April 2025

Rev 1

Hydrodynamics and Water Quality Assessment

Northwest Treatment Hub Review of Environmental Factors Report Addendum

aurecon ARUP

Document control record

Document Control					
Report Title	Northwest Treatment Hub Review of Environmental Factors Report Addendum – Hydrodynamics and Water Quality				
Project Name	Northwest Treatment Hub – Water Quality Response Modelling				
Project number	26973100		**Document reference number**		
Rev	**Date**	**Revision details/status**	**Prepared by**	**Reviewed by**	**Approved by**
1	29/01/2025	Draft	Jiawei Liang Bill Tran	Ed Beling	Paul Dunne
2	01/04/2025	Final	Jiawei Liang Bill Tran	Ed Beling	Paul Dunne
Current Revision					

Approval			
Author Name	**Bill Tran**	**Approver Name**	**Paul Dunne**
Author Title	Water Engineer	**Approver title**	Senior Water Resources Engineer
Author Signature	[redacted]	**Approver Signature**	[redacted]

Table of Contents

Contents

Figures

Tables

1 Introduction

A hydrodynamic and water quality assessment was undertaken in 2022 to support and inform the Review of Environmental Factors (REF) for capacity upgrades to Sydney Water's Northwest Treatment Hub (NWTH). The NWTH consists of the following Sydney Water water resource recovery facilities (WRRF):

- Castle Hill WRRF with treated water releases to Cattai Creek.
- Rouse Hill WRRF with treated water releases to Second Ponds Creek, a tributary of Cattai Creek; and
- Riverstone WRRF with treated water releases to Eastern Creek, approximately 3 km upstream from the confluence with Wianamatta-South Creek.

The increased average dry weather flows (ADWF) capacity of the treatment plants will result in increased treated water release. The phased upgrades and associated projected ADWF values which were investigated in the original NWTH REF are detailed in Table 1-1.

Table 1-1 Projected ADWF for NWTH plants by year (Sydney Water, 2022)

NWTH Plants	Projected ADWF Capacity (ML/d)		
	2021 (Current)	2026	2036
Castle Hill WRRF	6.9	8.2	10.1
Rouse Hill WRRF	28.1	32.1	42.6
Riverstone WRRF	13.1	17.4	27.8

In the original NWTH REF, the 2036 ADWF capacity for Riverstone WRRF was reported as 30 ML/d, despite Table 1-1 stating 27.8 ML/d. Since the REF, the capacity upgrades to Riverstone WRRF have been reviewed and amended. Consequently, an increase in ADWF to 41 ML/d is now projected by 2036. Rouse Hill and Castle Hill WRRF projected ADWF has not changed since the NWTH REF assessment in 2022. This has prompted the need to reassess the following:

1. How do the hydrodynamics and water quality conditions change downstream of the release points, compared with baseline and background scenarios, due to the NWTH upgrades?
2. How do wet and dry climatic conditions affect the hydrodynamics and water quality of the receiving waterways?

This report addendum serves as an extension to the existing REF, summarising the hydrodynamic and water quality assessment undertaken with the increased flows to 41ML/d and the revised impact assessment results.

2 Model Setup and Testing Scenario

2.1 Original Modelling Scenarios

Three modelling scenarios were previously undertaken to assess the impacts of the proposed upgrades to the NWTH plants on the receiving waterways. These scenarios also included representative changes in catchment conditions and other plant operations. Further details on the modelling scenarios can be found in Section 3.5.3 of the original REF. Table 2-1 summarises the conditions represented in the original REF modelling scenarios.

Table 2-1 Scenario descriptions for NWTH hydrodynamic and water quality modelling

Scenario	Representative Period in Time	Landuse and Catchment Conditions	NWTH Plant Flows	All other Plant Flows
Baseline	2020	2017	2020	2017/20
Background	2036	2036	2020	2036
Impact	2036	2036	2036	2036

All three scenarios were run over a duration of two years and two months. This simulation duration incorporated the following time periods and climatic conditions:

- 1st May 2013 to 30th June 2013 – a two month 'warm up/condition' period to allow the model to adjust to new loading conditions, not included in subsequent analysis.
- 1st July 2013 to 30th June 2014 – a representative dry climatic year (~510 mm/year).
- 1st July 2014 to 30th June 2015 – a representative wet climatic year (~1060 mm/year).

