PFAS in Water Supply- Riverina Water's journey

Author: Jason Ip, Manager Operations, Riverina Water County Council

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Abstract:

Riverina Water County Council's journey dealing with PFAS risks commenced from 2017, when Defence (associated with Wagga RAAF Base) initiated its national program to manage impacts of PFAS from historical use of legacy fire-fighting foams. This PFAS contamination source jeopardises East Wagga bore field comprising of three bores that contributes up to 25ML/day (or 18% of Wagga Wagga's combined source & treatment headworks supplying potable water to approx. 33,000 connections in Wagga and surrounding rural areas).

Riverina Water further encountered other sources of PFAS contamination at two of its West Wagga bores and at Tarcutta village bore source. The PFAS contamination source at these locations are still unknown and being investigated.

Riverina Water's journey is on-going and has overlays of discoveries, complexities and challenges, such as PFAS contamination in other source works, managing communities' expectations, changing 'goal posts' regarding ADWG PFAS limits, and dealing with a complex co-regulator environment (i.e. NSW Health, NSW Department Climate Change, Energy, the Environment and Water (DCCEEW), NSW EPA and the commonwealth defence department).

This paper focuses on Riverina Water's current PFAS contamination threatening (and affecting) various water supply source works and outlines a risk management framework that has assisted Riverina Water in communicating its response to its customers, communities and regulators.

Introduction:

Riverina Water County Council is a NSW local government water supply utility originally established in 1938 to perform water supply functions under the NSW Local Government Act in the local government areas of Wagga Wagga City Council, Lockhart Shire Council and parts of Greater Hume Shire Council and Federation Council – refer Figure 1.

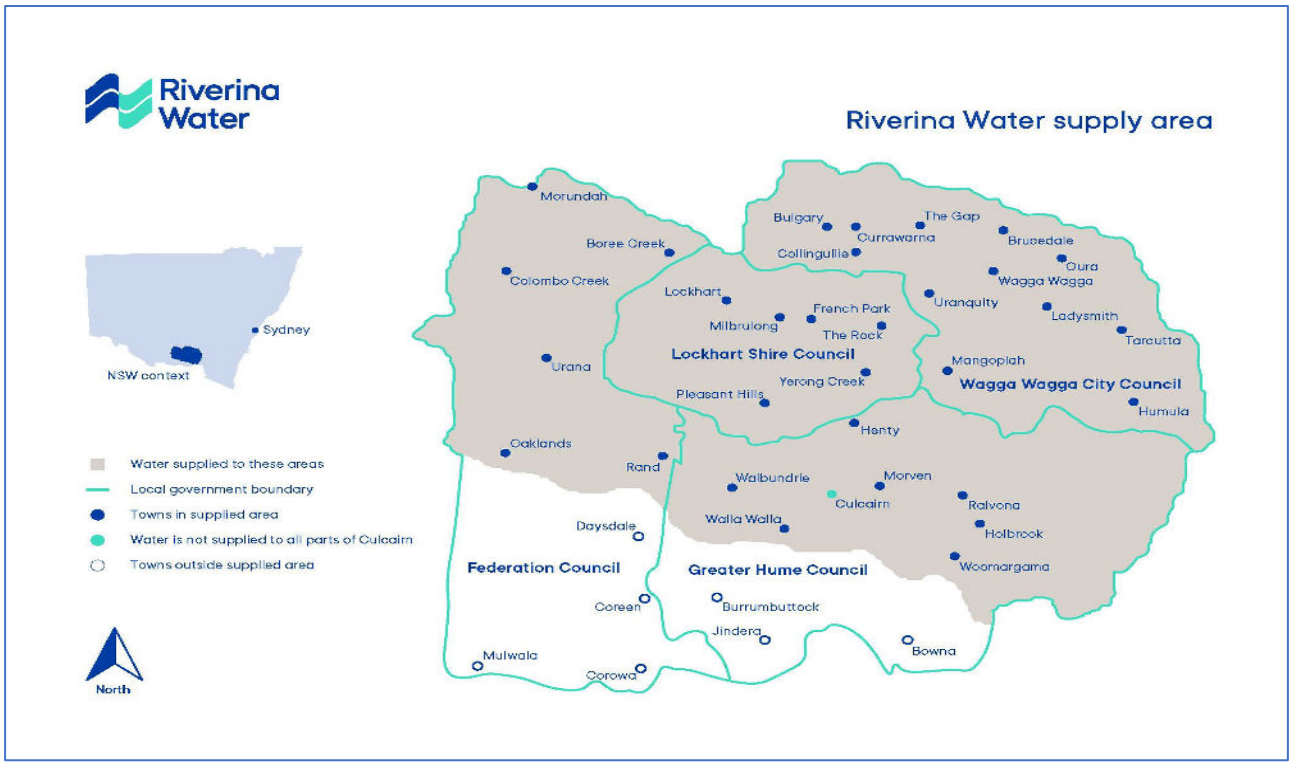

Figure 1: Riverina Water supply area with respect to constituent local government council areas

A brief understanding of Riverina Water's supply network is required to appreciate the PFAS risks and responses to its treatment headworks operations.

Riverina Water's Systems:

Riverina Water's supply network is quite complex and comprises of interconnected urban system and two rural trunk main systems, and eight independent village water supply systems. Much of the integrated system is suppled from the combined Wagga Wagga source and treatment headworks and supplies urban areas of Wagga Wagga and villages along the Southern Trunk Main and Western Trunk Main systems – refer Figure 2. The integrated system provides potable water to approximately 33,000 connections of which 95% are in urban Wagga Wagga area.

The predominant water source comes from the Murrumbidgee Alluvial Groundwater Source in and around Wagga Wagga, where Riverina Water has a 14GL groundwater town entitlement shared across its three Wagga bore fields: East Wagga Wagga (three bores), West Wagga Wagga (four bores) and North Wagga Wagga (three bores). The Wagga WTP headworks also has a 7GL surface water town entitlement supplied from the Murrumbidgee Regulated River source also in Wagga Wagga.

Approximately 18.1% of Wagga's source water headworks is currently experiencing heightened or actual PFAS contamination risk in two of the three bore fields in around Wagga Wagga e.g. West

Wagga bore field and East Wagga bore field. This potentially has major implications to serve future population growth in and drought resilience.

