Victorian reporting approach for Matter 12

Victoria developed its reporting on matter 12 using four key principles:

- Meet the requirements of the Basin Plan as guided by the MDBA
- Use existing data and information;
- Present a useful and meaningful narrative; and
- Use lessons learned during the reporting to inform future data collection and management.

This report is divided into three main parts:

Water Quality Targets for Flow Management	The Basin Plan identifies targets that can be influenced by river operations including environmental watering. This section provides information and narrative on the recreational blue-green algae targets, and dissolved oxygen. This addresses Victoria's responsibilities for reporting on Targets of 9.14.
Victoria's Long-Term Salinity Targets.	This section reports on data of Victoria's end-of valley targets, addressing Victoria's responsibilities for reporting on progress towards targets of 9.19
Victoria's Measures to contribute to Basin Plan water quality objectives	In line with the Guidelines for Schedule 12 Reporting, this section provides a progress report on measures included in Water Quality Management Plans, in some cases focussing on one specific area. This addresses Victoria's responsibilities for reporting on progress towards targets of 9.15-9.18.

2. Water quality targets for flow management

2.1 Victoria's Regulated Water Systems

Within Victoria's Murray-Darling Basin regions, there are both regulated and unregulated waterways and systems. The regulated systems can contain dams or storages, are connected through pipes, channels, and have water moved through gravity fed releases or pumps. Water managers are therefore able to influence or control the storage of water, when, how fast and to where the water is released, and in some cases move it to new locations through pumps.

The ability to regulate water means we can store it for when it is needed by cities, households, industry and agriculture. Through these same mechanisms, water is able to be targeted and distributed for environmental outcomes such as filling wetlands, or supporting fish breeding cycles. In Victoria's climate of variable rainfall and flows, regulation of water systems is critical for ensuring there is sufficient water when and where it is required.

2.2 Water Quality and Regulated Water Systems

By being able to regulate water flow, there is an ability to influence water quality. This can include the ability to achieve water quality improvements or remedies through water releases within limits, as well as the need to plan and manage the potential for negative water quality impacts that could arise through a water release.

The Basin Plan, through its targets for managing flows, requires water managers and environmental water planners and managers to 'have regard to'[1] salinity targets, dissolved oxygen targets, and blue-green algae targets when undertaking planning and operations.

2.3 Victorian Water Managers and Environmental Water Planners and Managers Having Regard to Water Quality in their work

Victoria's water managers, catchment management authorities, and the Victorian Environmental Water Holder, consider these targets and these potential water quality risks when undertaking their work.

Each year under the Basin Plan's Matter 14 reporting, Victoria has reported how this occurs.

Blue-green algae, and dissolved oxygen are addressed specifically in the following sections. It is understood the Murray-Darling Basin Authority will report on salinity targets in the Murray and lower Darling River.

2.4 Blue-Green Algae and Recreation

2.4.1 Blue-green algae background

Blue-green algae (BGA), or cyanobacteria, are photosynthetic bacteria. They are a natural part of most aquatic environments and are found in streams, lakes, estuaries and the sea. Significant levels of BGA in water bodies can affect the natural ecosystem and potentially impact human health.

Some species of BGA can produce chemical compounds that can taint the drinking water supply by causing discoloration and a musty odour and taste. More significantly, some species produce toxins that could cause serious health outcomes for humans, animals, birds and livestock if they are consumed, inhaled or come into contact with skin.

As environmental conditions become favourable, typically in the warmer months, algae numbers can increase rapidly resulting in a bloom. Blooms can make recreational water unappealing and unsafe for activities such as swimming, boating and water skiing. While algal blooms are more prevalent in the warmer months, with favourable conditions, blooms can occur all year round and without warning.

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Blooms have the potential to move through water bodies by growing over time, being transported down a river or stream, and on release of bloom affected waters from a dam or weir. They can be defined at a local, regional or broader scale depending on their extent.

2.4.2 Victoria's BGA Management Framework

Victoria manages, monitors and stores information on BGA under its BGA Management Framework as described in the Victorian BGA Circular, a document outlining roles and responsibilities for managing agencies. The objectives of the BGA Management Framework are for parties to work together to effectively manage BGA blooms through:

- minimising the impact of BGA blooms on waterways, public health and safety and local amenity;
- providing a coordinated response;
- communicating potential risk to water and waterway users and the broader community promptly and effectively;
- investigating the likely cause of the bloom and identifying what actions to take to minimise future occurrences; and
- where appropriate, providing timely and effective briefings and communication to the relevant Minister.

The structure of this framework is built on scaled responses from local management, to regional coordination giving advice and oversight of larger blooms, to state level oversight and management of emergency level blooms. Part 7 of the Emergency Management Manual Victoria (EMMV) details the roles of different organisations regarding emergency management arrangements.

Monitoring for BGA is a responsibility of local waterbody managers in accordance with their local BGA Risk Management Plans.

Notifications to the Department of Environment, Land, Water and Planning (DELWP) or the Department of Health and Human Services are required based on BGA trigger levels being breached.

DELWP manages the Algal Bloom Module of the Floodzoom application, which stores all notifications and data from local waterbody managers and regional coordinators. The focus of this database is for operational BGA management, rather than long term data collection and analysis.

2.4.3 Monitoring and responding to blue-green algae

Monitoring for BGA is the responsibility of local waterbody managers. Many of Victoria's Murray Darling Basin major water bodies are monitored for BGA by rural water corporations on a monthly basis as part of the Major Storages Operational Monitoring Program (MSOMP). Most major storages in Victoria are used for recreation, including primary contact, as well as raw supplies for treatment for drinking, or for agricultural use.

When a level for one of the relevant triggers is reached or exceeded, storage operators may investigate, report, and manage a potential bloom.

Three trigger levels are used within the Victorian BGA Management Framework:

- Drinking water
- Recreational water
- Other (which includes aquaculture).

The recreational trigger level is based on the national recreational trigger level, with slight adjustment.

Victorian Recreational Trigger Levels

Recreational water bodies when any one or more of the following occurs:
- *Microcystis aeruginosa* is present at ≥ 50,000 cells/mL;
- Total combined biovolume of known toxic *cyanobacterial* species is ≥ 4 mm3/L;
- Total combined biovolume of all *cyanobacterial* species is ≥ 10 mm3/L; or
- *Cyanobacterial* scums are consistently present[3].

Water bodies may be monitored at one or more sites, and in response to a triggered bloom, local water body managers may follow through with further investigation, site inspections, and a management decision.

The outcome of a recreational trigger, and subsequent investigations, is the warning notification to users to avoid contact activities with the water.

2.4.4 Reporting on BGA

Victoria is reporting on BGA as monitored and managed through two major rural water corporations, Goulburn Murray Water, and Grampians Wimmera Water, primarily in major storages. It is noted that Lower Murray Water (LMW) also manage BGA monitoring and reporting as part of its service. As many of these sites are on the Murray River, and LMW does not itself manage any major storages, no reporting of recreational water closures in LMW's region of the Mallee are included in this report.

Goulburn Murray Water Region – North East and North Central Victoria

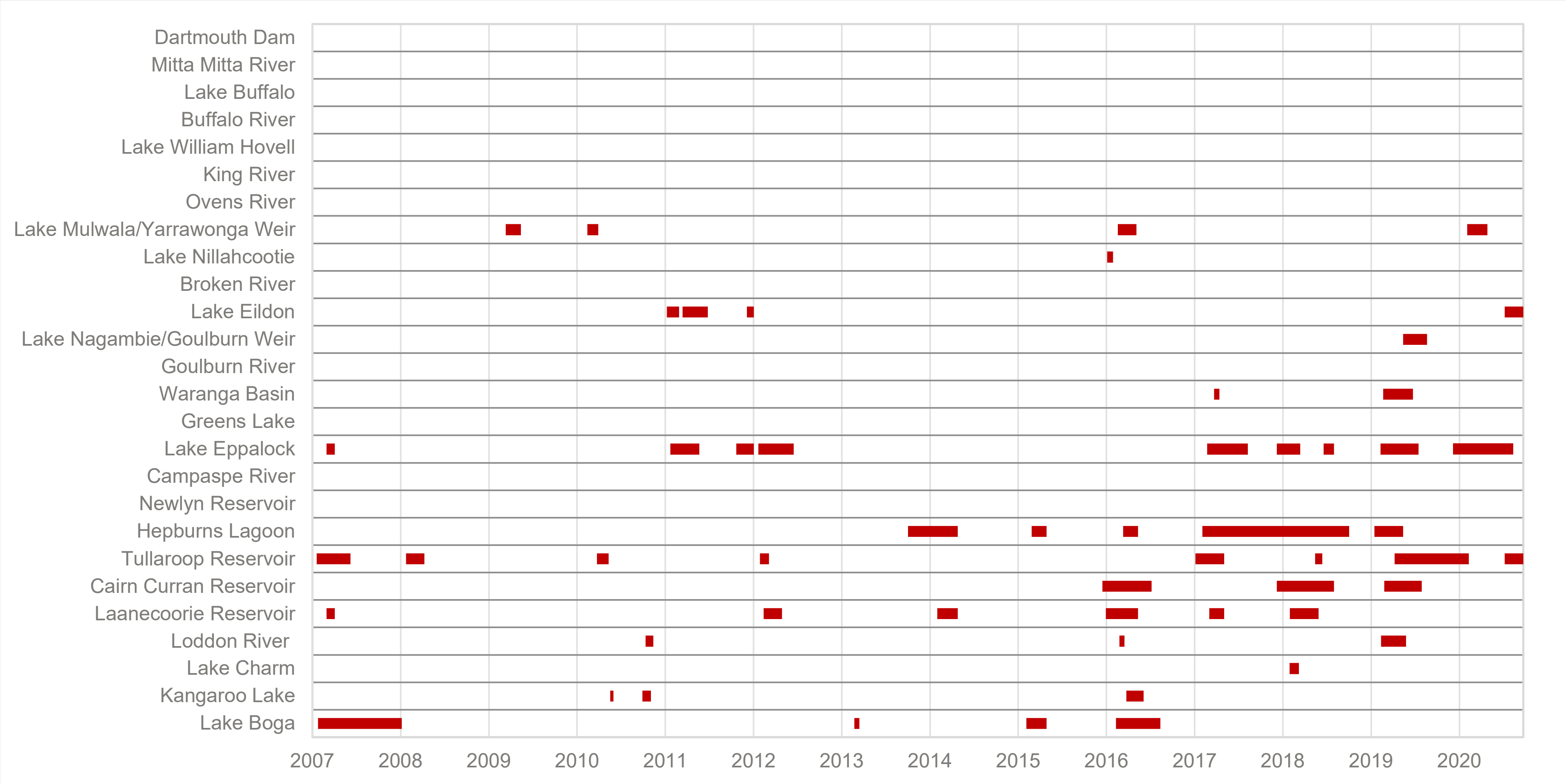
Goulburn Murray Water (GMW) manages major storages across north east and north central Victoria and is the regional coordinator under the BGA Management Framework in Victoria's north east and north central regions. Monitoring for BGA is undertaken regularly in many of these waterbodies. Table 1 describes the monitoring undertaken at key sites for recreation.

Table 1 BGA Monitoring of Water Bodies North Central and North East

Monitoring Approach	Water Body
Major storage with monthly BGA monitoring at one or more sites	Lake Buffalo, Lake William Hovell, Dartmouth Dam, Lake Mulwala/Yarrawonga Weir, Lake Nillahcootie, Lake Eildon, Waranga Basin, Lake Nagambie//Goulburn Weir, Lake Eppalock, Cairn Curren Reservoir Newlyn Reservoir Tullaroop Reservoir, Laanecoorie Reservoir,
Recreational or other water bodies with monthly BGA monitoring at one or more sites	Greens Lake, Hepburns Lagoon, Lake Charm, Kangaroo Lake, Lake Boga
Regular sampling at offtakes for urban water supplies	King River, Mitta Mitta River, Goulburn River, Campaspe River, Loddon River
Sampled in response to BGA warning in upstream storage	Broken River (Lake Nillahcootie), Buffalo River (Lake Buffalo),

Figure 1 shows the periods of recreational use warnings at key recreational sites since 2007.

Figure 1 Periods of recreational use warnings at major recreational waters from Blue Green Algal Blooms in north east and central north Victoria 2007-2020



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[2] Note: warnings at Lake Eildon and Tullaroop Reservoir were still active at date of reporting 5 October 2020

Figure 1 shows a number of water bodies that have not experienced a warning for recreational use over the reporting period including Lake Buffalo and its host Buffalo River, Lake William Hovell and its source river the King River, Dartmouth Dam and its source river Mitta Mitta River. These storages and rivers are located in the uplands of north east Victoria, where there is limited development upstream.

GMW has issued warnings against primary contact recreation at Lake Eildon, and Lake Nagambie (Goulburn Weir). Importantly, Goulburn River, downstream of these storages, like the rivers of the north east, did not experience a recreational warning as a result of these blooms, indicating that there was not a spread of the bloom below the storage wall.

Some storages have had quite frequent blooms over the reporting periods including: Lake Eppalock, Hepburns Lagoon, Tullaroop Reservoir, Cairn Curren Reservoir, and Laanecoorie Reservoir.

GMW'S Major Storages water quality sampling program shows that water quality declines from east to west across GMW's operating area. The differences in water quality observed across the regions may be in part due to different land use and management practices, while natural characteristics such as geology and soil type will also have an influence. The impacts of rainfall in any given year are also evident.

There appears to be an increase in the number of waterbodies experiencing blooms each year since 2016.

2.4.5 Grampians Wimmera Mallee Water – Wimmera Region

The Wimmera region has a series of water storages connected by rivers, streams, channels and pipes.

There are three on-stream reservoirs (Lake Wartook on the MacKenzie River, Lake Lonsdale on Mount William Creek and Lake Bellfield on Fyans Creek), and several off-stream storages (Taylors Lake, Lake Fyans and Toolondo Reservoir).

