Incorporating Climate Change Risk into Water Corporation Emergency Management Planning

Victorian water sector climate trends, amplified risks, and actions

Objective: Climate change is a business-as-usual consideration in water sector emergency management

Victorian water corporations play a vital role in responding to emergency management events. They develop risk management and emergency management plans to respond to events which impact their assets or disrupt water supply, wastewater, irrigation and drainage services. These events include bushfires in our water catchments, algal blooms in river systems, dam safety issues, and more.

The Royal Commission into National Natural Disaster Arrangements heard that climate-driven hazards are expected to become more frequent and intense.[1] This has implications for the Victorian water sector.

Climate change in Victoria: observed trends

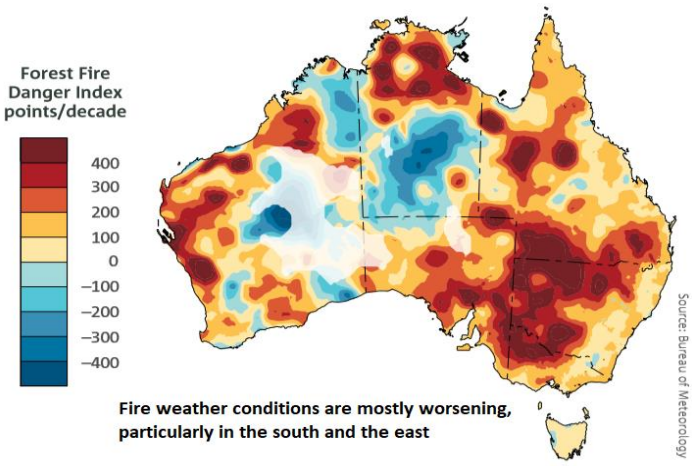
Victoria is already experiencing the impacts of climate change and Victoria's climate is expected to continue to change in the future[2,3,4,5]. As climate amplified emergency events represent a real and foreseeable risk to Victorian water sector service provision, Victorian water corporations have a duty of care to incorporate climate change into emergency planning and mitigate those risks[6]. Observed climate change impacts in Victoria include:

- a 1.2°C increase in average temperatures since 1910, with a 1.6°C increase in the south-west since 1950;
- an increased rate of warming since the 1960s. Eight of Australia's 10 warmest years have occurred since 2005;
- a lengthened heatwave season and an increase in the number of heatwave days;
- average rainfall reductions and significant cool season reductions across all parts of Victoria since 1950;
- an increase in the intensity of extreme rainfall events;
- rising sea levels increasing inundation risk; and
- a long-term increase in extreme weather conducive to fire and in the length of the fire season since 1950.

Climate change is amplifying emergency risks to the water sector

Bushfire risk in our catchments and regions

- The number of days with a Forest Fire Danger Index (FFDI) over 25 (very high risk) per year is increasing[7].
- 1972-2002 had only five years where Victoria's fire season started earlier than September, and there were on average 66 days per year with FFDI ratings above 25[7].
- Between 2002-2017 there were 10 years where the fire season started before September. There are now on average 94 days per year with FFDI ratings above 25[7].
- Bushfire ash and debris inflow contamination has significant impacts for water availability and quality.
- While fires can result in short-term increases in water inflows to our catchments, they can also result in a long-term decrease in inflows as vegetation regrows.
- Bushfires can also cause significant damage to vital water supply infrastructure and assets.



Trend between 1978-2017 in the annual sum of the daily FFDI[5]. The decadal trend highlighted shows fire danger is increasing in Victoria.

[1] Commonwealth, Royal Commission into National Disaster Arrangements, *Report*, 2020.

[2] Clarke JM, Grose M, Thatcher M, Hernaman V, Heady C, Round V, Rafter T, Trenham C & Wilson L. *Victorian Climate Projections 2019 Technical Report*. CSIRO, 2019.

[3] Steffen, W, Hughes, L, Perkins, S. *Heatwaves: Hotter, Longer, More Often*. The Climate Council, 2014.

[4] Hope, P, Timbal, B, Hendon, H, Ekström, M, Potter, N. *A synthesis of findings from the Victorian Climate Initiative (VicCI).* Bureau of Meteorology, 2017.

[5] Bureau of Meteorology & CSIRO. *State of the Climate 2018*, 2018.

[6] See "*Managing Climate Change Risk: Guidance for Board Members and Executives of Water Corporations and Catchment Management Authorities*", DELWP, 2019.

[7] Harris, S, Mills, G, Brown, T. *Victorian Fire Weather Trends and Variability*, 2019.