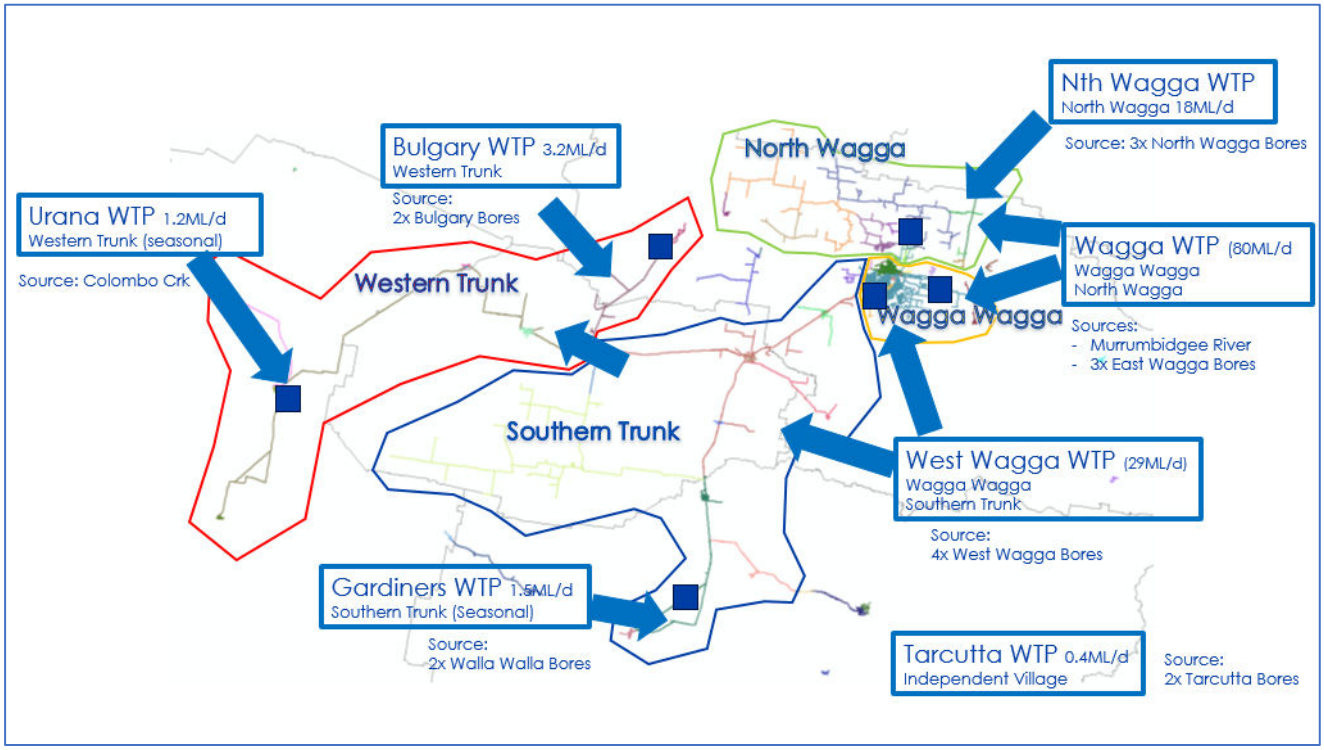

Figure 2: Water Supply systems and source & treatment headworks

Development of PFAS Risk Response Matrix:

Riverina Water's PFAS journey began in 2017 with Defence nationally investigating its RAAF operations for PFAS contamination from fire-fighting foams and retardants. It wasn't until 2023 when Defence completed its Wagga PFAS management and monitoring plan and discovered PFAS in a sentinel ('canary') bore only 650m from the nearest town water bore, and realised the PFAS impacts were more imminent that originally forecasted e.g. this was despite a groundwater model (based on particle tracing predicted PFAS impacts for 55 years into the future).

A PFAS Risk Response framework was developed to assist Riverina Water's response escalation and provide response measures to assist in managing the risk of PFAS, including additional monitoring, dilution of supply, alternative sources and treatment/disposal options. These PFAS control measures allow practical planned actions to be undertaken and clear consistent messaging to stakeholders regarding how PFAS risks are being managed (i.e. NSW Health, NSW DCCEEW, NSW EPA, media, communities and customers) as well as meeting ADWG compliance.

Admittedly, the description of PFAS Risk Response Matrix response levels was quite complex/wordy due to incorporation of NMHRC's proposed PFAS Limits (introduced in October 2024) running alongside current ADWG PFAS Limits. This was recently simplified with final adoption of the NMHRC's PFAS Limits released on 25th June 2025 – refer Table 1.

The PFAS Response Matrix used the following principles:

- In accordance with Australian Drinking Water Guidelines (ADWG), as part of NSW Health's quality assurance program under the Public Health Act 2010 and Public Health Regulation 2022

- Emphasis on practical and effective PFAS sampling and monitoring to assist benchmarking and ongoing risk management e.g. trend analysis, frequency distribution.
- Accepting PFAS concentrations in raw and treated water's within ADWG Limits, including means to dilute PFAS with other water sources
- Initiating investigations and development of contingencies and response plans
- Building in 'hold points' before response escalation to allow coordination of messaging to the communities, customers and media by co-regulators and councils

Tabled 1: Outline of Riverina Water PFAS Risk Response Matrix

PFAS Risk Response Matrix

Tier	PFAS Response Level Description	Some Examples of Responses
0 Green	PFAS is NOT detectable, AND NO Foreseeable risk	- BaU - Annual sampling or source works
1 Yellow	PFAS is NOT detectable AND Heightened Risk	- Bau - Monthly sampling of source works
2 Orange	PFAS is detectable AND below ADWG limits	- BaU - Monthly sampling of source works to establish baseline data trends to eliminate temporal variation - Develop dilution mitigation procedures & controls - Investigate treatment options, alternative sources - Develop contingency plans, impact assessments, demand v. supply options such as alternative sources, demand mgt

