Mill Stream Environment Management Plan (EMP) Annual Compliance Report

Report Number 2

Period 1 January 2025 to 31 December 2025

In Compliance with

Authorisation Number 01/2024

Sydney WATER

Water IS OUR LIFE

Acknowledgement of Country

Sydney Water respectfully acknowledges the Traditional Custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.

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1 Executive Summary

Sydney Water received a new Authorisation on 7 June 2024 to operate Emergency Relief Structures (ERSs) located on Sydney Airport land that discharge to Mill Stream. The previous Authorisation expired on 31 March 2024. This report provides the second annual update on Sydney Water's performance against the conditions of the Authorisation and implementation of the Environment Management Plan (EMP) during the reporting period 1 January 2025 to 31 December 2025, as approved by the Airport Environment Officer (AEO).

Sydney Water has continued to work collaboratively with key stakeholders, including Sydney Airport, Bayside Council, the NSW Environment Protection Authority (EPA), the Department of Infrastructure, Transport, Regional Development, Communications, Sports and the Arts (DITRDCSA), and the Port Authority of NSW, to progress EMP actions and support regulatory compliance.

As detailed in this report, Sydney Water's performance has been strong, however one condition in the Authorisation remains non-compliant due to access, legal and technical constraints, which are being worked through as a priority. This is the Botany Low Level Carrier Delivery Project, for which the revised due date is March 2027. Sydney Water is otherwise compliant with all reporting, monitoring, notification and stakeholder engagement requirements and continues to implement operational and strategic improvements to the Mill Stream system.

Comparison with the Previous Annual EMP Compliance Report

The previous Annual EMP Compliance Report (Report No.1) covered the period 7 June 2024 to 17 January 2025 and represented the first reporting cycle under the new Authorisation. During that initial period, Sydney Water was largely compliant; however, several actions were in early stages of delivery, and some timeframes were affected by access constraints, approval processes and operational dependencies associated with the airport environment. Minor timing issues were also identified, including a delayed quarterly report submission to Sydney Airport and partial achievement of grit pit cleaning shift targets.

In contrast, this second reporting period demonstrates a maturing compliance position and improved delivery certainty. All monthly and quarterly reports were submitted within the required twenty-one-day timeframe, supported by improved data validation processes and clarified reporting schedules. Operational access arrangements at Sydney Airport have stabilised, enabling more consistent delivery of grit pit maintenance activities and improved coordination of desilting works. Stakeholder engagement has also strengthened, with regular Stakeholder Reference Group (SRG) meetings, supported by Hydraulic Improvement Leadership Group (HILG) input, and targeted briefings supporting transparency and shared understanding of system performance and constraints.

System Performance and Environmental Outcomes

At the commencement of the Authorisation period, Mill Stream overflows averaged 19 events per year with an annual volume of approximately 3,094 ML. Through a combination of operational optimisation, pump setting adjustments, desilting of SWSOOS1, and improved flow balancing between SWSOOS barrels, Sydney Water achieved a reduction to a modelled performance of 13 events and 1,238 ML per year which is still current for modelled performance for 2025

For the current reporting period (1 January 2025 to 31 December 2025), the Mill Stream ERS discharged 2,385 ML of diluted wastewater across 23 wet weather overflow events, with no dry weather discharges recorded. The majority of overflow activity occurred during periods of severe rainfall in July, August and September 2025, where stormwater inflows exceeded system capacity. Sydney Water responded to all overflow events in accordance with EMP requirements, undertaking thirty-eight inspections and eight environmental clean-ups, removing approximately 152 m^3 of gross pollutants from Mill Stream and Foreshore Beach.

Compliance Obligations and Summary of Compliance

Sydney Water's compliance obligations under the Authorisation and EMP include, but are not limited to:

- Submission of Annual EMP Compliance Reports and Quarterly Reports within approved timeframes
- Monthly monitoring and reporting of overflow frequency, duration and volume
- Timely notification of overflow events and incidents of material harm
- Implementation of EMP actions across all seven objectives, including desilting, source control, grit pit maintenance, hydraulic investigations, and public health protection measures
- Water quality, air quality and dry-weather sewer performance monitoring
- Complaint investigation and resolution
- Stakeholder engagement through SRG meetings, HILG forums and community updates
- Compliance with additional Authorisation conditions, including bird strike risk management, IPART submissions, and reporting to Sydney Airport

For the current reporting period, Sydney Water has met most applicable compliance obligations. Only one non-compliance had been identified. Where EMP actions extend beyond the reporting period due to their scale or dependency on external approvals, these have been transparently documented, and delivery pathways remain active and endorsed by regulators.

Overall Compliance Position

This second Annual EMP Compliance Report demonstrates continued improvement in both environmental performance and regulatory compliance at Mill Stream. Compared with the previous reporting period, Sydney Water has strengthened its compliance assurance processes, improved reporting timeliness, and advanced delivery of key operational and strategic initiatives. Sydney Water remains committed to implementing the EMP in full and to working collaboratively with regulators, stakeholders and the community to further reduce overflow frequency and volume and protect the Mill Stream environment.

2 Introduction

2.1 Context

Sydney Water owns and operates the Malabar Sewage Treatment System, servicing nearly 1.8 million people. The system carries wastewater from as far as Campbelltown in the southwest, Fairfield and Hoxton Park in the West, Concord in the North and the southern extents of the Sydney CBD to the Malabar Water Resource Recovery Facility (WRRF) for treatment prior to discharge from deep ocean outfalls.

The trunk main of the Malabar System is the South-Western Sydney Ocean Outfall Sewer (SWSOOS); a multi-barreled carrier that transfers wastewater from Arncliffe eastward across the Airport site to the Malabar WRRF at Malabar Headland. The original pipeline (called SWSOOS No.1) lies to the north. The SWSOOS was amplified with the construction of two pipelines (called SWSOOS No.2) to the south.

The SWSOOS has four monitored Emergency Relief Structures (ERSs) located at Kingsford Smith Airport, collectively known as the Mill Stream ERS. Additionally, there is an ERS on a smaller main entering the trunk sewer from the north. These ERSs are crucial for the proper operation of the wastewater network. Periodically, the ERSs discharge wastewater that has backed up in the sewer and releases into the Mill Stream seaward of the saltwater exclusion weir. This weir separates the tidally flushed waters of the Mill Stream and Botany Bay from the impounded freshwaters of the Engine Pond. The Mill Stream flows into Botany Bay near Foreshores Beach.

ERSs are vital components of any wastewater network and are included in all sewer systems around the world. They release excess flows from the sewer to prevent surcharging through surface openings into inhabited areas, (people's homes), and to avoid excessive pressure build-up within the sewer. These structures and their discharges are commonly referred to as overflows. The released flows are directed to stormwater systems, streams, and estuaries, and in some cases, to structures designed for temporary storage. ERSs activate in response to rainfall, when the volume of stormwater entering the sewer exceeds its capacity.

The Mill Stream ERS discharge is located on and potentially impacts air, land and waters of the Kingsford Smith Airport site. Given this, it requires Authorisation (Licensing) under federal *Airport Act* and *Airports (Environment Protection) Regulations 1997*. In addition to federal regulation, the Mill Stream ERSs are regulated under the *Protection of the Environment Operations Act 1997* (POEO Act). Wastewater reticulation systems and wastewater overflow structures are included in the definition of Sewage Treatment, which is a Scheduled Activity. The Mill Stream ERS is included under the Malabar wastewater system's Environment Protection Licence (EPL 372) overseen by the NSW Environment Protection Authority (EPA).

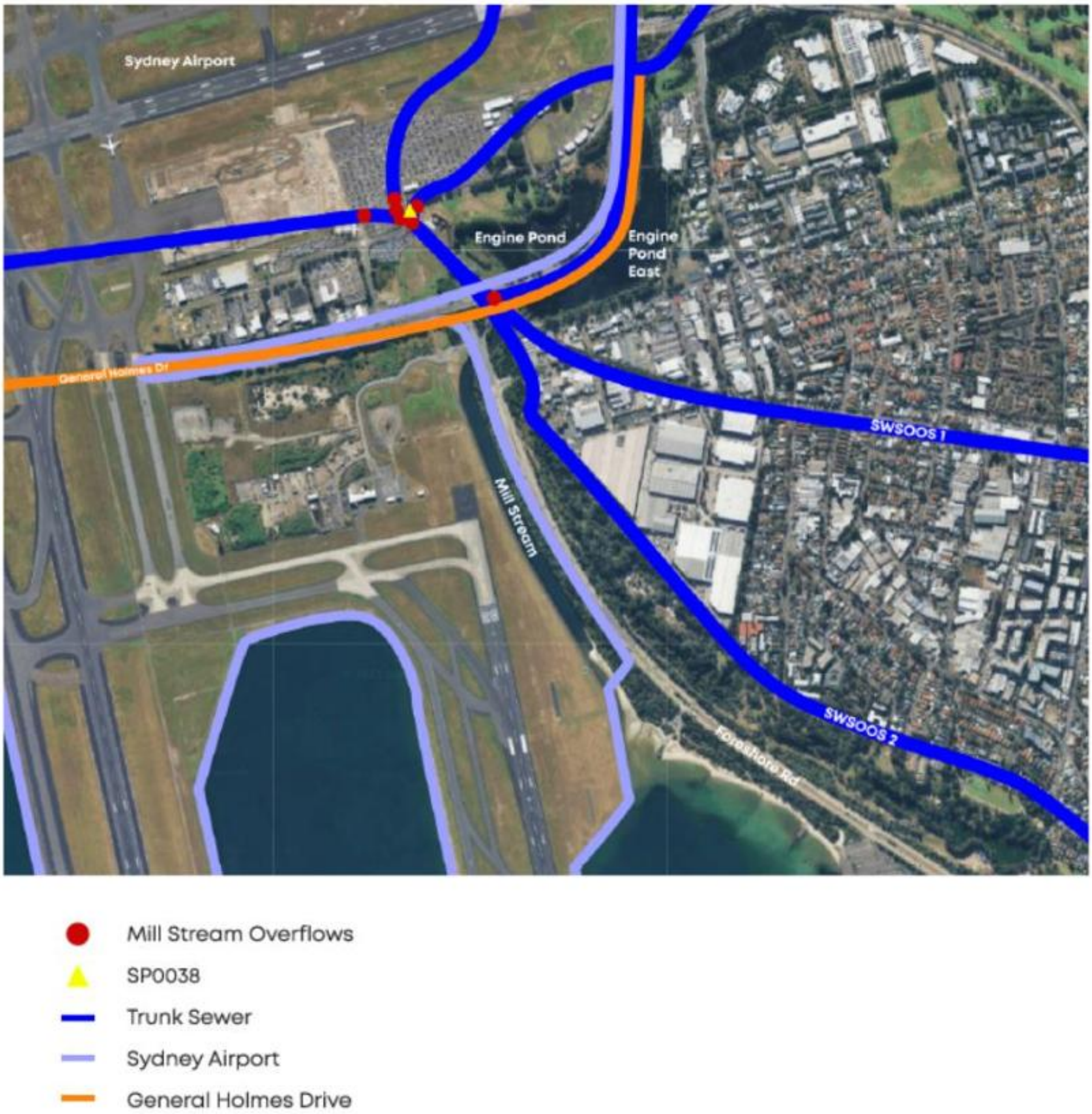

Figure 1: Location of emergency relief structures discharging to the Mill Stream

2.2 Authorisation 2024 to 2027

On 7 June 2024, the former Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (DITRDCA) issued Sydney Water a conditional Authorisation under the *Airports (Environment Protection) Regulations 1997*. This Authorisation permits the periodic discharge of untreated diluted wastewater from the SWSOOS ERS overflow points to the Mill Stream. The Authorisation period extends from

7 June 2024 to 31 March 2027. The discharge must comply with the Environment Management Plan (EMP) dated 7 May 2024, which was submitted by Sydney Water in support of its application for the Authorisation, and the operating conditions outlined in Appendix A of the Authorisation.

2.3 Reporting (EMP Objective 7)

This document constitutes Environmental Management Plan (EMP) Compliance Report Number 2, prepared in accordance with Operating Condition 2 of Authorisation Number 01/2024. The report outlines Sydney Water's performance in implementing the requirements of the Authorisation and the associated EMP for the period 1 January 2025 to 31 December 2025.

As context, during the previous reporting cycle, Sydney Water sought an extension to the submission date of the EMP Compliance Report Number 1 (2025). A formal request was submitted to the Airport Environment Officer (AEO) on 20 January 2025, and the extension was approved on 24 January 2025, revising the submission deadline to 28 February 2025. This variation also aligned the timing of the Mill Stream Community Forum, which was subsequently held on 27 February 2025. Sydney Water submitted the prior year's compliance report to the AEO and Mill Stream stakeholders on 18 January 2025, consistent with the AEO's revised approval. This background provides important regulatory context for the subsequent variation requested and approved for the current reporting period.

For this reporting cycle, on 27 January 2026, the AEO approved Sydney Water's request to vary the EMP reporting period and submission deadline. In accordance with this approval, the compliance assessment period has been aligned to 1 January 2025 to 31 December 2025, incorporating the outcomes from Quarterly Report 5. To maintain transparency, project-specific updates within this Annual Report continue to reflect operational progress across the original Authorisation period of 17 January 2025 to 17 January 2026.

The report addresses the matters in regulation 5.17(a) to (c) of the AEPR as well as Operating Conditions of the Authorisation (Appendix A Operating Conditions of the Authorisation)

Table 1: Authorisation Requirements

Legislation	Clause No.	Clause	See Section
Airports (Environment Protection) Regulations 1997	5.17	The holder of an Authorisation granted for a period longer than 1 year must give the Airport Environment Officer who granted the Authorisation (or that person's successor) a report for each year that the Authorisation is in force, setting out:	2.2
		Details of the holder's performance in giving effect to the holder's plan under sub-regulation 5.07(3)1; and	3
		Details of progress (if any) made in reducing the generation of pollution or noise that is generated in excess of the approved limit, under the Schedules, for pollution or noise of that kind; and	3.5
		Any failure by the holder to comply with the terms and conditions (if any) of the authorisation	3 & 4

Table 2: Environment Management Plan Compliance Report Requirements

Authorisation Condition	Subject	Authorisation requirement	See Section
2	Reporting	Sydney Water must submit to the AEO a comprehensive report on its compliance with the EMP (EMP Compliance Report) in accordance with the requirements of clauses 5.17(a) to (c) of the Regulations by the following dates, for the following time periods: (b) by 31 January 2026, covering the period from which the authorisation	All

Authorisation Condition	Subject	Authorisation requirement	See Section
		period begins to 17 January 2025. (NB: a variation was granted by the AEO on the 27 January 2026. New report due date 28 February 2026 covering the authorisation period begin 1 January 2025 to 31 December 2025.)	
3a (EMP Action 5.1)	Monitoring	Provide a report on the monthly frequency, duration and volume of all overflow events into Mill Stream.	3.5.1
3b	Monitoring	Provide a graph that includes monthly rainfall plots onto the Emergency Relief Structures (ERSs) gauge level to show baseline and overflow conditions and provide a written explanation of the conditions that led to each overflow event.	3.5.1
3c	Monitoring	Provide a graph with the total volume of overflows in ML per year since at least 2020.	3.5.1
3d (EMP Action 6.1)	Complaints management	Provide a summary of all environmental complaints received during the reporting period and provide evidence as to how each of the complaints has been addressed and resolved.	3.6.1
3e (EMP Action 1.1)	Overflow events	Detail the progress made in the reporting period	3.1.1

Authorisation Condition	Subject	Authorisation requirement	See Section
		towards the desilting of SWSOOS 2 referred to as Objective 1, Action 1.1 of the EMP.	
3f (EMP Action 1.2	Overflow events	Detail the progress made in the reporting period to source control implementation referred to as Objective 1, Action 1.2 of the EMP.	3.1.2
3g and 11 (EMP Action 1.3)	Overflow events	Report the dates of the eight grit pit maintenance cycles undertaken and provide tonnage removed per cycle, referred to as Objective 1, Action 1.3 of the EMP.	3.1.3
3h (EMP Action 1.4)	Overflow events	Detail the progress made in the reporting period to the Malabar Strategic Business Case (SBC) referred to as Objective 1, Action 1.4 of the EMP.	3.1.4
3i and 20 (EMP Action 1.5)	Overflow events	Detail the progress made in the reporting period to the Botany Low Level Carrier Rehabilitation referred to as Objective 1, Action 1.5 of the EMP.	3.1.5
3j and 17 (EMP Action 1.3 and 2.1)	Grit Pits	Detail the progress made in the reporting period to the feasibility assessment and relocation of the SWSOOS Grit Pits referred to as Objective 2, Action 2.1 of the EMP.	3.2
3k (EMP Objective 3)	Hydraulic Improvement Plan	Detail the progress made in the reporting	3.3

Authorisation Condition	Subject	Authorisation requirement	See Section
		period to the Hydraulic Improvement Plan referred to as Objective 3 of the EMP.	
3l (EMP Action 4.2)	Protect the environment and public health	Detail the progress made in the reporting period to wastewater screening implementation referred to as Objective 4, Action 4.2 of the EMP.	3.4.2
3m (EMP Action 5.4)	Monitoring	Detail the progress made in the reporting period to further reduce the concentration of discharge and improve compliance with the Regulations, including the water pollution limits in Schedule 2 of the Regulations.	3.5.4
3n	Monitoring	Describe, and provide evidence, of Sydney Water's compliance with condition L7.1 (Hydraulic Sewer System Model) of the Malabar Wastewater System Environmental Protection Licence (No. 372, issued by the NSW EPA).	4.1
3o and 18	Bird Strike	Detail Sydney Water's progress on the implementation of bird strike mitigation measures implemented in accordance with condition (18) and provide justification for any delay in	4.2

Authorisation Condition	Subject	Authorisation requirement	See Section
		implementation of such measures.	
3p (EMP Action 4.1)	Protect the environment and public health	Detail the volume of gross pollutants removed, syringe presence, photos, general observations, and water quality sampling results for overflow events and incidents of material harm.	3.4.1
3q (EMP Action 5.4)	Monitoring	Detail evidence of improvement in the receiving environment in consideration of affected ecosystems and the health and wellbeing of the community (water quality, community expectations, beach suitability grade, odour, First Nations community values).	3.5.4
4	Monitoring	In the period between the commencement of the Authorisation and 17 January 2026, the total number of wet weather overflow events into Mill Stream must not exceed a modelled performance of: • 13 overflow events per year; and • an overflow volume of 1,238 ML per year as measured by the hydraulic sewer system model. Compliance with this condition is to be reported in the 31 January 2025 and 31	4.3

Authorisation Condition	Subject	Authorisation requirement	See Section
		January 2026 EMP compliance reports.	
6	Monitoring	In each annual EMP Compliance Report Sydney Water is to present any shortcomings in the achievement of proposed EMP targets and set out any corrective actions required to reduce modelled discharges to no more than the above limits by the required dates.	4.3
7-8	Reporting	Quarterly Reporting- Sydney Water must submit Quarterly Reports to the AEO within 21 days of the end of each quarter commencing with the report on the first quarter concluding on 30 September 2024.	3.7.1
9-10	Communication of compliance and compliance reporting	By 1 February 2026, Sydney Water must provide an annual update on the progress of the implementation of the EMP at a community meeting to be held locally (e.g. Botany Town Hall). By 28 February 2025, finalised copies of the Annual EMP Compliance Report must be provided to Bayside Council and published on the Sydney Water website.	4.4
12 (EMP Action 5.2)	Monitoring	Sydney Water must notify Sydney Airport	3.5.2

Authorisation Condition	Subject	Authorisation requirement	See Section
		Corporation Limited (Sydney Airport), Bayside Council and the AEO of any overflow event within 24 hours of Sydney Water becoming aware of the event.	
13	Monitoring	Sydney Water must notify Sydney Airport, Bayside Council and the AEO of any incident of material harm within 24 hours of Sydney Water becoming aware of the event.	3.5.2
14	Performance and other conditions	Annual EMP Compliance Reports, Quarterly Reports, the bird strike risk assessment letter required under condition (18), the Water Quality Monitoring Report required under condition (21), and any other investigations undertaken for the duration of this Authorisation must be provided to Sydney Airport within 21 days of their finalisation.	4.5
15	Hydraulic Improvement Plan	Sydney Water must chair the Mill Stream Hydraulic Improvement Leadership Group (HILG) with representatives from Bayside Council, Sydney Airport, Department of Infrastructure, Transport, Regional Development, Communications and the Arts and the NSW	3.3

Authorisation Condition	Subject	Authorisation requirement	See Section
		Environment Protection Authority.	
16	Performance and other conditions	In addition to Stakeholder Reference Group (SRG) meetings, Sydney Water must attend meetings with Bayside Council, all Sydney Airport Community Forum meetings, and Planning and Coordination Forum meetings to which it is invited, and provide an update to those forums on the progress of the implementation of the EMP.	4.6
19	Performance and other conditions	By 30 September 2024, Sydney Water must submit its pricing proposals to the New South Wales Independent Pricing and Regulatory Tribunal (IPART), including funding allocation and milestones for: a. the 2025-2030 Wet Weather Overflow Abatement (WWOA) program (source control works); and b. the planning and commencement of works for the preferred network augmentation option identified in the Malabar SBC; and	4.7

Authorisation Condition	Subject	Authorisation requirement	See Section
		provide evidence including funding allocation and milestones of the submission to the AEO within 21 days of the submission of the proposal to IPART.	
20	Operational Works	By 31 December 2024 Sydney Water must complete all operational works for the Botany Low Level Carrier Rehabilitation project.	3.1.5
2	Reporting	Sydney Water must submit to the AEO a comprehensive report on its compliance with the EMP (EMP Compliance Report) in accordance with the requirements of clauses 5.17(a) to (c) of the Regulations by the following dates, for the following time periods: by 31 January 2025, covering the period from which the authorisation period begins to 17 January 2025;	All
3a (EMP Action 5.1)	Monitoring	Provide a report on the monthly frequency, duration and volume of all overflow events into Mill Stream.	3.5.1
3b	Monitoring	Provide a graph that includes monthly rainfall plots onto the Emergency Relief Structures (ERSs) gauge level to show baseline and overflow conditions and provide a written	3.5.1

Authorisation Condition	Subject	Authorisation requirement	See Section
		explanation of the conditions that led to each overflow event.	
3c	Monitoring	Provide a graph with the total volume of overflows in ML per year since at least 2020.	3.5.1
3d (EMP Action 6.1)	Complaints management	Provide a summary of all environmental complaints received during the reporting period and provide evidence as to how each of the complaints has been addressed and resolved.	3.6.1
3e (EMP Action 1.1)	Overflow events	Detail the progress made in the reporting period towards the desilting of SWSOOS 2 referred to as Objective 1, Action 1.1 of the EMP.	3.1.1
3f (EMP Action 1.2	Overflow events	Detail the progress made in the reporting period to source control implementation referred to as Objective 1, Action 1.2 of the EMP.	3.1.2
3g and 11 (EMP Action 1.3)	Overflow events	Report the dates of the eight grit pit maintenance cycles undertaken and provide tonnage removed per cycle, referred to as Objective 1, Action 1.3 of the EMP.	3.1.3
3h (EMP Action 1.4)	Overflow events	Detail the progress made in the reporting period to the Malabar Strategic Business Case (SBC) referred to as	3.1.4

Authorisation Condition	Subject	Authorisation requirement	See Section
		Objective 1, Action 1.4 of the EMP.	