2.2 Revised Impact Modelling Scenario

The impact scenario was revised to represent the revised capacity upgrade condition at Riverstone WRRF. Land use, catchment conditions and all other plant flow conditions remained unchanged from the original REF assessment. The Riverstone WRRF boundary condition file was revised to consider the increase in ADWF capacity to 41 ML/day. No amendments were made to the water quality parameters and adopted speciation. Table 2-2 presents the median treated water quality adopted for the Riverstone WRRF releases.

Table 2-2 Median treated water quality for Riverstone WRRF releases under baseline/background and revised impact modelling scenarios

Water Quality Parameters	Baseline / Background (2020)	Revised Impact (2036)
Total Nitrogen (TN) (mg/L)	2.4	3.00
Ammonium (mg/L)	0.01	0.21
Oxidised Nitrogen (NOx) (mg/L)	1.37	1.80
Total Phosphorus (TP) (mg/L)	0.018	0.054
Filterable Reactive Phosphorus (FRP) (mg/L)	0.012	0.03
Salinity (g/L)	0.54	0.54
Dissolved Oxygen (mg/L)	5.9	5.9
Enterococci (cfu/100mL)	1.0	1.0

Water Quality Parameters	Baseline / Background (2020)	Revised Impact (2036)
E. coli (cfu/100mL)	1.0	1.0

2.3 Hydrodynamic and Water Quality Modelling

In line with the methodology of the original REF assessment, the Wianamatta-South Creek Water Quality Response Model (WQRM) was applied to simulate impacts on the hydrodynamic and water quality of Wianamatta-South Creek. The impact scenario was executed under the existing model configuration and with the revised Riverstone WRRF boundary condition incorporated. Simulations of the baseline and background scenarios were not undertaken as there were no changes to the existing model configuration or parameters. The results of the baseline, background, impact and revised impact scenarios were plotted and reviewed to assess the relative changes in predicted water quality and flows within the creek system.

It was ultimately decided that the Hawkesbury Nepean (HN) WQRM would not be applied for the purposes of this assessment. This decision was based on the following:

- The change in concentrations of the water quality constituents between the impact and revised impact scenarios within Eastern Creek and Wianamatta-South Creek were considered insignificant, with Section 3 presenting further details of the assessment results.
- The relative change between the modelled results for the impact and revised impact scenarios decreased at the Wianamatta-South Creek and Eastern Creek confluence. With this region also tidally influenced, the relative change is likely to decrease further downstream.
- The tidal dynamics between the Hawkesbury River and Wianamatta-South Creek will further attenuate the impacts of the treated water releases to the Hawkesbury River. Impacts from the Riverstone WRRF upgrades are therefore considered to be sufficiently captured in the Wianamatta-South Creek WQRM.

3 Impact Assessment

3.1 Hydrodynamic Model Results

In line with the original REF assessment, the hydrodynamics of Eastern Creek and Wianamatta-South Creek is not predicted to experience a material impact from the increased release volume from Riverstone WRRF. Dry year results summarised in Figure 3-1 show that the maximum impact in water level downstream of Riverstone WRRF, between the background and impact scenarios, was predicted to be 0.05 m. The same magnitude was also observed from the revised impact scenario.

Wet year results, as presented in Figure 3-2, show that the maximum increase in water level, between the background and impact scenarios, was predicted as 0.07 m. Between the background and revised impact scenario, the maximum increase was 0.09 m. With both impact scenarios exhibiting comparable results for the dry and wet year against the background scenario, the inherent risk and hydrodynamic impacts of the increased capacity upgrades to Riverstone WRRF is unlikely to be significant to what has already been investigated.