3
Red
	PFAS is above ADWG limits	- BaU and monthly sampling of source works and treated water
		- Inform NSW Health and DCCEEW
		- Implement operational modifications to dilute source or treated water to below ADWG limits
		- If dilution ineffective, cease source production & inform NSW Health and DCCEEW
		- Implement contingency plans:
		  - Demand Management
		  - Water Restrictions
		  - Treatment and disposal options
		  - Communications plans

The history of ADWG PFAS Limits is tabulated in Table 2 below:

Table 2: History of ADWG PFAS Limits

Chemical	Previous ADWG PFAS Limits	Previous Proposed ADWG PFAS Limits (October 2024)	Adopted ADWG PFAS Limits (June 2025)
PFOS	Less than 0.07 micrograms per litre of PFOS and PFHxS combined (ug/L)	0.004 micrograms per litre (ug/L)	0.008 micrograms per litre (ug/L)
PFHxS		0.03 micrograms per litre (ug/L)	0.03 micrograms per litre (ug/L)
PFOA	0.56 micrograms per litre	0.2 micrograms per litre (ug/L)	0.2 micrograms per litre (ug/L)
PFBS		1 microgram per litre (ug/L)	1 microgram per litre (ug/L)

Situational Analysis:

Figure 3 summarises current PFAS situation with reference to PFAS Response Matrix and the adopted ADWG PFAS Limits, where:

- G = Green, Tier 0 - PFAS is NOT detectable, AND NO Foreseeable risk
- Y = Yellow, Tier 1 - PFAS is NOT detectable AND Heightened Risk
- O = Orange, Tier 2 - PFAS is detectable AND below ADWG limits
- R = Red, Tier 3 - PFAS is above ADWG limits

There are currently three water source locations of concern:

1) East Wagga Bore field ➔ PFAS contamination from known source ie. Defence (Wagga RAAF Base) immediately threatening two of the three bores
2) West Wagga Bore fields ➔ PFAS contamination from unknown source affecting two of the four bores
3) Tarcutta (independent) township bores ➔ PFAS contamination from unknown source affecting both bores, where one bore is consistently above the adopted ADWG PFAS Limits

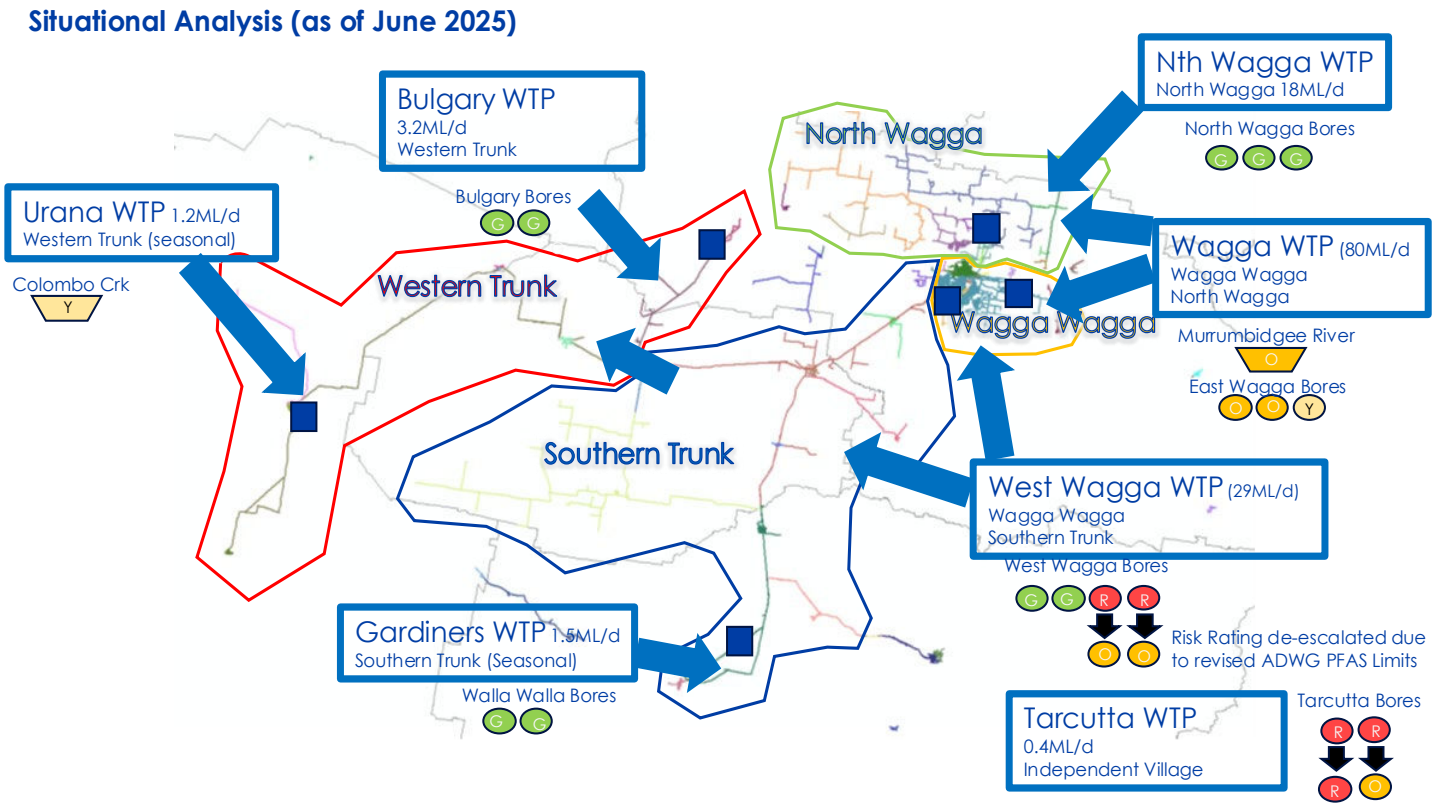

Figure 3: Riverina Water Situation Analysis, modified after release of updated ADWG PFAS Limits

Riverina Water began PFAS sampling of its Wagga source works as part of the Defence PFAS management and monitoring plan in 2017. However like many other Local Water Utilities (LWUs), sampling to even lower thresholds of detection began after introduction of NMHRC's proposed ADWG PFAS Limits in October 2024.