Table 3: Environmental Management Plan (EMP) Actions

Objective	Actions	Performance Indicator/s	Refer Section
Objective 1 Increase capacity of the wastewater system to reduce frequency and volume of overflow	**Action 1.1** Desilt SWSOOS 2 - SP0038 to Malabar WRRF	Procurement and contract award to be completed by December 2024	3.1.1
	Action 1.2 Implement source control for the Malabar system to reduce wet weather inflows into the SWSOOS	Prospect, Greater Parramatta to Olympic Peninsula, Lower NGRS/Cooks and Lower Georges River catchment completed by June 2025 Completion of further WWOA stages as indicated in Appendix A and to be reported in Annual Compliance reports	3.1.2
	Action 1.3 Conduct Grit Pit Maintenance	Grit Pit Hardstand constructed November 2024 Achieve 8 maintenance cycles each 12-month period Increase tonnage removed per quarter	3.1.3
	Action 1.4 Implement Malabar Strategic Business Case (SBC) – network augmentation preferred option	Confirmation that Sydney Waters IPART pricing submission includes network augmentation funding allocation	3.1.4
	Action 1.5 Botany Low Level Carrier Rehabilitation	Completion of all operational works by December 2024 Provide increased storage when wastewater screens are operational	3.1.5
Objective 2 Feasibility of Grit Pit relocation	**Action 2.1** Conduct a feasibility assessment for the	Report submitted to AEO by 30 June 2024 and present findings at the following SRG	3.2.1

Objective	Actions	Performance Indicator/s	Refer Section
	relocation of the SWSOOS Grit Pits		
Objective 3 Hydraulic Improvement Plan (HIP)	**Action 3.1** Chair Hydraulic Improvement Leadership Group (HILG)	Quarterly meetings conducted to support implementation and completion of Phase 2B and 3	3.3.1
	Action 3.2 Conduct HIP Phase 2B	Cost sharing agreement in place June 2024 Studies conducted and report submitted to AEO by February 2026 Progress of activities will be provided in Annual Compliance reports	3.3.2
Objective 4 Protect the environment and public health	**Action 4.1** Inspect Mill Stream and Foreshores Beach after all overflow events and remove gross pollutants	All inspections initiated correctly and adhere to Work Instructions – Mill Stream/Foreshore Beach wet weather clean-up Inspections within two days of discharge event ceasing and next daylight low tide Volume of gross pollutants collected in m3/event AEO and Sydney Airport notified of all material harm incidents within one business day	3.4.1
	Action 4.2 Implement wastewater screening at Airport Site	All works completed and screening implemented by December 2026 Completion of project stages as indicated in Appendix A and to be reported in Annual Compliance reports	3.4.2
	Action 4.3 Maintain permanent signage at Foreshore Beach	Permanent signage maintained at Foreshore Beach, all overflow inspections to include signage checks External review of public health content and language to be completed and implemented if required by October 2024	3.4.3

Objective	Actions	Performance Indicator/s	Refer Section
	Action 4.4 Ensure all maintenance personnel and contractors are aware of threatened species fact sheets	No impact to threatened bird species, fact sheet included in Work Instruction – Mill Stream/Foreshore Beach wet weather clean-up	3.4.4
	Action 4.5 Store gross pollutants appropriately during clean-ups	All waste correctly stored prior to disposal, evidenced by clean up photos and reports	3.4.5
	Action 4.6 Dispose of gross pollutants appropriately	All waste correctly disposed	3.4.6
Objective 5 Monitor wastewater system performance, odour and receiving waterway health	**Action 5.1** Conduct continuous overflow monitoring and routine monthly reporting	All monthly reports provided to AEO and Sydney Airport	3.5.1
	Action 5.2 Provide overflow alerts to AEO and Sydney Airport representatives	SMS overflow alerts are received for all overflows	3.5.2
	Action 5.3 Monitor the dry weather sewage capacity in the SWSOOS	Minimum wastewater level for a rolling 6-month period is maintained at 0.45m	3.5.3
	Action 5.4 Monitor water quality at Mill Stream	April 2024 – July 2025 Monitoring is complete and the final report delivered July 2025, including recommendations for future monitoring options	3.5.4
	Action 5.5 Air quality monitoring (H2S) near discharge location	October 2024 – September 2025 Monitoring completed and results reported by September 2025	3.5.5
Objective 6	**Action 6.1** Respond to and investigate all	Response provided to complainant within 2-5 working days	3.6.1

Objective	Actions	Performance Indicator/s	Refer Section
Conduct effective complaint management	complaints regarding the Mill Stream ERS	Complaints recorded and included in annual report	
Objective 7 Progress Reporting	**Action 7.1** Provide Quarterly Update Report	Quarterly report to be provided within 21 days of the quarter ceasing.	3.7.1
	Action 7.2 Chair Quarterly Stakeholder Reference Group (SRG) meeting	SRG conducted within 4 weeks of the quarter ending	3.7.2
	Action 7.3 Provide Annual EMP Compliance Report	Annual Compliance Report submitted by 28 February 2026 or each year of the Authorisation	3.7.3

3 Environment Management Plan (EMP) 2024-2027

The EMP was prepared to support the application for a new Authorisation to operate the Mill Stream ERS, as required by Clause 5.07 of the *Airports (Environment Protection) Regulations 1997*. The EMP focuses on the near-term actions that are to be implemented during the operation of the ERS in the 2024-2027 Authorisation period. The EMP also covers long-term strategic work currently being progressed for the improvement of the Mill Stream ERS and the Malabar wastewater system.

The EMP was developed to:

- Review and manage identified environmental risks from the operation of the ERS to the receiving environment.
- Specify requirements on how environmental safeguards will be implemented to improve the operation of the Mill Stream ERS and water quality within Mill Stream and Foreshore Beach.
- Define responsibilities and reporting lines for implementation.
- Provide clear and appropriate performance indicators for the delivery and completion of EMP actions.
- Define the requirements for reporting and meetings.
- Meet the requirements of the Authorisation.

This report provides updates on all the actions detailed within objectives 1 to 7 of the EMP, these objectives are:

- **Objective 1** – Increase capacity of the wastewater system to reduce frequency and volume overflows
- **Objective 2** – Feasibility of relocating the Grit Pit
- **Objective 3** – Hydraulic Improvement Plan (HIP)
- **Objective 4** – Protect the environment and public health
- **Objective 5 –** Monitor wastewater system performance, odour and receiving waterway health
- **Objective 6 –** Conduct effective complaint management
- **Objective 7 –** Progress Reporting

3.1 EMP Objective 1 -Increase capacity of the wastewater system to reduce frequency and volume of overflow Environment Management Plan (EMP) 2024-2027

The most effective way for Sydney Water to improve the performance of the Mill Stream ERSs over time and comply with the requirements of the *Airports (Environment Protection) Regulation 1997* is to increase the capacity of the wastewater system. The actions updated below will deliver greater capacity and reduced overflow volume and frequency, in particular desilting, grit removal and reducing the ingress of stormwater into the wastewater system.

3.1.1 EMP Action 1.1 – Desilt SWSOOS 2 -SP0038 to Malabar WRRF (Condition 3e)

Due to the asset length and varying complexities of the project, the work is planned to be delivered in 6-8 work packages. The initial two packages of work are currently in progress.

Package A1 - North Barrel

The first package includes desilting of the first 330 linear metres of the North Barrel, as well as the construction of new ventilation hatches and enlargement of access points to facilitate future work. This work commenced in Quarter 4 of 2024 with approximately 35 tonnes of silt having been removed to date (Figure 2, Figure 3, Figure 4).

However, the continuation of works was hampered by flow isolation constraints required for safe access for crews. Additional site investigation and design work were required beyond the initial scope to address factors impacting the mitigation of dry weather overflow risk and the provision of safe access within the asset. These developments led to expanded technical assessments and design modifications to ensure compliance with regulatory standards and operational safety.

In 2025, work external to the asset were completed including, widening of the access hatch and installation of temporary covers. The permanent covers are currently being manufactured. The additional design works for the flow isolation valve have substantially been completed with final design expected in early 2026. The Planning Approval documentations have been issued to stakeholders for review.

The completion of final design and external approvals are now expected to be completed by March 2026. This has delayed the completion of package A1 works to April 2026, at which point 4% (330 metre of 9 kilometres) of SWSOOS2 will have been desilted, with approximately 320 tonnes of silt expected to be removed.

Package A2 - South Barrel

The second work package will commence after the completion of works within Package A1. Package A2 includes the desilting of 330 linear metres of the South cell with approximately 380 tonnes of silt is expected to be removed. Once completed, 7% (additional 330 metre of 9 kilometre) of SWSOOS2 will be desilted. The completion of Package A1 and A2 desilting work will deliver 9.5% of performance progress (tonnage removed) by June 2026.

Future Packages

Planning work for future packages commenced in November 2025.

Figure 2: Desilting SWSOOS2 Package A1

Figure 3: Site set-up for cross connection 2 Desilting

Figure 4: Decanting wastewater before moving silt off-site

3.1.2 EMP Action 1.2 – Implement source control for the Malaba System to reduce wet weather inflows into the SWSOOS (Condition 3f)

Source control works reduce the amount of stormwater entering the wastewater system and decrease the frequency and volume of overflows from ERSs during wet weather. These works will be conducted in sewer catchments across the Malabar system and will be crucial to the medium to long-term improvement of the Mill Stream ERS. Three types of source control works will be used to address stormwater ingress (Refer Table and Table).

Table 4: Source Control Stages

Source Control Stage	Definition
Stage 1 – Inflow management	Involves rectifying ERS by installing backflow prevention valves. These valves prevent stormwater from flowing into the wastewater system from the overflow discharge pipe.
Stage 2 – Infiltration management	Focuses on reducing infiltration through damaged pipes and maintenance holes. This stage targets assets that are in high infiltration areas. Rectification works include pipe lining, maintenance hole repairs and installation of anti-infiltration devices (rain stoppers) in maintenance holes that are at risk of stormwater ponding or overland stormwater flow and flooding.
Stage 3 – Private properties	Implementation of smoke testing and property inspections to identify stormwater connections and rectifying defective assets.

Rectification works include repairing faulty overflow relief gullies and redirecting roof drainage connections from the sewer to the stormwater

The progress of work programs across the prioritised catchments within the Malabar system is provided below (Table).

Table 5: Source Control Works-Status Update

Prioritised catchment within the Malabar system	Refer To Figure	Update	Stage 1- Inflow Management	Stage 2- Infiltration Management	Stage 3- Private Properties
Prospect Catchment	Figure 5	Source control works delivery complete.	90 ERSs equipped with backflow prevention valves 400 Maintenance holes fitted with rain stoppers	11 km of pipes relined	11,300 properties smoke tested 530 property defects rectified
Lower North Georges River Submain (NGRS) & Cooks River Catchment	Figure 5	Source control delivery works complete	101 ERSs equipped with backflow prevention valves	-	-
Greater Parramatta & the Olympic Peninsula (GPOP) areas in the Cooks River catchment	Figure 5	Source control delivery works are in progress	14 ERSs equipped with backflow prevention valves	-	-
Wet Weather Overflow Abatement (WWOA) 2024-25 catchments- Peakhurst, Lugarno & Padstow	Figure 5	Source control works delivery is complete	147 ERSs equipped with backflow prevention valves 500 maintenance holes repaired and fitted with rain stoppers	9 km of pipes investigated 2.4km of pipes relined	14,000 properties were smoke tested 700 property defects rectified

Prioritised catchment within the Malabar system	Refer To Figure	Update	Stage 1- Inflow Management	Stage 2- Infiltration Management	Stage 3- Private Properties
Mill stream Long-term source control works	Figure 6 Figure 7	Source control investigation began in August 2025 but was delayed due to cost proposal negotiations. Now that these issues have been resolved, field investigation works have commenced.	124 ERSs to be equipped with backflow prevention valves	1215 maintenance holes to be fitted with rain stoppers	225 schools to be smoke tested
Wet Weather Overflow Abatement (WWOA) 2025-30 - source control works in 9 catchments: Kensington & Rockdale, Kingsgrove & Randwick Banksia & Ashfield Clementon Park & Lewisham Liverpool & Wakely Mt. Pritchard Prairiewood & Ashcroft Edensor Park Wetherhill Park	Figure 8 Figure 9	The source control investigation is underway but has been delayed due to cost proposal negotiations. These are expected to be resolved soon and field investigations will commence in February 2026	240 ERSs to be equipped with backflow prevention valves	3,500 maintenance holes to be investigated for repair and fitted with rain stoppers 35 km of pipes to be investigated for relining	50,000 properties to be smoke tested to identify defects and repair

Prioritised catchment within the Malabar system	Refer To Figure	Update	Stage 1- Inflow Management	Stage 2- Infiltration Management	Stage 3- Private Properties
Growth 2025-30 - source control works in 5 catchments: Alexandria, South Sydney, Mascot Homebush, Strathfield Moorebank, Chipping Norton, Liverpool Riverwood Concord West and Concord East	Figure 10 Figure 9 Figure 11	The source control business case has received approval, and investigation works are programmed to commence in March 2026	60 ERSs to be equipped with backflow prevention valves	1,050 maintenance holes to be investigated for repair and fitted with rain stoppers 17 km of pipes to be investigated for relining	12,000 properties to be smoke tested to identify defects and repair