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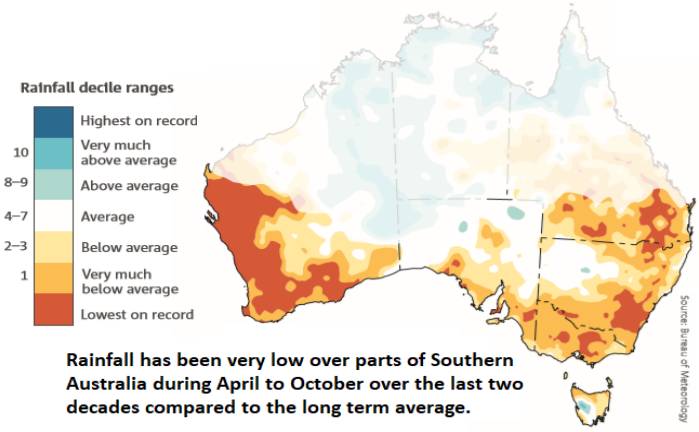
Extreme rainfall and flood events

- Research suggests rainfall intensity is increasing for sub-daily events[8] and for events lasting under 1 hour[9].
- Based on our understanding of these processes, the intensity of extreme rainfall should increase by at least 7% for each degree of warming. Observations show an average increase of 14% per degree of warming[5,9].
- Increased flooding due to increasing rainfall intensity is most likely to occur in urban catchments, in small and steep catchments, and during rare to extreme events.
- While evidence suggests increasing rainfall extremes there is a lack of corresponding evidence to suggest that flood magnitudes have increased in rural catchments, particularly for relatively frequent events[10].This is likely due to drier antecedent soil conditions resulting from an observed reduction in annual rainfall.



1999-2018 average rainfall variation compared to long-term average[4]. Despite this trend, extreme rainfall events are becoming more likely.

Water and wastewater service disruptions

- Low flow rates and warmer temperatures can promote sulphide generation in wastewater pipes and sewer headspaces, resulting in higher rates of corrosion[11].
- Reduction in soil moisture can cause soils to harden and move, increasing pressure on pipes and infrastructure[12].
- Dry conditions and low dam levels resulted in cracking and increased seepage during the Millennium Drought.
- More extreme heat days are causing infrastructure and equipment to exceed safe operating levels more often.
- Saltwater intrusion due to, for example, sea level rise can impact water supply and increase maintenance costs for distribution networks.

Water quality concerns: algal bloom events and emerging water contaminants such as e-coli

- More warmer days, reductions in stream flows, and increased CO_2 are linked to an increase in algal blooms.
- The Murray River experienced no algal blooms between 1978-2006. Between 2006-2016, the Murray river experienced four major blooms[13].
- The cause of the 2016 bloom was directly linked to elevated water temperatures[14].
- Increases in large scale fish kills have been observed in recent years, caused in some cases by algal outbreaks.
- Some Victorian regions are experiencing an increase in environmental e-coli, particularly in warmer months during periods of low rainfall and runoff.

The impact of climate change on water corporations' ability to respond to climate enhanced emergencies

Emergency management planners should consider the impacts of climate change both on the emergency event itself, and the systems, processes, and people responding to the event. Climate-related risks which impact an organisation's ability to respond to climate enhanced emergencies can increase and compound the physical risks resulting from climate enhanced emergencies.

With that in mind, emergency planners should consider how climate change may impact the ability of the business itself to respond to longer, more frequent, overlapping, and/or compounding emergency events.

Examples of climate impacts on a water corporation's emergency management workforce:

- higher potential for staff to be exposed to emergency conditions/health and safety issues;
- longer periods spent in emergency mode at the expense of business-as-usual activities and projects;
- emergency management workforce fatigue may result from longer periods at surge capacity;
- increased fatigue for non-emergency management staff as they cover more business-as-usual activities;
- adverse and compounding psychological impacts on staff faced with more frequent emergency situations;

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[8] Westra, S, Sisson, SA. *Detection of non-stationarity in precipitation extremes using a max-stable process model*. J. Hydrol. 406, 119-128, 2011.

[9] Bureau of Meteorology. '*Rainfall extremes are getting more extreme' – are they?. Victorian Water and Climate Initiative*, 2019.