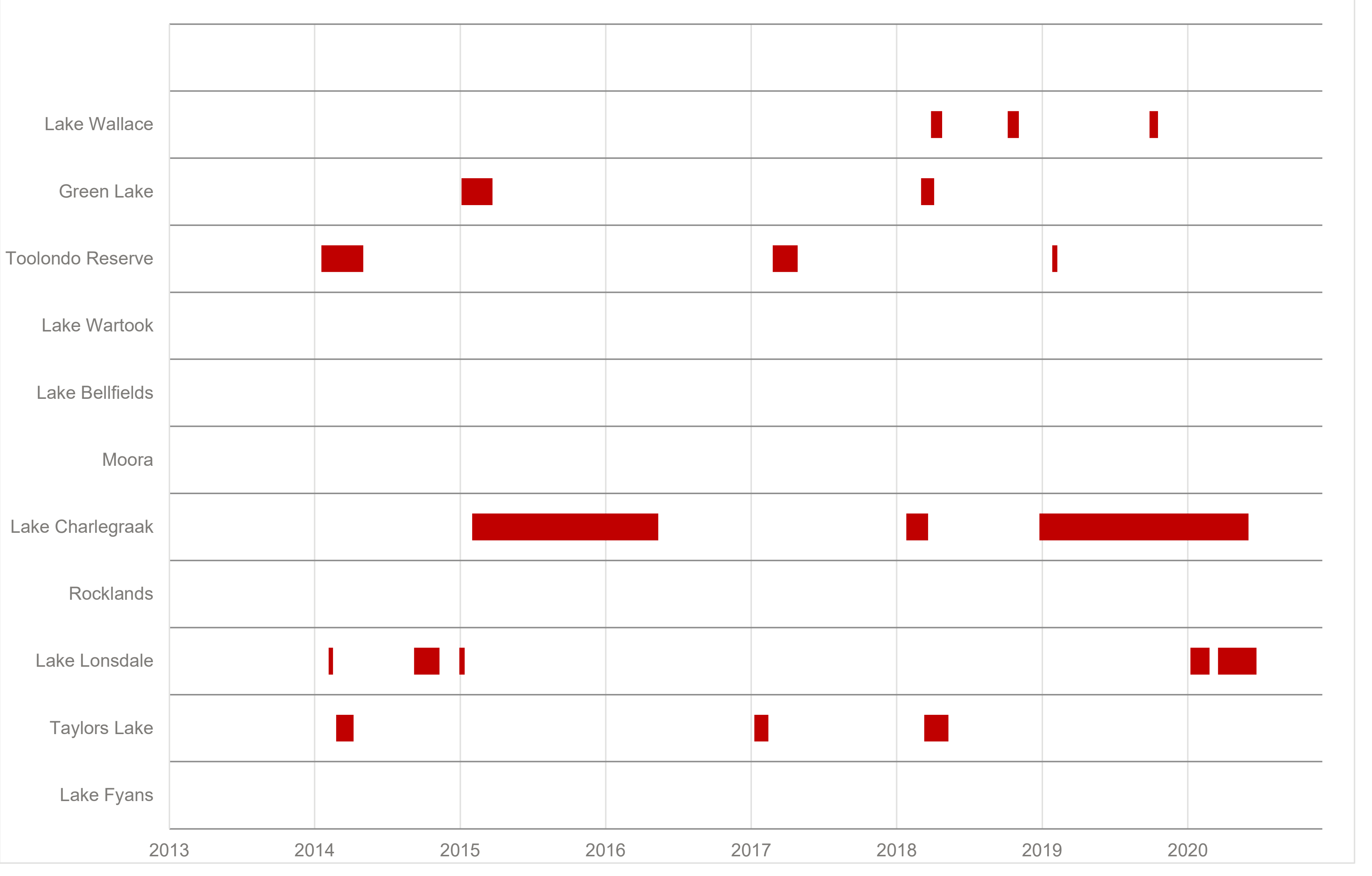
Water can also be transferred from Rocklands Reservoir in the Glenelg system to the Wimmera system via the Rocklands-Toolondo Channel and from Moora Moora Reservoir via the Moora Channel. The connected storages and channels are collectively called the Wimmera-Mallee system headworks, and harvested water is used for towns and stock and domestic supply throughout the Wimmera catchment and parts of the Avoca, Hopkins, Loddon, Glenelg and Mallee catchments. Passing flows are provided to the Wimmera River and to lower Mount William and Fyans creeks[3].

Major storages used for recreation within the Wimmera, as well as those that can supply water to the Wimmera system have been included for reporting.

Figure 2 shows periods of warnings for recreational use for major recreational sites of the Wimmera from 2013 until 2020.

[3] Victorian Environmental Water Holder, 2020, Vewh.vic.gov.au

Figure 2 Periods of recreational warnings at major recreational waters from blue-green algae the Wimmera 2013-2020



2.4.6 Future Reporting and Analysis of BGA

Victoria has relied on databases of individual rural water corporations for the preparation of this report. Opportunities to automate reporting and data management for future reporting have been identified through this reporting process and will be progressed going forward.

Victoria is also developing the first Water Cycle System Climate Change Adaptation Action Plan for release in October 2021 as required under Victoria's *Climate Change Act 2017*. Any algal management actions identified in this plan will build on a project currently underway to better understand the latest science on how climate change impacts on algal blooms, consolidate our understanding of current approaches to manage algal blooms, and outline a new framework approach to improve management of algal outbreaks, and better understand both current and future risks of blooms in Victoria going forward.

2.5 Dissolved Oxygen

Dissolved oxygen is monitored monthly across the Victorian Murray Darling Basin. As impacts of low dissolved oxygen can have significant impacts over a short period, analysis has been conducted on the percentage of samples that attained the Basin Plan minimum target of 50% saturation, rather than a median. Victoria's dissolved oxygen data is collected and stored as parts per million (ppm), and so data was converted to % saturation using required reference data. See Appendix A for details.

Error! Reference source not found. presents an analysis of data for sites across the Victorian Murray Darling Basin. It shows sites in the north east showed almost every sample collected attained the target of 50% saturation, with a few exceptions at Morass Creek@uplands. Heading west there are more incidences of samples not attaining the target. In a given year at a given site, if 90-100% of samples met the target, the square is coloured green, where 75-89% of samples met the target the square is yellow, and where <75% of samples at a site met the target, the square is coloured red.

Table 2 - Percentage attainment of DO target (minimum 50% saturation) by monitoring samples from 2012-2020

	Valley	Site Number	Site Name	Altitude	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
North East	401 Upper Murray	401201	MURRAY RIVER @ JINGELLIC	214	100	100	100	100	100	100	100	100
		401203	MITTA MITTA RIVER @ HINNOMUNJIE	556	100	100	100	100	100	100	100	100
		401211	MITTA MITTA RIVER @ COLEMANS	310	100	100	100	100	100	100	100	100
		401204	MITTA MITTA RIVER @ TALLANDOON	224	100	100	100	100	100	100	100	100
		401212	NARIEL CREEK @ UPPER NARIEL	507	100	100	100	100	100	100	100	100
		401215	MORASS CREEK @ UPLANDS	705	100	100	100	83	100	92	83	92
		401216	BIG RIVER @ JOKERS CREEK	720	100	100	100	100	100	100	100	100
		401226	VICTORIA RIVER @ VICTORIA FALLS	962	100	100	100	100	100	100	100	100
	402 Kiewa	402203	KIEWA RIVER @ MONGANS BRIDGE	263	100	100	100	100	100	100	100	100
		402204	YACKANDANDAH CREEK @ OSBORNES FLAT	216	100	100	100	100	100	100	100	100
		402223	KIEWA RIVER WEST BRANCH @ U/S OF OFFTAKE	611	100	100	100	100	100	100	100	100
		402222	KIEWA RIVER @ KIEWA (MAIN STREAM)	174	100	100	100	100	100	100	100	100
		402205	KIEWA RIVER @ BANDIANA	161	100	100	100	100	100	100	100	100
	403 Ovens	403244	OVENS RIVER @ HARRIETVILLE	498	100	100	100	100	100	100	100	100
		403205	OVENS RIVERS @ BRIGHT	293	100	100	100	100	100	100	100	100
		403241	OVENS RIVER @ PEECHELBA	249	100	100	100	100	100	100	100	100
		403210	OVENS RIVER @ MYRTLEFORD	210	100	100	100	100	100	100	100	100

	Valley	Site Number	Site Name	Altitude	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
		403230	OVENS RIVER @ ROCKY POINT	208	100	100	100	100	100	100	100	100
		403213	FIFTEEN MILE CREEK @ GRETA SOUTH	197	100	100	100	90	100	100	100	100
		403217	ROSE RIVER @ MATONG NORTH	338	100	100	100	100	100	100	100	100
		403223	KING RIVER @ DOCKER ROAD BRIDGE	170	100	100	100	100	100	100	100	100
Goulburn Broken	404 Broken	404207	HOLLAND CREEK @ KELFEERA	190	92	92	83	91	100	100	80	90
		404214	BROKEN CREEK @ KATAMATITE	119	78	89	75	100	45	67	67	100
		404216	BROKEN RIVER @ GOORAMBAT (CASEY WEIR H. GAUGE)	167	100	100	100	100	100	92	100	100
		404224	BROKEN RIVER @ GOWANGARDIE	144	100	100	100	100	100	100	100	100
	405 Goulburn	405219	GOULBURN RIVER @ DOHERTYS	308	100	100	100	100	100	100	100	100
		405203	GOULBURN RIVER @ EILDON	219	83	100	92	100	92	100	100	100
		405201	GOULBURN RIVER @ TRAWOOL	153	100	100	100	100	100	92	100	100
		405200	GOULBURN RIVER @ MURCHISON	122	100	100	100	100	100	100	100	100
		405204	GOULBURN RIVER @ SHEPPARTON	112	100	100	100	100	100	100	100	100
		405205	MURRINDINDI RIVER @ MURRINDINDI ABOVE COLWELLS	335	100	100	100	100	100	100	100	100
		405209	ACHERON RIVER @ TAGGERTY	204	100	100	100	100	100	100	100	100
		405212	SUNDAY CREEK @ TALLAROOK	165	92	77	50	50	80	50	50	82
		405214	DELATITE RIVER @ TONGA BRIDGE	332	100	100	100	100	100	100	100	100
		405231	KING PARROT CREEK @ FLOWERDALE	177	100	100	100	100	100	100	100	100
		405234	SEVEN CREEKS @ D/S OF POLLY MCQUINN WEIR	448	100	100	100	100	100	100	100	100
		405237	SEVEN CREEKS @ EUROA TOWNSHIP	160	83	92	83	75	100	92	99	100
		405264	BIG RIVER @ D/S OF FRENCHMAN CREEK JUNCTION	477	100	100	100	100	100	100	100	100
North Central	406 Campaspe	406208	CAMPASPE RIVER @ ASHBOURNE	619	86	100	83	87	90	89	100	100
		406213	CAMPASPE RIVER @ REDESDALE	225	100	100	100	100	100	100	100	92
		406207	CAMPASPE RIVER @ EPPALOCK	170	100	100	100	100	100	100	100	100
		406214	AXE CREEK @ LONGLEA	201	67	67	62	50	73	45	92	92

	Valley	Site Number	Site Name	Altitude	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
	407 Loddon	406235	WILD DUCK CREEK @ U/S OF HEATHCOTE-MIA MIA ROAD	219	100	100	100	50	100	100	100	91
		406263	MULLERS CREEK @ MURRAY VALLEY HIGHWAY	98	ND	0	100	100	100	91	100	83
		406756	MOSQUITO CREEK DEPRESSION @ CURR ROAD[4]	94	ND	100	100	100	83	92	100	100
		407215	LODDON RIVER @ NEWSTEAD	213	100	100	83	67	91	100	82	92
		407203	LODDON RIVER @ LAANECOORIE	150	100	100	100	100	100	100	100	92
		407229	LODDON RIVER @ SERPENTINE WEIR	112	100	100	100	100	83	100	100	92
		407205	LODDON RIVER @ APPIN SOUTH	86	100	100	82	92	82	100	100	100
		407202	LODDON RIVER @ KERANG	81	100	100	100	100	87	100	100	100
		407209	GUNBOWER CREEK @ KOONDROOK	85	100	100	100	100	100	100	100	100
		407221	JIM CROW CREEK @ YANDOIT	279	83	100	92	58	100	92	92	100
		407255	BENDIGO CREEK @ HUNTLY	161	100	92	100	100	100	100	100	100
	408 Avoca	408202	AVOCA RIVER @ AMPHITHEATRE	279	92	83	80	92	83	75	67	83
		408200	AVOCA RIVER @ COONOOER	152	83	83			70	67	50	33
		408203	AVOCA RIVER @ QUAMBATOOK[5]	98	100	100	ND	ND	57	100	ND	67
Mallee	414 Mallee	414204	MURRAY RIVER @ RED CLIFFS	53	100	100	100	ID	ID	ID	94	100
Wimmera	415 Wimmera	415200	WIMMERA RIVER @ HORSHAM	131	100	100	100	100	92	100	100	83
		415246	WIMMERA RIVER @ LOCHIEL RAILWAY BRIDGE	101	92	100	100	100	100	100	100	100
		415203	MOUNT WILLIAM CREEK @ LAKE LONSDALE (TAIL GAUGE)	194	92	67	70	100	92	100	67	64
		415220	AVON RIVER @ WIMMERA HIGHWAY[6]	155				90				

[4] Lots of DO% readings indicate severe eutrophication

[5] Less than 5 years with 6 or more samples but included this site anyway as there aren't a lot of sites with enough data in the Avoca

[6] Insufficient data to analyse individual years. This is the percent fail from a total of 30 samples taken in the study period

Valley	Site Number	Site Name	Altitude	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
	415237	CONCONGELLA CREEK @ STAWELL[7]	207				33				
	415251	MACKENZIE RIVER @ MCKENZIE CREEK	145	100	100	91	100	92	82	70	62
	415257	RICHARDSON RIVER @ DONALD[8]	119	13	11	0	0	0	20	17	10

2.5.1 Future Reporting of DO

As well as monthly monitoring of DO, through its Regional Water Monitoring Partnership (RWMP), Victoria has continuous dissolved oxygen monitoring at 53 sites. Conversion of data from these sites to % saturation requires temperature and EC data, which was not readily available. Opportunities to more readily access and convert this data will be explored for future reporting and analysis.

[7] Insufficient data to analyse individual years. This is the percent fail from a total of 30 samples taken in the study period

[8] A large number of the DO readings indicated severe eutrophication.

3. Long Term Salinity Management and Planning

3.1 Background

Salinity levels in the Murray River have been a rising concern since in 1950's. These concerns peaked in the 1980's when changes to land use and land management practices had increased salt concentrations to a level that caused soil degradation, loss of irrigated crops and loss of water supply to towns using the Murray River for water supply. Following this crisis, the Victorian, New South Wales and South Australian governments signed the Salinity and Drainage Strategy in 1988 committing to managing future salinity impacts within agreed limits while taking actions to manage the impacts of the past. This Strategy, and those that have followed (the Basin Salinity Management Strategy and the Basin Salinity Management 2030 Strategy) have continued this work and developed End of Valley Targets (EoVTs) across the Murray-Darling Basin.

The original purpose of the targets was to provide an indication of increasing levels of salinity coming from the upper catchments, so that salinity management actions could be put in place prior to significant impact on the Murray River. During the development of the BSM2030 strategy, it was recognised that the risk from the upper catchments on salinity levels in the Murray River are low. The EoVTs have been maintained and monitoring continues to provide a long-term record and an indication of impact on water quality from the upper tributaries as a result of historic land clearing and dryland farming.

There are three types of targets which may be applied to the different EoVT sites. The median (50th percentile) target seeks to keep the median concentration of salts below a certain level. The peak target seeks to keep the maximum concentration of salts below a certain level. The salt load targets seek to keep the gross volume of salt below a certain mass – salt load targets consider both the concentration of salt and the volume of water moving through the valley.

The Basin Plan Chapter 9 targets for long term salinity management and planning are the EoVT which are listed in Appendix 1 of Schedule B of the Murray-Darling Basin Agreement. There are nine target sites in Victoria, eight from tributaries and one at the Murray River at Lock 6 which is reported on by the MDBA.

The implementation of BSM2030 is over seen by the Basin Salinity Management Advisory Panel, consisting of members from each of the five Basin governments, the Commonwealth Government and the MDBA. This group has agreed to review all the EoVTs by the mid-term review of BSM2030 in 2026.