Testing to lower detection thresholds (i.e. by a factor of 10 compared to previous sampling) has resulted in 1) more water supplies detecting PFAS than previously known, and 2) various NSW townships water supply systems (including Riverina Water's Tarcutta system and West Wagga Bores 4 & 5) were found to have PFAS above proposed ADWG Limits.

Table 3 summarises raw water PFAS testing results (up to June 2025), and indicates the number of samples taken and whether those samples detected PFAS and whether they were above the ADWG PFAS Limits.

Currently Riverina Water is still reviewing its strategies and tactical responses to its operations after the recent adoption of the new NMHRC's ADWG PFAS Limits on 25th June 2025. For example, the increase of proposed PFOS Limit from 0.004 ug/L to the adopted 0.008 ug/L has reduced Risk Response Ratings for:

- West Wagga Bores 4 & 5, from Tier 3 to Tier 2
- Tarcutta Bore 4, From Tier 3 to Tier 2, however Tarcutta Bore 5 remains Tier 3

If the proposed PFAS Limits were adopted (especially relating to PFOS Limit at 0.004 ug/L), the following implications would have arisen:

1) Production output from West Wagga bore field would have reduced by 25% (eg. from current 33ML/day to 25ML/day) due to insufficient dilution supply from remaining unaffected bores when affected Bores 4 & 5 operate simultaneously
2) Tarcutta bore field: Tarcutta Bore 5 is still over the adopted ADWG PFOS Limit by a factor of 2 and cannot be used. Tarcutta Bore 4 meets the adopted ADWG PFOS Limit but with an improved safety margin i.e. The highest recorded PFOS at Tarcutta Bore 4 was 0.06 ug/L.

Table 3: Riverina Water's PFAS Raw Water Summary Table

Units: Micrograms ug/L, µg/L			PFOA (Limit <0.2ug/L)			PFBS (Limit <1.0ug/L)			PFHxS (Limit<0.03ug/L)			PFOS (Limit <0.008ug/L)		
Source Site Location	**Current Risk Rating**	**Response Level**	**No. of Samples**	**No. Detections**	**No. Exceedance >0.2ug/L**	**No. of Samples**	**No. Detections**	**No. Exceedance >1ug/L**	**No. of Samples**	**No. Detections**	**No. Exceedance >0.03ug/L**	**No. of Samples**	**No. Detections**	**No. Exceedance >0.008ug/L**
East Wagga Bore 1	Actual Risk	Tier 2	21	0	0	21	0	0	21	5	0	21	2	0
East Wagga Bore 2	Actual Risk	Tier 2	22	0	0	22	3	0	22	6	0	22	5	0
East Wagga Bore 3	Actual Risk	Tier 2	5	0	0	5	0	0	5	1	0	5	1	0
West Wagga Bore 1	No Foreseeable Risk	Tier 0	10	0	0	10	0	0	10	1	0	10	0	0
West Wagga Bore 2	No Foreseeable Risk	Tier 0	9	0	0	9	0	0	9	1	0	9	0	0
West Wagga Bore 4	Actual Risk	Tier 2	15	3	0	15	7	0	15	9	0	15	7	0
West Wagga Bore 5	Actual Risk	Tier 2	11	3	0	11	3	0	11	3	0	11	3	0
Murrumbidgee River	Actual Risk	Tier 2	7	0	0	7	0	0	7	4	0	7	1	0
North Wagga Bore 1	No Foreseeable Risk	Tier 0	3	0	0	3	0	0	3	0	0	3	0	0
North Wagga Bore 2	No Foreseeable Risk	Tier 0	1	0	0	1	0	0	1	0	0	1	0	0
North Wagga Bore 3	No Foreseeable Risk	Tier 0	3	0	0	3	0	0	3	0	0	3	0	0
Tarcutta Bore 4	Actual Risk	Tier 2	6	0	0	6	0	0	6	3	0	6	3	0
Tarcutta Bore 5	Mitigation required	Tier 3	7	2	0	7	7	0	7	7	0	7	7	7

Note 1: Exceedance limits based on new (June 2025) ADWG PFAS Values

Note 2: Frequency of sampling based on Risk Rating

Note 3: Higher accuracy of analysis/detection adopted from Nov-Dec 2024

Response Level	**Risk Response Rating**	**Response Level Description**	**Sampling Frequency**
Tier 0	No Foreseeable Risk	PFAS is NOT detectable in raw water AND NO foreseeable risk	6 Monthly to Annual Sampling
Tier 1	Heightened Risk	PFAS is NOT detectable in raw water AND heightened Risk	Monthly Sampling
Tier 2	Actual Risk	PFAS is detectable in raw water source(s) AND BELOW ADWG limits	Monthly Sampling
Tier 3	Mitigation required	PFAS is detectable in raw water source(s) AND ABOVE ADWG limits	Monthly Sampling

East Wagga Bore Field (East Wagga Bores 1,2 & 3):

PFAS contamination source threatening East Wagga bore field was identified originating from Wagga RAAF base at Forest Hill, approximately 8.5 kilometres away. Extensive investigations have been completed by Defence and a wealth of public material is available from their website: https://www.defence.gov.au/about/locations-property/pfas/pfas-management-sites/raaf-base-wagga.

A ground water model (refer Figure 4) was developed and modelled and predicted PFAS bloom to affect the nearest East Wagga town water bore in approximately 55 years. Unfortunately, a number of sentinel monitoring bores (affectionate known as 'canary' bores) confirmed PFAS much closer to East Wagga bore field at 650m away.