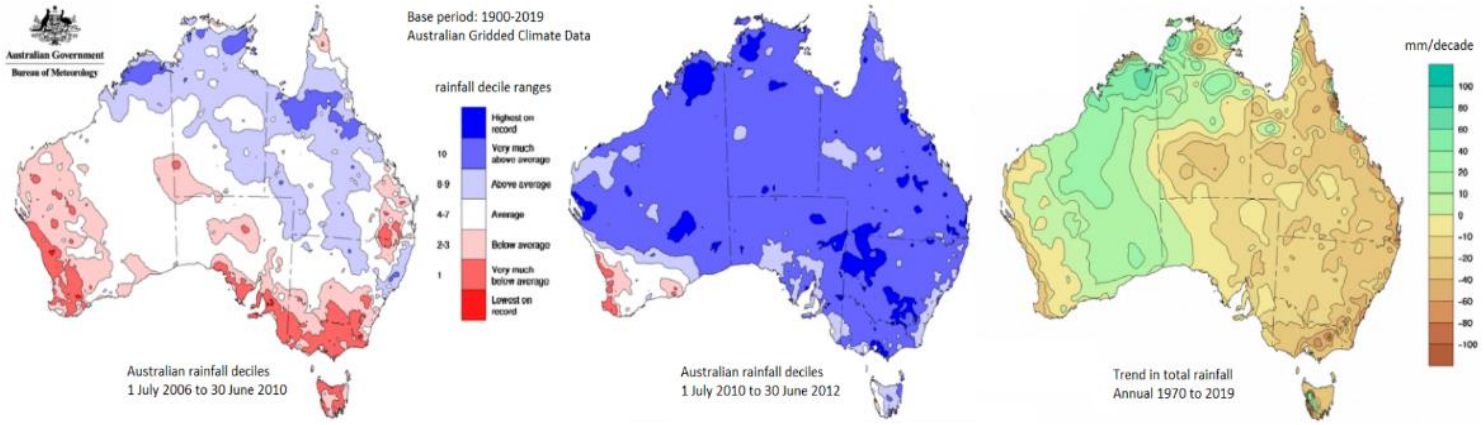
[10] Wasko, C, Nathan, R. *Influence of changes in rainfall and soil moisture on trends in flooding. Journal of Hydrology* 575, 432-441, 2019.

[11] Jacobs Group, *Climate Change Impacts on the Victorian Sewer System – Discussion Paper 5: Odour and Corrosion Modelling and Management*, 2019.

[12] Ware, D. *Climate change impacts on coastal water supply and wastewater management*. National Climate Change Adaptation Research Facility, 2017.

[13] Baldwin, D. *Are toxic algal blooms the new normal for Australia's major rivers?*. CSIRO, 2016.

[14] Clune, T, Eburn, M. *Blue green algae in the Murray Darling Basin: a case for Commonwealth leadership*. Australian Journal of Emergency Management, 2017.



Natural climate phenomena make Australia's climate highly variable. The record breaking 1997-2009 millennium drought was followed in 2010 and 2011 by record breaking rainfall and flooding. Climate change can exacerbate climate extremes. Figure adapted from Bureau of Meteorology.

- reduced willingness and capability of personnel to respond to events the longer those events continue;
- an inability to retain staff trained in emergency management roles due to more consistently heightened levels of stress, increasing risk to personal safety, and more time spent responding to events; and
- increased degradation of non-human resources, such as assets and infrastructure, through increased usage.

Examples of climate impacts on a water corporation's emergency management assets, information and communication systems, and processes:

- increasing number and severity of extreme heat days may increase the amount of time assets are undergoing maintenance and the likelihood of asset failure;
- increasing number and severity of extreme heat events may increase the number of days where conditions exceed safe asset operating levels;
- increasing severity, likelihood, or compounding nature of emergencies mean increased risks to key response (such as roads) and communications (such as powerline) infrastructure;
- static and inflexible emergency planning and response tools may entrench or exacerbate climate related emergency risks (for example, as sea levels rise and flood risks change due to climate change, are our flood hazard maps reflecting this changing risk?);
- more frequent, intense, and complex climate related emergencies may mean system resources and attention are more often diverted away from other systems, increasing the sector's vulnerability to non-climate emergencies and impacting on service delivery;
- increasing climate-related risks may place pressure on the insurability of assets – with flow on effects for the maintenance and operability of assets critical to effective emergency management response; and
- cross-border systems and processes are stretched as individual agencies are unable to lend the support they have in the past to neighbouring, or partner, agencies.