3.2 End of Valley Target Results 2015-2020

Assessment and progress against EoVT are undertaken using daily flow and salinity models of the relevant valleys over the 25-year benchmark period from 1975 to 2000. Therefore, the salinity and salt load estimates of any one year should not be used to indicate whether an EoVT has been achieved.

The results (presented in Table 1 and Figures 1 through 8) indicate that the median salinity in the Ovens, Kiewa, and Goulburn rivers has been maintained below the end-of-valley median target value during every year between July 2015 and June 2020. At Victoria's five other sites a minimum of one year saw an exceedance of the end-of-valley median target value between July 2015 and June 2020.

Examining monitoring for the full period between July 2015 and June 2020, the Ovens, Kiewa, Goulburn, Loddon and Wimmera Rivers recorded median salinity values below their end-of-valley median target values. In contrast, Broken Creek, Campaspe and Avoca Rivers observed median salinity values exceeding their respective end-of-valley median target values. While the targets have been exceeded, it is not considered that this poses a risk to the water quality within these systems or the Murray River, as the exceedances are minor, flows from these tributaries are diluted by River Murray flows and the targets themselves were set using limited data.

Data for the Ovens, Kiewa and Wimmera Rivers indicates that the peak salinity values have remained below their end-of-valley peak target values throughout the July 2015 and June 2020 monitoring period.

At the Avoca EoVT reporting site there were extended periods with little or no flow. It is not possible to monitor salinity levels during these cease to flow periods, as the river will be a series of disconnected pools.

In these situations, it can be concluded that the total salt load from the Avoca River to the Murray River was low given the low flows.

Salt loads for Ovens, Kiewa and Wimmera Rivers (tonnes/yr) were above the median target value in 2016/17. These salt loads were influenced by very high flows during widespread flooding across Victoria in October-November 2016. In all other individual monitoring years salt loads were under the target values.

3.3 Flow and Salinity Summary Graphs

3.3.1 Ovens River at Peechelba-East

Results for the Ovens River, as indicated in Figure 6 below indicate that both median and peak salinity were maintained below their respective targets between July 2015 and June 2020.

Annual salt loads for the Ovens River (tonnes/yr) consistently met the target value, only exceeding this target mean in the 16/17 period. Salt load during this period was influenced by very high flows during widespread flooding across Victoria in October-November 2016.

Salinity data for short periods of 2016/17 is unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

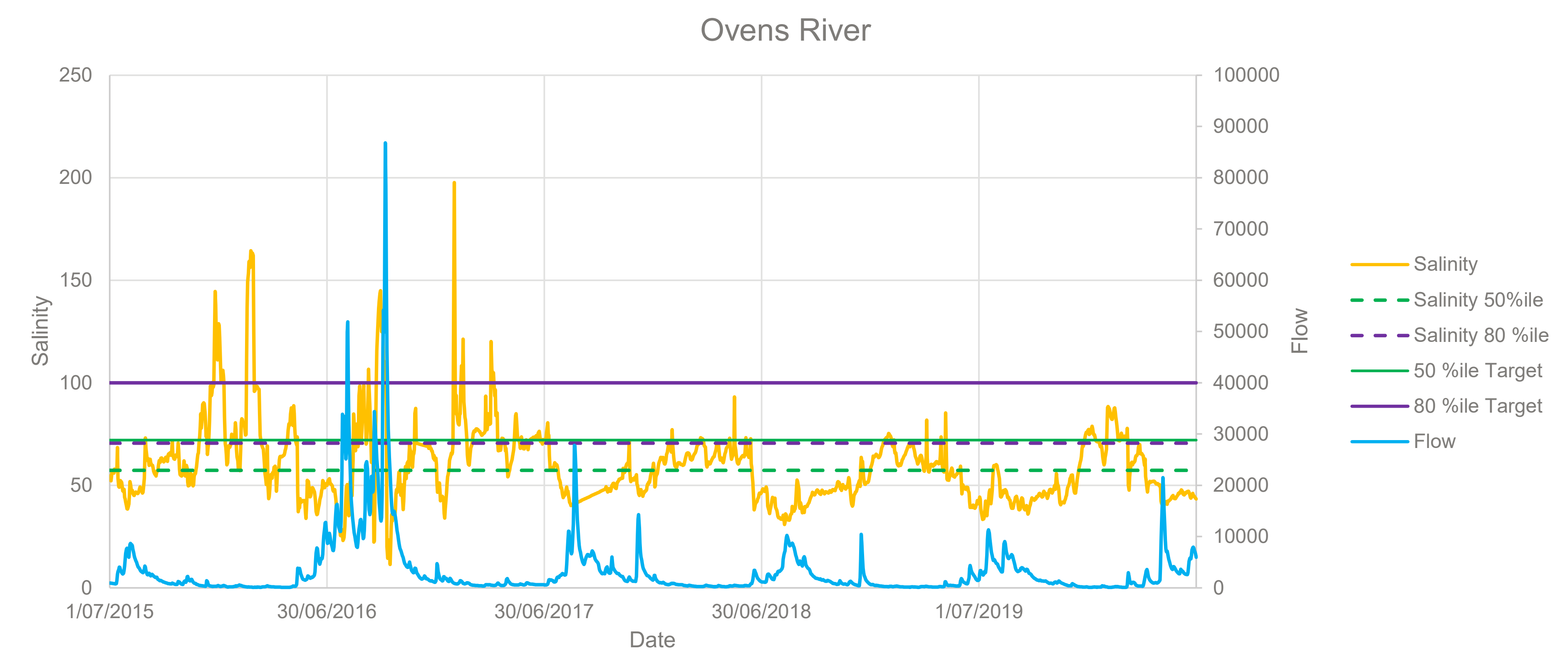


Figure 4: Available flow and salinity record for Ovens River @ Peechelba-East, 1 July 2015 to 30 June 2020

3.3.2 Kiewa River at Bandiana

Results for the Kiewa River, as indicated in Figure 7 below indicate that both median and peak salinity were maintained below their respective targets between July 2015 and June 2020.

Annual salt loads for the Kiewa River (tonnes/yr) consistently met the target value, only exceeding this target mean in the 16/17 period. Salt load during this period was influenced by very high flows during widespread flooding across Victoria in October-November 2016.

Salinity data for short periods of 2016/17 and very select days in 2019 is unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

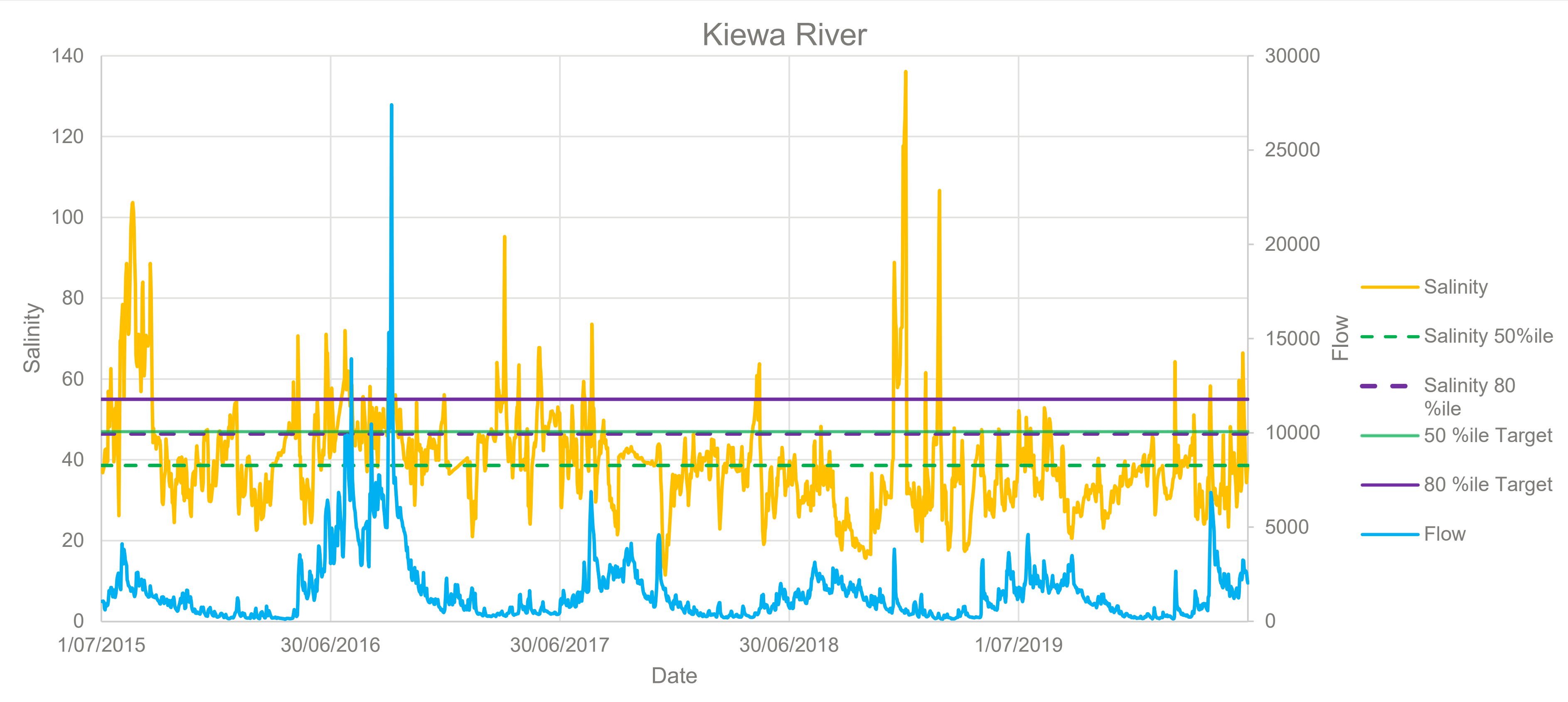


Figure 5: Available flow and salinity record for Kiewa River @ Bandiana, 1 July 2015 to 30 June 2020

3.3.3 Goulburn River at Goulburn Weir

Results for the Goulburn River, as indicated in Figure 8 below indicate that median salinity was maintained below the target between July 2015 and June 2020.

No peak salinity or salt export targets are set for the Goulburn River.

Streamflow and salinity data for short periods of the monitoring period are unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

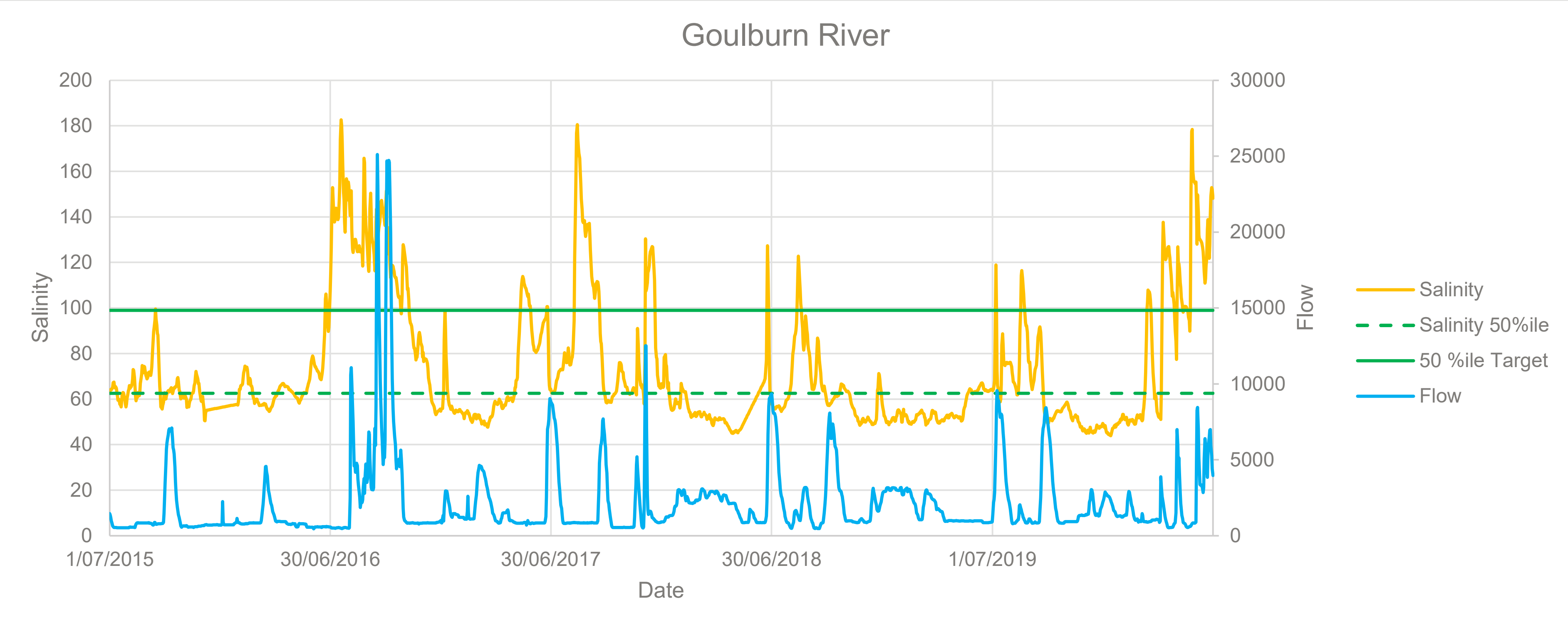


Figure 6: Available flow and salinity record for Goulburn River @ Goulburn Weir[9] , 1 July 2015 to 30 June 2020

9. Goulburn River EoVT site (405259) does not measure daily flow. Annual flow data was sourced from a downstream gauge (405200).

3.3.4 **Broken Creek at Casey's Weir**

Results for the Broken Creek, as indicated in Figure 9 below indicate that median salinity exceeded the target between July 2015 and June 2020. The implications of this exceedance for Murray River salinity is considered minor because the tributary flow was diluted by the much higher flow of the Murray River.

No peak salinity or salt export targets are set for the Broken Creek.