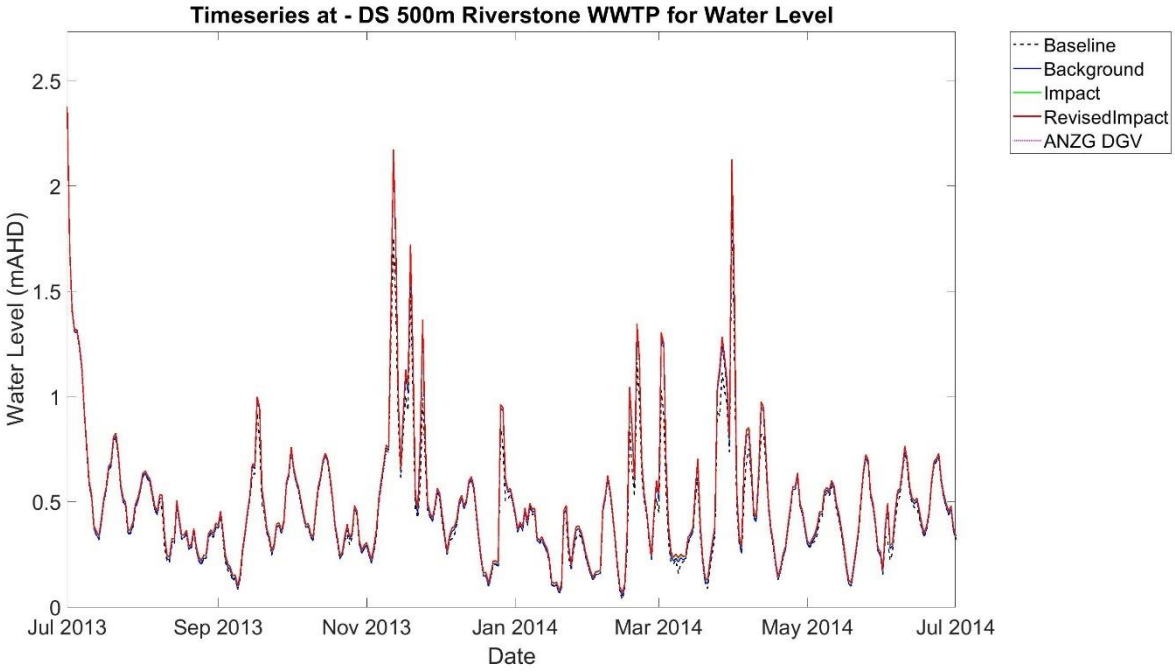

Figure 3-1 Timeseries of predicted Eastern Creek water level 500m downstream of Riverstone WRRF by scenario for representative dry year (2013/2014)

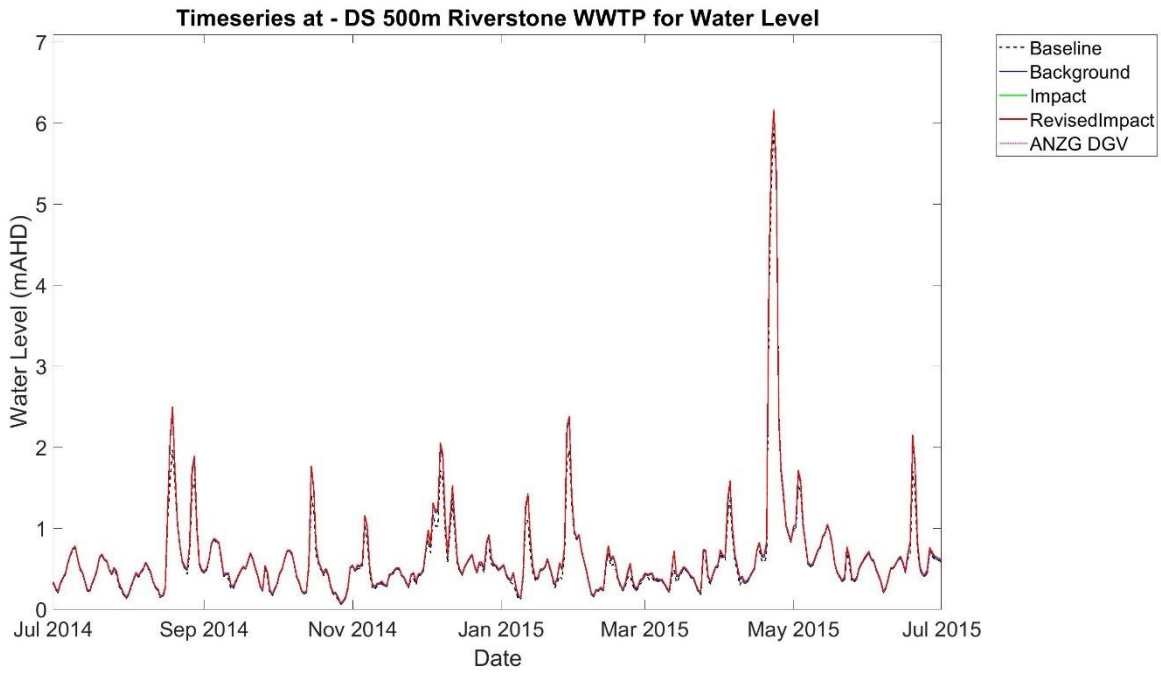

Figure 3-2 Timeseries of predicted Eastern Creek water level 500m downstream of Riverstone WRRF by scenario for representative wet year (2014/2015)