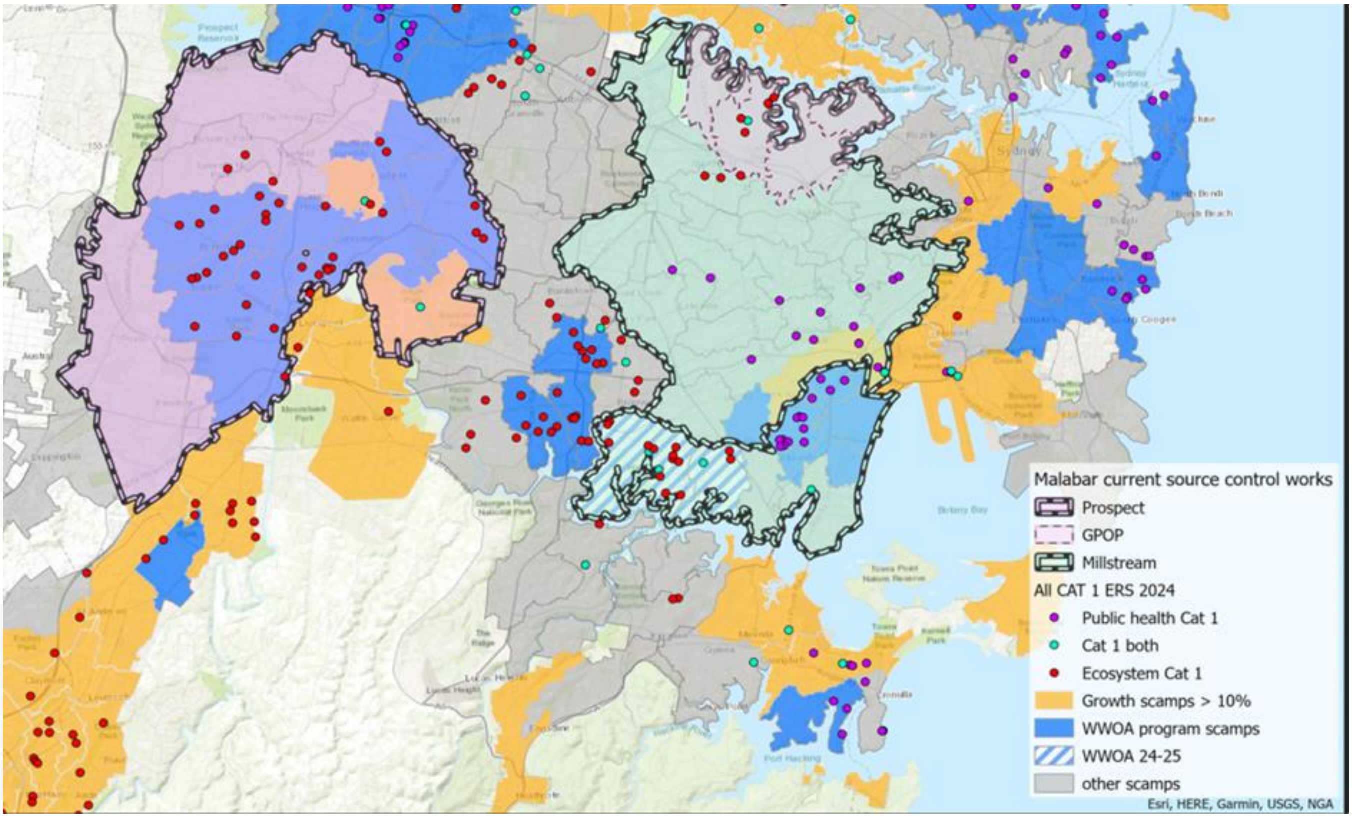

Figure 5: Source Control Catchments in the Malabar System

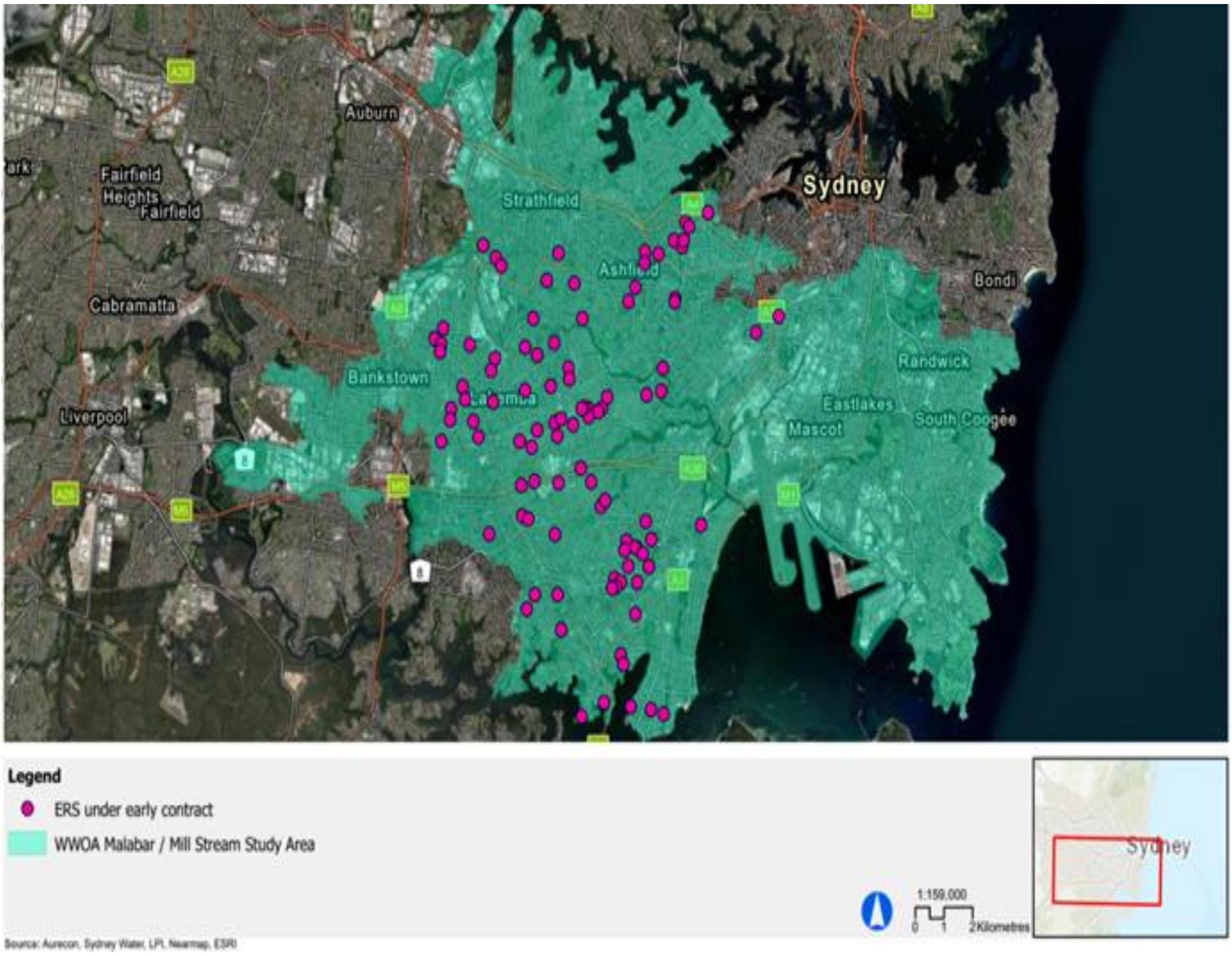

Figure 6: Mill Stream Source Control-ERS under consideration

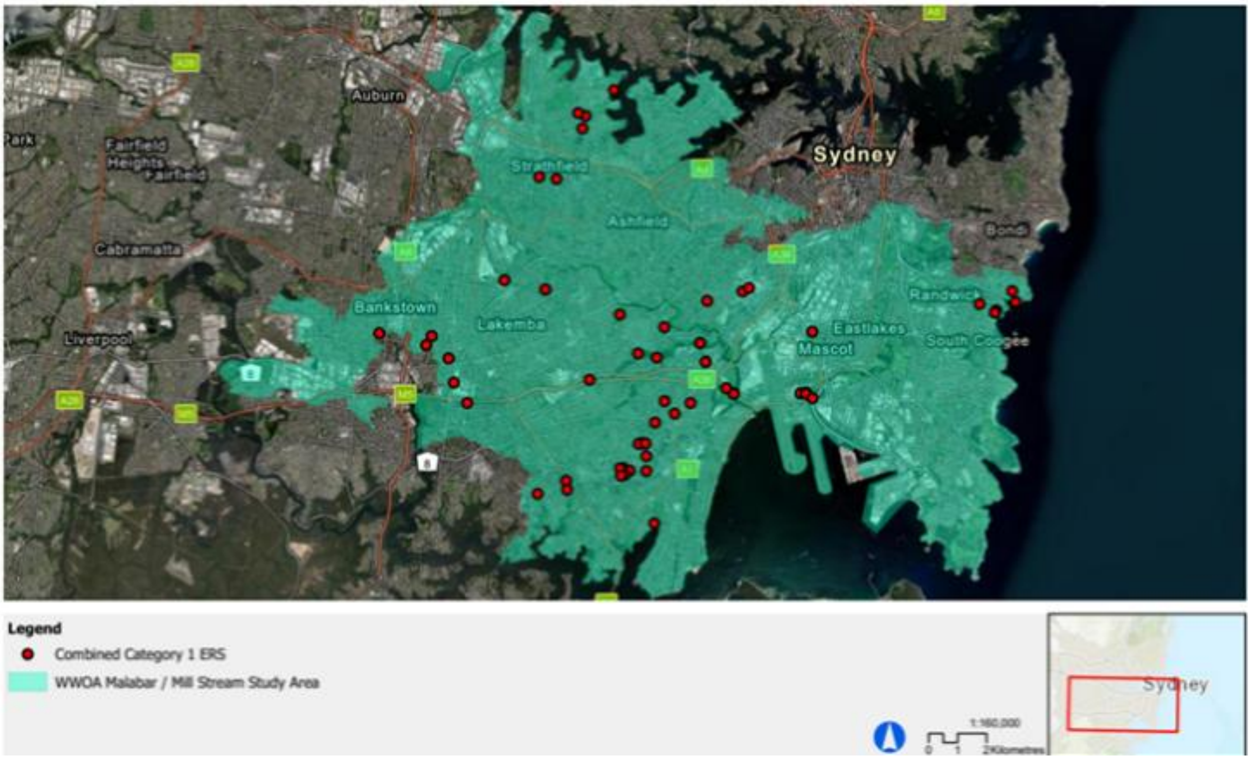

Figure 7: Mill Stream Source Control -Private properties under consideration

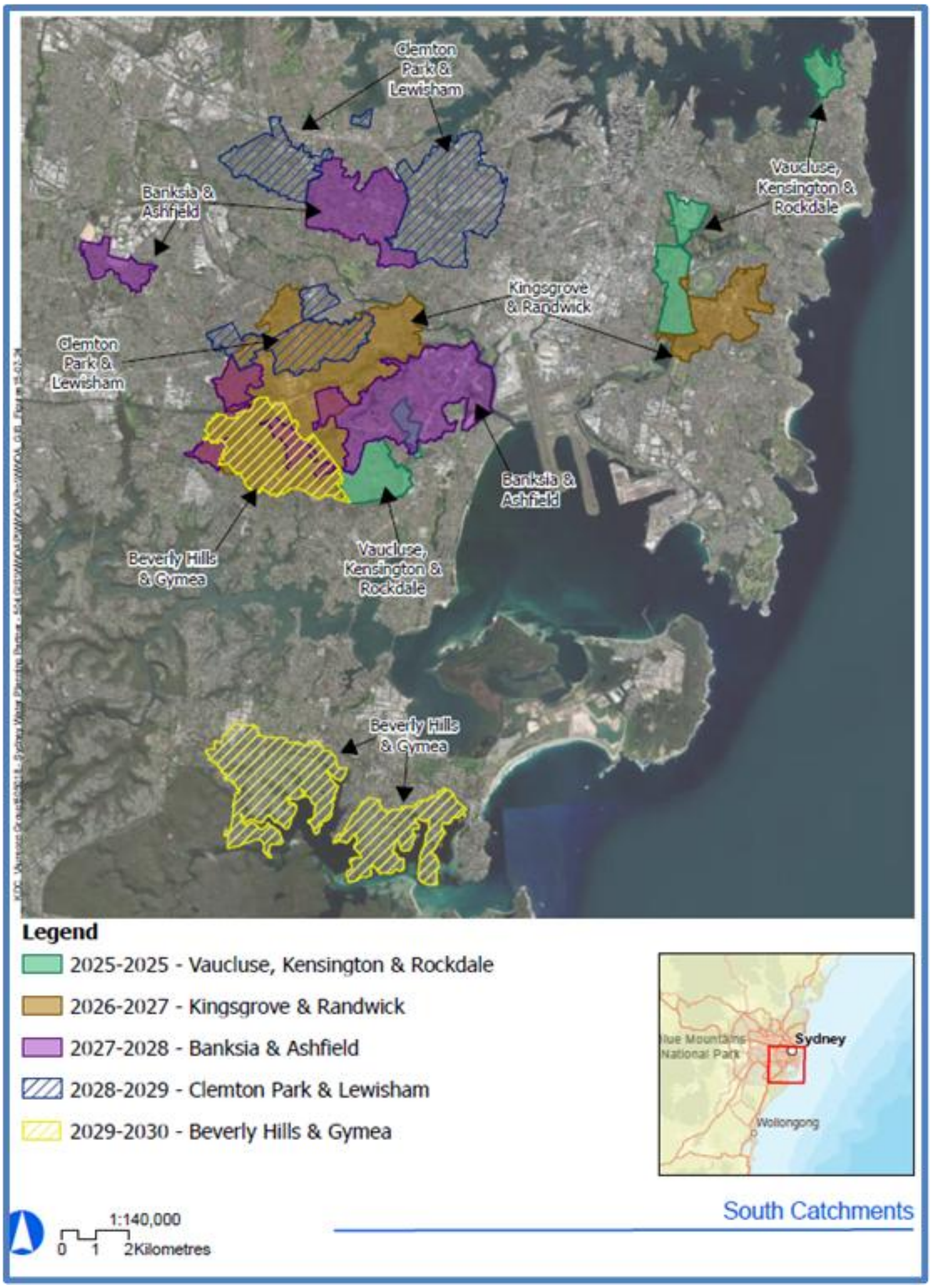

Figure 8 : WWOA 2025-2030 Catchments – Area South

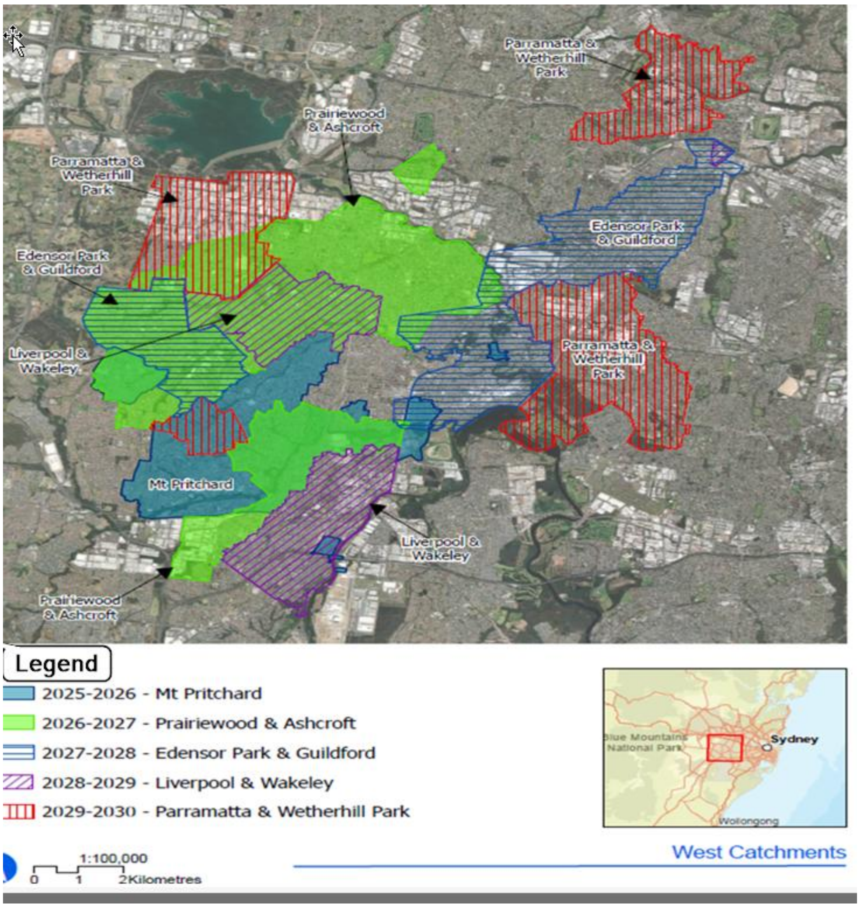

Figure 9: WWOA 2025-2030 Catchments Area West

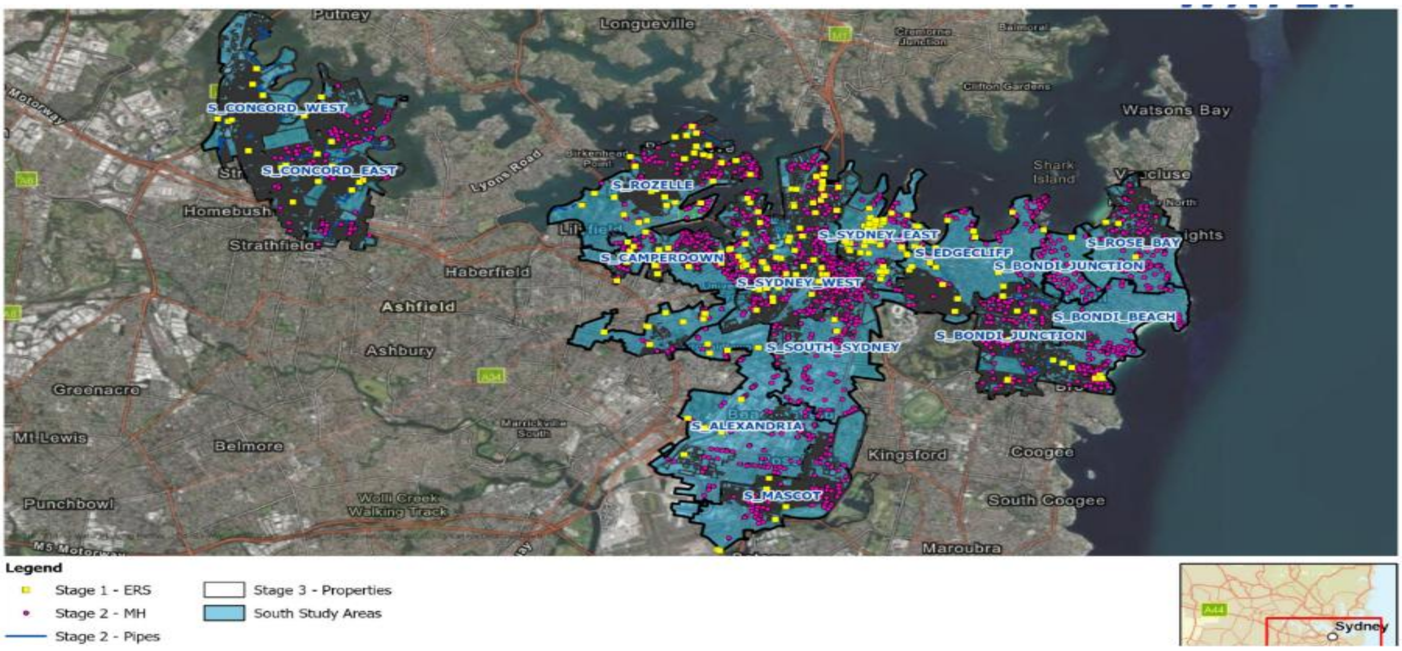

Figure 10: Growth 2025 – 2030 Catchments- Area South

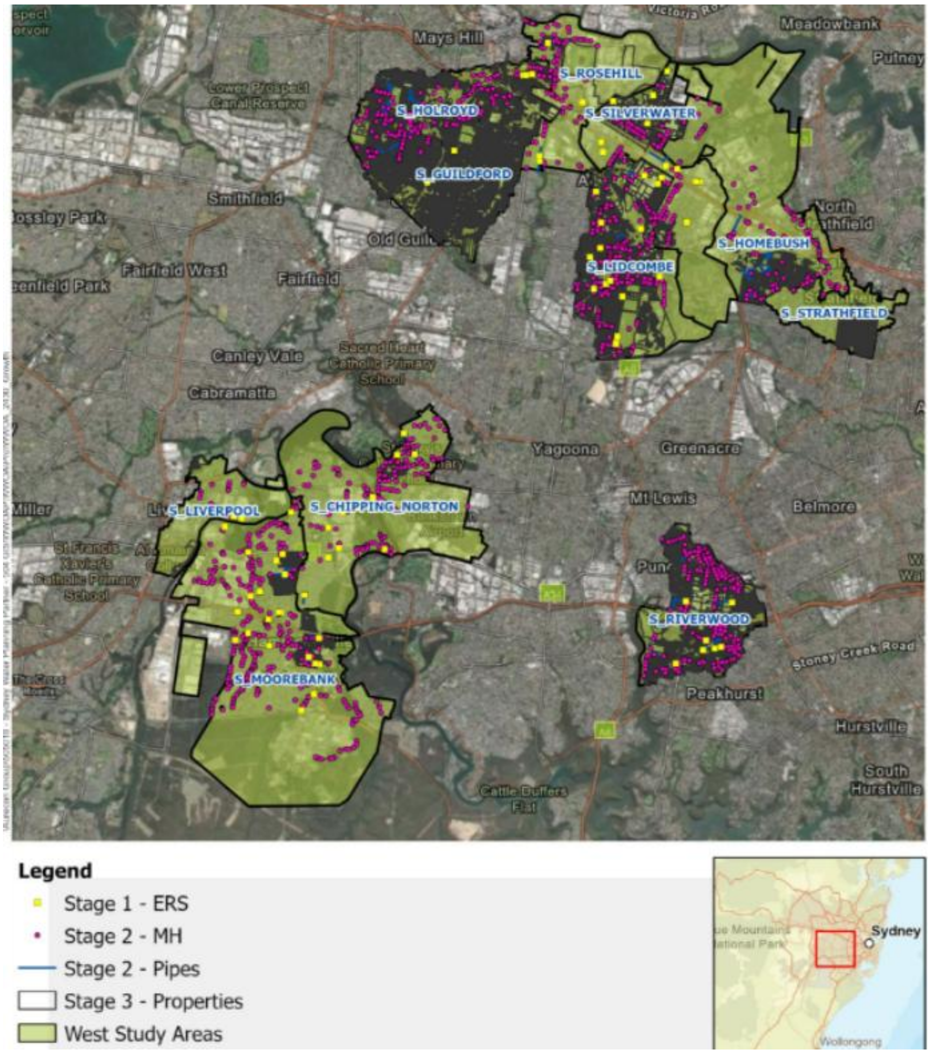

Figure 11: Growth 2025-2030 Catchments – Area West

3.1.3 EMP Action 1.3 – Conduct Grit Pit Maintenance (Condition 3g)

Sydney Water is compliant with EMP Action 1.3 for the reporting period 17 January 2025 to 31 December 2025. Routine maintenance of the grit pits located within the Sydney Airport precinct (SWSOOS1, SWSOOS2 North and SWSOOS2 South) was undertaken throughout the reporting period to prevent downstream grit accumulation and maintain system performance. A total of 1,312.9 tonnes of silt was removed across seven completed maintenance cycles. As the January 2025 cycle formed part of the previous compliance period, the first cycle for this reporting year commenced in March 2025. The eighth cycle, scheduled for December 2025, was delayed due to Aviation Security Identification Card (ASIC) renewal constraints and has been rescheduled for completion in early 2026.

Operational efficiency has continued to improve, supported by the completion of the hardstand area in October 2024, which enabled safe, all-weather access for maintenance crews and facilitated Sydney Airport's approval for daytime cleaning. Ongoing collaboration with Sydney Airport Operations has also strengthened planning and coordination for desilting activities and reduced the number of shifts required – all weather access for maintenance crews and facilitated Sydney Airport's approval for daytime cleaning (Refer to Figure 12 & Figure 13).

Based on the maintenance completed, the volume of material removed, and the operational improvements implemented, Sydney Water has met the intent and operational requirements of EMP Action 1.3 and remains compliant with this condition (Refer to Table 6).

Table 6: Grit Pit Maintenance Cycles

Maintenance cycles	Dates	Silt removed (Tonnes)	Comments
Cycle 1	03-07 March2025 10-14 March 2025	210	
Cycle 2	22-24 April 2025 29-30 April 2025 01-02 May 2025 05-09 May 2025	310	No work 28 April high flow due to wet weather
Cycle 3	16-18 June 2025 23-27, 30 June 2025	173.5	High flow due to wet weather limited work from July1-4
Cycle 4	4, 6-8 August 2025 11-15 August 2025	196.2	Full cycle completed with 1 shift lost for bad weather (fog)
Cycle 5	22-26 September 2025 29-30 September 2025 01-03 October 2025	181.5	Full cycle completed

Maintenance cycles	Dates	Silt removed (Tonnes)	Comments
Cycle 6	3-7 November 2025 10-12 November 2025	126.6	Full cycle completed
Cycle 7	15-16 December 2025 18-19 December 2025 22-23 December 2025	115.1	Delayed by one week due to issues with renewal of ASIC passes. completed.
Cycle 8	05-09 January 2026 12-16 January 2026		Deferred to Feb 9, 2026, due to delayed completion of December 2025 cleaning cycle
Total Silt (Tonnes) Removed for the reporting period		**1312.9**	

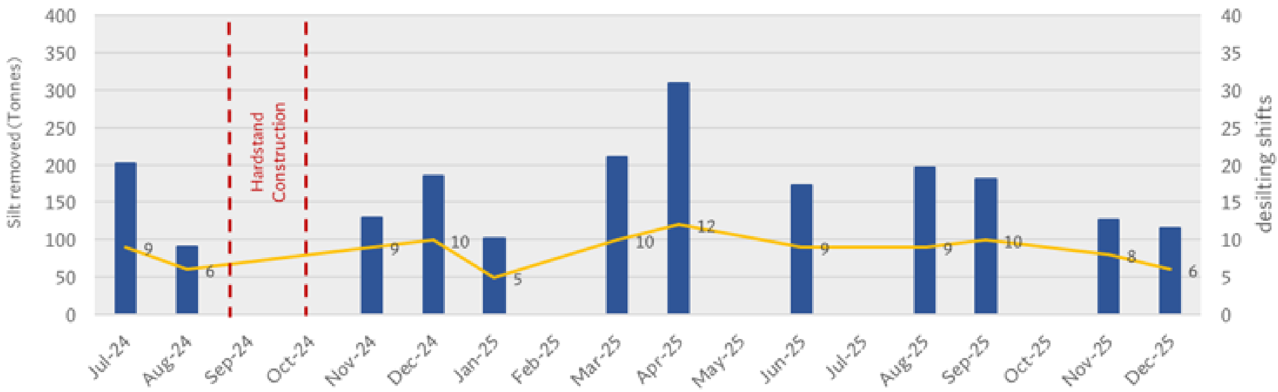

Figure 12: SWSOOS Airport Grit Pits Silt Removal 2024-2025

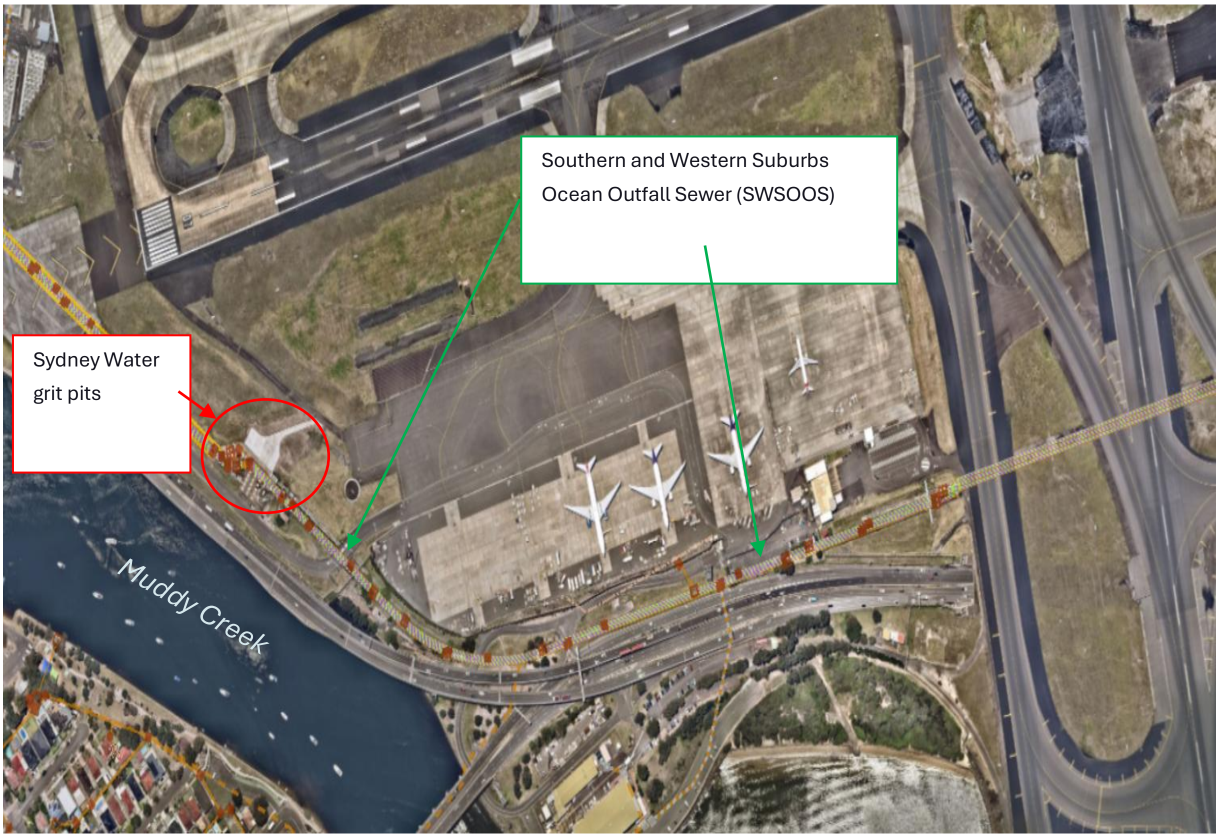

Figure 13: SWSOOS Sydney Airport Grit Pit Location

3.1.4 EMP Action 1.4 – Implement Malabar Strategic Business Case – Network Augmentation (Condition 3h)

The near to mid-term (formerly referred to as long-term) strategy for the Malabar Wastewater System is documented in the Malabar System Investment Program Strategic Business Case (SBC). While progressing the options planning for the SBC, Sydney Water's investigations showed that releasing highly treated water to the Georges River (system disconnection) or building a new SWSOOS pipeline from Arncliffe to Malabar (system augmentation) would cater to demand through to 2046. The modelling also showed additional benefits would be achieved with planned operational measures of in-catchment source control and SWSOOS desilting. These provide better value for money than the highly expensive deep tunnel from Arncliffe to Malabar or a new wet weather treatment plant at Mill Stream, both considered in the earlier SBC. Sydney Water is currently finalising the preferred option to service Growth till 2046, and a decision will occur in 2026. Sydney Water will progress the delivery planning of the preferred option considering the capped budget scenario.