Streamflow and salinity data for short periods of the monitoring period are unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

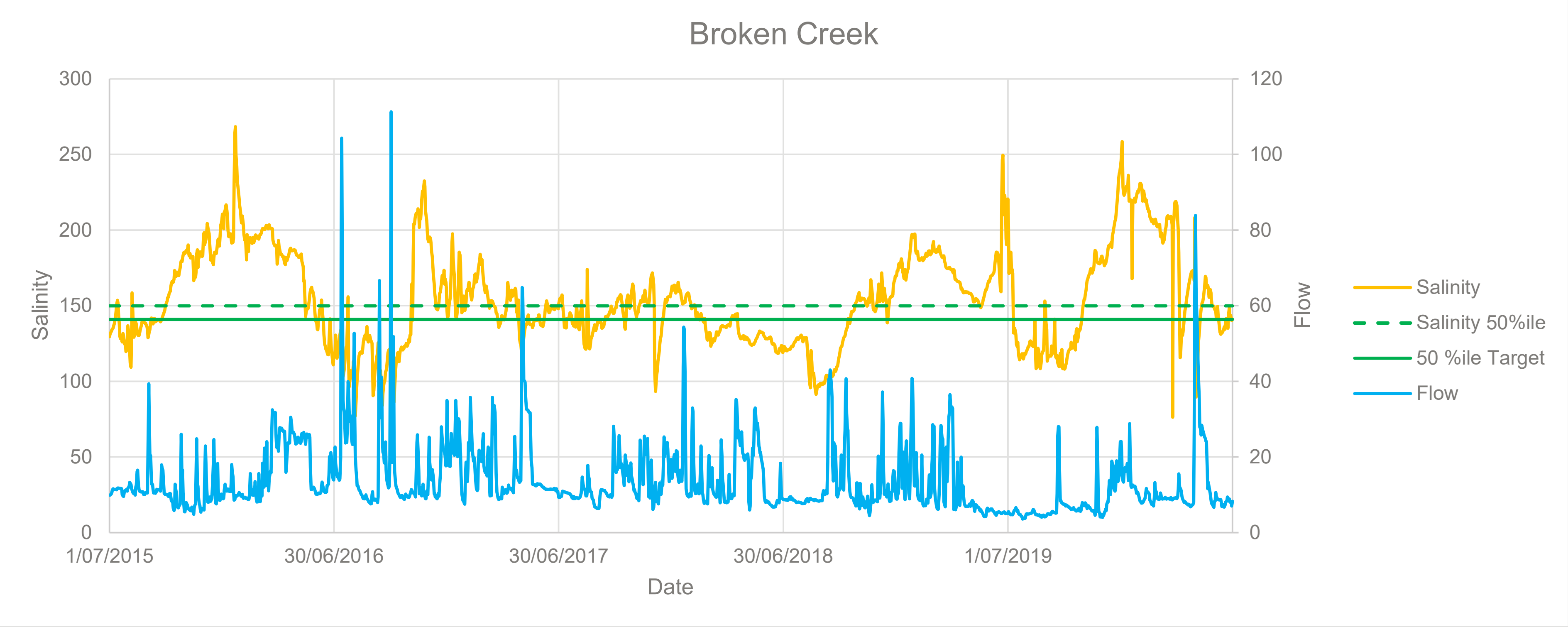


Figure 7: Available flow and salinity record for Broken Creek @ Casey's Weir[10] , 1 July 2015 to 30 June 2020

10. Broken Creek EoVT site (404217) does not measure EC and missing a large proportion of flow data therefore a downstream gauge (404224) was used for EC and flow.

3.3.5 **Avoca River at Quambatook**

Results for the Avoca River, as indicated in Figure 10 below indicate that median salinity exceeded the target between July 2015 and June 2020.

No peak salinity or salt export targets are set for the Avoca River.

At the Avoca EoVT reporting site there were extended periods with little or no flow. It is not possible to monitor salinity levels during these cease to flow periods, and it can be concluded that the total salt load from the Avoca River to the Murray River was low given the low flows.

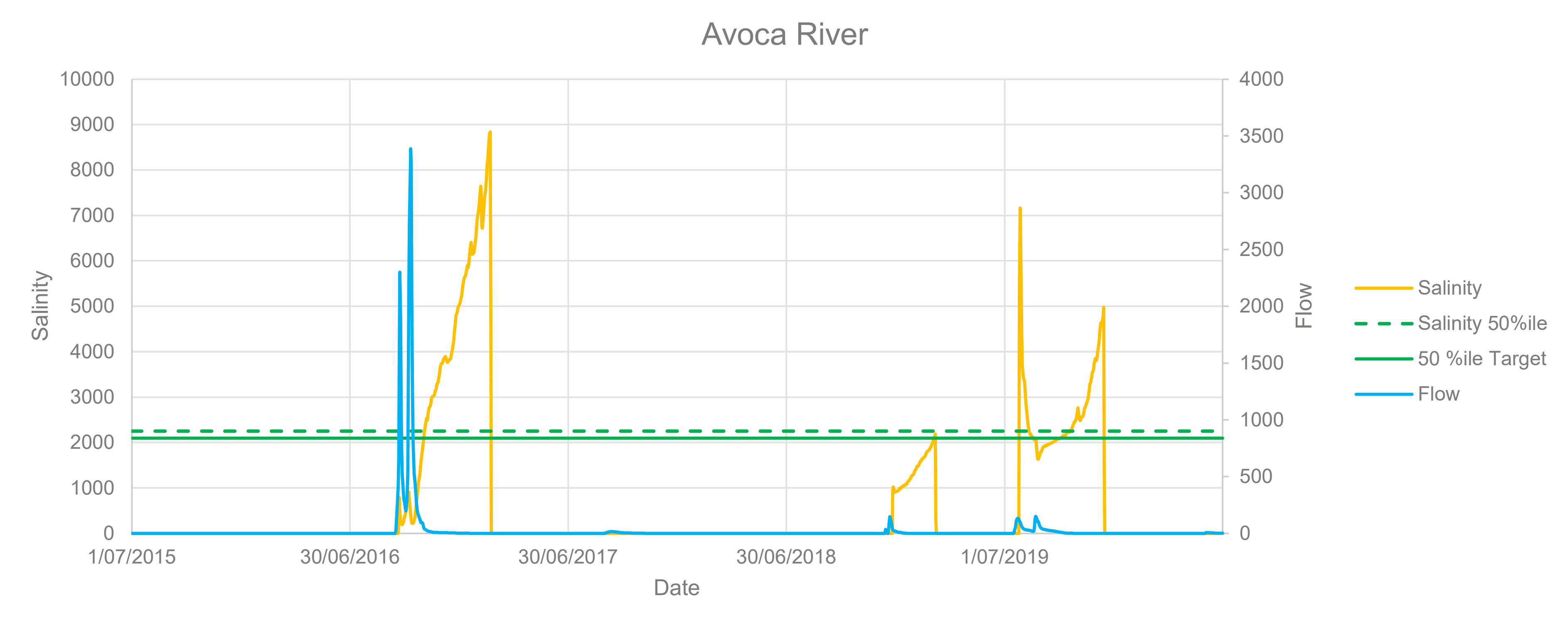


Figure 8: Available flow and salinity record for Avoca River @ Quambatook[11], 1 July 2015 to 30 June 2020

11. Flows at the Avoca River EoVT site (408203) were too low for measurement for much of the monitoring period.

3.3.6 **Loddon River at Laanecoorie**

Results for the Loddon River, as indicated in Figure 11 below indicate that median salinity was maintained below the target between July 2015 and June 2020.

No peak salinity or salt export targets are set for the Loddon River.

Streamflow and salinity data for short periods of the monitoring period are unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

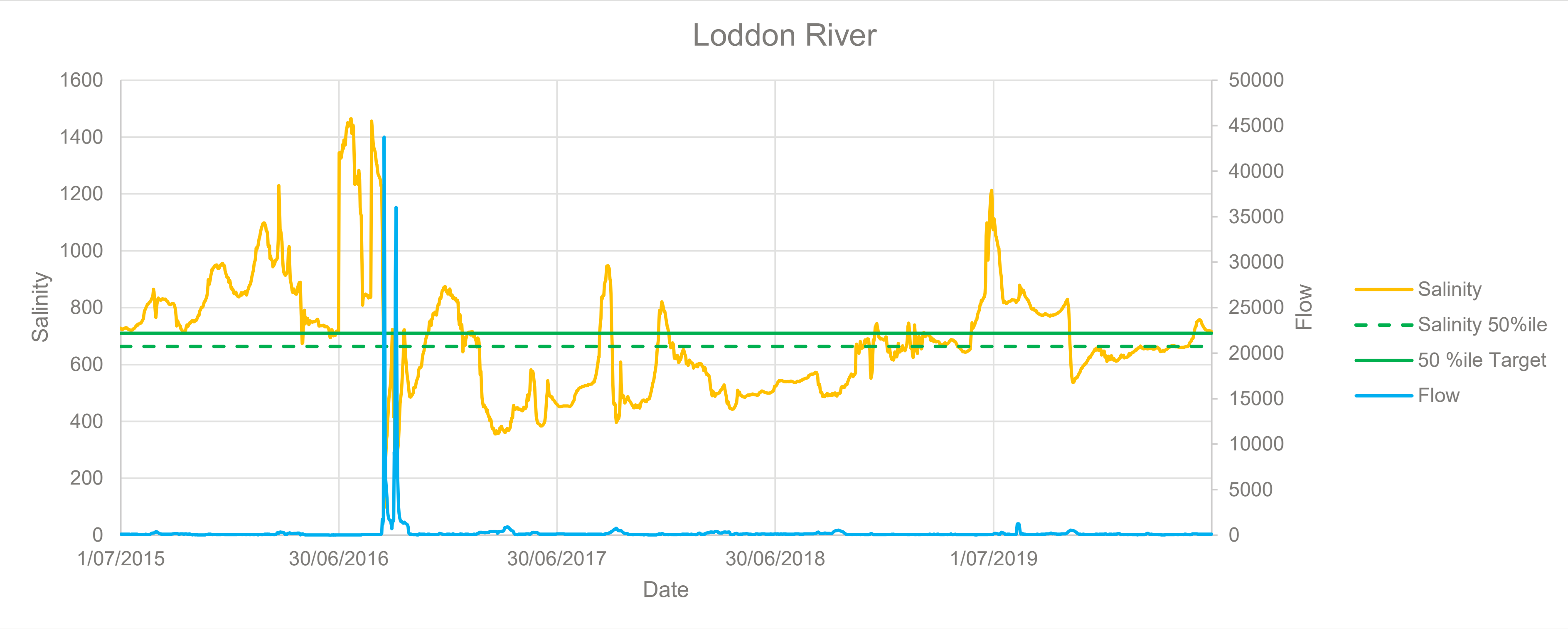


Figure 9: Available flow and salinity record for Loddon River @ Laanecoorie[12] , 1 July 2015 to 30 June 2020

12. Salinity data infilled using low flow and salinity relationships over the 2014/15 data collection period due to an equipment malfunction from 28 April to 30 June 2016.

3.3.7 **Campaspe River at Campaspe Weir**

Results for the Campaspe River, as indicated in Figure 12 below indicate that median salinity exceeded the target between July 2015 and June 2020. The implications of this exceedance for Murray River salinity is considered minor because the tributary flow was diluted by the much higher flow of the Murray River

No peak salinity or salt export targets are set for the Campaspe River.

Streamflow and salinity data for short periods of the monitoring period are unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

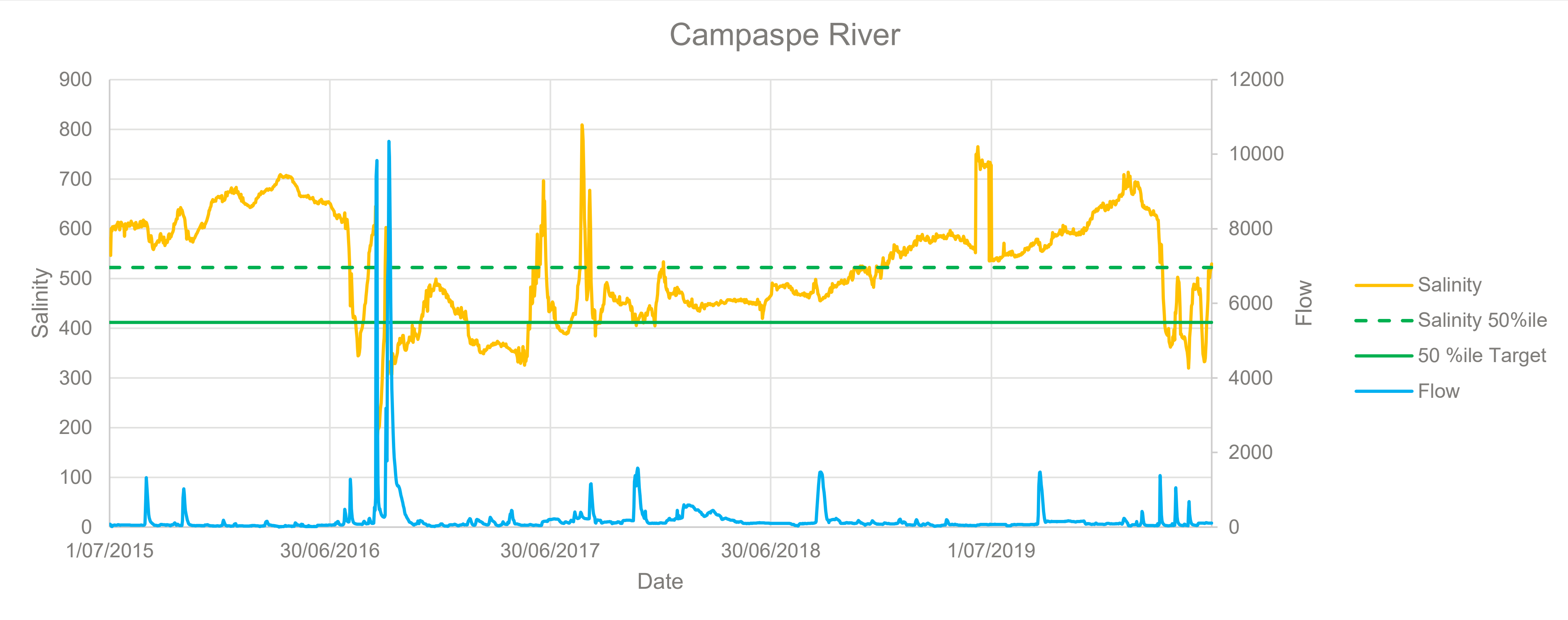


Figure 10: Available flow and salinity record for Campaspe River @ Campaspe Weir[13], 1 July 2015 to 30 June 2020

13. Campaspe River EoVT site (406218) does not measure daily flow. Flow data was sourced from a downstream gauge at Rochester (406202).

3.3.8 **Wimmera River at Horsham Weir**

Results for the Wimmera River, as indicated in Figure 13 below indicate that both median and peak salinity were maintained below their respective targets between July 2015 and June 2020.

Salt loads for the Wimmera River (tonnes/yr) were consistently below the target value, only exceeding this target mean in the 16/17 period. Salt load during this period was influenced by very high flows during widespread flooding across Victoria in October-November 2016.

Salinity data for a very short period during 2015 is unavailable due to conditions outside of the instrumentation threshold, interference to monitoring infrastructure or faulty instrumentation. These periods of limited data were predominately of short duration and were infilled using interpolation techniques.