Results from the flooding, ecohydrology and geomorphology assessments further supports the hydrodynamic modelling results. Less than 0.01 m difference in flood level for the 1% AEP Event was expected because of the increased flows from Riverstone WRRF. The ecohydrological impact assessment further identified marginal impacts to fish movement with respect to the nominated native fish species evaluated. The geomorphology assessment however identified that sand was likely to experience erosion in response to the elevated velocities at localised locations. These impacts were considered to be short lived and easily managed/mitigated by the recommendations provided. Further information can be found in the NWTH Flooding, Ecohydrology and Geomorphology Assessment REF.

3.2 Water Quality Model Results

Between the impact and revised impact scenarios, the longitudinal profile plots demonstrated that there were only minor variations in the water quality results. Table 3-1 and Table 3-2 summarise the percentage change observed for all the water quality parameters at three locations:

- Release point immediately downstream of Riverstone WRRF.
- 1 km downstream of Riverstone WRRF.
- Wianamatta-South Creek and Eastern Creek confluence.

Table 3-1 Percentage change in median concentration between impact scenarios for representative dry year (2013/2014)

Water Quality Parameters	Percentage Change in Median Concentration between Impact Scenarios		
	Wianamatta-South Creek Eastern Creek Confluence	1 km DS Riverstone WRRF	Riverstone WRRF
Total Nitrogen (mg/L)	1.74%	3.46%	3.98%
Ammonium (mg/L)	5.40%	7.33%	2.00%

Water Quality Parameters	Percentage Change in Median Concentration between Impact Scenarios		
	Wianamatta-South Creek Eastern Creek Confluence	1 km DS Riverstone WRRF	Riverstone WRRF
Nitrogen Oxides (mg/L)	3.24%	5.43%	4.20%
Total Phosphorus (mg/L)	-1.61%	0.57%	1.89%
Filterable Reactive Phosphorus (mg/L)	0.07%	1.57%	1.81%
Salinity (g/L)	0.82%	2.90%	2.31%
Total Suspended Solids (mg/L)	0.18%	3.43%	2.39%
Dissolved Oxygen (mg/L)	0.16%	-0.76%	-0.93%
Chlorophyll (µg/L)	-2.59%	-4.19%	-2.86%

Table 3-2 Percentage change in median concentration between impact scenarios for representative wet year (2014/2015)

Water Quality Parameters	Percentage Change in Median Concentration between Impact Scenarios		
	Wianamatta-South Creek Eastern Creek Confluence	1 km DS Riverstone WRRF	Riverstone WRRF
Total Nitrogen (mg/L)	1.74%	2.78%	2.20%
Ammonium (mg/L)	3.72%	5.19%	1.36%
Nitrogen Oxides (mg/L)	2.78%	6.65%	5.16%
Total Phosphorus (mg/L)	-1.90%	-1.70%	-2.66%
Filterable Reactive Phosphorus (mg/L)	-0.40%	-0.94%	-0.41%
Salinity (g/L)	1.14%	2.63%	2.08%
Total Suspended Solids (mg/L)	-1.17%	-0.47%	1.11%
Dissolved Oxygen (mg/L)	0.64%	0.28%	-0.19%
Chlorophyll (µg/L)	-2.34%	-1.01%	0.00%

The nitrogen species exhibited the largest predicted variation between the original and revised impact scenarios. Percentage increases of up to 7.33% (Ammonium) were predicted 1 km downstream of the Riverstone WRRF in the representative dry year. The percentage increase, however, soon attenuated at the Wianamatta-South Creek and Eastern Creek confluence. Water quality impacts generally diminish upon joining another creek or river system due to increased dilution from additional flows. Considering the Wianamatta-South Creek and Eastern Creek confluence is also tidally influenced, the results are therefore highly likely to be more conservative. The largest percentage increased observed at the Wianamatta-South Creek and Eastern Creek confluence was 5.40% for Ammonium during the dry year. The percentage change for the other water quality parameters were considered minor.

Annual median profiles of TN, TP, Enterococci and the different forms of nitrogen and phosphorus concentrations were all concluded to not comply with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Default Guideline Values (ANZG DGVs). These results were consistent under all three scenarios assessed (baseline, background and impact) for both dry and wet years in the

original NWTH REF assessment. From the percentage change in median concentrations observed in Table 3-2, the predicted compliance (or otherwise) with the ANZG DGV waterway objectives is expected to remain unchanged under the revised impact scenario.