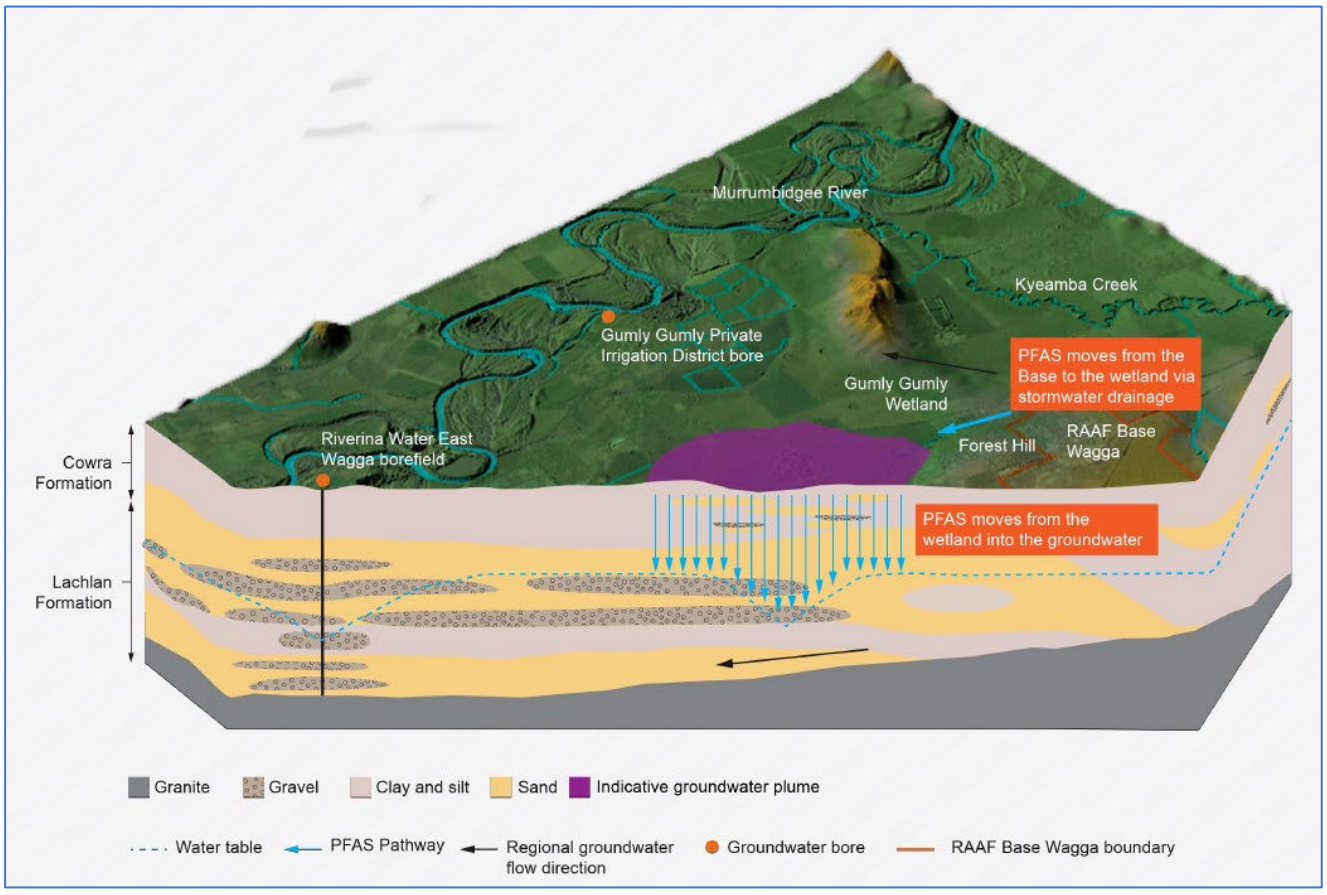

Figure 4: Conceptual hydrogeological model of PFAS contamination from Wagga RAAF Base (image courtesy of Defence, Fact Sheet 1 September 2019, page 2)

Currently all PFAS sampling results from East Wagga bore field are below adopted PFAS ADWG Limits. However, due to PFAS contamination from Wagga RAAF base being only approximately 650m away from East Wagga Bore 2 and a further 240m away from East Wagga Bore 1, both East Wagga Bores 1 & 2 are classified as Heighten Risk (Tier 1). East Wagga Bore 3 is further 1 kilometre away and is slightly up-gradient and therefore classified as Tier 0 at this stage.

Current responses include:

- Business as Usual (BaU)
- Continue benchmarking with monthly sampling and trend analysis
- Work with Defence to monitor migration of PFAS towards East Wagga bore field

- Contingencies:
    - If PFAS is above adopted limits, implementing dilution regime with less PFAS affected raw water bores to below PFAS limits, and sample both raw and treated water monthly
    - If PFAS is dilution from East Wagga bores cannot be effective to below adopted PFAs limits, Riverina Water is able to dilute with treated river water at the shared clear water storage
    - Currently seeking Special Purpose Access License (SPAL) within Murrumbidgee Regulated Water Sharing Plan to allow surface water substitution with affected groundwater
    - Initiated high level discussions with defence regarding further assistance to Riverina Water to manage (future) impacts to East Wagga bore field
    - Keeping abreast of treatment & disposal options

Historical PFAS sampling results for East Wagga bore field is illustrated below in Figure 5.