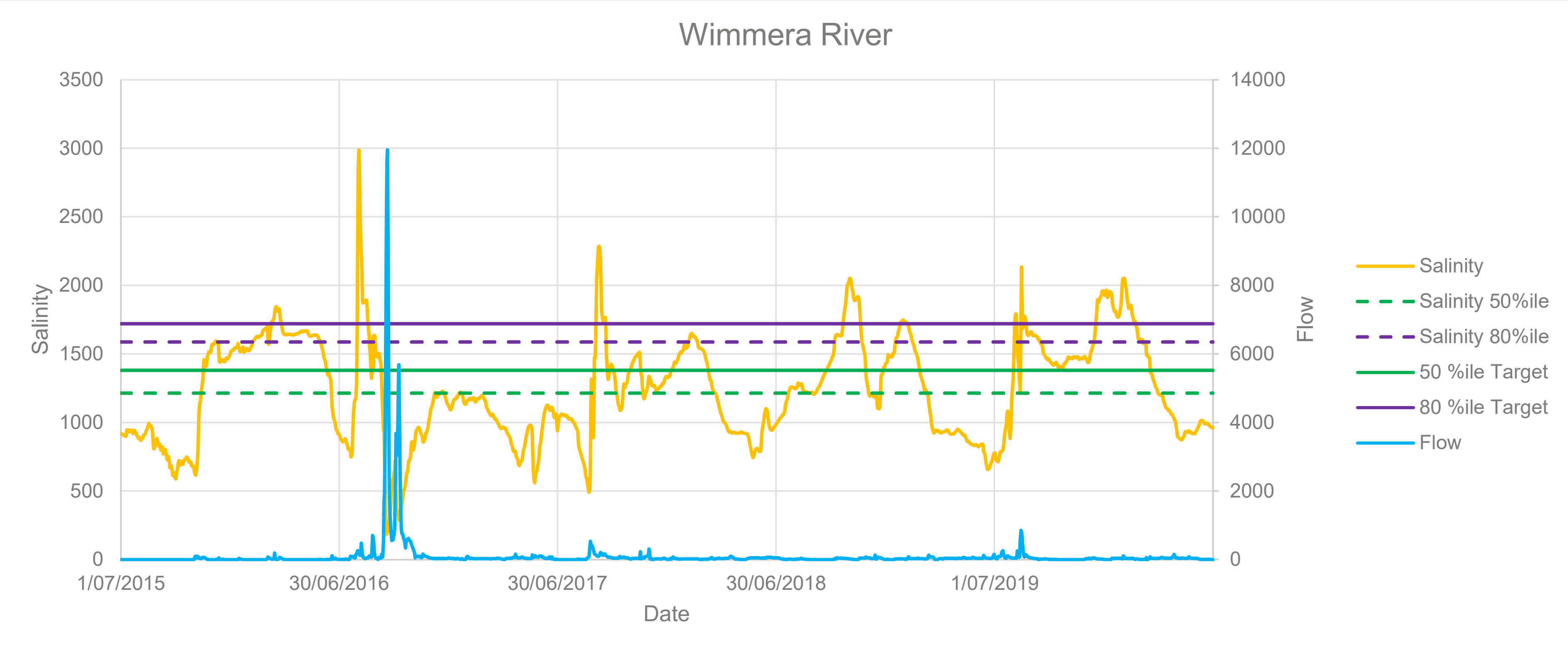


Figure 11: Available flow and salinity record for Wimmera River @ Horsham Weir, 1 July 2015 to 30 June 2020

3.4 5-Yearly Flow and Salinity Summary Statistics

The following table presents aggregated summary statistics for flow and salinity at Victoria's EoVT sites. Appendix B provides annual data for the same period.

Table 3 Average monitoring results of salinity and salt loads at EoVT sites between 2015/16 and 2019/20 compared to target value

Region	Valley	Reporting site	AWRC Site Number	End-of-Valley Targets (as absolute value assessed over the Benchmark Period, 1975-2000)			2015/16 to 2019/20 monitoring results			Comparison of monitoring results to End-of-Valley Target value		
				Salinity (EC)		Salt Load (t/yr)	Salinity (EC µS/cm)		Salt Load (t/5yr)	Salinity (EC)		Salt Load (t/yr)
				Median (50%ile)	Peak (80%ile)	Mean	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total
North East (Interim target)	Ovens	Ovens River @ Peechelba-East	403241	72	100	54,000	57	71	214,500	Maintained below target	Maintained below target	Salt Load target not met
	Kiewa	Kiewa River @ Bandiana	402205	47	55	19,000	39	47	78,700	Maintained below target	Maintained below target	Salt Load target not met
Goulburn Broken	Goulburn	Goulburn River @ Goulburn Weir	405259	99	-	-	63	90	198,600 #	Maintained below target	-	-
	Broken	Broken Creek @ Casey's Weir	404217	141	-	-	150*##	183##	2,400#	Target value exceeded	-	-
North Central	Avoca	Avoca River @ Quambatook	408203	2,096	-	-	2,254^# #	4,320^ ##	17,600 ^	Target value in 50% of years with sufficient data	-	-
	Loddon	Loddon River @ Laanecoorie	407203	711	-	-	664	824	143,100	Maintained below target	-	-
	Campaspe	Campaspe River @ Campaspe Weir	406218	412	-	-	522*	626	106,900 #	Target value exceeded	-	-
Wimmera (Interim target)	Wimmera	Wimmera River @ Horsham Weir	415200	1,380	1,720	31,000	1,214	1,587	80,500	Maintained below target	Maintained below target	Salt Load target not met
Mallee	Vic Mallee Zone	Murray River @ Lock 6	426200	+15EEC[8]	-	-	-	-	-	^^	-	-

^ Calculated averages are based on 2 years of available data, due to extended periods in which flow ceases in the Avoca River # Salt load calculated using flow and salinity (EC) from downstream gauging station; ## Salinity data from downstream gauging station; ^^ The target relates to Victoria's contribution to river salinity throughout the entire Mallee zone. This contribution is assessed using the EM2 model, rather than modelled surface water salinity; * Salinity exceeded target, but should not be deemed a threat to the Murray River;

[8] Equivalent Electrical Conductivity – refer to Basin Salinity Management Strategy Operational Protocols Version 2.0, Murray-Darling Basin Commission, Figure 4, pg. 100.

4. Water Quality Management Plans – Implementing Victoria's Measures

4.1 Introduction

Victoria has developed water quality management plans (WQMPs) for each of its five Water Resource Plan Areas.

The Wimmera-Mallee Water Quality Management Plan met the requirements for the Wimmera-Mallee (surface) water resource plan area, and the Wimmera-Mallee (groundwater) water resource plan area.

The North and Murray Water Quality Management Plan met the requirements for the Victorian Murray and the Northern Victoria (surface) water resource plan areas, and the Goulburn-Murray (groundwater) water resource plan area.

These plans were accredited recently in September 2019, and June 2020 respectively.

The plans:

- present causes or likely causes of water quality degradation in the areas;
- highlight moderate to high risks to water quality in the areas and Victorian strategies to address them;
- identify measures that contribute to the achievement of water quality objectives located in Chapter 9 of the Basin Plan; and
- present water quality targets considered in the development of those measures.

This part of the report presents an update on delivery of the measures identified in the WQMPs.

4.2 Measures of the Water Quality Management Plans

Victoria identified a number of measures that contribute to the achievement of the water quality objectives of Chapter 9 of the Basin Plan within the WQMPs, they are:

- Implementation of the State Environment Protection Policy (Waters) or its future equivalent – which was applied to surface and groundwater in both WQMPs;
- Implementation of the Wimmera Mallee Long-Term Water Plan Objective to Maintain Adequate Surface Water Salinity to Enable Growth and Reproduction of Aquatic Vegetation – which was applied to surface water in the Wimmera-Mallee WQMP;
- Implementing the South Australian-Victorian Border Groundwaters Agreement – which was applied to groundwater in the Wimmera-Mallee WQMP; and
- Implementation of Victoria's commitments under BSM2030 (the Basin Salinity Management Strategy) – which was applied to surface waters in the North and Victoria WQMP.

In addition, under 10.35c and 10.35d of the Basin Plan as amended in 2018, a number of rules and measures rules to contribute to/ensure that water quality is maintained against the effects of elevated levels of salinity and other types of water quality degradation were identified for groundwater in the North and Murray WQMP including.

Table 4Table 4 maps out the Victoria's measures and their application to surface and/or groundwater in each of the Wimmera-Mallee and the North and Murray regions.

Table 4 Measures (and rules) applying to surface and/or groundwater in Victoria's Wimmera-Mallee and North & Murray Water Quality Management Plans

Wimmera-Mallee WQMP		North and Murray WQMP	
Surface water	Groundwater	Surface water	Groundwater
Implementation of the State Environment Protection Policy (Waters) or future equivalent			
Implementation of Wimmera-Mallee Long Term Watering Plan – salinity objective	South Australian-Victorian Border Groundwaters Agreement	BSM2030	10.35c and 10.35d – Rules and Measures for water quality and salinity • Conditions on take and use licences • Maintenance of register of State Observation Bores • Scheduled groundwater level readings from identified bores • Salinity monitoring under statutory management plans

4.3 Progress of Measures 1 - Implementation of the state environment protection policy (Waters) and its future equivalent

4.3.1 Background to SEPP (Waters)

The new state environment protection policy (SEPP) (Waters), gazetted in 2018, ensures that Victoria has a contemporary statutory policy for the protection and management of surface water and groundwater in Victoria. This is achieved by establishing in law the uses and environmental values to be protected, defining the level of environmental quality required for their protection, and setting rules and obligations to ensure management actions are taken to protect water quality.

SEPP (Waters) updates and replaces two previous SEPPs, SEPP (Waters of Victoria) and SEPP (Groundwaters of Victoria), to provide a single instrument to guide water quality management in Victoria and improve protection of our waterways, bays and coastal waters. It provides environmental quality objectives which better reflect conditions of our water environments and is based on extensive monitoring data, the latest scientific understanding and relevant national standards. It also more clearly identifies rules for decision makers and obligations on industry to guide the protection and management of water quality in Victoria.

By approving the new SEPP (Waters), the Victorian Government confirmed policy positions on a range of issues as well as setting new environmental standards based on contemporary science. This will provide a streamlined transition to the new regulatory framework that will come into place following the commencement of the *Environment Protection Amendment Act 2018* intended for mid-2021.

4.3.2 SEPP (Waters) in the WQMPs

The implementation of SEPP (Waters) was identified as a measure to contribute to water quality objectives of the Basin Plan (Chapter 9). Table 5 presents how SEPP (Waters) was identified as contributing to the different objectives.

Table 5 The contribution of SEPP (Waters) to Basin Plan Water Quality Objectives

Basin Plan Water Quality Objective	How SEPP (Waters) Contributes to Achieving the Objective.
Water dependent ecosystems and Ramsar wetlands: ecosystems is that the quality of water is sufficient to maintain the ecological character of those wetlands. The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient to protect and restore ecosystems and their function and to ensure that the ecosystems are resilient to climate change and other risks and threats.	The SEPP (Waters) includes water-dependent ecosystems and species as a beneficial use to be protected in Victoria's surface waters. This beneficial use is consistent with the Basin Plan objective for water-dependent ecosystem. Therefore, implementation of SEPP (Waters) will protect the Basin Plan fresh water-dependent ecosystem. Water-dependent ecosystems and species are protected in all rivers and streams. Numerical environmental quality objectives have been set for rivers and streams to guide water managers on the appropriate levels of relevant indicators to protect the ecosystems. If these objectives are not attained, further investigation is required to understand if a threat is real, and what action needs to be taken
Raw water for treatment for human consumption, to: minimise the risk that the quality of raw water taken for treatment for human consumption results in adverse human health effects • maintain the palatability rating of water taken for treatment for human consumption at the level set out in the Australian Drinking Water Guidelines • minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers	The SEPP (Waters) identifies 'water suitable for human consumption after appropriate treatment' as a beneficial use of Victoria's surface waters. It is protected where water is sourced for supply in accordance with the special water supply catchments area set out in Schedule 5 of the *Catchment and Land Protection Act 1994* or *the Safe Drinking Water Act 2003*. The SEPP (Waters) beneficial use is consistent with the intent of the Basin Plan raw water for treatment for human consumption. Therefore, implementation of SEPP (Waters) will protect the Basin Plan raw water for treatment for human consumption. SEPP (Waters) does not establish specific numeric environmental quality objectives for raw or treated water for human consumption for surface waters. However, because the protection of water-dependent ecosystems and species, which has the most stringent environmental quality objectives, is identified in all segments, the measures/activities to protect water-dependent ecosystems and species will provide protection for raw water for human consumption
Irrigation water: that the quality of surface water, when used in accordance with best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.	The quality of source water for irrigation is maintained through Victoria's water quality framework which includes the implementation of SEPP (Waters).
Recreational water quality, to achieve a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact from recreational use of Basin water resources.	Recreational use of water is recognised as a beneficial use in SEPP (Waters), which is categorised as primary and secondary contact recreation and aesthetic enjoyment of the waters. The three uses are protected across all rivers and streams in Victoria, except where public access is legally restricted or has specifically been exempted by the policy. SEPP (Waters) provides comprehensive environmental quality objectives for primary and secondary contact, with *E.coli* as the freshwater indicator of pathogenic bacterial contamination. SEPP (Waters) beneficial use is consistent with the intent of the Basin Plan recreational water consumption. As a result, implementation of SEPP (Waters) will protect the Basin Plan recreational water
Maintaining good levels of water quality: being the maintenance of water quality characteristics at a level that is better than the target	The Basin Plan (section 9.08) outlines the objective to maintain good levels of water quality as SEPP (Waters) identifies environmental quality objectives of beneficial uses that are appropriate to the segment in which they are applied. The objectives define the level of water quality necessary to protect beneficial uses. Environmental quality objectives describe the concentration, level, state

Basin Plan Water Quality Objective	How SEPP (Waters) Contributes to Achieving the Objective.
value set out in Part 4 of Chapter 9 of the Basin Plan.	or biological condition of an indicator for different segments that would not cause harm or pose a significant risk to beneficial uses.

As part of the development of SEPP (Waters), the Victorian government identified key actions for investment through an Implementation Plan. Critical actions identified in the Implementation Plan included:

- setting interim regional targets to rehabilitate priority areas;
- achieving pollutant load targets;
- managing urban stormwater and sewerage;
- managing wastewater discharges; and
- managing onsite domestic waste.

This report will focus on giving an update on the process and method of setting interim regional targets to rehabilitate priority areas.

4.3.3 Implementation of SEPP (Waters) – Interim Regional Target Setting

The following section focusses on the process and trial of regional target setting as a tool to achieve water quality improvements and to support water managers to respond meaningfully and systematically to non-attainment of the water quality objectives.

SEPP (Waters) sets environmental objectives for rivers and streams which vary by geographic segments across the state. Data shows that these objectives values are not being met by many waterway reaches across the state. SEPP (Waters) provides a framework for response where it is unlikely the objectives will be attained during the life of the Policy. It says:

(1) If it is recognised that environmental quality objectives are unlikely to be attained during the life of this Policy, and water quality is a threat to priority reaches (or equivalent) as identified in a regional waterway strategy for a catchment management region, waterway managers must establish interim regional targets to drive the progressive rehabilitation of environmental quality in a measurable manner and over a fixed timeframe.

(2) Interim regional targets must include the following—

a) interim environmental quality objectives;

b) a basis for maximising the protection of beneficial uses and the attainment of the environmental quality objectives set out in this Policy;

c) management outcomes that provide measurable and time-bound progress towards the attainment of interim environmental objectives by taking into account regional environmental, social and economic values;

d) a demonstrated and measurable link between implementation of management outcomes and resultant water quality condition.[14]

DELWP has been working with regional waterway managers to develop and trial an approach to implementing interim regional target setting. This process involves a combination of considering value and risk.

Priority waterways, where water quality was identified as a potential threat were identified by catchment management authorities.

Sites that had not triggered (not attained) a relevant SEPP (Waters) objective based on up to 10 years of data or based on the available data record were given a ‘green light’ for minimal risk and no further action was required and were set aside.

[14] SEPP (Waters) 2018, clause 18.

Sites that had triggered a relevant SEPP (Waters) objective based on 10 years of data or the available data record and were a high value ecosystem were given a ‘red light’ for further investigation.