The Wianamatta-South Creek and Eastern Creek model results and plots can be found in Appendix A and Appendix B for the dry and wet year respectively.

3.3 Load Analysis

3.3.1 Riverstone WRRF Nutrient Loads

An updated analysis of estimated TN and TP loads to Eastern Creek has been undertaken to understand the contribution of the capacity upgrades to Riverstone WRRF. The contributing median annual loads from Riverstone WRRF are projected to increase to 57.68 tonnes/year for TN and 0.97 tonnes/year for TP under the revised impact scenario and is presented in Table 3-3. The current compliance with the Sackville subzone load limit remains unchanged.

Table 3-3 Nutrient loads for Sackville Subzone 2 compliance summary

WRRF	2036 Impact – TN (tonnes/yr)	2036 Impact – TP (tonnes/yr)	2036 Revised Impact – TN (tonnes/yr)	2036 Revised Impact – TP (tonnes/yr)
Riverstone	43.6	0.7	57.7	1.0
St Marys	37.9	1.0	37.9	1.0
Quakers Hill	21.6	0.4	21.6	0.4
AWRC	1.7	0.1	1.7	0.1
Total Estimated Load	**104.8**	**2.2**	**118.9**	**2.5**
Subzone Load Limit	**126.1**	**2.7**	**126.1**	**2.7**

3.3.2 Nutrient Loads Downstream of Riverstone WRRF.

Figures below present the analysis of TN and TP loads in the waterway at 250 meters downstream of Riverstone WRRF. These values represent the average annual mass loads derived from the model results. As a result of the capacity upgrades to Riverstone WRRF, average TN and TP loads have increased from the original impact scenarios. TN loads increased by 11.61% and 9.39% for the dry and wet year respectively. TP load impacts were less significant, at 6.21% and 5.41% for the dry and wet year respectively. While notable, the overall change in impact to water quality is expected to remain minimal as concentrations of the water quality constituents continue to attenuate further downstream as highlighted in 3.2.