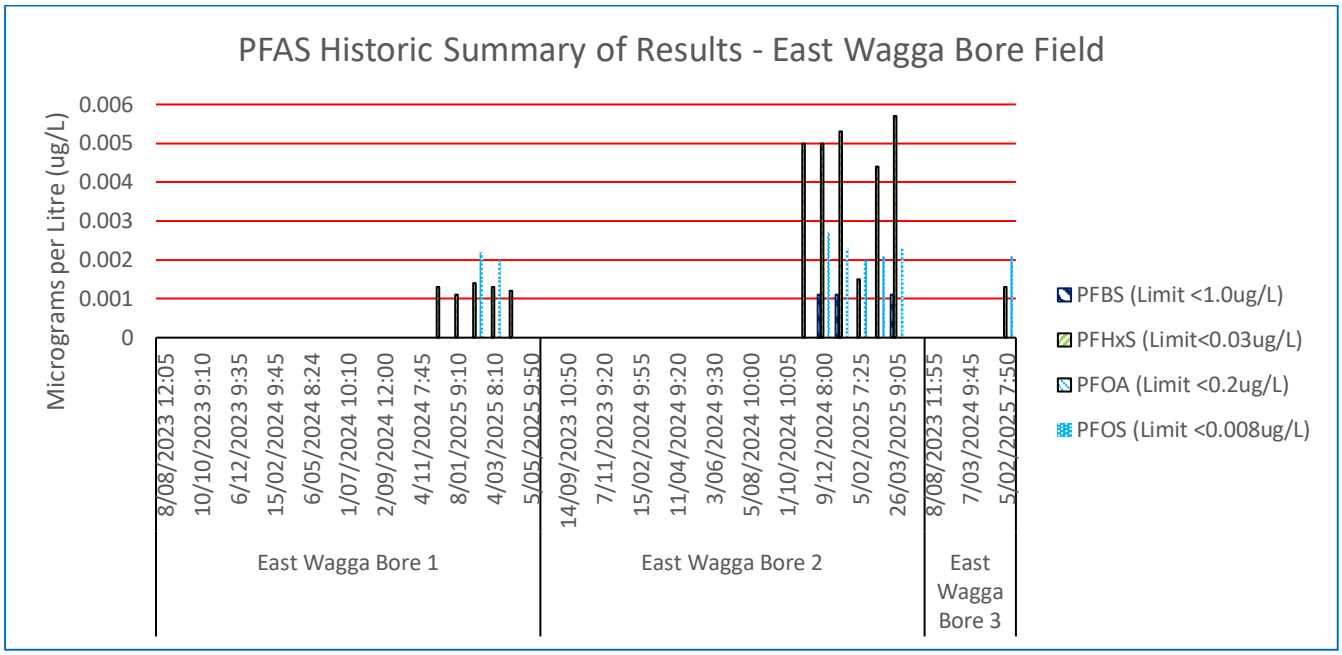

Figure 5: Historical PFAS Results of East Wagga bores 1, 2 & 3

West Wagga Bore Field (West Wagga Bores 4 & 5):

PFAS was initially detected at West Wagga Bore 4 as part of screening exercise of all Wagga ground water bores in September 2019 and was under (then) current ADWG Limits. Release of the proposed ADWG PFAS limits in October 2024, prompted testing to lower thresholds of detection and resulted in PFOS concentrations above proposed limits at both West Wagga Bores 4 and 5 (ie. up to twice the proposed PFOS limit or 0.008 ug/L).

After the adoption of the new ADWG PFAS Limits in June 2025, PFAS risk level at West Wagga Bores 4 & 5 was downgraded from Teir 3 to Tier 2 in in response to PFOS limits increasing from proposed 0.004 ug/L to adopted 0.008 ug/L. This was a great relief as West Wagga bore operations could remain Business as Usual, though under close scrutiny.

Current responses include:

- Business as Usual (BaU), though testing of both raw water and treated water would be required if either West Wagga Bore 4 or 5 operated individually or together)
- Continue benchmarking with monthly sampling and trend analysis
- Initiate local investigation of potential contamination sources and pathways together with NSW EPA, NSW DCCEW and Wagga Wagga City Council
- Contingencies:
    - If either/both bores escalate to Teir 3, implement a dilution regime with other less affected raw water sources, and sample both raw and treated water monthly
    - Develop pipeline concepts to allow alternate/backup supply of treated water into Southern Trunk Main, as West Wagga bores are currently only water source into Southern Trunk Main
    - Keeping abreast of treatment & disposal options

There is currently no indication that PFAS contamination of West Wagga Bores 4 & 5 are related to Defence's RAAF (Forest Hill) Base or Kapooka Army Base.

Historical PFAS sampling results for West Wagga bore field is illustrated below in Figure 6.

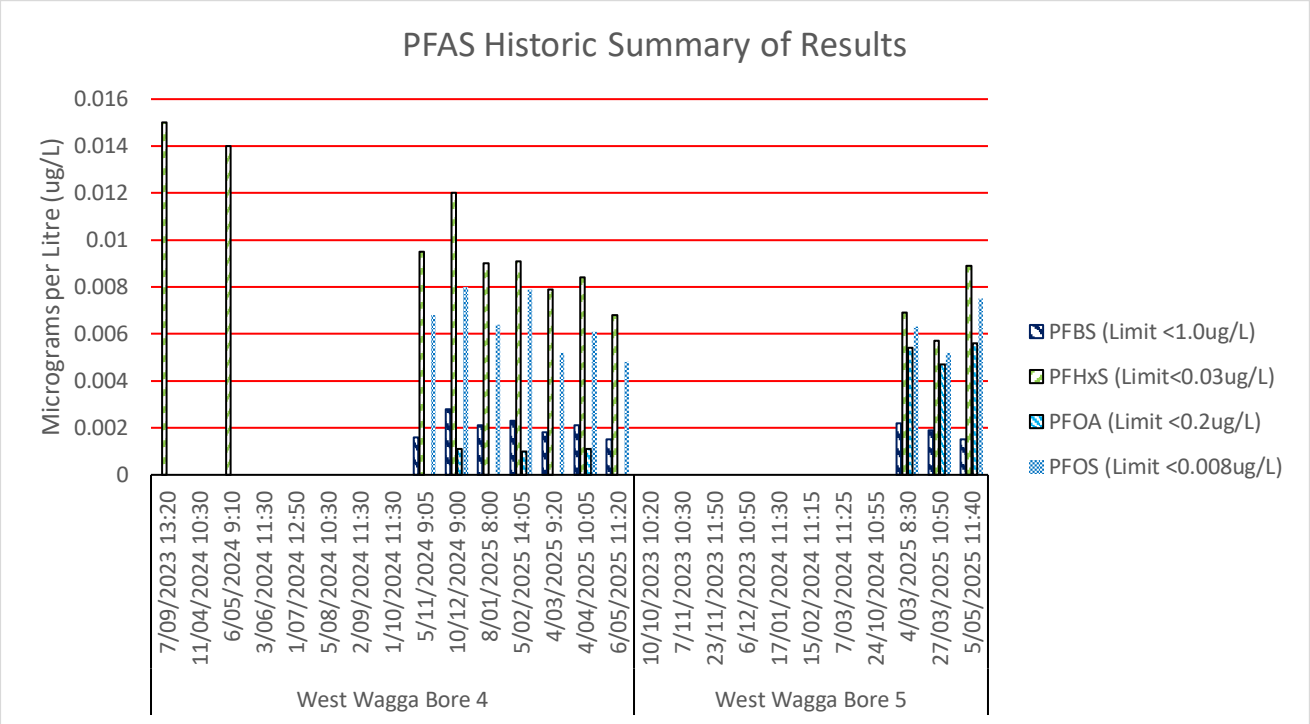

Figure 6: Historical PFAS Results of West Wagga bores 4 & 5

Tarcutta Town Bore Field (Tarcutta Bores 4 & 5):

Tarcutta is supplied from two township ground water bores, one of which (i.e. Tarcutta Bore 5) is located at the lowest elevated part of the town at the edge of Tarcutta Creek Alluvial floodplain and near Colluvial sediments where much of the township is located. The other bore (i.e. Tarcutta Bore 4) is adjacent to Tarcutta Creek approximately 400m in the middle of Tarcutta Creek Alluvial – refer

Figure 7. Both bore screens are approximately 38m deep and water sourced from the Tarcutta Creek Alluvial formation.