Capital investments for the near-term system works are provisioned in the 2025-2030 IPART submission, with a final determination received in September 2025. Capital investments for mid-term system works will be provisioned in the 2030-2035 Independent Pricing and Regulatory Tribunal (IPART) submission.

Sydney Water met with the Airport Environmental Officer (AEO) on 9 October 2025 to present an update on the IPART determination. The presentation covered the background and newly approved pricing structure, an overview of expenditure allowances for the 2025–2030 regulatory period and outlined the next steps.

The meeting was conducted online and provided a summary of the current determination as approved by IPART.

Sydney Water is currently prioritising its delivery commitments and remains dedicated to ensuring that every dollar spent delivers tangible value for our customers.

Between now and March 2026, Sydney Water will:

- Finalise the prioritisation of expenditure plans
- Present the prioritised plan to the Board for endorsement
- Communicate the outcomes of the prioritisation process to staff, customers, and stakeholders
- The next meeting to provide an update to the AEO is scheduled for early March 2026.

3.1.5 EMP Action 1.5 – Botany Low Level Carrier Rehabilitation (Condition 3i & 20)

Sydney Water is non-compliant with EMP Action 1.5 for the reporting period 17 January 2025 to 31 December 2025.

The Botany Low Level Carrier is a disused gravity main that requires extensive rehabilitation to prevent asset failure. Once rehabilitated, this asset can be utilised to increase wet weather storage at Sewer Pumping Station 38 (SP0038) in Mascot. During periods of high flow, sewage will accumulate in the sewer and be pumped to SP0038 for wastewater screening. The accumulated wastewater will then be discharged into the SWSOOS2 via SP0038 once sewer flows have subsided.

The project, originally scheduled for operational completion in December 2024, was delayed due to limited accessible areas without an access agreement and the extended negotiations required to secure the access license with Sydney Airport.

The license agreement negotiation completed in February 2025, enabling Sydney Water to review the project scope and re-engage the construction contract. Cleaning and assessment of an 82 m section between SP0038 and Ross Smith Avenue were completed in May 2025. It was determined that additional civil works, including dig-and-lay sections and raising maintenance holes, require a revision to license terms. Further, the scope review also included reassessment of benefits to consider if a focus on subsidence repairs would be supported. Sydney Water has been negotiating these changes with Sydney Airport, after which the revised license will be submitted for legal review prior to commencement.

In parallel to access negotiation, Sydney Water has completed contractor engagement and finalised design approval for the relining option. Subject to finalisation of the license agreement with Sydney Airport, site mobilisation is scheduled for early 2026, with project completion forecasted for early 2027.

Further to the current schedules, Sydney Water submitted a Variation to the Authorisation in September 2025. In addition, Sydney Water will be submitting a variation to the Environment Management Plan (EMP), in conjunction with the September 2025 Authorisation variation, to address the Botany Low Level Carrier Project.

3.2 EMP Objective 2 – Feasibility of Grit Pit Relocation

Sydney Water grit pits are situated within the boundaries of Sydney Airport. To ensure appropriate maintenance, regular access to these facilities is essential; however, such access is often complicated by operational and security constraints inherent to the airport environment. In response to these challenges, Sydney Water has conducted a feasibility assessment to evaluate the potential relocation of the grit pits to a site outside airport land.

3.2.1 EMP Action 2.1 – Conduct feasibility assessment for the relocation of the SWSOOS Grit Pits (Condition 3j & 17)

The details of the feasibility assessment for the relocation of Sydney Water's grit pits have been reported in the Annual Compliance Report 1. In accordance with condition 17 of the Authorisation, Sydney Water delivered the final feasibility report to the Airport Environment Officer (AEO) on 30 July 2024. The report's final recommendation was to proceed with Option 2—maintaining daytime access to the grit pits, and to monitor the effectiveness of this arrangement over a 12-month period.

Daytime access has been successfully implemented over the past year, supported by the completion of a hard stand, which has facilitated access during wet periods and enhanced silt removal operations. Nevertheless, some cancellations have occurred due to the unavailability of security escorts from Sydney Airport. This issue has been formally raised with Sydney Airport, and Sydney Water will continue to engage with airport representatives to develop a viable long-term solution. Progress and ongoing challenges will be discussed at future Mill Stream Stakeholder Reference Group (SRG) meetings.

3.3 EMP Objective 3 – Hydraulic Improvement Plan (HIP)

Opportunities to enhance the hydraulic performance of the Mill Stream were systematically investigated, leading to the development of a comprehensive delivery plan by Sydney Water. To provide strategic oversight and guidance for the ongoing implementation of the Hydraulic Improvement Program (HIP), Sydney Water established the Hydraulic Improvement Leadership Group (HILG). This group comprises representatives from Bayside Council, Sydney Airport (SYD), the Department of Infrastructure, Transport, Regional Development, Communications, Sport and Arts (DITRDCSA), the NSW Port Authority, and the NSW Environment Protection Authority (EPA). The HILG is responsible for ensuring effective governance and coordination throughout the continued staging of the HIP.

3.3.1 EMP Action 3.1 – Chair Hydraulic Improvement Leadership Group (HILG) (Condition 3k & 15)

Sydney Water continues to lead collaborative efforts under the Hydraulic Improvement Leadership Group (HILG) and the broader Stakeholder Reference Group (SRG) to deliver key environmental and operational improvements for the Mill Stream system. These initiatives align with the Environment Management Plan (EMP) and Authorisation requirements for 2024–2025.

Sydney Water continues to provide updates on progress for EMP Action 3.2 through the Stakeholder Reference Group (SRG), which is attended by all members of the Hydraulic Improvement Leadership Group (HILG). The HILG comprises representatives from Sydney Water, Sydney Airport, Bayside Council, the NSW Port Authority and the Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts (DITRDCSA).

Strategic-level discussions between Sydney Water and Sydney Airport have focused on the key tasks associated with Phase 2B of the Hydraulic Improvement Plan and the indicative cost considerations required to support internal funding approvals and project development.

The HILG agreed that updates on progress and further design development for the Mill Stream mouth desilting project will continue to be provided through future SRG meetings, subject to project creation being approved and a project manager being appointed. The HILG will recommence meeting as a separate entity to the SRG when the project to dredge the mouth of the Millstream is created and a project manager appointed. At that time the function of the group will be that of the "Project Board"

3.3.2 EMP Action 3.2 – Conduct HIP Phase 2B (Condition 3k)

Dredging the sand from the mouth of the Millstream is being progressed as the preferred option. Sydney Water and Sydney Airport aim to contribute to this outcome according to their respective needs and governance requirements. Sydney Water and Sydney Airport are progressing projects and submitting funding requests to achieve the required internal and external approval for works. The primary needs for Sydney Water are to ensure the free flow of the stormwater mains draining Botany, located at Folkestone Parade and The Esplanade. For Sydney Airport, the drivers are to maintain water depths and manage sediment accumulation. Both organisations share the goal of maintaining the health and natural flows of the waterway.

3.3.3 EMP Action 3.3 – Conduct HIP Phase 3 Implementation (Condition 3k)

Sydney Airport is continuing to progress the project through its internal budget allocation and approval processes.

The implementation of Phase 3 plan for the operational solution will be dictated by the approval and governance requirements of each organisation. Each organisation is developing its own plan, which will then be combined to capitalise on any synergies in delivery. Sydney Water has submitted its project prospect for internal approval. This will be taken up through Sydney Water's internal process for Investment prioritisation and optimisation with the outcome expected in early 2026.

3.4 EMP Objective 4 – Protect the environment and public health

Sydney Water remains committed to enhancing the performance of the Mill Stream Emergency Relief Structures (ERS). To reduce both the frequency and volume of overflows, all practicable measures will continue to be implemented to minimise associated environmental and public health risks.

3.4.1 Action 4.1 -Inspect Mill Stream and Foreshores Beach after all overflow events and remove gross pollutants (Condition 3p)

Sydney Water crews attend the site after every notified overflow event and assess whether gross pollutants are present, and an environmental clean-up is required.

3.4.2 Monitored discharges

The total recorded discharge for the reporting period was 2,385 ML, occurring over 23 overflow events and 61 discharge days. Detailed monthly volumes, event durations, and discharge summaries for the period 1 January 2025 to 31 December 2025 are provided (Appendix 1: Sewer Overflow Volume of Discharge (ML) estimate report Mill Stream (Botany Bay)).

A comparison of Monthly totals for wastewater discharge and rainfall at Marrickville Bowling Club, Kogarah Golf Club and Bexley can be reviewed in Appendix 1: Sewer Overflow Volume of Discharge (ML) estimate report Mill Stream (Botany Bay) Rain Gauge locations used for reporting comparison can be viewed in

Figure 21 and Figure 22.

During preparation of this report, Sydney Water undertook a quality review of all underlying discharge data used throughout the year. This review identified several inconsistencies in previously extracted datasets. After correction, the reported discharge volumes for August and September decreased, resulting in an overall reduction of approximately 2% in the total annual discharge volume. Monthly totals presented in this report therefore reflect the corrected data. The monitoring sensors which are used for measuring volume are located at the overflow points (Figure 21).

3.4.3 Overflow inspections and clean-up

Sydney Water monitors overflow activity at all Mill Stream Emergency Relief Structures (ERSs). When an overflow occurs at any ERS, an alert is registered. Once the overflow has ceased, the alert is transmitted to the Systems Operations Centre (SOC), which raises a work order for a field crew to attend site and undertake a material harm assessment. Where material harm is identified, an incident is declared and an environmental clean-up is initiated.

Between 1 January 2025 and 31 December 2025, a total of thirty-eight site inspections were conducted in response to overflow alerts with approximately 150.19 m3 debris collected. Most call outs were experienced in August 2025 and September 2025 with clean-ups carrying over to the next month. Of these, eight inspections met the material harm assessment criteria, and environmental cleanups were subsequently undertaken at Mill Stream and Foreshore Beach (Table 7) and (refer to Appendix 3: Summary of Mill Stream Incident Responses during the reporting period). Gross pollutants and debris were collected, bagged and removed from site, as illustrated in (Figure 14). Clean-ups were subsequently undertaken at Mill Stream and Foreshore Beach.

Field Sampling and Testing Analytical results from Sydney Water Environmental Response Team undertaken for each of the eight material harm incidents were provided to Mill Stream stakeholders during and following the material harm updates, references to the Analytical reports are tabled in Appendix 3: Summary of Mill Stream Incident Responses during the reporting period.

Table 7: Mill stream incident responses for authorisation period 1 January 2025 to 31 December 2025

Month	Number of Inspections	Number of Clean-Ups	Gross pollutants removed m3	Syringes removed
January 2025	5	2	6	9
February 2025	3	1*	3.33	0
March 2025	3	2*	2.37	0
April 2025	4	2*	14.44	4
May 2025	9	1*	5.81	3
June 2025	0	0	0.00	0
July 2025	4	2*	2.11	2
August 2025	6	1*	68.56	25
September 2025	2	1*	43.96	25
October 2025	0	0	0.00	0
November 2025	2	1	5.44	1
December 2025	0	0	0.00	0
Total 1 Jan 2025 to 31 Dec 2025	**38**	***8**	**152.03**	**69**

Note: *Clean-up activities were carried over from the previous month. Debris volumes are reported in the month when clean-up activities were undertaken (Refer).*

Figure 14: Foreshore Beach Clean-up Photos

3.4.4 EMP Action 4.1 – Inspect Mill Stream and Foreshore Beach after all overflow events and remove gross pollutants. (Condition 3p)

Sydney Waters is compliant with all Foreshore Beach overflow events and removal of gross pollutants. Operational teams have responded to all overflow events during the reporting period. For detailed information on the responses to overflows, please refer to Section- 3.4

3.4.5 EMP Action 4.2 – Implement wastewater screening at Airport site (Condition 3L)

The objective of wastewater screening is to reduce the transport of gross pollutants via Mill Stream wet weather overflows to Foreshore Beach, thereby minimising potential harm to public health and the environment. In March 2023, a feasibility and options study identified wastewater screening at Sewer Pumping Station 38 (SP0038) as the preferred option. The screens will provide preliminary treatment of overflows by redirecting discharges through a screening system to remove debris and rags prior to reaching Mill Stream. In October 2024, the initial concept design of the preferred option indicated significant impact to the heritage fabric of the state heritage listed SP0038, resulting in prolong delivery timeframe and construction challenges.

In January 2025, an analysis was completed to explore alternative solutions that could meet project objectives within the required timeframe. Based on this analysis, a Gross Pollutant Trap (GPT) was selected, and a concept design was completed. However, during detailed design and market engagement revealed that the GPT would not achieve the desired level of pollutant removal in significant rainfall events due to hydraulic challenges, coupled with site constraints.

In response, Sydney Water is now progressing a design feasibility and constructability investigation for a new alternative solution. This change in approach involves a revised delivery timeframe which is expected to start construction in late 2026.

3.4.6 EMP Action 4.3 – Maintain permanent signage at Foreshore Beach

Sydney Water and Sydney Airport will continue to maintain the signage and updates implemented in November 2024. These updates were documented in the Mill Stream Quarterly Report for Period 2 (1 January to 31 March 2025) and reaffirmed in the subsequent Period 3 report (1 April to 30 June 2025) (Figure 17, Figure 18).

The signage includes:

- QR codes linking to Beachwatch updates and Mill Stream information.
- Multi-language notifications.
- Interpreter service details.
- Permanent signage at Foreshore Drive Car Park and Mill Stream Lookout.

At the Mill Stream Stakeholder Reference Group (SRG) meeting on the 12 February 2025, Sydney Airport informed Sydney Water that they had engaged with several stakeholders regarding signage at Tower Beach, particularly in relation to recreational use. These stakeholders are collaboratively drafting revised signage to reflect current guidance for both Tower Beach and Botany Bay. Given the differences between the proposed Tower Beach signage currently in place at Mill Stream and Foreshore Beach, considering the proximity of these locations, Sydney Airport shared details of Sydney Water's signage with the NSW EPA in February 2025. This was done to support EPA's review and ensure consistency across signage prior to finalising an update for Tower Beach (Figure 15).

Sydney Airport has noted that its primary concern relates to potential changes in the size of the signage. The most recent update provided by Sydney Airport was on the 17 October 2025. At the time, Sydney Airport had not received any further information from the EPA regarding updated fishing advice. It is understood that the EPA is aiming to provide this advice by early 2026. Sydney Airport has also received confirmation that Beachwatch monitoring will continue for at least the next twelve months until 2026.

Both organisations are preparing for potential changes based on new Fishing advice and Beachwatch updates.

Sydney Water wishes to note that there is an ongoing issue of vandalism affecting the Sydney Water signage at Mill Stream Lookout (Figure 15).

In response, Sydney Water has engaged with Bayside Council and the NSW Port Authority regarding the replacement of the damaged pole at the lookout area. The NSW Port Authority confirmed that a contractor had reinstalled the pole and Sydney Water has updated the damaged sign with are placement sign (Figure 16).

Figure 15 : Sydney Airport Signage at Tower Beach

Figure 16: Damaged sign 3 June 2025 & Updated sign 10 January 2025

Figure 17: Mill Stream Signage showing QR codes & Interpreter Service

Figure 18: Mill Stream Map of Signage at Mill Stream Look out.

3.4.7 EMP Action 4.4 – Ensure all maintenance personnel and contractors are aware of threatened species fact sheets.

Sydney Water maintains a dedicated Work Instruction for Mill Stream and Foreshore Beach wet weather clean-ups (D0001845.02). This document is accessible to all maintenance personnel and contractors and includes guidance on threatened species, ensuring that all parties are informed and compliant with relevant environmental considerations (Refer Appendix 5: D0001845.02 – Mill Pond/Foreshore Beach Material Harm Assessment)

3.4.8 EMP Action 4.5 – Store gross pollutants appropriately during clean-ups (Condition 3p)

D0001845.02 outlines procedures for appropriate storage of gross pollutants during clean-ups activities. Specifically, it mandates that all solids be bagged and placed on a temporary waterproof membrane (e.g. taupe) if they are to remain onsite for a short period prior to removal (Refer Figure 19: Gros Pollutants stored onsite prior to removal).

Document Update and Workshop Outcomes

On 4 July 2025, Sydney Water conducted an internal workshop focused on improving wet weather clean-up procedures for Mill Stream and Foreshore Beach. As a result of this workshop, an updated version to D0001845 has been completed. The new version D0001845.02 is currently in use.

Figure 19: Gros Pollutants stored onsite prior to removal

3.4.9 EMP Action 4.6 – Dispose of gross pollutants appropriately

During this reporting period, Sydney Water's operational staff adhered to the appropriate disposal process for waste collected after each clean-up. The bagged waste was periodically collected and removed from the site during the clean-ups. It was then transported to Sydney Water's depots and subsequently disposed of at an appropriate waste management facility as per D0001845.02.

3.5 EMP Objective 5 – Monitor wastewater system performance, odour and receiving waterway health

Sydney Water undertakes extensive monitoring of the wastewater network (Mill Stream ERS and associated assets), receiving waterway and air quality.

3.5.1 EMP Action 5.1 – Conduct continuous overflow monitoring and routine monthly reports (Condition 3a, 3b, 3c & 14)

Sydney Water monitored Mill Stream overflows in accordance with the requirements of the Environmental Management Plan (EMP) for the reporting period from 1 January 2025 to 31 December 2025. Monthly Overflow Reports for this period were submitted to the Airport Environment Officer (AEO) and relevant stakeholders, including Sydney Airport, Bayside Council and the Environment Protection Authority (EPA). Each report provides a summary of debris removed (in cubic metres) during clean-up activities, together with graphical representations of overflow levels and rainfall data. (Refer to Figure 20)

During the reporting period, Sydney Water also monitored Emergency Relief Structure (ERS) gauge levels at four locations within the Sydney Airport precinct. These gauges are located at the Mill Stream overflow points (802063, 802064, 802065 and 802310) (Refer Figure 21).

The Mill Stream overflow is located on the Southern Division Submain sewer, immediately upstream of its connection to the South Western Sydney Ocean Outfall Sewer (SWSOOS). Due to this proximity, while the overflow structure is situated on a branch sewer, it also functions as a relief point for the SWSOOS main trunk sewer. (Refer Figure 1)

The graphs provided in this report present rainfall, overflow volume and sewer level data for the reporting period. For ease of reference, quarterly graphs are included in Appendix 7: Sydney Water Monitored ERS Gauge levels at Mill Stream Quarterly Periods Rainfall plots, Overflow Volumes and Sewer Levels. These plots include two traces representing Mill Stream conditions: the sewer carrier level and a flat-line trace indicating the overflow threshold. To demonstrate the hydraulic relationship with the main trunk sewer, the SWSOOS No. 1 level trace from nearby SP0038 is also shown, with an offset applied to account for differences in carrier elevations. The graphs also include two rainfall traces representing precipitation in the upstream catchment influencing the SWSOOS (Refer Figure 22).

As part of the preparation of this report, Sydney Water undertook a quality review of the data used for annual reporting. This review identified minor inconsistencies in previously extracted datasets. Following correction, reported discharge volumes for August 2025 and September 2025 were marginally lower, resulting in an overall annual volume reduction of approximately 2 per cent (Refer to Appendix 1: Sewer Overflow Volume of Discharge (ML) estimate report Mill Stream (Botany Bay).