All other sites were assessed for severity of risk considering: the frequency of non-attainment, the degree of non-attainment, whether four or more different objectives were triggered, and whether the current trajectory showed a deterioration of water quality. Sites that met any of these criteria were given an ‘amber light’ for consideration of further investigation.

‘Further investigation’ could typically commence with an assessment of the risks to the reach. A useful approach to this type of Ecological Risk Assessment (ERA) is identified in the EPA Victoria documents ‘Guideline for environmental management - risk-based assessment of ecosystem protection in ambient waters’ (EPA 2004) and ‘Guidelines for risk assessment of wastewater discharges to waterways’ (EPA 2009).

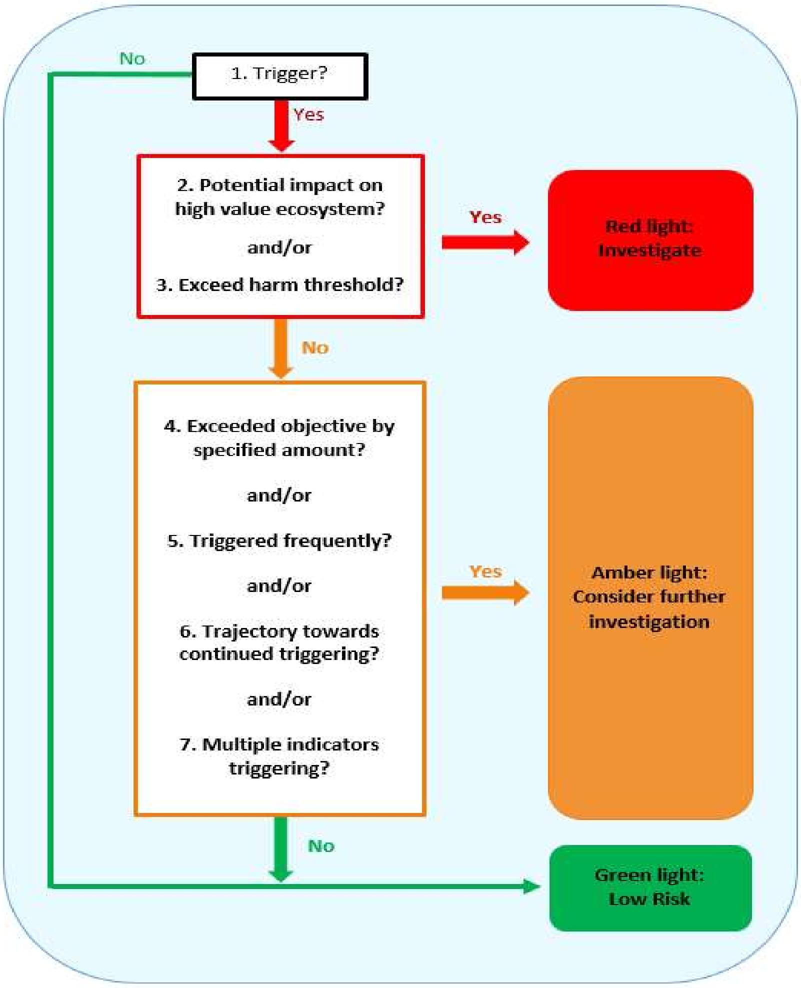


Figure 12 A Method for assessing the scale and severity of non-attainment of SEPP (Waters) Water Quality Objectives (DELWP 2020)

Following the risk assessment for the reach, the Interim Regional Water Quality Target Setting Approach can be used to derive:

water quality targets for the indicators that have not attained SEPP (Waters);

management action targets to identify the management actions that should be undertaken to achieve the water quality targets.

In the Murray-Darling Basin, preliminary work has identified a range of sites, from across nine catchments being reviewed for Regional Target Setting due to their priority to catchment management authorities. Of these a number were as having drought refuge[15] in an assessment under Victoria’s AVIRA framework [16], and a number have indicated levels of water quality against at least one parameter that could cause ecological harm. Parameters of most concern were dissolved oxygen, turbidity, total nitrogen and total phosphate.

One of the sites analysed is Holland Creek at Kelfeera in the Broken Basin. It was identified as needing Regional Target Setting and work has commenced to develop this. The following case study presents further information on the work being conducted for this site.

[15] Drought refuge was identified as a value in an assessment under Victoria’s Aquatic Value Identification and Risk Assessment framework. That is the site had modelled drought refuge for one or more significant fish species OR a site was a nominated drought refuge for significant fauna and/or significant EVCs

[16] Aquatic Value Identification and Risk Assessment (AVIRA) – developed in Victoria and used in the development of Regional Waterway Strategies across the state.

Trial Interim Regional Target Setting Case Study: Holland Creek at Kelfeera

Priority Reach – WQ Triggering SEPP objectives – Scale and Severity of Triggering – Environmental Risk Assessment – Management Actions

Working with the Goulburn Broken CMA, Victoria has trialled the application of the Interim Regional Target Setting methodology to Holland Creek at Kelfeera and presented the findings in a case study.

Background: Holland Creek is situated in the foothills of the Broken River Basin and was assessed as a high priority reach by the Goulburn Broken CMA. It is a drought refugia for three native threatened fish species, Macquarie perch, river blackfish and two-spined blackfish

Scale and severity assessment of non-attainment of SEPP (Waters) Objectives: Examination of 10 years of data (2009-2018) showed the water quality of the reach:

triggered SEPP Objectives in a Drought refugia (Red light – undertake further investigation)

triggered SEPP Objectives for dissolved oxygen, turbidity, total nitrogen and total phosphorus multiple times (Amber light – consider further investigation)

triggered turbidity by more than 40% above the objective (Amber light – consider further investigation).

Table 6 Scale and severity assessment of non-attainment of water quality the Holland Creek at Kelfeera

HOLLAND CREEK @ KELFEERA							
	Triggered SEPP	DO%	pH	Turb	EC	TN	TP
RED LIGHT	AVIRA score = 5 or Yes?	Drought refugia ✓					
	Exceed harm threshold?						
AMBER LIGHT	Exceed high magnitude?			✓			
	Exceed triggering frequency	✓		✓		✓	✓
	Trajectory concerns?						
	Multiple indicators	✓					

Drought refugia are usually large and deep pools where biota can survive low or no flow periods and from which, once flow returns, biota can disperse back into the broader stream system. Drought refugia are, therefore, critical for the ecological components of stream systems. Threats to drought refugia include high water temperatures and low dissolved oxygen, often the result of high nutrient levels promoting algal blooms.

Assessing impact of water quality on the values:

An Environmental Risk Assessment (ERA) for this reach (from 2007) identified riparian vegetation, channel condition and physical habitat diversity as values in good condition. The assessment focussed on populations of the three native fish populations: Macquarie perch, river blackfish and two-spined blackfish. The ERA, using probability, exposure and consequence to determine risk level, identified the six major threats to the native fish, including water quality. The others being: barriers to migrations, exotic fish, insufficient flows, reduced food availability and loss of physical habitat.

Evaluate water quality: Each of the four triggering parameters were examined further. It was determined that

the greatest water quality threats to the native fish populations (the end point measures) in Holland Creek at Kelfeera are: dissolved oxygen, in particular its occasional drops to potentially lethal levels; and total phosphorus as a contributing factor to eutrophication and therefore to dissolved oxygen stress.

Turbidity and total nitrogen were recorded much less of a threat, though work to propose suitable targets for them was completed.

It was also considered that temperature, despite having no SEPP (Waters) objective, was an important influence on native fish populations particularly in low flow low level periods of drought when this drought refuge could reach 25-30 degrees Celsius.

Table 4 presents proposed interim targets for Holland Creek.

Table 7 Suggested potential interim regional targets in case study

Target indicator	SEPP Objective	Proposed Interim Target
Dissolved oxygen	25^{th} %ile 70 % saturation	**25^{th} percentile for dissolved oxygen ≥ 60% saturation**
Total phosphorus	0.050 mg/L	**75^{th} percentile <0.100 mg/L (five years)** **75^{th} percentile <0.070 mg/L (ten years)** **75^{th} percentile <0.050 mg/L (twenty years)**;
Turbidity	20 NTU	**75^{th} percentile ≤ 20 NTU (= current objective)**
Total nitrogen	≤ 0.800 mg/L	**75^{th} percentile ≤ 0.800 mg/L (= current objective)**.
Temperature	NA	**Temperature 'trigger'** of 26 degrees is provided to protect Macquarie Perch populations.

Management actions and current water quality:

Significant management actions have been undertaken to effectively address threats and improve water quality since 2008. Recent water quality data examined in 2019 showed total phosphorus, total nitrogen and dissolved oxygen all showed improving trajectories; turbidity showing an increasing trajectory, and temperature gradually increasing over 20 years.

The case study proposed management actions to improve water quality should focus on reducing stock access to the creek (e.g. via fencing), regeneration of riparian vegetation and decreasing weed spread (e.g. via riparian revegetation, assisted by fencing). These activities will also contribute to an increase in habitat for the native fish as well as improving conditions for food sources, thereby leading to increased food availability.

The current concentrations for total phosphorus, total nitrogen and dissolved oxygen are approaching the SEPP (Waters) objectives, if the current trends continue. It cannot conclusively be said, however, that the actions undertaken have directly resulted in the observed water quality improvements, although they no doubt have substantially contributed.

4.3.4 *Environment Protection Amendment Act 2018* – Future change to the status of SEPP (Waters)

Victoria has undertaken a major review and reformation of environmental protection over the last several years. An independent review of the Environment Protection Authority (EPA), and the government's response to that review in 2017 set the direction for the future environmental protection framework and role of the EPA. The resulting overhaul of the *Environment Protection Act 1970*, and its subordinate instruments and tools, led to the *Environment Protection Amendment Act 2018.*

In support of the *Environment Protection Amendment Act 2018*, Environment Reference Standards and Environment Protection Regulations are being developed and are intended to all come into force from 1 July 2021.

With this change in instruments, the SEPP (Waters) will be retained as a state of knowledge document.

Subordinate legislation: Environment Protection Regulations and Environment Reference Standards

Key clauses of SEPP (Waters), highlighted in Victoria's Water Quality Management Plans are proposed to be rehoused in the following ways:

Beneficial uses of ground water and surface water – will be contained within new Environment Reference Standards.

Environmental quality indicators and objectives – will be contained within the new Environment Reference Standards.

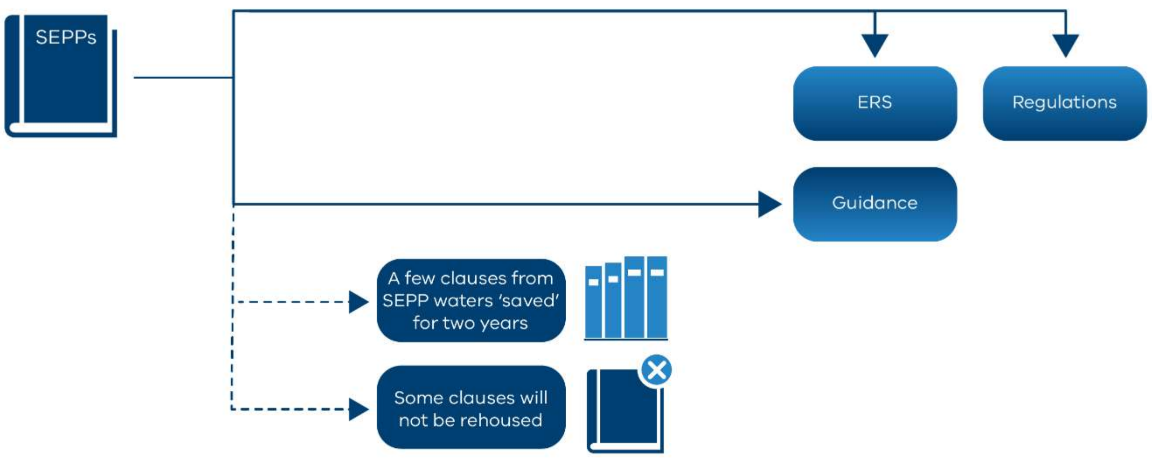
A number of the obligations expressed in SEPP (Waters) will be covered by the General Environmental Duty within the Amendment Act.

In the proposed Regulations and related documents that support the Regulations

Tools and mechanisms for improving environmental management, are proposed to be embedded in guidance material for government agencies.

Figure 13 shows how clauses in SEPP (Waters) will be rehoused into new instruments and guidance.

Figure 13 Conceptual diagram showing rehousing of SEPP clauses to new instruments and guidance



Following the release of the final subordinate legislation tools to support the new Act, Victoria will review its Water Quality Management Plans to determine any relevant updates or changes required.

4.4 Progress of Measures 2 - Implementation of the Wimmera Mallee Long-Term Watering Plan Objective to Maintain Adequate Surface Water Salinity to Enable Growth and Reproduction of Aquatic Vegetation

The Wimmera-Mallee Long Term Watering Plan (the Wimmera-Mallee LTWP), through its objective to 'Maintain Adequate Surface Water Salinity to Enable Growth and Reproduction of Aquatic Vegetation', was identified as a measure to contribute to surface water quality objectives in the Wimmera-Mallee Water Quality Management Plan.

In the Wimmera-Mallee LTWP:

- Surface water salinity is one of four main ecosystem functions identified for the Wimmera-Mallee LTWP along with hydrological connectivity between river reaches, refuges for native fish species, and geomorphic habitat.
- To 'maintain adequate surface water salinity to enable growth and reproduction of aquatic vegetation' is one of 13 of the LTWP's objectives.

This objective was built from the *Wimmera System Environmental Water Management Plan 2015* (WCMA, 2015) which identified the objective: 'Enable growth and reproduction of submerged aquatic macrophytes and emergent vegetation through mitigating salinity impacts'.

Working to achieve this objective through environmental water planning and operations was considered to contribute to Basin Plan Chapter 9 Water Quality Objectives in the following ways.

Basin Plan Water Quality Objective	How the Wimmera-Mallee Long Term Water Plan – contributes to Basin Plan Water Quality Objectives.
Water dependent ecosystems and Ramsar wetlands: that the quality of water is sufficient to maintain the ecological character of those wetlands. The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient to protect and restore ecosystems and their function and to ensure that the ecosystems are resilient to climate change and other risks and threats.	The Wimmera–Mallee LTWP recognises the importance of suitable salinity levels to enable aquatic vegetation to grow and reproduce. This vegetation in turn is important for its broader ecosystem. Maintaining suitable salinity levels is one of four priority ecosystem functions of the LTWP. Watering plans, Basin-scale priorities and strategies together with annual watering plans support this objective.
Recreational water quality, to achieve a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact from recreational use of Basin water resources.	Release of water for environmental watering purposes must have regard to the water quality targets for flows, which includes targets for salinity, dissolved oxygen and blue-green algae. By having regard to blue-green algae in the delivery of environmental water consideration is given to improving water quality for recreational users.

The Wimmera–Mallee LTWP and the Wimmera River System Environmental Water Management Plan documents inform environmental watering planning at state and interjurisdictional levels including informing:

- Wimmera Catchment Management Authority (WCMA) Annual Environmental Watering Proposals,
- The Victorian Environmental Water Holder's (VEWH's) Annual Environmental Watering Plan. As well as;
- Basin-wide Watering Strategy and Basin Annual Watering Priorities;
- water resource plans, particularly environmental watering requirements; and

- long-term outcomes and environmental water demands in the Commonwealth Environmental Water Holder's (CEWH) portfolio management plans.