NSW Health PFAS screening of NSW town water supplies during October-November 2024 identified Tarcutta, alongside with Bungendore, Narrabri and Warialda, as having treated PFAS concentrations above the proposed ADWG PFAS limits in the water supply distribution system.

Immediate investigation concluded that both bores (i.e. Tarcutta Bore 4 and Tarcutta Bore 5) contained PFAS, with Tarcutta Bore 5 having PFOS up to four times the proposed ADWG PFOS limit or 0.012-0.016 ug/L, and Tarcutta Bore 4 having PFOS up to one and a half times proposed ADWG PFOS limit or 0.0055 ug/L.

A preliminary hydrogeological study was completed in February 2025 together with detailed testing of available urban salinity bores (including a known Transport for NSW Bore) in March 2025. The purpose of the investigation was to:

1. Identify possible origin(s) and pathways of PFAS contamination considering hydrogeology (surface water, groundwater and geology) in and around Tarcutta
2. Identify possible location(s) of replacement groundwater source not (potentially) affected by PFAS contamination

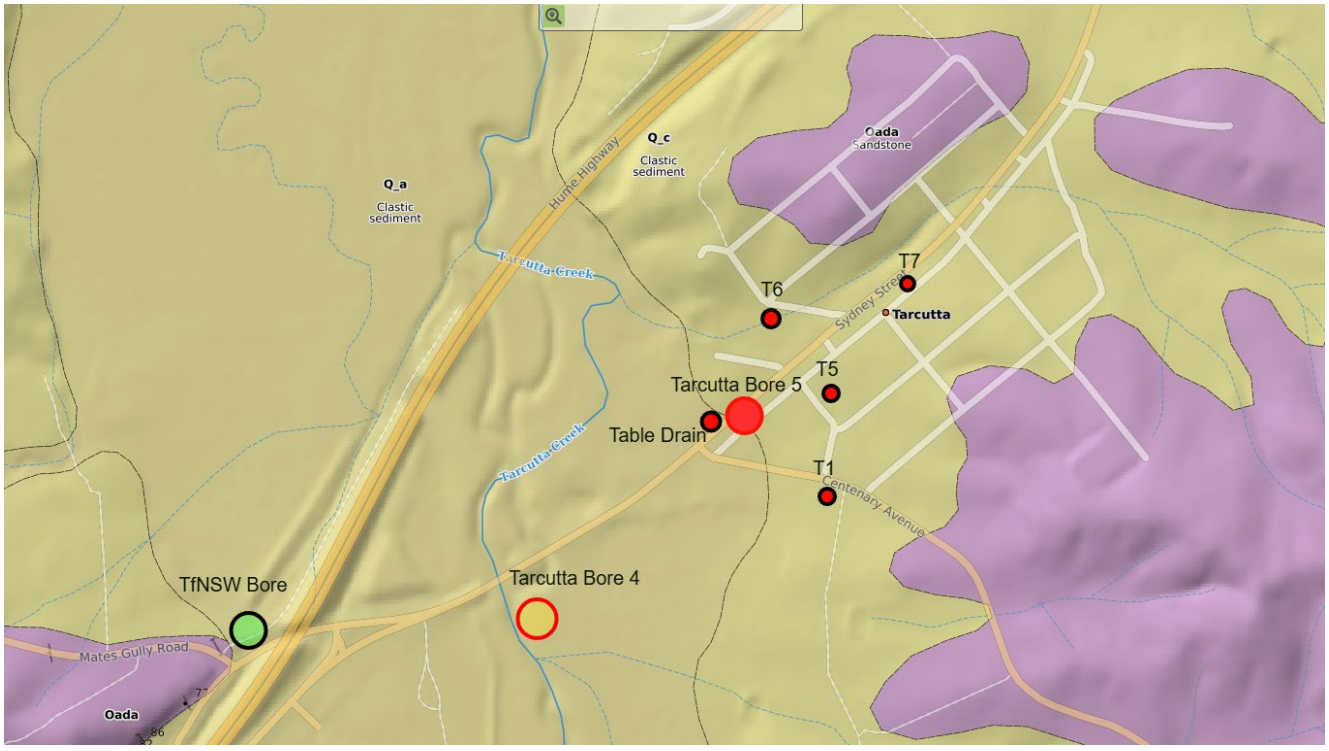

Figure 7: Surface geology Tarcutta identifying Tarcutta township bores 4 & 5, and potential alternative (TfNSW) bore source

Some of the outcomes from the investigation include (refer Figure 7):

- Identification of at least two sources of PFAS contamination within the township up-gradient of Tarcutta Bore 5

- Urban salinity monitoring bores tested contained PFAS, with a significant PFAS result at salinity bore (T6) up to six times the proposed ADWG PFOS limit or 0.024 ug/L. This bore is located at near the lowest elevated part of town in a natural drainage corridor
- Other results were:
    - T1: ½ times proposed ADWG PFOS limit
    - T5: ½ times proposed ADWG PFOS limit
    - T7: 1 ½ times proposed ADWG PFOS limit
    - Table Drain in front of Tarcutta Bore 5: 2x proposed ADWG PFOS limit
- The Transport for NSW bore: no PFAS was detected and very low likelihood of connectivity between alluvial formation and the fractured rock water sources. The TfNSW bore is approximately 95m deep.