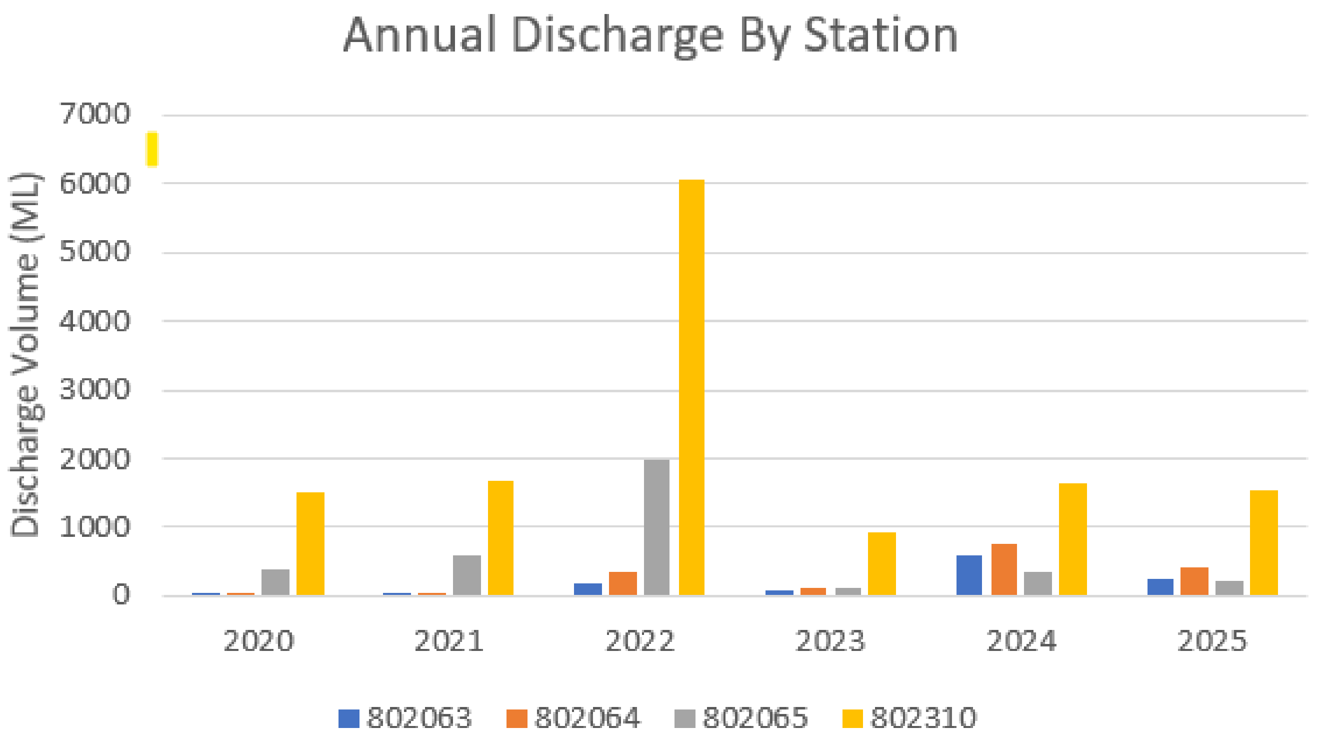

Figure 20: Annual Total Discharge (ML) per ERS Gauge

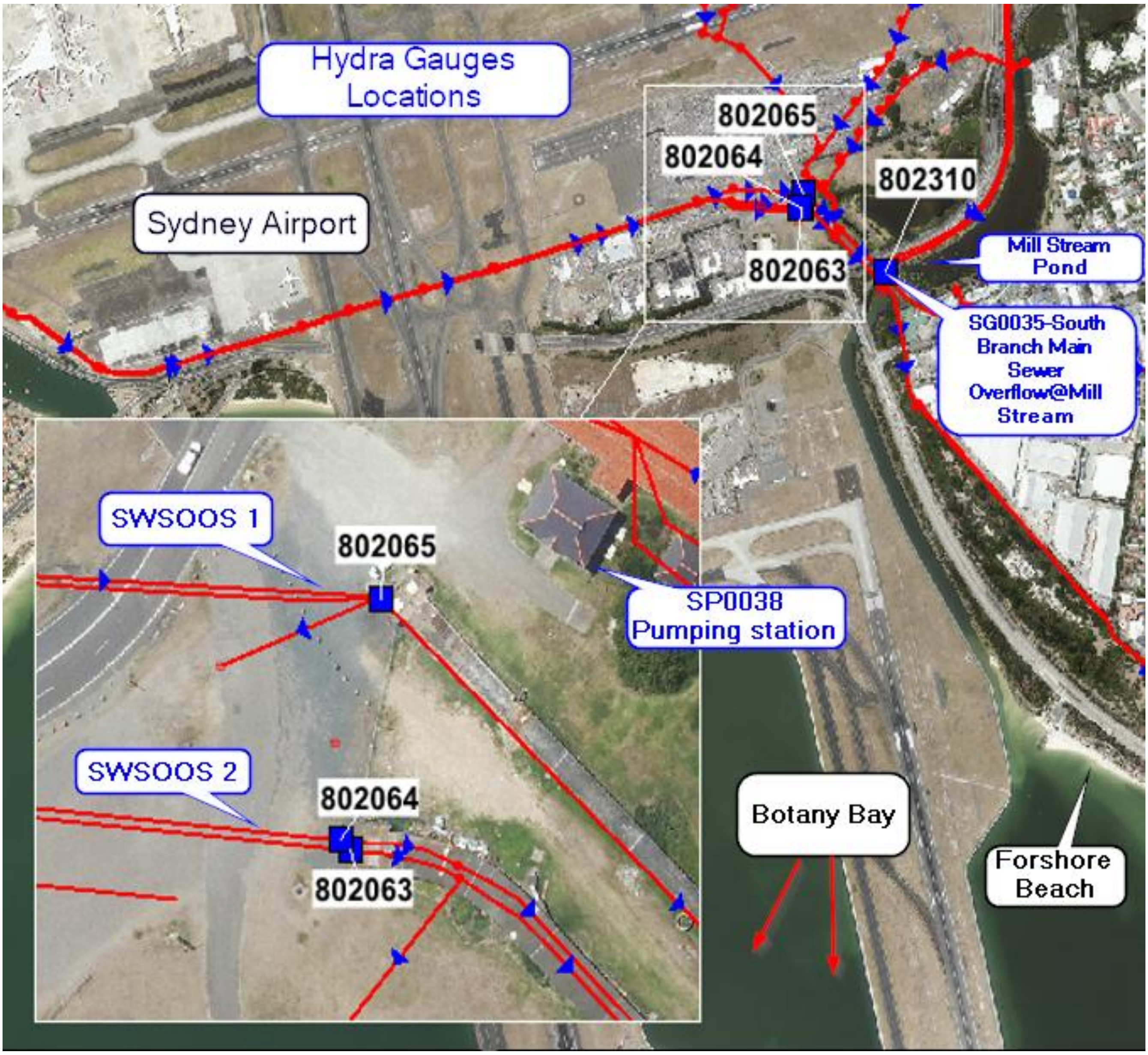

Figure 21: Mill Stream Gauge Sensor Locations Sydney Airport

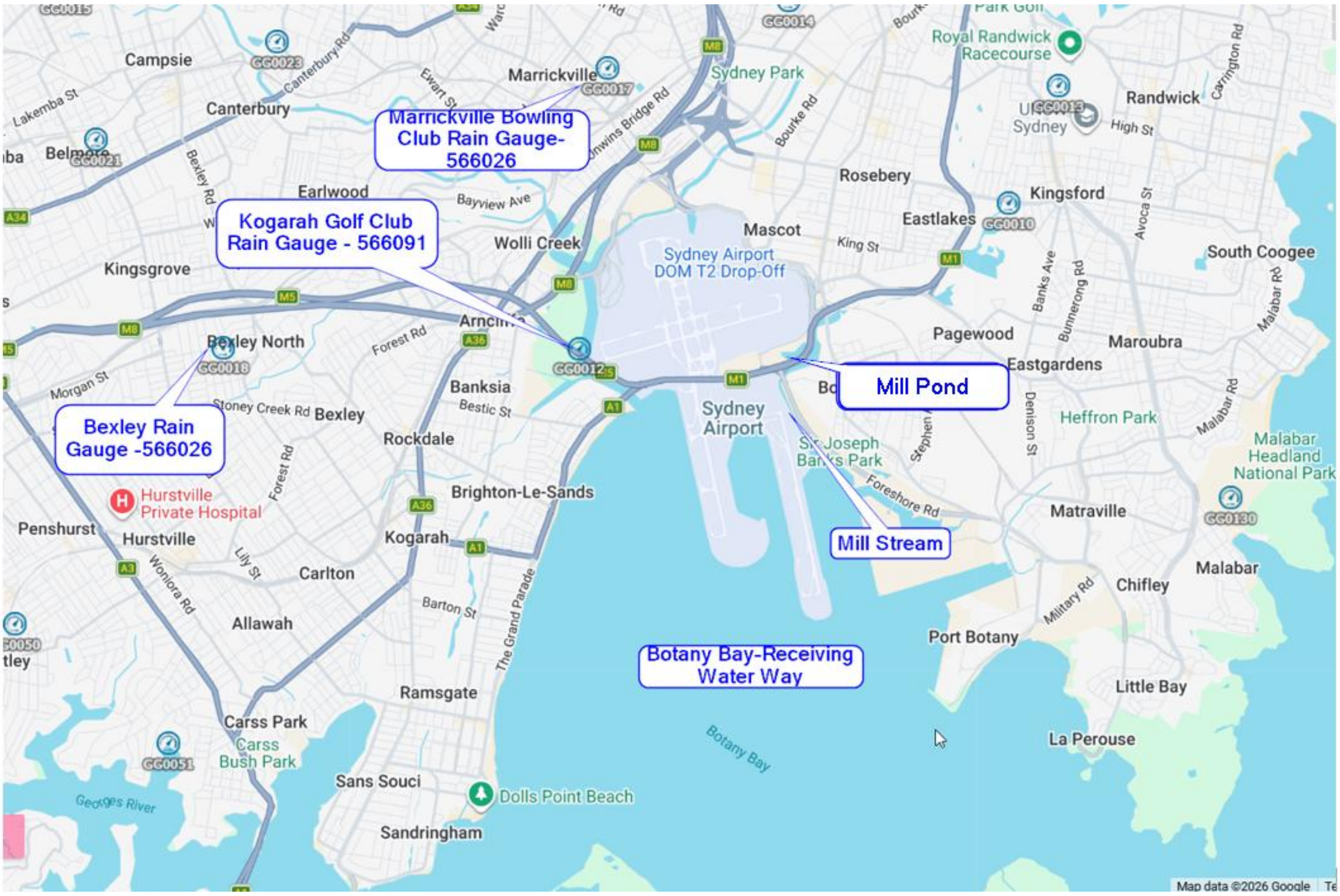

Figure 22: Mill Stream Rain Gauge Locations

EMP Action 5.2 – Provide overflow alerts to AEO and Sydney Airport representatives (Condition 12 & 13)

Sydney Water provided relevant IICATS overflow alerts to Mill Stream stakeholders via email for the period 01 January 2025 to 31 December 2025.

At the Stakeholder Reference Group (SRG) meeting held on 23 July 2025, it was agreed that the Airport Environment Officer (AEO), Sydney Airport and Bayside Council would receive email alerts for SG0035 Bay Street overflow start and stop events. Sydney Airport and Bayside Council representatives also requested to continue receiving alerts for SP0038 (ERS 9393735 and ERS 8136185).

This alert distribution arrangement was revisited at the SRG meeting held on 23 October 2025 to support a shared understanding of the notification process and the rationale underpinning it. As a result, the recipient email notification list was updated (Refer to Table 8).

The contact list for overflow alerts was amended to include group email addresses rather than individual email addresses.

- AEO Sydney- aeosydney@infrastructure.gov.au
- Sydney Airport Environment - environment@syd.com.au,
- Bayside Council- millstreamsewage@bayside.nsw.gov.au
- Alerts generated by IICATS Sewer System and sent from -Sewer System <NO_ Reply_IICATS @sydneywater.com.au> Table 8

Table 8: IICATS Alert Email Stakeholder List

Stakeholder	IICAT Alert Overflow Started	IICAT Alert Overflow Stopped
AEO Sydney **Bayside Council** **Sydney Airport**	**Subject: SG0035 BAY ST overflow started** Message: SG0035 BAY ST overflow started at 10/09/2025 22:23 Email auto-generated by system Sent by: Name: S.BOTANY.SG0035 BAY ST.SG0035.SGS01.Level Alarm Time: 10/09/2025 22:23:17 Value: 1.475 m State: 4 High	**Subject: SG0035 BAY ST overflow stopped.** Message: SG0035 BAY ST overflow stopped at 13/09/2025 01:23 Email auto-generated by system Sent by: Name: S.BOTANY.SG0035 BAY ST.SG0035.SGS01.Overflow Ceased Alarm Time: 13/09/2025 01:23:00 Value: 1 State: ALARM
Sydney Airport **Bayside Council**	**Subject: SP0038 - SWOOS1 overflow started** Message: SP0038 - SWOOS1 overflow started at 10/09/2025 22:18 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038 MASCOT.SX0038.LTX57.Level Alarm Time: 10/09/2025 22:18:47 Value: 1.7 m State: 4 High	**Subject: SP0038 - SWOOS1 overflow stopped** Message: SP0038 - SWOOS1 overflow stopped at 10/09/2025 22:28 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038 MASCOT.SX0038.LTX57.Level Alarm Time: 10/09/2025 22:28:30 Value: 1.38 m State: Normal
Sydney Airport **Bayside Council**	**Subject: SP0038 - SWOOS2 N overflow started** Message: SP0038 - SWOOS2 N overflow started at 10/09/2025 22:06 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038	**Subject: SP0038 - SWOOS2 N overflow stopped** Message: SP0038 - SWOOS2 N overflow stopped at 10/09/2025 23:39 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038

	MASCOT.SX0038.LTX58.Level Alarm Time: 10/09/2025 22:06:14 Value: 2.01 m State: 4 High	MASCOT.SX0038.LTX58.Level Alarm Time: 10/09/2025 23:39:47 Value: 1.97 m State: 3 High
Sydney Airport **Bayside Council**	**Subject: SP0038 - SWOOS2 S overflow started** Message: SP0038 - SWOOS2 S overflow started at 10/09/2025 21:39 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038 MASCOT.SX0038.LTX59.Level Alarm Time: 10/09/2025 21:39:09 Value: 1.99 m State: 4 High	**Subject: SP0038 - SWOOS2 S overflow stopped** Message: SP0038 - SWOOS2 S overflow stopped at 10/09/2025 22:17 Email auto-generated by system Sent by: Name: S.BOTANY.SP0038 MASCOT.SX0038.LTX59.Level Alarm Time: 10/09/2025 22:17:02 Value: 1.99 m State: 3 High

NB: multiple email alerts will be sent for ERS SP0038 sensors until overflows stop and SG0035 stops.

3.5.2 EMP Action 5.3 – Monitor the dry weather sewage capacity in the SWSOOS

Sydney Water monitors the wastewater level in the SWSOOS in the vicinity of the overflows as a check for deterioration (and/or improvement) in capacity over time. The measure being used is the minimum wastewater level below 0.45m for a rolling 6-month period. The gauge measuring the sewer level (SG0035) is in the SWSOOS (Refer Figure 21).

The gauge is connected by telemetry to the Sydney Water Integrated Instrumentation Control Automation and Telemetry System (IICATS) and flow depths are captured and recorded every 15 minutes.

The minimum wastewater level is used because it is not affected by fluctuations in wastewater depths due to wet weather. A rolling 6-month period is used to ensure that a measured period isn't fully influenced by wet weather.

To simplify data presentation, we now present only the minimum daily values in the raw data, as this measure directly reflects the minimum dry levels for the rolling 6-monthly period.

The minimum dry weather sewer level recorded during the 6-monthly period (1 August 2025 to 31 December 2025) was 0.352 metres, recorded 27 December 2025. The raw data is presented in Appendix 4: Dry Weather Sewer Level Daily Data- 6 monthly period (1 August 2025 to 17 January 2026).

3.5.3 EMP Action 5.4 – Monitor water quality at Mill Stream (Condition 3m, 3q, & 14)

Sydney Water has undertaken water quality monitoring to assess potential impact of the ERS on the receiving waterway and identify pollutants of potential concern. This monitoring enables characterisation of the conditions against:

- Schedule 2 criteria of *Airports (Environment Protection) Regulations* 1997
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
- PFAS National Environmental Management Plan (NEMP) Version 3.0.

The fourth and final round of quarterly water quality monitoring was completed between 1 January 2025 and 31 March 2025. Detailed data analysis from all monitoring periods (2020, 2023, 2024 and 2025) was included in the final Water Quality Monitoring Report submitted to the AEO on the 31 July 2025 (**Error! Reference source not found.**), in compliance with condition 21(a) of the Authorisation. The AEO acknowledged receipt of the report on the 1 August 2025.

Overall, the results from the water quality monitoring program indicated that receiving water immediately downstream of Mill Pond Weir and the ERS was the most degraded in both wet weather overflow and dry weather conditions. Bacteria and nutrients (nitrogen and phosphorus) concentrations were the most influenced by the ERS discharge, with the highest concentrations immediately downstream of the ERS. Concentrations decreased with distance likely due to dilution, dispersion and decay.

Chlorophyll-α did not appear to be impacted by ERS overflows with concentrations consistently higher at the upstream site in both dry and wet weather.

There was minimal spatial variation in results for metals, organics, PFAS, sulphide and other physico-chemical parameters in dry and wet weather. This suggests less influence from specific ERS overflow events and likely reflective of the baseline stormwater condition and inputs.

The results from the water quality monitoring program have informed how Mill Stream overflows influence the receiving waterway and allowed characterisation against relevant guideline levels. However, there are opportunities to refine and improve the monitoring program design. The final report made a series of recommendations that should be considered for future monitoring programs:

- Monitor wet weather (rainfall) events without discharge from the Mill Stream ERS, to understand baseline stormwater conditions (without influence from Mill Stream overflows).
- Continue to assess water quality results against the current reference guideline levels (Schedule 2 and ANZG 2018).
- Review the current water quality parameters and collection methods.
- Investigate the possibility of standardised monitoring approaches for the routine (Environmental) and reactive (Emergency Response) monitoring programs to enhance the available data for analysis and reporting. This would need to consider regulatory and resourcing requirements during incident/event sampling.
- Monitor different sized overflows, where possible. Larger events are required to collect ERS discharge samples (in-pipe wastewater quality), while smaller events cease before sampling teams can attend the site.
- Capture variation in receiving environment water quality in response to short and long overflow durations, and multiple events over the 5 monitoring days.

In response to the recommendations, Sydney Water will develop a targeted monitoring plan for implementation in 2026. A key focus of the monitoring will be to understand baseline receiving water quality during wet weather, i.e. no discharge from the ERS, to compare with receiving water quality during different sized overflow events. The suitability of the parameters monitored will also be reassessed prior to implementation of the monitoring plan.

3.5.4 EMP Action 5.5 – Air quality monitoring (H2S) near discharge location (Condition 3d)

Sydney Water implemented continuous air quality monitoring near the Mill Stream overflows to assess potential odour impacts associated with overflow events. Monitoring targeted the summer period of 2024/25 and remained in place long enough to capture data during periods when overflows were occurring. The results of this program complement the odour monitoring previously undertaken in 2020/21.

Continuous air quality monitors were installed on 18 September 2024 at three locations: upstream of the overflows near Botany Public School, at the Emergency Relief Structure (ERS) overflow, and near the Botany Container Terminal along Foreshore Drive (Refer to Figure 23 and Figure 24). Monitoring remained in place until 22 October 2025, with the program concluding on 28 October 2025 to ensure adequate coverage of overflow discharge conditions.

Hydrogen sulphide (H_2S) odour monitoring data, prepared by Sydney Water were analysed for the period from 1 September 2024 to 30 September 2025 and are presented in (Figure 25). During this period, H_2S concentrations detected at all three monitoring sites were consistently low. Recorded levels were generally below 150 parts per billion (ppb) (0.15 parts per million) and dissipated to non-detectable levels within approximately 10 metres.

An isolated H_2S concentration of 0.21 ppm was recorded at the ERS overflow site; however, no corresponding elevated readings were detected downstream, indicating that the gas release dissipated locally. Conversely, a short-term spike of 0.43 ppm recorded at the Mill Stream outlet near Foreshore Beach did not coincide with a preceding spike at the ERS overflow site, indicating that the events were not directly linked.

Overall, the monitoring data indicate that current H_2S emissions associated with Mill Stream overflows are minimal, localised, and contained, with no measurable impact on surrounding areas. These findings inform ongoing environmental risk assessments and operational planning.

Based on the consistently low hydrogen sulphide (H_2S) concentrations recorded during Phase 2 monitoring at all three monitoring locations, the SRG endorsed the recommendation to discontinue odour monitoring and remove the equipment.

Sydney Water complied with EMP Action 5.5 through the implementation of continuous hydrogen sulphide (H_2S) air quality monitoring at three locations adjacent to the Mill Stream Emergency Relief Structures. The monitoring outcomes were documented in the *Mill Stream Odour Monitoring Report – September 2025* and provided to the Airport Environment Officer (AEO) on 26 September 2025.

The findings and recommendations of the odour monitoring program were presented and discussed at the Stakeholder Reference Group (SRG) meeting held on 23 October 2025 (refer Table 11). Based on the consistently low H_2S concentrations recorded during Phase 2 monitoring at all three locations, the SRG endorsed the recommendation to discontinue odour monitoring and remove the monitoring equipment.