Table 1 presents the inclusion of the objective in the LTWP and the EWMP, the subsequent inclusion of potential water watering for the Wimmera River, and the annual environmental water release to the Wimmera River for all relevant objectives.

Table 8 Inclusion of Objective 4 in the Wimmera EWMP/LTWP, Annual VEWH Seasonal Watering Plans, and Volume of Environmental Water Released to the Wimmera River .

	Wimmera-Mallee Long Term Watering Plan/ Wimmera System Environmental Water Management Plan (Vic) Water Quality Objectives that were in place	**VEWH Seasonal Watering Plan –** The plan identified potential actions with Water Quality outcomes for the Wimmera River	**VEWH Annual 'Reflections' Report** Volume of environmental water released to the Wimmera River each year[17]
2015/16	Maintain Adequate Surface Water Salinity to Enable Growth and Reproduction of Aquatic Vegetation/ 'Enable growth and reproduction of submerged aquatic macrophytes and emergent vegetation through mitigating salinity impacts'	✓	3890 ML[18]
2016/17		✓	7116 ML[19]
2017/18		✓	8640.8ML[20]
2018/19		✓	10602 ML[21]
2019/2020		✓[22]	Information not yet available

Observations of Wimmera CMA[23]:
Whilst it is not the intention of this report to provide detailed information on the outcomes of the inclusion of this measure, the following observations have been made by the Wimmera CMA.

The Wimmera CMA reports that 'maintaining surface water salinity in the Wimmera River is for the purpose of enabling growth and reproduction of aquatic vegetation, and in turn the fauna that rely on it. Aquatic vegetation is not being monitored and so water quality acts as a proxy indicator of this aspect of environmental health. 2017 to 2020 were dry years, making it challenging to mitigate the salinity impacts at Tarranyurk in the last three years with long period (months) with no flow until regulated environmental flows have been able to dilute and mobilise saline water that intrudes into the river channel from groundwater. When flows cease the salinity levels steadily increase again'.

[17] Note: Environmental water released to the Wimmera River is done so to address a range of environmental objectives, one of which is Objective 4.

[18] VEWH, Reflections 2015-16

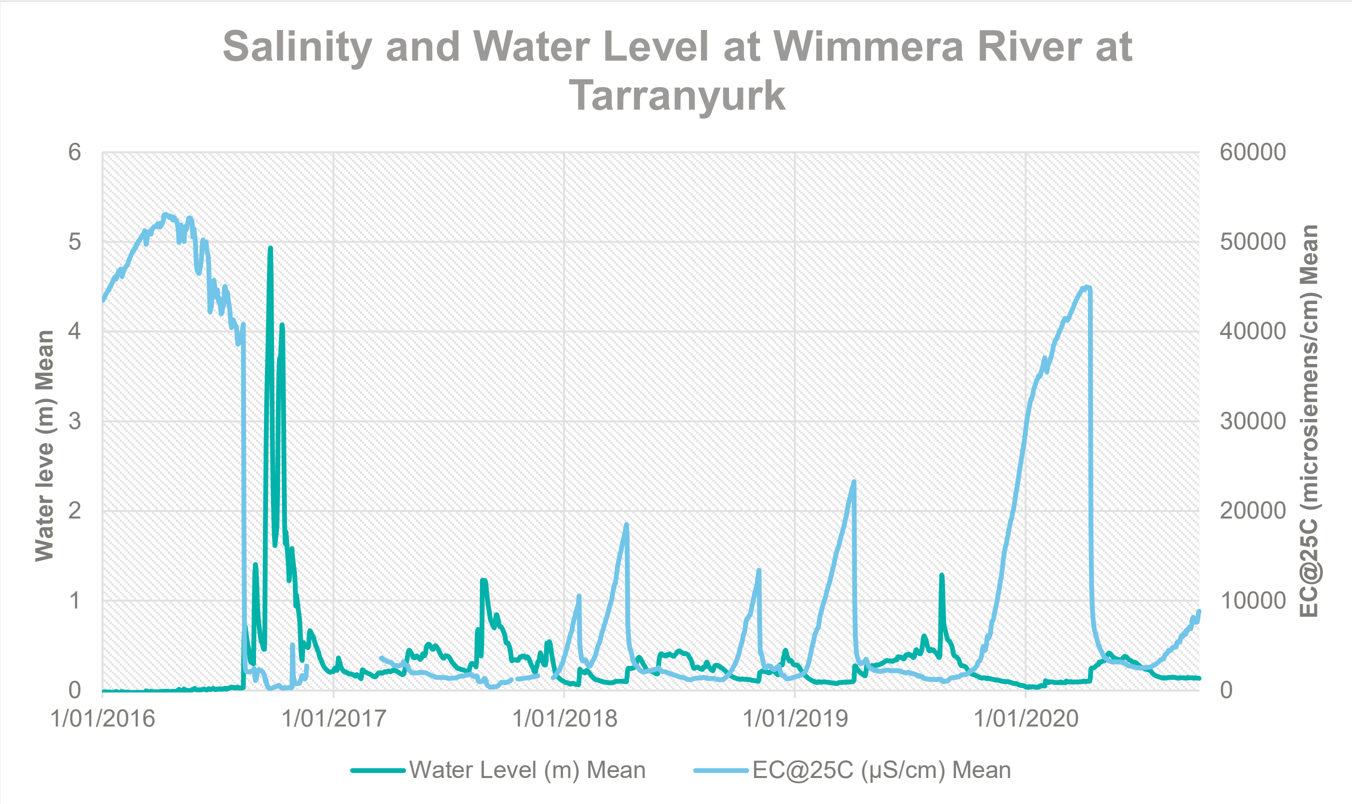
[19] VEWH, Reflections 2016-17

[20] VEWH, Reflection 2017-18 Water from both the VEWH and the Commonwealth Environmental Water Holder (CEWH)

[21] VEWH, Reflections 2018-19 https://www.vewh.vic.gov.au/__data/assets/pdf_file/0011/515783/VEWH-Reflections-2018-19_web_REV.pdf Water from both the VEWH and the CEWH.

[23] Pers comms Fletcher, Greg, Wimmera CMA 2020

Figure 14 Salinity and Water Level of Wimmera River at Tarranyurk



4.4.1 Updates to the Wimmera-Mallee Long Term Watering Plan

The Wimmera-Mallee Long Term Watering Plan has been revised and updated in 2020. As part of the updates, the target for the objective to 'Maintain adequate surface water salinity to enable growth and reproduction of aquatic vegetation' was updated to align with long term salinity management and planning in the Wimmera. Table 9 identifies the previous, and the revised target.

Table 9 Revised Salinity target for Objective to: Maintain adequate surface water salinity to enable growth and reproduction of aquatic vegetation[24]

Theme	Objective	Previous Target	Revised Target	Recommended Assets *CMA priority
Functions	Maintain adequate surface water salinity to enable growth and reproduction of aquatic vegetation	Salinity targets for the Wimmera River at Horsham Weir (end of valley target) met 100% of the time	End-of-valley salinity targets for the Wimmera River at Horsham Weir of median 1,380 EC and eightieth percentile of 1,720 EC are met in every year in the ten years to 2025	Wimmera River

[24] DEWLP, 2020. Wimmera-Mallee LTWP 2020 Minor Update DRAFT

For information regarding salinity levels at this site, Wimmera@horsham, please refer to Part 3 Long Term Salinity Management and Planning. It is noted that this target is well upstream of the end of valley and that the nearest water quality measurements are several kilometres downstream at 415200 Wimmera River@Horsham.

In 2020, Victoria is also reporting on Basin Plan, Schedule 12, ‘Matter 8: Environmental outcomes at an asset scale’. Further information is available here about environmental outcomes of Victoria’s environmental watering programs.

4.5 Progress of Measures 3 - Implementation of South Australian-Victorian Border Groundwaters Agreement

The South Australian – Victorian Border Groundwaters Agreement (the Agreement) is an arrangement between the South Australian and Victorian Governments, enshrined in two state Acts, to protect and equitably manage the groundwater located along the shared state border. 'Along the South Australian–Victorian border, groundwater is the only reliable natural water source, it is used extensively for irrigation, industry and public water supplies, as well as livestock and domestic uses. for domestic, agricultural, and irrigation use, and so its protection from degradation or depletion is critical'[25].

The objectives of the Agreement are:

- Protection of groundwater and to guard against its undue depletion or degradation
- Cooperative management; and
- Equitable sharing of the resource.

The Agreement is implemented by the independent Border Groundwaters Agreement Review Committee (the Review Committee) which meets quarterly and is responsible for the operation of the Agreement. The Review Committee is required, amongst other things, to review the management prescriptions at periods not greater than 5 years and to prepare an annual report to the Ministers, which the Ministers are required to table in Parliament. The Review Committee can make recommendations to the respective state Ministers and has powers set Permissible Annual Volumes of Extractions.

The Wimmera-Mallee Water Quality Management Plan identified the Implementation of the South Australian-Victorian Border Groundwaters Agreement as a measure to contribute to the achievement of Basin Plan Chapter 9 Water Quality Objectives for groundwater in the following ways:

Basin Plan Chapter 9 Water Quality Objective	How the SA-Vic Border Groundwaters Agreement contributes to the Basin Plan Water Quality Objectives
Raw water for treatment for human consumption: to minimise the risk that the quality of raw water taken for treatment for human consumption results in adverse human health effects • maintain the palatability rating of water taken for treatment for human consumption at the level set out in the Australian Drinking Water Guidelines • minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers	Some local use of waters in this border management area is for domestic purposes. State monitoring and management undertaken on advice from the Review Committee, helps protect the resource from salinisation, and therefore the users of this resource for domestic purposes.
Irrigation water: that the quality of surface water, when used in accordance with best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.	Local direct diverters of these groundwaters for various uses including local irrigation are supported by this measure.
Maintaining good levels of water quality: being the maintenance of water quality characteristics at a level that is better than	Monitoring the resource for quality, and commitments to manage the resource within managed use constraints, enables the quality of the water to be maintained.

[25] BGARC 34th Annual Report 2019.

the target value set out in Part 4 of Chapter 9 of the Basin Plan.	

Reports of the BGARC are located online at the following location:
https://www.environment.sa.gov.au/topics/water/resources/border-groundwaters-agreement/annual-reports

4.6 Progress of Measures 4 - Implementation of Victoria's Commitments under BSM2030 – Basin Salinity Management Strategy

Following interjurisdictional agreements since 1988, in 2000 all Basin states became signatories to the Basin Salinity Management Strategy 2000- 2015 (BSMS) to manage salinity in the Murray and Darling Rivers. Victoria's North and Murray WQMP recognised the contribution implementation of BSM 2030 can make to the achievement of water quality objectives of Chapter 9 of the Basin Plan.

Basin Plan Water Quality Objective	How Victoria's Implementation of BSM2030 Contributes to Achieving the Objective.
Water dependent ecosystems and Ramsar wetlands: ecosystems is that the quality of water is sufficient to maintain the ecological character of those wetlands. The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient to protect and restore ecosystems and their function and to ensure that the ecosystems are resilient to climate change and other risks and threats.	Managing salinity concentrations in the River Murray maintains the water quality of this waterway at a level suitable for the ecosystems and species within it. Under BSM2030 Victoria has committed to the objective of maintaining the quality of the shared water resources of the River Murray and Darling River for all beneficial uses such as agricultural, environmental, urban, industrial and recreational.
Raw water for treatment for human consumption to: minimise the risk that the quality of raw water taken for treatment for human consumption results in adverse human health effects • maintain the palatability rating of water taken for treatment for human consumption at the level set out in the Australian Drinking Water Guidelines • minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers	BSM2030 makes use of the salinity targets in Schedule B and in the Basin Plan. Many communities in Victoria, New South Wales and South Australia depend on the waters of the River Murray. Maintaining the BSM2030 target, which is the Basin Plan target, of 800 EC at Morgan plays a critical role in ensuring that the salinity levels of the river are suitable for treatment for drinking.
Recreational water quality, to achieve a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact from recreational use of Basin water resources.	The recreational water quality objective is least affected by salinity, as primary and secondary contact recreation can occur in waters up to very high levels of salt (marine water concentrations and beyond). Under BSM2030 Victoria has committed to the objective of maintaining the quality of the shared water resources of the Murray and Darling Rivers for all beneficial uses such as agricultural, environmental, urban, industrial and recreational.
Maintaining good levels of water quality: being the maintenance of water quality characteristics at a level that is better than the target value set out in Part 4 of Chapter 9 of the Basin Plan.	BSM2030 has an explicit and dedicated role in maintaining the good levels of salinity of the River Murray in a clear and audited manner over the long term.
Salt export	Victorian accountable actions undertake monitoring programs that inform Victoria's accountable action reviews to enable management of Victoria's salt contribution to the Murray River.

	BSM2030 principles and objectives are incorporated in the Victorian Sustainable Irrigation Program that reduce and/or mitigate the exportation of salt (e.g. farm planning and drainage management).

BSM2030, also contributes to the quality of irrigation water extracted from the Murray River.

In implementing its obligations Victoria:

Each year monitors and reports on the end-of-valley salinity targets recorded in Division 4 of Part 4 of Chapter 9 of the Basin Plan and Appendix 1 of Schedule B of Schedule 1 of the Commonwealth Water Act to provide a valley-scale context to the identification and management of salinity risk to the shared water resources and within-valley assets. These targets are due for review before 2026.

The register of salinity credits and debits is subject to regular reviews and independent audits. These audits have confirmed that Victoria has consistently complied with the requirements of Schedule B. Salinity management activities in Victoria will continue to comply with the requirements of Schedule B, and as such have positive effects on South Australia and New South Wales.

Victoria's latest Annual and Comprehensive reports on BSM2030 can be found here: https://www.water.vic.gov.au/murray-darling-basin/compliance/salinity.

Part 3 of this report presents a summary of salinity monitoring and results developed as part of BSM2030 over five years.

4.7 Progress of Measures 5 – Rules and Measures of 10.35c/d that support maintenance of water quality in groundwater SDL units against effects of elevated levels of salinity and other types of water quality degradation

Amendments to the Basin Plan came into force in 2018. These amendments changed the requirements of Water Quality Management Plans for groundwater. Clauses 10.35c and d were established, and required consideration, or implementation of rules and measures that support the maintenance of water quality within groundwater SDL resource units against the effects of elevated levels of salinity and other types of water quality degradation.

Victoria's North and Murray WQMP was prepared in line with the amended Basin Plan and identified a range of rules and measures for this purpose. These included:

- The maintenance of register of State Observation Bores;
- Scheduled groundwater level readings from identified bores;
- Conditions on take and use licences; and
- Salinity monitoring under statutory management plans.