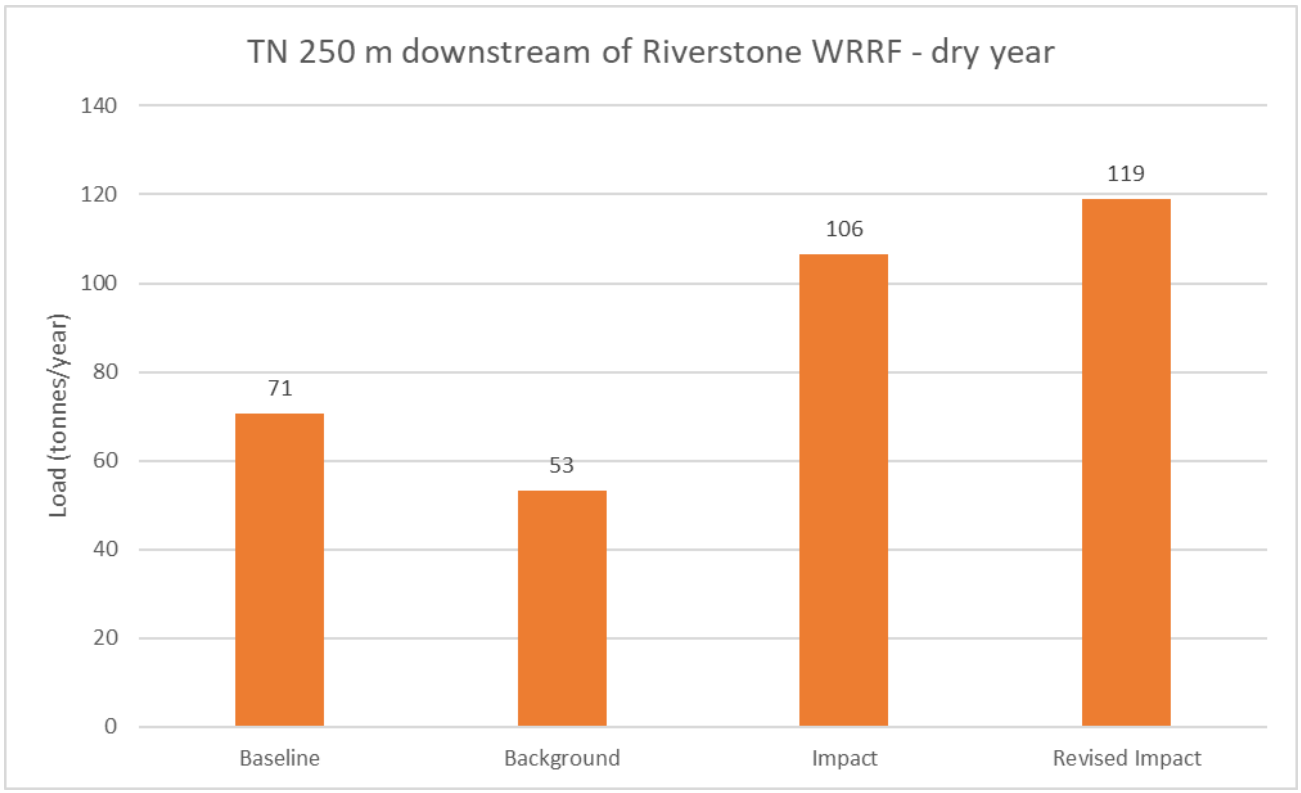

Figure 3-3 TN waterway loads 250m downstream of Riverstone WRRF by scenario for the representative dry year (2013/14)

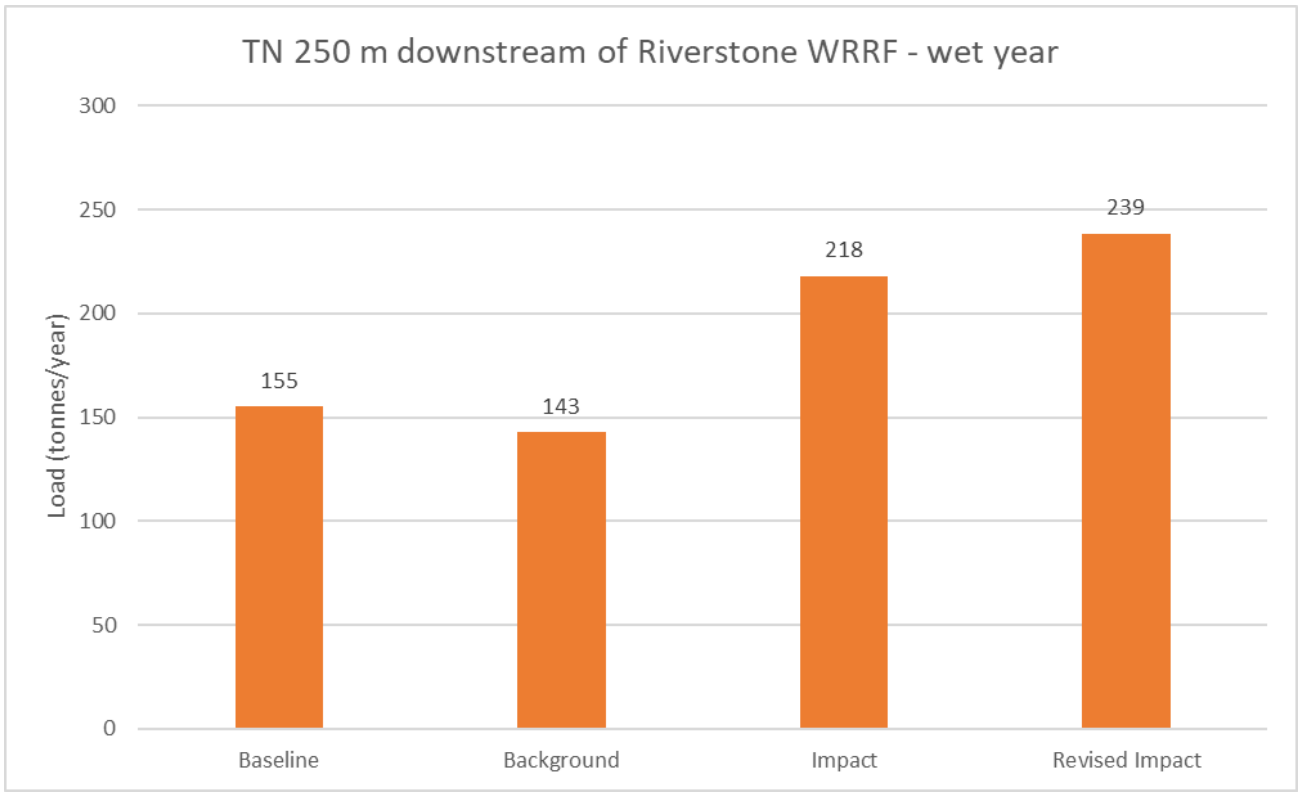

Figure 3-4 TN waterway loads 250m downstream of Riverstone WRRF by scenarios for the representative wet year (2014/15)