Following the SRG meeting, Sydney Water received written confirmation from both the Airport Environment Officer (AEO) and the NSW Environment Protection Authority (EPA) supporting cessation of the Mill Stream odour monitoring program. The EPA formally confirmed its agreement with the recommendation to discontinue monitoring and remove the monitors in correspondence dated 7 November 2025.

In accordance with the SRG endorsement and regulator confirmation, odour monitoring at Mill Stream was discontinued and the monitors were removed.

Figure 23: Map of Sewer Overflow Odour Monitoring Location

M O/F Ambient is located at Foreshore Beach above the seawall

Mill Stream Outlet is located at the ERS Structure

Air West Fenceline is located between Botany Public School and Mill Pond (Upstream of ERS overflow)

Figure 24: Odour Monitoring Locatons-Foreshore Beach, ERS Structure, Upstream Botany Public School

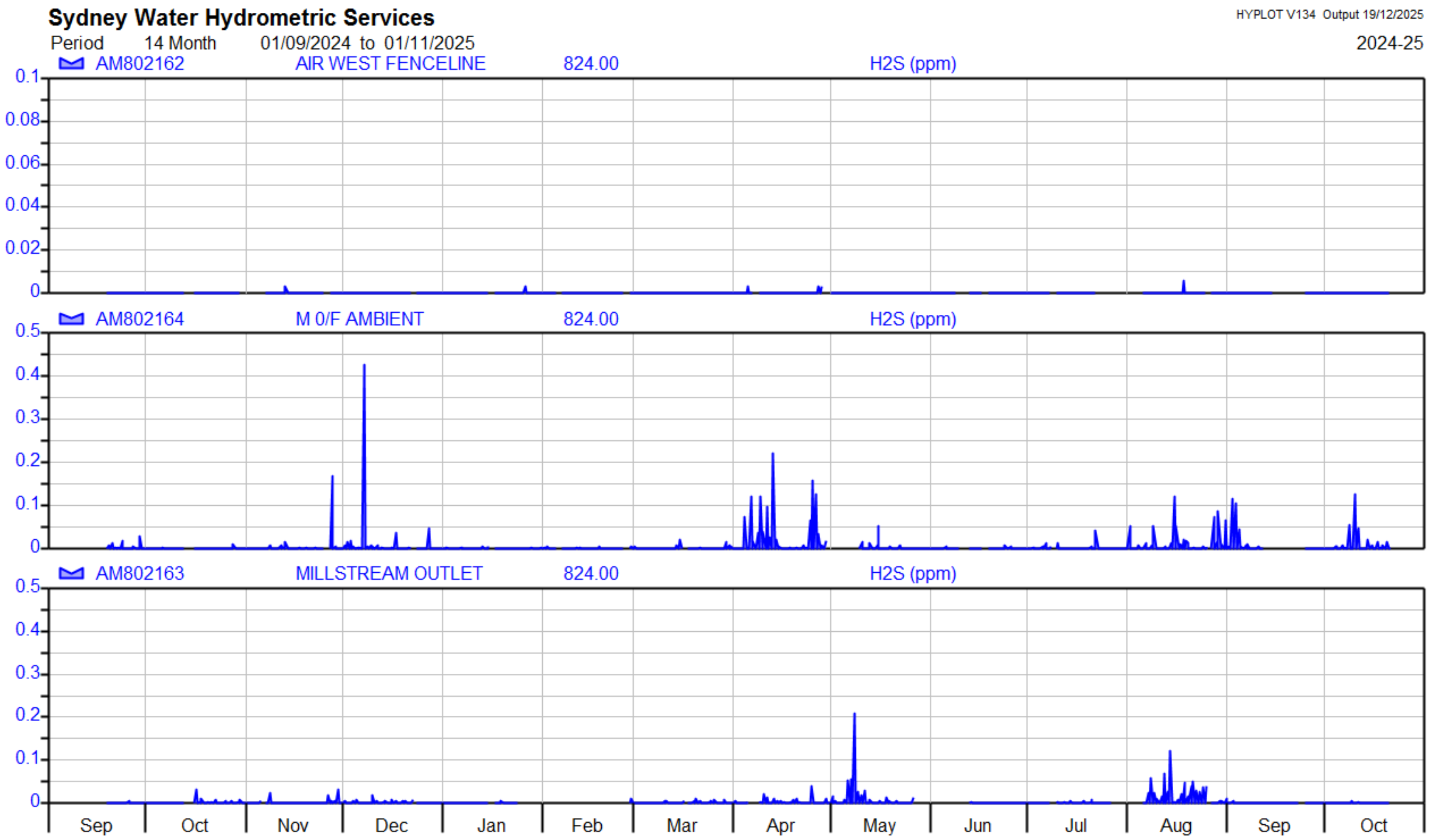

Figure 25: Hydrometrics Services Hydrogen Sulphide (H_2S) Sulphide odour monitoring reporting period

3.6 EMP Objective 6 – Conduct effective complaint management

3.6.1 EMP Action 6.1 – Respond to and investigate all complaints regarding the Mill Stream ERS (Condition 3d)

Between 1 January 2025 and 31 December 2025, no noise or water complaints were received in relation to the Mill Stream Emergency Relief Structure. One odour-related enquiry was received on 16 May 2025 (SR 8004307407, Work Order 95046615). The complaint was located to the east of the Mill Stream ERS off Bay Street (Refer to Figure 26).

Follow-up actions for the odour enquiry raised on 7 January 2025 (CRM 8003962182), regarding the replacement of activated carbon media at the Sewer Odour Control Unit (SY0041), are provided in Table 9.

Table 9: Mill Stream Complaints

Sydney Water Reference	Date Complaint Received	Description	Sydney Water (SW) Resolution & Response
CRM-8003962182	7 Jan 2025	Waste Water-Odour Enquiry-Mascot-	**Follow up Action:** The activated carbon media at SY0041 was replaced on Friday, 5 December 2025. This occurred 11 months after the previous change on 10 January 2025. Typically, the carbon media is replaced every 12 months; however, Sydney Water brought the replacement forward in December 2025 to avoid potential issues during the Christmas and New Year holiday period, when staffing levels are lower. This ensured the unit remained in optimal working condition throughout the busy holiday season. Odour Concentration Measurement were conducted at the OCU on the 22 Dec 2025. Odour sample results confirmed that the OCU is operating very well following the media change. The calculated odour removal efficiency based on the sample is >99% and the outlet emissions are within specification at <500 ou. (Refer to Appendix 6: Odour Control Unit-Odour Concentration Measurement Report 22 results)

SR: 8004307407 Work Order 95046615	16 May 2025	Waste Water Odour Enquiry Botany St Botany	A Sydney Water Network Technician attended the site at 10:55 am on 16 May 2025. The nearby manholes associated with the odour enquiry were inspected, and no faults were found on Sydney Water assets. The crew observed contractors working in the area. The customer was informed of the investigation outcome.

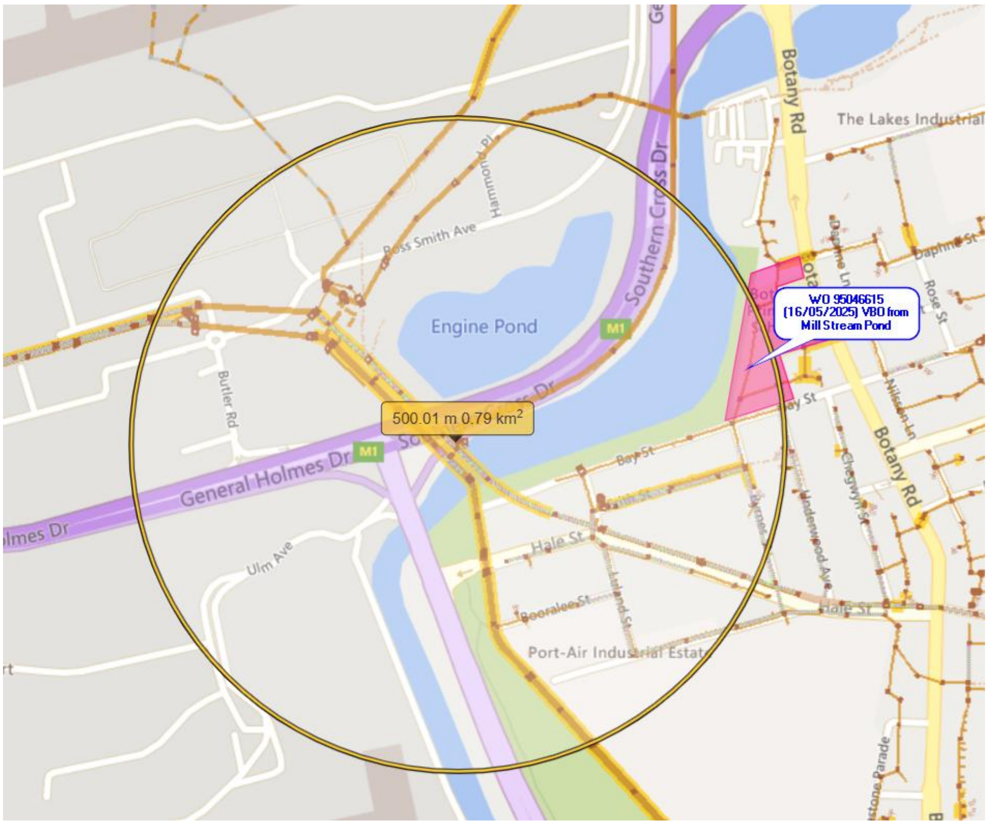

Figure 26: Odour Complaints around Mill Stream on 16 May 2025

Mill Stream Fish Kill Response Protocol Development – Workshop Summary

Following an incident in April 2025 involving a fish kill near Sydney Airport and Mill Stream, it became evident that gaps existed in communication and incident response procedures with Mill Stream stakeholders. As a proactive measure, Sydney Water and Sydney Airport engaged an independent external expert to facilitate a workshop aimed at developing a formal Fish Kill Response Protocol for future incidents.

The first workshop was held on 2 September 2025 and was attended by representatives from Sydney Airport, Sydney Water, and the Airport Environment Officers (AEO). The workshop was facilitated by Hydrobiology.

A Fish Kill Management Plan has since been prepared by Hydrobiology, and both Sydney Water and Sydney Airport are currently reviewing the document and reviewing incorporating the plan in with internal procedures.

3.7 EMP Objective 7 – Progress Reporting

3.7.1 EMP Action 7.1 - Provide Quarterly Update Report (Condition 7 & 8)

Quarterly reports were completed by Sydney Water and shared with the Airport Environment Officer (AEO) and Sydney Airport as shown in Table 10.

Table 10: Summary of Sydney Water's Quarterly Report submission

Report Description	Date Sent	Submitted to
Mill Stream Quarterly Report No: 2- **Period: (1 January 2025 to 31 March 2025)**	**17 April 2025**	**Airport Environment Officer (AEO):** **Mariana Torres -** Assistant Director Airport Environment Officer-Sydney Airport (Mascot) • Environmental Regulation Section/Airport Environment Branch • Domestic Aviation and Reform Division mariana.torres@infrastructure.gov.au **Sydney Airport:** **Jake Atkins** - General Manager Environment and Sustainability jake.atkins@syd.com.au **Rhonda Lenardon** -Senior Manager Environment rhonda.lenardon@syd.com.au **Nicole Cheung** -Environment Manager-Major Projects nicole.cheung@syd.com.au
Mill Stream Quarterly Report No: 3 **Period:** **(01 April 2025 to 30 June 2025)**	**21 July 2025**	**AEO:** **AEO Group inbox** aeosydney@infrastructure.gov.au **Peter Goodier –** Airport Environment Officer-Sydney Airport (Mascot) • Environmental Regulation Section/Airport Environment Branch • Domestic Aviation and Reform Division **Julie Coughlan -** Airport Environment Officer HUB Manager- Sydney Airport (Mascot) • Environmental Regulation Section/Airport Environment Branch • Domestic Aviation and Reform Division **Sydney Airport:**

Report Description	Date Sent	Submitted to
		Jake Atkins - General Manager Environment and Sustainability jake.atkins@syd.com.au **Rhonda Lenardon** -Senior Manager Environment rhonda.lenardon@syd.com.au **Nicole Cheung** -Environment Manager-Major Projects nicole.cheung@syd.com.au
Mill Stream Quarterly Report No: 4 **Period:** **(1 July 2025 to** **30 September 2025)**	**21 October 2025**	**AEO** aeosydney@infrastructure.gov.au **Peter Goodier –** Airport Environment Officer- Sydney Airport (Mascot) • Environmental Regulation Section/Airport Environment Branch • Domestic Aviation and Reform Division peter.goodier@infrastructure.gov.au **Julie Coughlan**- Airport Environment Officer HUB Manager- Sydney Airport (Mascot) • Environmental Regulation Section/Airport Environment Branch • Domestic Aviation and Reform Division julie.coughlan@infrastructure.gov.au **Sydney Airport:** environment@syd.com.au **Jake Atkins** - General Manager Environment and Sustainability jake.atkins@syd.com.au **Rhonda Lenardon** -Senior Manager Environment rhonda.lenardon@syd.com.au **Nicole Cheung** -Environment Manager-Major Projects nicole.cheung@syd.com.au
Mill Stream Quarterly Report No: 5 **Period:** **(1 October 2025 to** **31 December 2025**	**30 Jan 2026**	Quarterly Report No. 5- Period 1 Oct 2025 to 31 Dec 2025 will be included in the Mill Stream EMP Compliance Report No. 2

3.7.2 EMP Action 7.2 - Chair Quarterly Stakeholder Reference Group (SRG) meeting (Condition 16)

Between 1 January 2025 and 31 December 2025, Sydney Water chaired four quarterly Stakeholder Reference Group (SRG) meetings and one out of session SRG specifically to update stakeholders on IIPART funding. Further details are provided in Table 11. These meetings included representatives from Sydney Water, Sydney Airport, Bayside Council, the Port Authority of New South Wales, and the DITRDCSA.

Table 11: Stakeholder Reference Group Meeting Summary

Meeting	Date completed	Agenda
SRG	12 February 2025	Welcome and Introductions, New Authorisation and SRG, Authorisation conditions, EMP, Overflow discharges and response, Grit Pit Relocation Feasibility Study.
SRG	07 May 2025	Welcome and Introductions, Sydney Water's new structure post re-alignment update, IPART -Pricing process and outcomes of the determination, EMP Action Updates.
SRG	11 June 2025	Out of Session SRG - Welcome and Introductions, IPART - Pricing process and outcomes of the determination.
SRG	23 July 2025	Welcome and Introductions, Sydney Water's new structure post re-alignment update, IPART -Pricing process and outcomes of the determination, EMP Action Updates.
SRG	23 October 2025	Welcome and Introductions, Sydney Water's new structure post re-alignment update, IPART -Pricing process and outcomes of the determination, EMP Action Updates.

3.7.3 EMP Action 7.3 - Provide Annual EMP Compliance Report (Condition 2 and 4)

EMP Action 7.3 relates to the requirement to prepare and submit the Annual EMP Compliance Report in accordance with Condition 2 of the Authorisation. Sydney Water submitted the Annual EMP Compliance Report in accordance with the revised reporting timeframes approved by the Airport Environment Officer under Condition 2 of the Authorisation.

EMP Compliance Report No. 1

The Annual EMP Compliance Report No. 1 for the Mill Stream Authorisation was originally due on 31 January 2025. On 20 January 2025, Sydney Water submitted a formal request to the Airport Environment Officer (AEO) seeking an extension of the reporting deadline to 28 February 2025, for the reporting period 1 June 2024 to 17 January 2025.

As part of this request, Sydney Water also sought approval to reschedule the Community Stakeholder Meeting (Condition 9) to occur prior to 28 March 2025, and to provide copies of the finalised Annual EMP Compliance

Report to Bayside Council and publish it online by 28 March 2025, in accordance with Condition 10 of the Authorisation.

On 24 January 2025, Sydney Water received written approval from the AEO, Cassandra Wadrop, confirming the extension to Conditions 2, 9 and 10 of the Mill Stream Authorisation. Sydney Water complied with the revised approval and submission requirements and was therefore compliant with EMP Action 7.3 for the reporting period 1 June 2024 to 17 January 2025.

EMP Compliance Report No.2

As noted in Section 5 (Mill Stream Authorisation Variation Request), Sydney Water submitted a variation request on 26 September 2025 seeking amendments to Condition 2 of the Authorisation, which governs the timing and reporting periods for the Annual EMP Compliance Report (Appendix 8: Sydney Water Variation Request under Requirement 5.16(3) of the Airports (Environment Protection) Regulations 1997).

EMP Compliance Report No.2 As noted in Section 5 (Mill Stream Authorisation Variation Request), Sydney Water submitted a variation request on 26 September 2025 seeking amendments to Condition 2 of the Authorisation, which governs the timing and reporting periods for the Annual EMP Compliance Report. On 27 January 2026, and amended on 20 February 2026, the Airport Environment Officer (AEO), Peter Goodier, approved the requested variation under R*egulation 5.16 of the Airports (Environment Protection) Regulations 1997*. The approved variation amended the reporting schedule for Condition 2(b) as follows:

a) 31 January 2025 – covering the period from commencement of the Authorisation to 17 January 2025;
b) 28 February 2026 – covering the period 1 January 2025 to 31 December 2025;
c) 31 January 2027 – covering the period 17 January 2026 to 17 January 2027; and
d) 31 March 2027 – covering the period 17 January 2027 to 17 March 2027.

The variation took effect on the date of approval, and all other terms and conditions of the Authorisation remain unchanged and fully enforceable.

4 Additional Authorisation Conditions

4.1 Condition 3n (L7.1 Licence Compliance)

To comply with condition L7.1(a) to L7.1(d), Sydney Water implements a quality management system (QMS) certified to ISO 9001:2015 for the hydraulic sewer system modelling processes. Quality assurance includes surveillance audits for select procedures and a technical management review of all models. The Millstream sewer model (Botany catchment) being used to predict the overflows for the reticulation system was adjusted to reflect changes and recalibrated. The new model is checked for accuracy and classified in accordance with the accuracy achieved. The hydraulic sewer system model used for Millstream overflow performance reporting has no temporal or magnitude bias in either flow volume or water levels at the licence gauges as referenced in the document titled "PRP101.1 System Model Performance Indicators, September 2000" and subsequent modifications made by the Criteria Review Committee (Refer to Appendix 10: Mill Stream Water Quality Report 2025- Mill Stream WQ Report 2025.pdf , Mill Stream App 7.3 WQ raw data.xlsx).

4.2 Condition 3o & 18 (Bird Strike)

Sydney Water has complied with the Authorisation requirements by submitting the Bird Strike Risk Assessment letter to the Airport Environment Officer (AEO) on 30 August 2024, as required under Condition 18. Throughout the reporting period, Sydney Water has maintained ongoing engagement with Sydney Airport and the AEO on bird strike risk through formal letters, responses, and routine coordination between the parties.

This engagement included Sydney Airport's written response on 4 November 2024 outlining data concerns and referencing the National Airports Safeguarding Framework, followed by Sydney Water's written proposal for a meeting in early 2025 to align on risk assessment approaches. Internal discussions have continued within Sydney Water to refine technical positions and ensure consistent handling of Sydney Airport's feedback.

Sydney Water acknowledges the concerns raised by Sydney Airport and remains committed to constructive dialogue and collaborative risk management. Any further actions or changes to the approach for managing bird strike risk will be developed jointly with Sydney Airport and guided by regulatory requirements and direction from the AEO. Sydney Water will continue to implement improvements at Mill Stream in line with the Environmental Management Plan (EMP) and Authorisation conditions, ensuring all reporting and risk-management activities meet regulatory expectations.

4.3 Condition 6 (Shortcomings)

The calibrated model used for the Mill Stream overflow performance reporting in December 2024 was validated using the flow monitoring data captured for the period January 2025 to November 2025. The Mill Stream overflow performance reported from the model is within the target set in the EMP (13 overflow events in 10 years and overflow volume of 1238 ML/year). There are no shortcomings in the proposed EMP targets set and no corrective actions are required. Refer to Mill Stream overflow performance reporting (Appendix 11: An Overview of Model Compliance with Condition L7.1-Millstream Overflow Performance Reporting Jan 2025 to Dec 2025 Ver1.pdf).

4.4 Condition 9 and 10 (Community meeting)

In 2025, Sydney Water held the Mill Stream community meeting on 27 February 2025, meeting Condition 9 of the Mill Stream Authorisation 2024–2027 and fulfilling our compliance obligations for the reporting period. The session was held at St Matts Anglican Church Hall in Botany and provided updates on the Environmental Management Plan (EMP) and key program milestones. Insights from the event showed that digital communication, particularly geotargeted social media advertisement, offers a more effective way to reach residents than traditional letterbox notifications, which formed the main focus of promotion in 2025 (with more than 6,000 invitations delivered). Key stakeholders were also invited, with representatives from Sydney Airport attending to support discussions on Mill Stream. Approximately 20 residents participated in the drop-in session. These results have informed the engagement approach for promoting the 2026 community meeting.

The 2026 Mill Stream community meeting was held on 29 January from 4pm to 7pm at St Matts Anglican Church Hall. This local drop-in session provided updates on work underway to improve the Mill Stream environment and invited participation from community members, residents and interested stakeholders.

To support broad awareness, residents were notified through geotargeted social media advertising and Bayside Council's online community channels, reaching over 11,500 people. Event details were also provided to the AEO, DITRDCSA, Bayside Council, Sydney Airport, the NSW EPA and the Port Authority of NSW on 22 January 2026.

The session included information on:

- Emergency relief structures
- Progress on the Environmental Management Plan including objectives, key actions and completed projects
- Information about both short term and longer-term plans for Mill Stream

Attendance at the 2026 session was low despite geotargeted promotion. Sydney Water staff were available to answer questions and capture community feedback, and attendees were encouraged to subscribe for future updates. The feedback received indicated that holding the event during the school holiday period contributed to reduced participation, noting that the 2025 session held in late February achieved higher engagement. Community feedback also highlighted a preference for an online format rather than a drop-in session, to improve accessibility for residents. These outcomes suggest an alternative format should be considered and that scheduling the session outside holiday periods is advised for 2027, subject to approval by the Department.