4.7.1 Focus on State Observation Bores Network and Monitoring

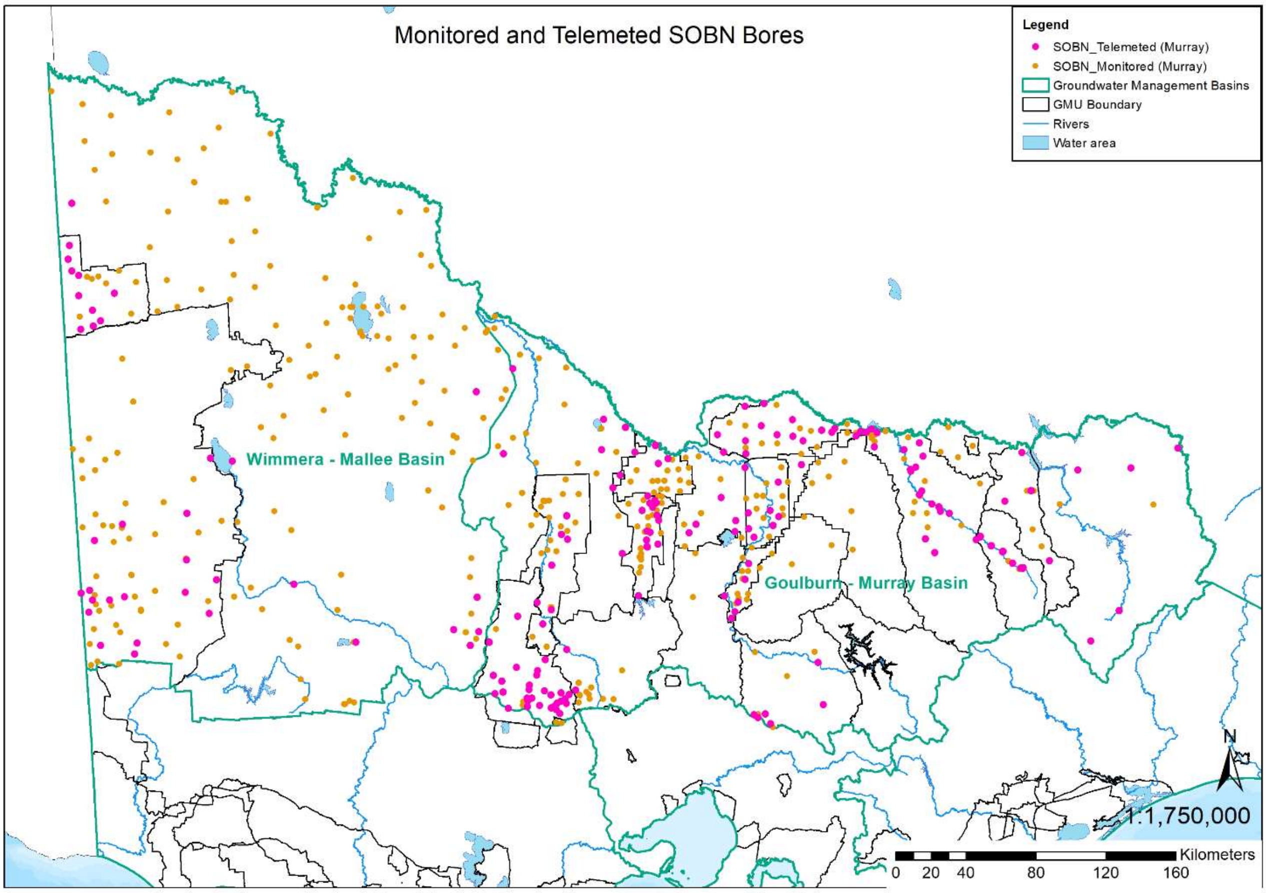
Victoria has maintained a dedicated database for the State Observation Bore Network (SOBN) bores for over 12 years. This database contains a wide range of information on bore construction and current condition, including links to downhole camera assessments, geophysical condition assessments, regular photos, regular depth readings, survey data, site maintenance work, and relevant documents such as bore construction reports.

In 2020 a new SOBN database was created on the Tableau platform. This new database allows for greater analysis of the SOBN network and mapping functionality. It will allow analysis of multiple attributes to make informed decisions on where we need to target programs for proactive maintenance and upgrade works.

The SOBN bores are also accounted for in the Capital assets database which records the asset valuations and depreciation.

There are 1634 bores within the Victorian Murray Darling Basin. 890 of these bores are routinely monitored for water level, of these 268 are set up with telemetry. The distribution of the SOBN monitoring bores, including bores with telemetry is presented in Figure 15.

Figure 15 Victoria's State Observation Bores monitoring groundwater level within the Murray-Darling Basin



SOBN bores are monitored for water levels at a minimum of 4 times a year (at non telemetered bores). These water levels readings are scheduled in February, May, August, and November. For consistency the readings are taken within the same week of the same months each year. There are also 268bores that linked to telemetry that record water levels hourly and transmit the data once a day to provide near real time water level data.

Each year a SOBN groundwater monitoring contract has a 'Spring Sampling program' where water quality samples are collected and analysed from a number of sites selected by the rural water corporations to meet their obligations under the groundwater management plans. 176 SOBN bores in the Victorian Murray Darling basin have some EC data over the past 5 year.

5. References

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8. Andrew D Eaton, American Public Health Association, American Water Works Association, Water Environment Federation. (2005). *Standard Methods for the Examination of Water & Wastewater* (21st ed.). APHA-AWWA-WEF, Washington, D.C. 2005.
9. Department of Environment, Land, Water and Planning (2015) Aquatic Value Identification and Risk Assessment (AVIRA) Manual https://www.water.vic.gov.au/__data/assets/pdf_file/0024/52539/1401106-AVIRA-Manual-DELWP-Format-5.pdf .

Appendix A.

Approach for reporting on blue-green algae and dissolved oxygen

Targets for Recreational Waters – Blue-Green Algae

The targets referenced in the Basin Plan are the recreational trigger levels of the Guidelines for Managing Risks in Recreational Waters. When recreational water quality trigger these levels, it is advised to post warnings to the public to not undertake primary contact recreation such as swimming.

A close modification of these trigger levels are used within the Victorian blue-green algae management framework and will be the basis of reporting, they are:

When any one or more of the following occurs:

- *Microcystis aeruginosa* is present at ≥ 50,000 cells/mL;
- Total combined biovolume of *known* toxic *cyanobacterial* species is ≥ 4 mm3/L;
- Total combined biovolume of all *cyanobacterial* species is ≥ 10 mm3/L; or
- Cyanobacterial scums are consistently present.

In reporting BGA, Victoria has reported the management response to identified blooms, that is the period during which warnings were issued to the public to avoid contact with the water.

Dissolved Oxygen (DO): minimum 50% saturation

Dissolved oxygen is sampled monthly across the Victorian Murray Darling Basin. It is recorded in concentration, parts per million, and data is recorded in the Water Measurement Information System (WMIS) database.

Both the Basin Plan target, and Victoria's on State Environment Protection Policy (Waters) objectives for DO are in % saturation.

Data in ppm can be converted to % saturation using additional reference data. Water temperature, pressure (calculated through altitude of the site), and electroconductivity, are used in the conversion. Data in ppm can be converted to % saturation using additional reference data. Water temperature, pressure (calculated through altitude of the site), and electroconductivity, are used in the conversion. **Error! Reference source not found.** provides the method from Eaton (2005) used for this report.

Figure 16 Eaton (2005) method to convert dissolved oxygen in ppm to dissolved oxygen % saturation

NOTE:

1. The table provides three decimal places to aid interpolation. When computing saturation values to be used with measured values, such as in computing DO deficit in a receiving water, precision of measured values will control choice of decimal places to be used.
2. Equations are available to compute DO concentration in fresh water[1–3] and in seawater[1] at equilibrium with water-saturated air. Figures and tables also are available.[3]

   Calculate the equilibrium oxygen concentration, C^*, from equation:

$$\ln C^* = -139.344\,11 + (1.575\,701 \times 10^5/T) - (6.642\,308 \times 10^7/T^2) + (1.243\,800 \times 10^{10}/T^3) - (8.621\,949 \times 10^{11}/T^4) - \text{Chl}\,[(3.1929) \times 10^{-2}) - (1.9428 \times 10^1/T) + (3.8673 \times 10^3/T^2)]$$

   where:

   C^* = equilibrium oxygen concentration at 101.325 kPa, mg/L,
   T = temperature (°K) = °C + 273.150 (°C is between 0.0 and 40.0 in the equation; the table is accurate up to 50.0), and
   Chl = Chlorinity (see definition in Note 4, below).

   Example 1: At 20°C and 0.000 Chl, $\ln C^* = 2.207\,442$ and $C^* = 9.092$ mg/L;
   Example 2: At 20°C and 15.000 Chl,
   $\ln C^* = (2.207\,442) - 15.000\,(0.010\,657) = 2.0476$ and $C^* = 7.749$ mg/L.

   When salinity is used, replace the chlorinity term (−Chl[. . .]) by:
   $-S(1.7674 \times 10^{-2}) - (1.0754 \times 10^1/T) + (2.1407 \times 10^3/T^2)$

   where:

   S = salinity (see definition in Note 4, below).

3. For nonstandard conditions of pressure:

$$C_p = C^* P \left[\frac{(1 - P_{wv}/P)(1 - \theta P)}{(1 - P_{wv})(1 - \theta)} \right]$$

   where:

   C_p = equilibrium oxygen concentration at nonstandard pressure, mg/L,
   C^* = equilibrium oxygen concentration at standard pressure of 1 atm, mg/L,
   P = nonstandard pressure, atm,
   P_{wv} = partial pressure of water vapor, atm, computed from: $\ln P_{wv} = 11.8571 - (3840.70/T) - (216\,961/T^2)$,
   T = temperature, K,
   $\theta = 0.000\,975 - (1.426 \times 10^{-5}t) + (6.436 \times 10^{-8}t^2)$, and
   t = temperature, °C.

   N.B.: Although not explicit in the above, the quantity in brackets in the equation for C_p has dimensions of atm^{-1} per Reference 4, so P multiplied by this quantity is dimensionless.

   Also, the equation for $\ln P_{wv}$ is strictly valid for fresh water only, but for practical purposes no error is made by neglecting the effect of salinity. An equation for P_{wv} that includes the salinity factor may be found in Reference 1.

   Example 3: At 20°C, 0.000 Chl, and 0.700 atm,
   $C_p = C^* P\,(0.990\,092) = 6.30$ mg/L.

4. Definitions:

   Salinity: Although salinity has been defined traditionally as the total solids in water after all carbonates have been converted to oxides, all bromide and iodide have been replaced by chloride, and all organic matter has been oxidized (see Section 2520), the new scale used to define salinity is based on the electrical conductivity of seawater relative to a specified solution of KCl in water.[5] The scale is dimensionless and the traditional dimension of parts per thousand (i.e., g/kg of solution) no longer applies.

   Chlorinity: Chlorinity is defined in relation to salinity as follows:

   Salinity = 1.806 55 × chlorinity

   Although chlorinity is not equivalent to chloride concentration, the factor for converting a chloride concentration in seawater to include bromide, for example, is only 1.0045 (based on the relative molecular weights and amounts of the two ions). Therefore, for practical purposes, chloride concentration (in g/kg of solution) is nearly equal to chlorinity in seawater. For wastewater, it is necessary to know the ions responsible for the solution's electrical conductivity to correct for their effect on oxygen solubility and use of the tabular value. If this is not done, the equation is inappropriate unless the relative composition of the wastewater is similar to that of seawater.

https://doi.org/10.2105/SMWW.2882.091 4

Victoria has reported the % of samples in each year that met the minimum target of 50% saturation of DO.

Flow and Salinity Summary Statistics

Table 10 Annual Monitoring results of salinity and salt loads at EoVT in the 2015/16 to 2019/20 reporting period compared to target value

Region	Valley	Reporting site	AWRC Site Number	End-of-Valley Targets (as absolute value assessed over the Benchmark Period, 1975-2000)			2015/16 monitoring results			2016/17 monitoring results			2017/18 monitoring results			2018/19 monitoring results			2019/20 monitoring results			Comparison of monitoring results to End-of-Valley Target value		
				Salinity (EC)		Salt Load (t/yr)	Salinity (EC µS/cm)		Salt Load (t/yr)	Salinity (EC)		Salt Load (t/yr)	Salinity (EC µS/cm)		Salt Load (t/yr)	Salinity (EC)		Salt Load (t/yr)	Salinity (EC)		Salt Load (t/yr)	Salinity (EC)		Salt Load (t/yr)
				Median (50%ile)	Peak (80%ile)	Mean	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total	Median (50%ile)	Peak (80%ile)	Total
North East (Interim target)	Ovens	Ovens River @ Peechelba-East	403241	72	100	54,000	61	79	21,500	70^	80^	118,000^~	59	65	29,200	50	63	17,500	48	67	27,500	Below Target 100% of years	Below Target 100% of years	Below Target 80% of years
	Kiewa	Kiewa River @ Bandiana	402205	47	55	19,000	41	52	13,400	46^	52^	32,400^~	36^	42^	11,600^	32^	39^	8,800^	35	40	11,600	Below Target 100% of years	Below Target 100% of years	Below Target 80% of years
Goulburn Broken	Goulburn	Goulburn River @ Goulburn Weir	405259	99	-	-	65^	70^	16,800^#	84^	127^	75,700^##	63^	81^	34,500^#	56	64	28,600#	62	103	4,800#	Below Target 100% of years	-	-
	Broken	Broken Creek @ Casey's Weir	404217	141	-	-	180##*	194##	3,500#	143##	163##	25,900^#	140##	153##	400^##	155^#	176^#	400^#	157^#	207^#	400^#	Above Target in 80% of years	-	-
North Central	Avoca	Avoca River @ Quambatook	408203	2,096	-	-	No flow^	No flow^	0^	Insufficient data^	Insufficient data^	0^	No flow^	No flow^	0^	1,343^##	1,789##^	100##^	2,264^##	3,394^##	5,100^##	Above target value in 50% of years with sufficient data	-	-
	Loddon	Loddon River @ Laanecoorie	407203	711	-	-	823^*	938^	18,900^	592^	848^	66,200^	505^	613^	18,600^	651^	691^	14,300^	666^	799^	22,200^	Below Target 80% of years	-	-
	Campaspe	Campaspe River @ Campaspe Weir	406218	412	-	-	646^*	669^	10,400^#	395^	476^	32,600^#	446*	457	26,900^#	516	574	15,600#	570	638	16,800#	Above Target 80% of years	-	-
Wimmera (Interim target)	Wimmera	Wimmera River @ Horsham Weir	415200	1,380	1,720	31,000	1,467^	1,639^	2,800^	1,025	1,188	41,200~	1,235	1,475	14,200	1,234	1,595	9,200	1,465	1,740	14,300	Below Target 60% of years	Below Target 80% of years	Below Target 80% of years
Mallee	Vic Mallee Zone	Murray River @ Lock 6	426200	+15EEC[8]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	^^	-	-

Guide to table:

^ Missing data due to instrument damage or conditions outside of instrumentation threshold- where feasible, data is interpolated using available data; # Salt load calculated using flow and salinity (EC) from downstream gauging station; ## Salinity data from downstream gauging station; ^^ The target relates to Victoria's contribution to river salinity throughout the entire Mallee zone. This contribution is assessed using the EM2 model, rather than modelled surface water salinity; * Salinity exceeded target, but should not be deemed a threat to the Murray River; ~ Salt load target exceeded due to high flows during flooding

[8] Equivalent Electrical Conductivity – refer to Basin Salinity Management Strategy Operational Protocols Version 2.0, Murray-Darling Basin Commission, Figure 4, pg. 100.