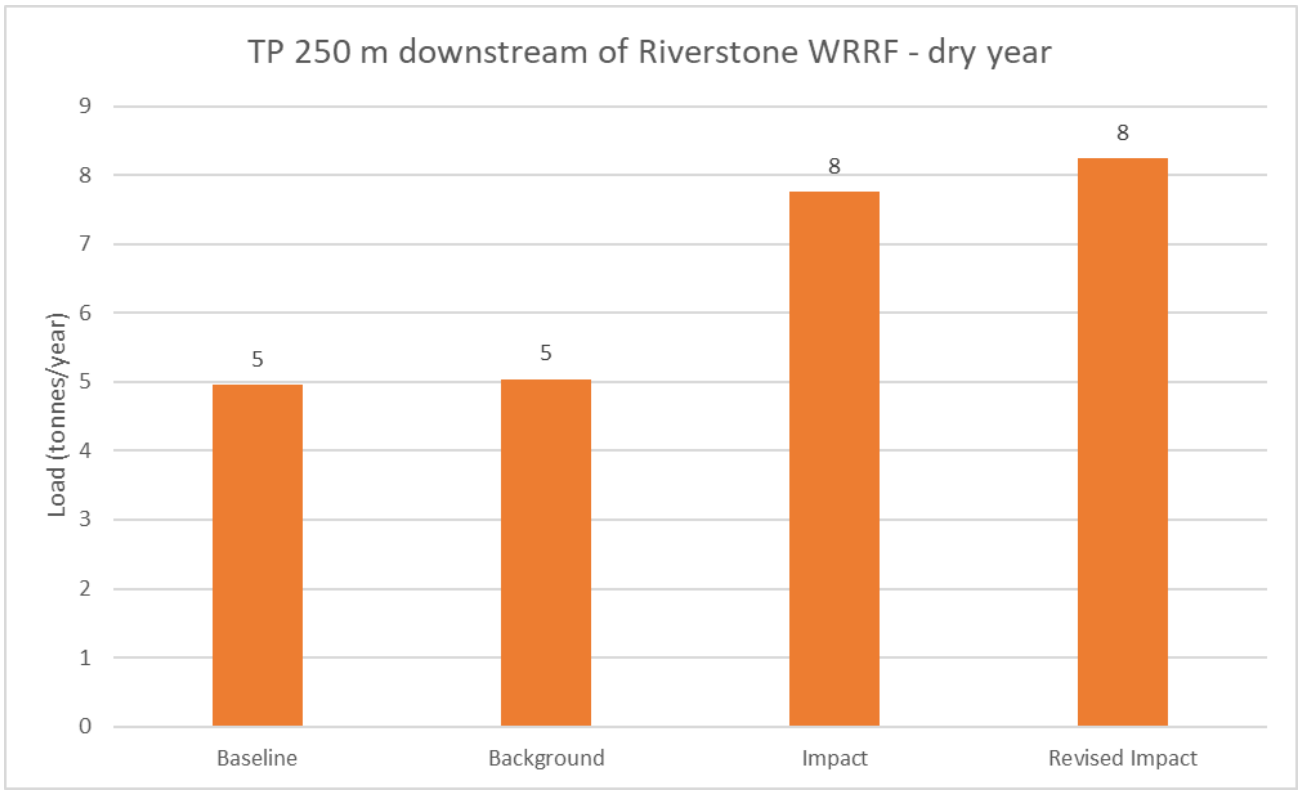

Figure 3-5 TP waterway loads 250m downstream of Riverstone WRRF by scenarios for the representative dry year (2013/14)