A copy of the annual EMP Compliance Report will be provided to Bayside Council by 28 February 2026 and uploaded to Sydney Water's website. Community members were able to register their interest at the event to receive an email notification once the report is available online.

4.5 Condition 14 (Providing reports to Sydney Airport)

Sydney Water is compliant with condition 14 and has completed and delivered all Mill Stream Monthly Overflow and Incident Reports, and the Mill Stream Quarterly EMP Compliance Reports were provided within the required 21-day timeframe following finalisation (Refer to Table 10 and Table 12).

Table 12: Sydney Water Report submission dates to Sydney Airport

Report	Report Period	Date of Submission	Recipient	Compliance Position
Mill Stream Monthly Overflow & Incident Report	January 2025 February 2025 March 2025 April 2025 May 2025 June 2025 July 2025 August 2025 September 2025 October 2025 November 2025 December 2025	14 February 2025 12 March 2025 8 April 2025 8 May 2025 24 June 2025 4 July 2025 6 August 2025 5 September 2025 9 October 2025 6 November 2025 4 December 2025 12 January 2026	AEOSydney aeosydney@infrastructure.gov.au Sydney Airport - Environment environment@syd.com.au Bayside Council millstreamsewage@bayside.nsw.gov.au EPA Matthew.Hart@epa.nsw.gov.au	Compliant on all submission dates

4.6 Condition 16 (Attending additional meetings)

In addition to SRG meetings, Sydney Water must attend meetings with Bayside Council, all Sydney Airport Community Forum meetings, and Planning and Coordination Forum meetings to which it is invited, and provide an update to those forums on the progress of the implementation of the EMP.

Sydney Water's Managing Director and senior executives met with the Sydney Airport Chief Executive Officer and senior executive team on 19 December 2025. The agenda included discussion of the IPART determination, the Long-Term Capital Operating Plan (LTCOP), the Sydney Airport Master Plan 2045, and matters concerning debris balls and bird-strike risk. The meeting also reaffirmed the collaborative working relationship between both organisations and their ongoing efforts to support implementation of the EMP.

4.7 Condition 19 (IPART Submission)

Condition 19 of Authorisation Number 01/2024 requires Sydney Water to submit an IPART price proposal in accordance with the requirements of the Independent Pricing and Regulatory Tribunal (IPART).

During the reporting period, Sydney Water submitted its price proposal for the 2025-30 determination period to IPART. The proposal was placed on public exhibition in accordance with IPART's statutory process and publicly available on the Sydney Water website under page titled *Our 2025–30 price proposal*.

IPART's Final Report acknowledges Sydney Water's role in providing safe, reliable, and affordable water to a rapidly growing metropolitan region, and recognises the scale of complexity of the work required to maintain service outcomes. IPART also acknowledged that Sydney Water's expenditure during the previous determination period was both prudent and efficient. The Final report further recognises Sydney Water's increasing maturity in procurement and program delivery, particularly in relation to major growth projects and regional strategies. Sydney Water's customer engagement program, *Our Water, Our Voice*, was considered by IPART to demonstrate genuine and measurable progress, and the organization's long-term planning was acknowledged as supporting investment decision making and proposed expenditure aligned with the NSW Government's strategy to improve water security and system resilience.

IPART has made its Final Determination, setting Sydney Water's prices for the 2025–30 period, with new prices taking effect from 1 October 2025. For a typical four-person household with an annual water usage of 200 kilolitres, bills are expected to increase by $168, or 13.8 per cent inclusive of inflation, in the first year of the determination period. Over the subsequent four years, annual increases are expected to average $77, or 5.1 per cent per year, plus inflation. Over the five-year determination period, prices are forecast to increase by a total of 35.7 per cent, excluding inflation. IPART has set Sydney Water's total operating expenditure allowance at $9.4 billion and the total capital expenditure allowance at $13.2 billion for the determination period.

Sydney Water remains committed to ensuring that expenditure delivers value for customers. Following the Final Determination, Sydney Water is progressing work to prioritise planned expenditure, including finalising a prioritisation plan, seeking Board endorsement, and communicating the outcomes of this process with employees, customers and key stakeholders. An update on expenditure prioritisation is scheduled to be provided at the next SRG meeting in early March 2026.

Based on the submission of the price proposal in accordance with IPART requirements and the progression of activities following IPART's Final Determination, Sydney Water is compliant with Condition 19 of Authorisation Number 01/2024 for the reporting period (Refer to Figure 27).

Mill Stream – Plan on a Page

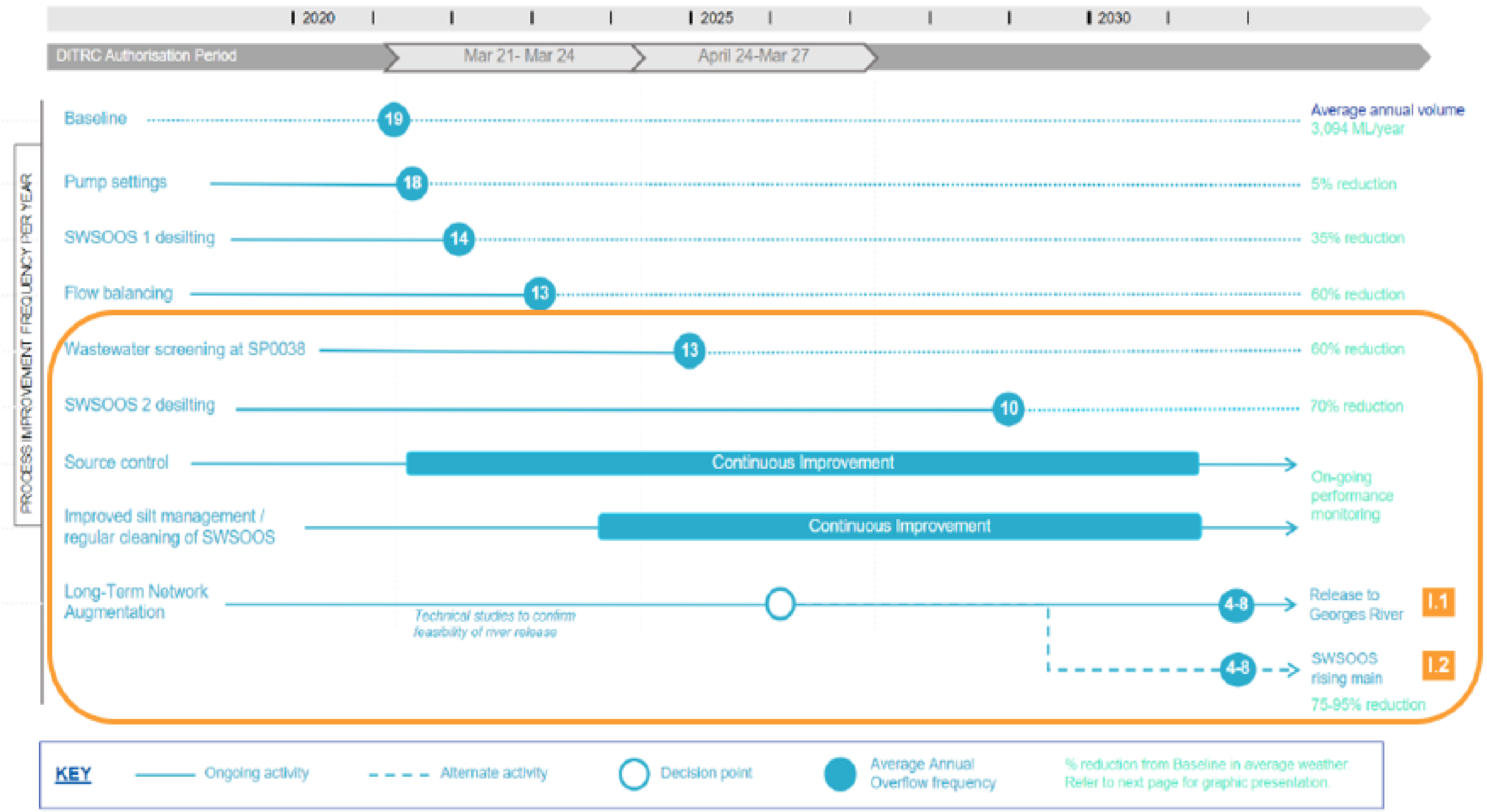

Figure 27: Mill Stream Plan on a Page

5 Mill Stream Authorisation Variation Request

On 26 September 2025, Sydney Water submitted a variation request for Mill Stream Authorisation No. 01/2025 to Ms Alpin at the Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts (DITRDCSA). The request proposed amendments to Conditions 2, 9, 10, 20, 23 and 24 in Appendix A of the Authorisation.

The endorsed request outlined:

- the reasons for seeking the proposed variations,
- the period within which the variations were sought, and
- the associated proposed amendments to the Environmental Management Plan (EMP).

Further details of the variation request are provided in Appendix 8 Sydney Water Variation Request under Requirement 5.16(3) of the Airports (Environment Protection) Regulation 1997
Compliance with the annual reporting requirements associated with Conditions 2 and 4 is addressed under Section 3.7.3 – EMP Action 7.3: Provide Annual EMP Compliance Report.

6 References

- Sydney Water Mill Stream Authorisation 2024 – 2027 - Appendix A Operating Conditions
- Sydney Water Mill Stream Environment Management Plan 2024-2027
- SW Document No: D0001845.02 Sydney Water Mill Stream/Foreshore Beach wet weather clean-up - Work instruction

.

7 Appendices

- **Appendix 1**: Sewer Overflow Volume of Discharge (ML) estimate report Mill Stream (Botany Bay)
- **Appendix 2:** Comparison of Monthly Totals for Wastewater Discharge and Rainfall at 2 local permanent rain gauges (Site ID 566026 and 566091)
- **Appendix 3:** Summary of Mill Stream Incident Responses during the reporting period
- **Appendix 4:** Dry Weather Sewer Level Daily Data- 6 monthly period (1 August 2025 to 17 January 2026)
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7.1.1 Appendix 1: Sewer Overflow Volume of Discharge (ML) estimate report Mill Stream (Botany Bay)

Month	Description	SWSOOS 2 South Hydra Station NO. 802063	SWSOOS 2 North Hydra Station NO.802064	SWSOOS 1 Hydra Station NO.802065	Southern Division Main Hydra Station NO.802310	Total
Jan-25	**Volume (ML)**	**2.37**	**7.12**	**8.72**	**68.23**	**86.44**
	Duration (days)	3	5	6	7	7
	*Event Count (see note below table)	3	4	5	5	5
Feb-25	**Volume (ML)**	**0.00**	**0.49**	**1.55**	**17.12**	**19.16**
	Duration (days)	0	1	2	2	2
	*Event Count (see note below table)	0	1	2	2	2
Mar-25	**Volume (ML)**	**9.78**	**17.61**	**15.46**	**103.46**	**146.31**
	Duration (days)	2	4	4	4	4
	*Event Count (see note below table)	1	2	2	2	2
Apr-25	**Volume (ML)**	**3.83**	**7.58**	**7.64**	**74.99**	**94.04**

Month	Description	SWSOOS 2 South Hydra Station NO. 802063	SWSOOS 2 North Hydra Station NO.802064	SWSOOS 1 Hydra Station NO.802065	Southern Division Main Hydra Station NO.802310	Total
	Duration (days)	1	2	5	5	5
	*Event Count (see note below table)	1	2	1	2	2
May-25	**Volume (ML)**	**39.99**	**62.72**	**33.30**	**262.87**	**398.88**
	Duration (days)	5	8	7	13	13
	*Event Count (see note below table)	3	4	4	4	4
Jun-25	**Volume (ML)**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	Duration (days)	0	0	0	0	0
	*Event Count (see note below table)	0	0	0	0	0
Jul-25	**Volume (ML)**	**25.02**	**36.37**	**24.46**	**125.21**	**211.05**
	Duration (days)	3	4	4	6	6
	*Event Count (see note below table)	2	2	2	2	2
Aug-25	**Volume (ML)**	**122.77**	**216.70**	**102.98**	**727.42**	**1169.87**

Month	Description	SWSOOS 2 South Hydra Station NO. 802063	SWSOOS 2 North Hydra Station NO.802064	SWSOOS 1 Hydra Station NO.802065	Southern Division Main Hydra Station NO.802310	Total
	Duration (days)	12	15	14	18	18
	*Event Count (see note below table)	4	4	4	4	4
Sep-25	**Volume (ML)**	**38.27**	**59.89**	**40.59**	**112.33**	**251.09**
	Duration (days)	2	3	2	3	3
	*Event Count (see note below table)	1	1	1	1	1
Oct-25	Volume (ML)	0.00	0.00	0.00	0.00	0.00
	Duration (days)	0	0	0	0	0
	*Event Count (see note below table)	0	0	0	0	0
Nov-25	Volume (ML)	0.00	0.15	0.03	8.14	8.32
	Duration (days)	0	1	1	3	3
	*Event Count (see note below table)	0	1	0	1	1
Dec-25	**Volume (ML)**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Month	Description	SWSOOS 2 South Hydra Station NO. 802063	SWSOOS 2 North Hydra Station NO.802064	SWSOOS 1 Hydra Station NO.802065	Southern Division Main Hydra Station NO.802310	Total
	Duration (days)	0	0	0	0	0
	*Event Count (see note below table)	0	0	0	0	0
Totals for period 1 Jan 2025 to 31 Dec 2025	**Volume (ML)**	**242.04**	**408.63**	**234.72**	**1499.77**	**2385.16**
	Duration (days)	**30**	**45**	**46**	**61**	**61**
	***Event Count (see note below table)**	**15**	**21**	**21**	**23**	**23**

**Note: regarding event Count Figures: Event Count and Duration are measured in whole days. Consecutive days of discharge are counted as one event. Events greater than 1 day apart are counted as separate events. If an event spans the end and start of a new month it is counted in the month within which the event ends.*

7.1.2 Appendix 2: Comparison of Monthly Totals for Wastewater Discharge and Rainfall at 2 local permanent rain gauges (Site ID 566026 and 566091)

Discharging Sewer: Receiving Water Body: Date:	SWSOOS 2S Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 2N Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 1 Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Southern Division S/M (SWSOOS) Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Marrickville Bowling Club 566026 Total Monthly Rainfall (mm)	Bexley 566091 Total Monthly Rainfall (mm)
Jan-25	2.37	7.12	8.72	68.23	152.50	150.00
Feb-25	0.00	0.49	1.55	17.12	79.00	30.00
Mar-25	9.78	17.61	15.46	103.46	122.00	130.00
Apr-25	3.83	7.58	7.64	74.99	123.50	112.00
May-25	39.99	62.72	33.30	262.87	168.00	205.50
Jun-25	0.00	0.00	0.00	0.00	13.50	6.00

Discharging Sewer: Receiving Water Body: Date:	SWSOOS 2S Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 2N Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 1 Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Southern Division S/M (SWSOOS) Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Marrickville Bowling Club 566026 Total Monthly Rainfall (mm)	Bexley 566091 Total Monthly Rainfall (mm)
Jul-25	25.02	36.37	24.46	125.21	128.50	123.00
Aug-25	122.77	216.70	102.98	727.42	327.50	325.50
Sep-25	38.27	59.89	40.59	112.33	104.50	109.00
Oct-25	0.00	0.00	0.00	0.00	19.00	22.50
Nov-25	0.00	0.15	0.03	8.14	62.50	51.00
Dec-25	0.00	0.00	0.00	0.00	20.50	19.00
Totals ML:	**242.04**	**408.63**	**234.72**	**1499.77**	**1321.00 mm**	**1283.50 mm**
Total Discharge ML for Reporting Period:		**2385.16 ML**				

Discharging Sewer: Receiving Water Body: Date:	SWSOOS 2S Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 2N Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	SWSOOS 1 Overflow @ Sydney Airport Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Southern Division S/M (SWSOOS) Mill Stream (Botany Bay) Total Daily Overflow Discharge (ML)	Marrickville Bowling Club 566026 Total Monthly Rainfall (mm)	Bexley 566091 Total Monthly Rainfall (mm)
1 Jan 2025-31 Dec 2025						

7.1.3 Appendix 3: Summary of Mill Stream Incident Responses during the reporting period

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
10 Jan 2025 to 22 Jan 2025	W)93606696	Yes	Yes	4.7	127	9	N/A	Job:93606696-IL02931 AR318423-10/01/25 AR318882-15/01/25 AR319065 18/01/25 AR319065-22/01/25 AR319140-23/01/25	Related Work Orders: 93606696-10/01/2025-Inspection 93616678-12/01/2025-Inspection superseded 93700663 17/01/2025 IL02957No Inspection superseded to IL02931 93611703 22/01/2025 Inspection Cancelled Crew onsite- superseded.
31 Jan 2025 carried over to Feb 2025	WO93820692 IL02994	Yes	*Yes	1.3	35	0	N/A	Job 93820692-IL02994 AR3195555-29/01/25	Related Work Orders(WO): 938515780-29/01/2025-Inspection 93820692-

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
									29/01/2025- Inspection superseded to 93616678 for Clean-up/Analytical results 93820674- 8/02/2025- Inspection
January 2025 Totals		**5**	***2**	**6**	**162**	**9**	N/A		
1 Feb to 8 Feb 2025	WO93820692 IL02994 Carried Over	Yes	*	3.33	90	0	N/A	Job 93820692- IL02994 AR319880 - 05/02/25	Related Work Order (WO): Clean-up carried over from January 2025 IL02994 93820692- 29/01/2025. 93929620- 12/02/2025 Inspection-Incident closed no environmental harm declared 93953823- 15/02/2025 Inspection- Incident closed no

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
									environmental harm declared
February 2025 Totals		**3**	*	**3.33**	**90**	**0**	**N/A**		* IL02994 31/01/2025 Carried Over
13 Mar 2025 to 14 Mar 2025	WO94171421 IL03146	Yes	Yes	0.50	14	0	N/A	Job 94171421-IL03146 AR322045-12/03/25 AR322349-17/03/25 AR322545-21/03/25	Related Work Orders(WO): 94171421-12/03/2025 Inspection
31 Mar 2025 ongoing into April 2025	WO94517266 IL03200	Yes	*Yes	1.85	50	0	N/A	Job 94517266-IL03200 AR323319-30/03/25 AR323320-31/03/25	Related Work Orders(WO): 94517266-30/03/2025-Inspection 94514808-30/03/2025-Inspection-superseded
March 2025 Totals		**3**	***2**	**2.37**	**64**	**0**	N/A		

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
January 2025 to March 2025 Totals		11	*4	11.70	316	9			*IL02994 31/01/2025 ongoing into Feb 2924 *IL03200 31 Mar 2025 ongoing into April 2025 Not counted in quarterly totals
31/03/2025-06/04/2025	WO94517266 IL03200	Yes	*	11.85	320	3	N/A	Job:94517266 IL03200 AR 323319 30/03/2025 AR 323320 31/03/2025 AR 323315 01/04/2025 AR 323307 2/04/2025	Clean up carried over from previous month Related Work Order(WO): WO 94545777 - 01/04/2025 WO 94562078-01/04/2025-Superseded IL03200 94730291-IL03279-23/04/2025-Superseded IL03200 9475027 IL03290-27/04/2025-Superseded IL03200
29/04/2025-30/04/2025 continued into April 2025	WO94766226 IL03293	Yes	*Yes	2.59	70	1	Yes	Job 94766226 IL IL03293 AR 324697 29/04/2025 AR324863 30/04/2025	Related Work Order(WO): 94730291 23/04/2025-Inspection 94750247 27/04/2025-Inspection

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
									94772758 30/04/2025 -supersede to IL03293
April 2025 Totals		**4**	***1**	**14.44**	**390**	**4**	**Yes**		*IL03293 31/03/25 carried over to April
01/05/2025 - 06/06/2025 Continued from May 2025	WO94792637 IL03293	Yes	*	**5.81**	**157**	**3**	**Yes**	Job 94766226 IL IL03293 AR 324864 01/05/2025 AR 324965 02/05/2025 AR 325398 09/05/2025 AR 325755 14/05/2025	Related Work Order(WO): 94778825 01/05/2025 - Inspection 94792637 03/05/2025 – Inspection
25/05/2025 - 26/05/2025	WO95165195 Superseded into IL0393	Yes	N/A					All FST Sampling under IL03293 Job 95165195 IL03416 AR 326330 25/05/2025 Job 94766226	Related Work Order(WO): 95165195 25/05/2025 -Superseded into IL03293 95170321 26/05/2025 - Superseded into IL03293

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
								IL IL03293 AR 326770 02/06/2025 – superseded into IL03293	WO95188660-27/05/2025-13:35 NO onsite No Material Harm WO Cancelled WO95207751 28/05/2025-14:07 NO onsite No Material Harm WO Cancelled WO95217679 29/05/2025 12:01 NO onsite No Material Harm WO Cancelled
May 2025 Totals		**9**	*****	**5.81**	**157**	**3**	**Yes**		*IL03293 31/03/25 carried over to May
June 2025 Totals		0	0	0	0	0	N/A		NO MATERIAL HARM INCIDENTS
April 2025 to June 2025		**13**	***1**	**20.26**	**547**	**7**	**Yes**		*2 incident clean-ups carried over for April and May 25
03/07/2025-10/07/2025	WO95568811	Yes	Yes	2.11	57	2	Yes	Job: 95568811 IL03591 AR-328567	Related Work Order (WO)