Key actions to improve water corporations' ability to respond to climate enhanced emergencies

Prepare for unprecedented conditions in both the scale and intensity of events

- Where possible, response and recovery teams should be ready for a rapid scale up in resources and have surge capacity resources available to call in for quick response.
- Ensure safety, welfare and fatigue guidelines are in place and well understood by the emergency workforce.
- Water corporations should consider forecasting the change in risks resulting from climate change alongside existing risks in emergency management plans guiding prevention, preparedness, response and recovery.
- Response and recovery planning should incorporate an assessment of multiple contingencies, scenarios with consequences potentially beyond the norm, and a broad range of response options with contingencies.

Undertake climate risk assessments and scenario planning to determine risks to business continuity, public safety, key assets (infrastructure and environmental), and emergency event mitigation strategies

- Factor climate change into emergency risk assessment as an assumed business-as-usual consideration.
- Establish current risks and apply plausible future climate change scenarios to determine where risks amplify.
- Rank and prioritise critical assets for protection and assess likely consequences to those assets.
- Consider how climate change impacts may affect the life, durability and performance of these prioritised assets, and adjust designs and maintenance accordingly.
- Determine mitigation strategies to maintain business continuity, and to protect public safety and assets.
- Build in interdependency risks into risk management processes. Under increasingly complex emergencies, more risks may "belong" to other organisations.

Designing for adaptive infrastructure[15,16]: technologies, assets, and systems which are climate-ready and flexible

- Acknowledge the need to continue the transition from 'fail safe' design to 'safe to fail' design.
- This approach acknowledges that infrastructure failure most often occurs when design conditions are exceeded, not when that asset or system "collapses".
- The safe to fail approach allows us to plan for failures and learn the strengths, weaknesses and tolerances of our assets and systems under emergency events.
- Ongoing investment in information systems and research and development can improve emergency preparedness and responsiveness.

Infrastructure managers must be committed to design and operational processes that can help them understand the uncertainty in the environment around them, and change their systems in response[15,16]

Improve arrangements with neighbouring regional and municipal agencies

Water corporations have strong and well-established relationships with their regional and municipal partners. However, cross-border emergencies are likely to become more complex – requiring more participants with different organisational responsibilities and divergent roles to become involved in response. As such, strong partnerships are now as important as ever. Water corporations should:

- identify the entities within and outside the water sector which they are dependent on for key service delivery;
- determine their criticality and identify key priority areas for action to improve collaboration and resilience;
- engage with priority agencies to ensure alignment of plans and test collective emergency response; and
- examine and test the mutual aid arrangements and agreements in place with other emergency responders.

Provide staff with emergency management training and improve and diversify the skills of those already trained

This can increase resilience against longer, more frequent, more complex, and overlapping emergencies. Water corporations should:

- analyse how their emergency management workforce needs change over time in response to climate change;
- undertake analysis to assess likely workforce needs for climate-amplified emergencies; and
- increase the proportion of their workforce trained in emergency management roles and improve the capability of those already trained as required.

Continue to engage with the Victorian water sector risk and resilience networks

- The Victorian Water Sector Resilience Network improves resilience of water sector's critical infrastructure assets and operations through joint planning and information sharing.
- The Victorian Water Industry Risk Management Network brings together Victorian water corporations to share knowledge and experience relating to risk management across the water industry.

Contact water.climatechange@delwp.vic.gov.au for more information on these networks.

Useful resources: climate impacts & adaptation

The Victorian Water and Climate Initiative (link)

Building on the *Victorian Climate Initiative*, the *Victorian Water and Climate Initiative* reports on research into the impact of climate change on Victoria's water resources.

Contact hcs.team@delwp.vic.gov.au for more information on these initiatives and information on plausible future climate scenarios for rainfall for Victorian water sector use.

The Victorian Climate Projections initiative 2019 (link)

The *Victorian Climate Projections 2019* provides various plausible scenarios of future climates to 2090 for use. The projections cover Victoria at a 5km by 5km scale and include a range of variables for moderate and high greenhouse gas emissions scenarios.

The initiative produced data sets of projected changes for 12 climate variables for 10 regions on annual, seasonal and monthly time scales, as well as 10 regional reports outlining climate projections for different regions across Victoria.

WSAA's climate change adaptation guidelines (link)

[15] Chester, MV, Allenby, B. *Toward adaptive infrastructure: flexibility and agility in a non-stationarity age*. J. Sustainable and Resilient Infrastructure 4, 173-191, 2019.

[16] Chester, MV, Underwood, S, Samaras, C. *Keeping infrastructure reliable under climate uncertainty*. Nature Climate Change 10, 488-490, 2020.