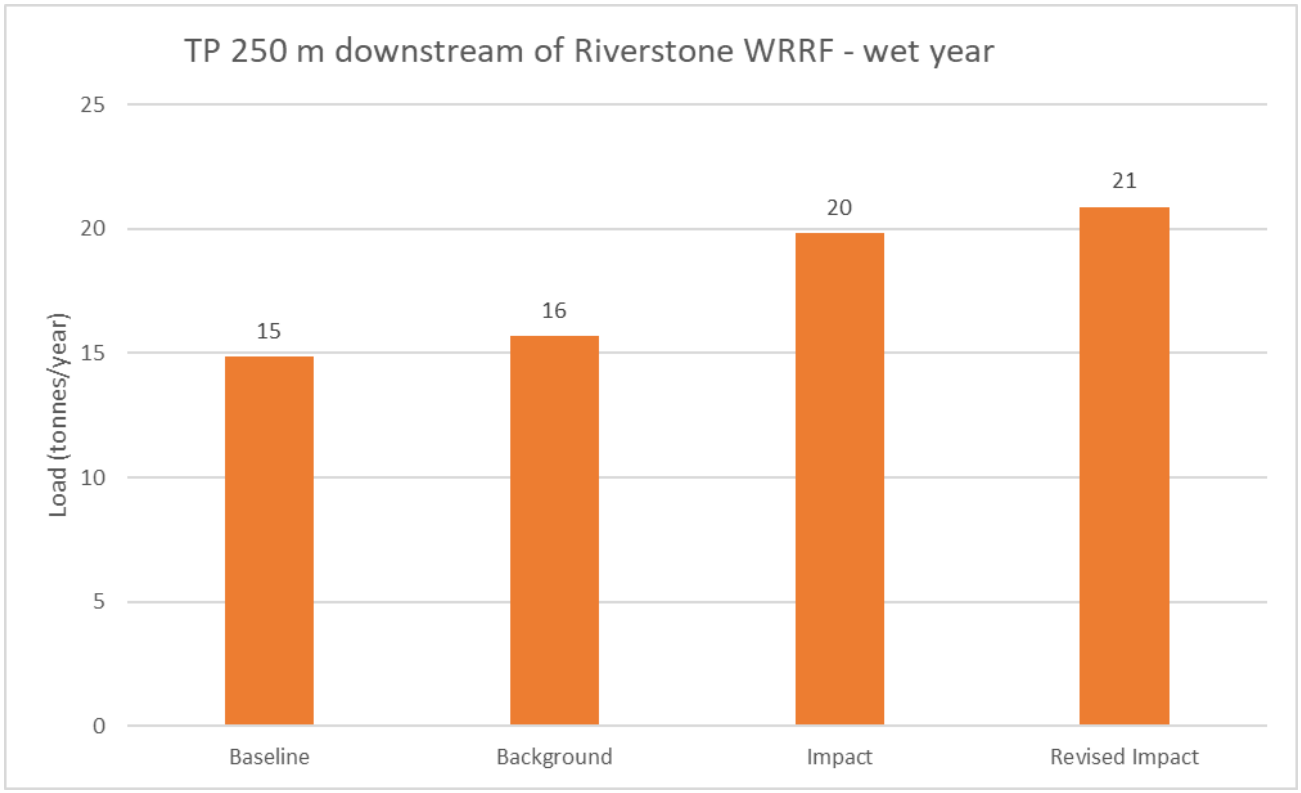

Figure 3-6 TP waterway loads 250m downstream of Riverstone WRRF by scenarios for the representative wet year (2014/15)

4 Conclusion

From the hydrodynamic and water quality assessment undertaken, impacts from the amended increase in release volumes from the capacity upgrade at Riverstone WRRF have been predicted. Based on the modelling results, the risk of additional impacts relating to water quality and hydrodynamics in Eastern Creek, Wianamatta-South Creek and ultimately the Hawkesbury River has been assessed as low.

The wet year showcased the greatest hydrodynamic impact, whereby the water level increased by 0.02 m from the previous impact scenario. For water quality, percentage increases of up to 8% were observed for ammonium, downstream of Riverstone WRRF. These changes reduced further downstream towards Wianamatta-South Creek.

Results from the load analysis for TN and TP highlighted notable impacts whereby TN loads increased by as much as 11.61% for the dry year while TP load impacts were less significant, at 6.21% for the dry year. However, the overall change in impact to water quality is expected to remain minimal as concentrations of the water quality constituents continue to attenuate further downstream.

The minor changes in hydrodynamics and tapering of water quality impacts in Wianamatta-South Creek demonstrates that there are no major adverse impacts from the capacity upgrades at Riverstone WRRF to what has been investigated in the original REF.

References

Sydney Water, (2022), Northwest Treatment Hub Review of Environmental Factors

Appendix A: Dry Year Scenario Results Plots

Appendix A Dry Year Scenario Results Plots.docx

Appendix B: Wet Year Scenario Results Plots

Appendix B Wet Year Scenario Results Plots.docx