Current responses include:

- Isolation of Tarcutta Bore 5, and only to be used for monthly PFAS sampling purposes
- Operation of Tarcutta Bore 4 as the new BaU. The adopted ADWG PFOS limits provides an acceptable margin of safety eg maximum recorded PFOS concentration was 0.006 ug/L
- Testing of TfNSW bore to determine suitability for alternate town water supply to replace Tarcutta Bore 5, in terms of both sustainable yield and water quality.

  If TfNSW bore is not suitable, then:

    - Further investigation of alternative replacement bore sites, or
    - 35km Pipeline option from Wagga Wagga, or
    - PFAS Treatment and disposal
- Continued investigation of PFAS contamination sources within Tarcutta township area with NSW EPA and NSW DCCEEW

Historical PFAS sampling results for Tarcutta bore field is illustrated below in Figure 8.

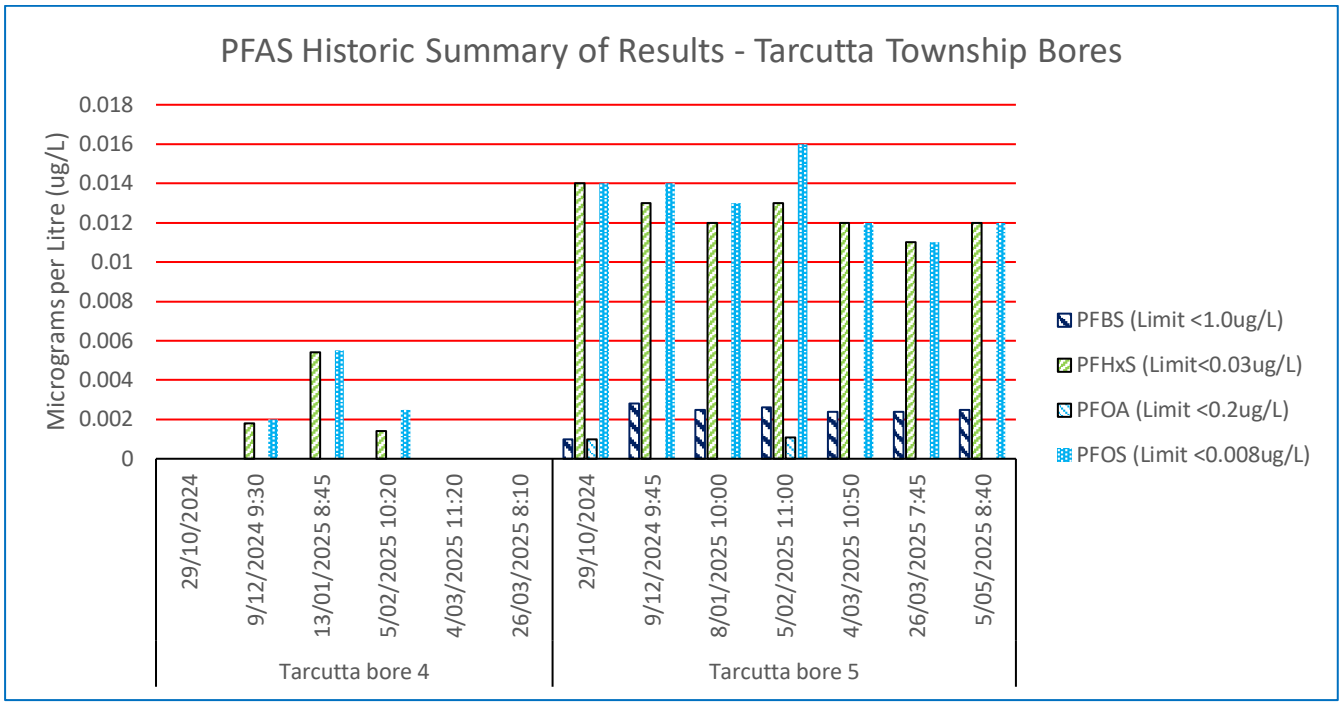

Figure 8: Historical PFAS Results of Tarcutta township bores 4 & 5

Summary:

Riverina Water's PFAS journey is continuing alongside the newly adopted ADWG PFAS limits (recently released in June 2025), and together with its co-regulators (namely NSW Health, NSW DCCEEW and NSW EPA). Like all NSW local government water supply utilities (LWUs), Riverina Water is committed to ensure provision of safe and reliable potable water safety to customers and communities, and adherence to ADWG limits are a cornerstone to achieve this.

The challenges to progress a 'whole of government' approach to PFAS is still emerging and involves coordination and commitment from state agencies, departments and local government. It has been an interesting journey understanding the delineation of roles and responsibilities between NSW EPA and NSW DCCEEW in the protection and management of the environment and water resources contaminated by PFAS, and especially when dealing with a commonwealth entity such as the Defence Department.

The development of PFAS Risk Response Matrix has helped provide a consistent framework to perform situational analysis of multiple PFAS contamination fronts and to explain escalation responses of increased PFAS contamination risk to decision makers, co-regulators, customers and the community. That said, the interim period between release of the proposed ADWG PFAS limits in October 2024 and the final adoption of PFAS limits in June 2025 has been problematic regarding provision of consistent community messaging and resetting of PFAS sampling benchmarking to establish long term trends and elimination any temporal variation of results e.g. PFAS was found in locations that previously had no detection.

The focus on 'dilution is the solution' methodology is the most effective initial response to manage PFAS below ADWG limits, at least until PFAS treatment technologies has matured further together with corresponding legislation to regulate management and disposal of PFAS waste streams.

Notwithstanding, the increase of the proposed ADWG PFOS limits from 0.004 ug/L to the adopted PFOS limit of 0.008 ug/L has certainly helped to down-grade risk response levels of West Wagga Bores 4 & 5 and Tarcutta Bore 4 i.e. back to more Business-as-Usual operations.

Lastly, the cost burden of responding to PFAS in water supplies (and wastewater) is being borne onto Local Government Water Utilities (LWUs) with limited assistance from State and Commonwealth governments, and focus to manage the source of materials and consumer products containing PFAS is not being coordinate or addressed effectively in a timely fashion.