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
from May 2025	IL03591							03/07/2025 AR-328568 05/07/2025 AR-328615 06/07/2025 A-328624- 07/07/2025 AR-328879 11/07/2025	WO95568811 - 3/07/2025 Operational WO95565336 03/07/2025 Closed-Superseded- WO9556881 IL03591 Operational WO95599248 Closed-superseded into existing clean-up WO9556881 IL03591 3/7/2025
31/07/2025 to 02/09/2025	WO9582686 7 IL03694	Yes	*Yes					Job 95826867 IL03694 AR-329937 31/07/2025	Related Work Order(WO): WO95826867 superseded into IL03694 31/7/2025
July 2025 Totals		4	*2	2.11	57	2	Yes		*IL03951 & IL03694 carried over
31/07/2025 to 2/09/2025 carried over	WO95826867 IL03694	Yes	*	68.56	1851	25	Yes	Job 95826867 IL03694 AR-330232 01/08/2025 AR-330233 02/08/2025	Related Work Order (WO) Operational Incident WO95887006 6/8/2025 Closed-Superseded into

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
								AR-330234 03/08/2025 AR-331526 31/08/2025 AR-332093 09/09/2025	95858822-IL03694 2/8/2025 Operational Incident WO95887006 6/8/2025 WO95887010 6/8/2025 WO95926870 12/8/2025 WO95926870 12/8/2025 WO95933033 13/8/2025 WO95953905 16/8/2025 WO96105342 24/8/2025 WO95858822-2/8/25 superseded into WO95568811-Il03591 Superseded for FST Sampling WO95826867-IL3694-31/7/2025
August 2025 Totals		**6**	**0**	**68.56**	**1851**	**25**	**Yes**		
31/07/2025 to 2/09/2025 carried over	WO95826867 IL03694			0.37	10	0	N/A	Job 96242381 IL03885 AR-332494	Related Work Order: WO96243658 IL03893 13/09/2025

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
								12/09/2025 AR-332565 15/09/2025 AR-332566 16/09/2025 AR-333006 25/09/2025	
September Totals 2025		**2**	**0**	**43.96**	**1187**	**25**	**Yes**		
July to September 2025 Totals		**12**	**2**	**114.63**	**3095**	**52**	**Yes**		
October Totals 2025		**0**	**0**	**0**	**0**	**0**	**N/A**		NO MATERIAL HARM INCIDENTS
23/11/2025-27/11/2025	WO96844445 IL04087	Yes	Yes	5.44	147	1	Yes	Job No.9684445 FST Analytical Report Job 336216 sampling 24/11/2025 FST Analytical Report Job 336217	Related Work Order WO96726780- 4/11/2025- NO Material Harm 96844445 23/11/2025

Date Range	Incident Reference	Inspection	Clean-up	Gross Pollutants removed m3	No. of bags of material removed	Syringes removed	Debris Balls Observed	Analytical Report (AR) Field Sampling Dates	Comments
								sampling 25/11/2025 FST Analytical Report Job 336288 sampling 26/11/2025	
November 2025 Totals		2	1	5.44	147	1	Yes		
December 2025 Totals		0	0	0	0	0	N/A		NO MATERIAL HARM INCIDENTS
October to December 2025 Totals		2	1	5.44	147	1			
January 2025 to December 2025 Totals		38	8	34.21	152.03	1			

7.1.4 Appendix 4: Dry Weather Sewer Level Daily Data- 6 monthly period (1 August 2025 to 17 January 2026)

*Sewer level at SG0035-Minimum value highlighted in green

Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value
1/08/2025	0.8224	1.0707	1.3201	13/08/2025	0.7844	1.0221	1.2271	25/08/2025	0.7581	0.9575	1.1451
2/08/2025	1.1065	1.2322	1.3259	14/08/2025	1.0205	1.2383	1.3334	26/08/2025	0.6592	0.899	1.13
3/08/2025	1.2062	1.2699	1.3485	15/08/2025	1.1346	1.2082	1.2857	27/08/2025	0.7869	0.9794	1.1296
4/08/2025	1.2053	1.265	1.3305	16/08/2025	0.7733	0.9986	1.1858	28/08/2025	0.7252	0.9404	1.1054
5/08/2025	0.8882	1.0873	1.276	17/08/2025	0.5818	0.8639	1.0642	29/08/2025	0.6856	0.9125	1.0596
6/08/2025	0.8762	1.05	1.2506	18/08/2025	0.7111	1.019	1.3282	30/08/2025	0.6393	0.8972	1.0234
7/08/2025	0.7403	0.9873	1.1681	19/08/2025	1.2073	1.2426	1.3349	31/08/2025	0.5792	0.8626	1.0344
8/08/2025	0.7231	0.9289	1.2692	20/08/2025	1.2071	1.2748	1.3827	1/09/2025	0.5953	0.8538	1.0272
9/08/2025	1.2185	1.2686	1.3445	21/08/2025	1.2702	1.3277	1.3709	2/09/2025	0.7188	0.8968	1.0298
10/08/2025	1.2107	1.2613	1.3145	22/08/2025	1.2246	1.2715	1.3416	3/09/2025	0.6042	0.8496	1.0228
11/08/2025	1.2071	1.2854	1.3287	23/08/2025	1.2051	1.2723	1.333	4/09/2025	0.5923	0.8189	1.0115
12/08/2025	0.8585	1.0958	1.2807	24/08/2025	0.8885	1.0959	1.2913	5/09/2025	0.5811	0.8177	0.9872

Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value
6/09/2025	0.5584	0.8216	0.9736	22/09/2025	0.5707	0.8407	1.0617	8/10/2025	0.5258	0.7554	0.9428
7/09/2025	0.5339	0.8099	0.9936	23/09/2025	0.6216	0.8544	1.0542	9/10/2025	0.5063	0.7372	0.9188
8/09/2025	0.561	0.8157	1.0095	24/09/2025	0.5809	0.8137	1.0113	10/10/2025	0.5034	0.7432	0.9016
9/09/2025	0.5981	0.8246	1.0022	25/09/2025	0.5703	0.8078	0.9866	11/10/2025	0.4815	0.7455	0.8891
10/09/2025	0.5811	1.0717	1.548	26/09/2025	0.5672	0.8055	0.9659	12/10/2025	0.4571	0.7301	0.9122
11/09/2025	1.2483	1.319	1.3996	27/09/2025	0.5391	0.7964	0.9371	13/10/2025	0.4747	0.7259	0.9463
12/09/2025	1.1643	1.2313	1.2874	28/09/2025	0.5048	0.7743	0.9427	14/10/2025	0.4868	0.7472	0.9113
13/09/2025	0.7538	0.9802	1.1643	29/09/2025	0.5343	0.7703	0.9738	15/10/2025	0.4852	0.7201	0.9418
14/09/2025	0.6009	0.8546	0.9988	30/09/2025	0.5438	0.7846	0.9653	16/10/2025	0.5002	0.7273	0.928
15/09/2025	0.5538	0.8356	1.0967	1/10/2025	0.5435	0.7693	0.9583	17/10/2025	0.502	0.7314	0.9126
16/09/2025	0.7083	0.9198	1.0863	2/10/2025	0.5289	0.7497	0.9319	18/10/2025	0.4718	0.7335	0.8797
17/09/2025	0.6414	0.8923	1.0696	3/10/2025	0.5192	0.7462	0.913	19/10/2025	0.4453	0.7222	0.9246
18/09/2025	0.6367	0.8666	1.0443	4/10/2025	0.4948	0.744	0.9027	20/10/2025	0.4777	0.7343	0.9334
19/09/2025	0.6301	0.8696	1.0263	5/10/2025	0.4883	0.7256	0.8813	21/10/2025	0.4842	0.7163	0.9185
20/09/2025	0.7561	0.938	1.0096	6/10/2025	0.4732	0.7204	0.9436	22/10/2025	0.4838	0.7236	0.9227
21/09/2025	0.5522	0.8388	1.0151	7/10/2025	0.5117	0.7422	0.9473	23/10/2025	0.4835	0.713	0.8962

Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value
24/10/2025	0.4714	0.7154	0.8785	9/11/2025	0.4532	0.7396	0.9155	25/11/2025	0.5572	0.7832	0.9877
25/10/2025	0.4542	0.7165	0.8694	10/11/2025	0.4712	0.7328	0.9298	26/11/2025	0.5112	0.7902	0.9825
26/10/2025	0.429	0.7014	0.8944	11/11/2025	0.4854	0.7064	0.9008	27/11/2025	0.5214	0.7327	0.9619
27/10/2025	0.4725	0.7167	0.9171	12/11/2025	0.4643	0.735	0.9224	28/11/2025	0.5208	0.7278	0.9031
28/10/2025	0.4623	0.6953	0.9219	13/11/2025	0.4844	0.7293	0.8864	29/11/2025	0.4814	0.7254	0.8781
29/10/2025	0.4791	0.8668	1.1104	14/11/2025	0.4833	0.7164	0.9015	30/11/2025	0.4493	0.7029	0.9011
30/10/2025	0.4006	0.6539	0.9887	15/11/2025	0.4668	0.7539	1.0063	1/12/2025	0.4761	0.7153	0.9227
31/10/2025	0.3647	0.6441	1.0174	16/11/2025	0.4565	0.7517	0.9279	2/12/2025	0.4721	0.7045	0.9198
1/11/2025	0.7318	0.9407	1.1707	17/11/2025	0.4742	0.7408	0.9277	3/12/2025	0.4768	0.6993	0.9137
2/11/2025	0.3613	0.6474	0.8659	18/11/2025	0.4775	0.7103	0.9306	4/12/2025	0.4943	0.7312	0.905
3/11/2025	0.5145	0.8422	1.2938	19/11/2025	0.4864	0.7201	0.9216	5/12/2025	0.4859	0.7233	0.8861
4/11/2025	0.5872	0.7985	1.2022	20/11/2025	0.4898	0.7186	0.901	6/12/2025	0.4579	0.7307	0.873
5/11/2025	0.5372	0.7855	0.9456	21/11/2025	0.4718	0.7053	0.8775	7/12/2025	0.4335	0.7015	0.886
6/11/2025	0.5155	0.7576	0.9242	22/11/2025	0.4543	0.7471	1.2433	8/12/2025	0.468	0.6995	0.8829
7/11/2025	0.5031	0.7318	0.8985	23/11/2025	0.6525	1.0233	1.2537	9/12/2025	0.4575	0.7153	0.8814
8/11/2025	0.4782	0.7474	0.8991	24/11/2025	0.5325	0.8108	1.0157	10/12/2025	0.4785	0.6872	0.907

Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value	Calendar Date	Minimum Result Value	Average Result Value	Maximum Result Value
11/12/2025	0.5193	0.7312	0.8889	27/12/2025	0.352	0.6357	0.8201				
12/12/2025	0.5401	0.8835	1.1897	28/12/2025	0.3886	0.6262	0.8146				
13/12/2025	0.3542	0.636	0.8061	29/12/2025	0.4182	0.6431	0.8542				
14/12/2025	0.6499	0.7599	0.8312	30/12/2025	0.441	0.665	0.8508				
15/12/2025	0.4716	0.6979	0.9209	31/12/2025	0.4413	0.6724	0.8397				
16/12/2025	0.5008	0.7079	0.8823								
17/12/2025	0.4964	0.714	0.9103								
18/12/2025	0.5087	0.7224	0.8913								
19/12/2025	0.4979	0.7557	0.968								
20/12/2025	0.3721	0.6942	0.9406								
21/12/2025	0.4866	0.7817	0.9402								
22/12/2025	0.5115	0.7256	0.8844								
23/12/2025	0.4805	0.7189	0.8669								
24/12/2025	0.4718	0.7084	0.8604								
25/12/2025	0.4365	0.6469	0.8387								
26/12/2025	0.3693	0.5976	0.7842								

7.1.5 Appendix 5: D0001845.02 – Mill Pond/Foreshore Beach Material Harm Assessment

Take care to keep away from threatened bird species and their nests, particularly between August and January – see page 3

Network Operator

Assess for material harm two hours each side of low tide. See page 4 for guidance regarding 'material harm'.

Assess areas A-B-C-D. Check for solids, syringes, debris balls and dead fish. Install signs and danger tape and locate on clean-up plan. Take photographs (use timestamp app). An incident must be declared for regulator reporting

- If there is new ***Material Harm*** (see page 4) call the Dispatcher to declare a Material Harm incident.
- **OTHERWISE -** Declare an ***Operational incident*** (e.g. clean-up is not required, or a clean-up is in progress from a previous incident)

Areas requiring clean-up					
A		B		C	

Area ‘A’ is usually worst affected

Take care to keep away from threatened bird species and their nests, particularly between August and January – see page 3

Clean-up Crews

Work can start at high tide and continue till 2-hours after low tide. Prioritise syringe removal.

In the areas marked above, gather and bag any sewage solids (debris balls, wet wipes, plastics, ear buds, sanitary products, syringes etc). Pay attention to debris wrapped around rocks, and small plastic items in the seaweed at the high tide line. Full bags to be temporarily stored on a waterproof membrane (e.g. tarp) – see page 3.

Daily email update - count and photograph (with timestamp), syringes, debris balls and rubbish bags collected. Also count bags removed / left on site. If solids collected using plant, estimate of the cubic metres of waste removed.
Email to environmentalregulation@sydneywater.com.au

PHOTOGRAPHS - Page 3/4

Gather and bag any sewage solids.
Full bags to be temporarily stored on a waterproof membrane (e.g. tarp) and enclosed in a temp fence.

Install signs and danger tape and locate on clean-up plan. Take photographs (use timestamp app).

Take care to keep away from threatened bird species and their nests, particularly between August and January

Pied Oystercatcher

Little Tern

MATERIAL HARM - Page 4/4

There is Material Harm if you find any <u>dead fish</u> OR any <u>debris balls</u> (can be black, grey or white).

There is Material Harm if you find any of the following in quantities that are <u>too much to collect in full as you conduct the material harm assessment (one bag)</u> and further clean-up is required.

Condoms

Sanitary Pad

Debris

Wet Wipes

Syringe

Syringe

7.1.6 Appendix 6: Odour Control Unit- Odour Concentration Measurement Report 22

THE ODOUR UNIT

☒ **Sydney Laboratory**
The Odour Unit Pty Ltd
Level 3, 12/56 Church Avenue
MASCOT NSW 2020
P: +61 2 9209 4420
E: info@odourunit.com.au
ABN: 53 091 165 061

☐ **Brisbane Laboratory**
The Odour Unit (QLD) Pty Ltd
2/57 Neumann Road
CAPALABA QLD 4165
P: +61 7 3245 1700
E: qldinfo@odourunit.com.au
ABN: 87 102 255 765

Odour Concentration Measurement Report

Sampling and Laboratory Information

Organisation	Sydney Water Corp	Telephone	+61 401 701 635
Contact	M. Kacprzak	Email	michael.kacprzak@sydneywater.com.au
Sampling Site	Mascot, NSW	Sampling Personnel	Sydney Water Corporation
Sampling Method	AS/NZS 4323.3	Laboratory Location	Mascot, NSW

Order and Project Information

Order requested by	M. Kacprzak	Order accepted by	A. Schulz
Date of order	25.11.2025	TOU Project #	N1604-01
Order number	Refer to Correspondence	Project Manager	A. Schulz
Signed by	M. Kacprzak	Panel Operator	A. Schulz

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag. Samples were analysed as received from the client and/or The Odour Unit. Results relate specifically to the samples as received.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian/New Zealand Standard: Stationary source emissions – *Part 3: 'Determination of odour concentration by dynamic olfactometry* (AS/NZS 4323.3). The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \le \chi \le 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting 2^{17}. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained at 22 °C ±3 °C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: TOU-OLF-004
Laboratory Precision	The precision of this laboratory (expressed as repeatability) for sensory quality must be $r \le 0.477$ in accordance with the AS/NZS 4323.3. $r = 0.135$ Compliance – Yes
Laboratory Accuracy	The accuracy of this laboratory for sensory quality must be $A \le 0.217$ in accordance with the AS/NZS 4323.3. $A = 0.208$ Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou, which is 4 times the lowest dilution setting.
Traceability	The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen. Note Disclaimers on last page of this document.

Accredited for compliance with ISO/IEC 17025 - Testing.
This report shall not be reproduced, except in full.

Date: Monday, 12 January 2026

Panel Roster Number: SYD20251222_122

NATA

Accreditation Number: 14974

A. Schulz
Authorised Signatory

The Odour Unit Pty Ltd
ABN 53 091 165 061
Form 06 – Odour Concentration Results Sheet

Issue Date: 13.11.2003
Issued By: SB
Last printed 16/01/2026 2:05:00 PM

Revision: 14
Revision Date: 17.08.2022
Approved By: TS

1

THE ODOUR UNIT

Accreditation Number: 14974

Odour Sample Measurement Results
Panel Roster Number: SYD20251222_122

Sample ID / Location	Laboratory ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Final Odour Concentration (ou)
SYD041 - Outlet #1	SC25964	22/12/2025 0930 - 0938 hrs	22/12/2025 1406 hrs	6	12	114
SYD041 - Outlet #2	SC25965	22/12/2025 1032 - 1040 hrs	22/12/2025 1443 hrs	6	12	102
SYD041 - Inlet #1	SC25966	22/12/2025 0930 - 0938 hrs	22/12/2025 1513 hrs	6	12	139,000
SYD041 - Inlet #2	SC25967	22/12/2025 1032 - 1040 hrs	22/12/2025 1538 hrs	6	12	147,000

Samples Received in Laboratory – From: SWC (M. Kacprzak) Date: 22/12/2025 Time: 1220 hrs

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit:

1. The collection of samples by a method that is not prescribed by AS/NZS 4323.3.
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit have performed the dilution of samples.

THE ODOUR UNIT

Accreditation Number: 14974

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS 4323.3 (Yes / No)
n-butanol	SYD20251222_122	46,000	$20 \leq \chi \leq 80$	724	64	Yes

Comments: Odour characters (non-NATA accredited) as determined by odour laboratory panel:

Sample ID / Location	Laboratory ID	Odour Character
Outlet #1	SC25964	musty, cabbage
Outlet #2	SC25965	slight cabbage
Inlet #1	SC25966	rotten egg
Inlet #2	SC25967	rotten egg

Disclaimers:

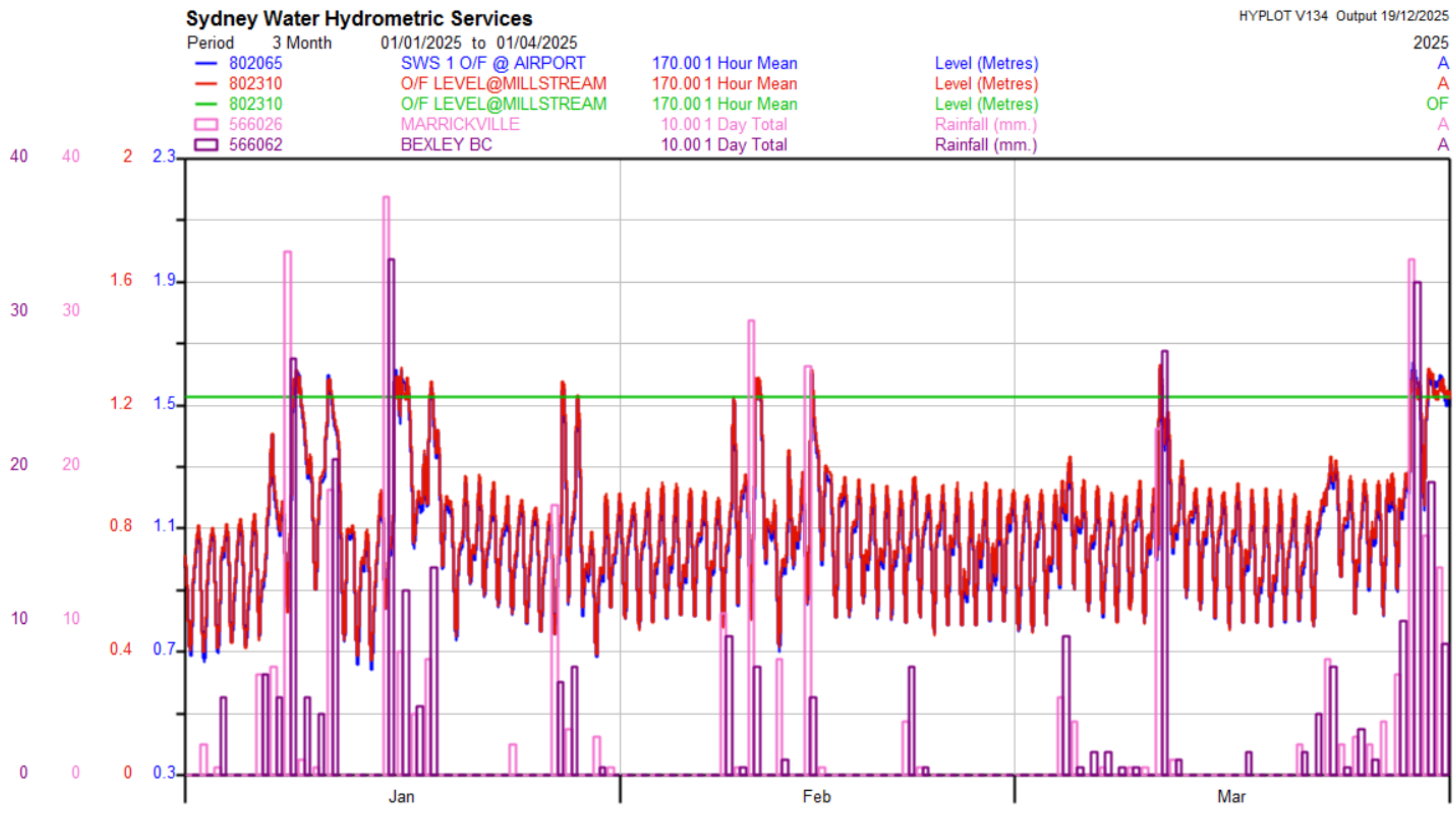
1. Parties, other than The Odour Unit, responsible for collecting odour samples have advised that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit for the purpose of odour testing.
2. The collection of odour samples by parties other than The Odour Unit relinquishes The Odour Unit from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.
3. Any comments included in, or attachments to, this Report are not covered by the NATA Accreditation issued to The Odour Unit.
4. This report shall not be reproduced, except in full, without written approval of The Odour Unit.

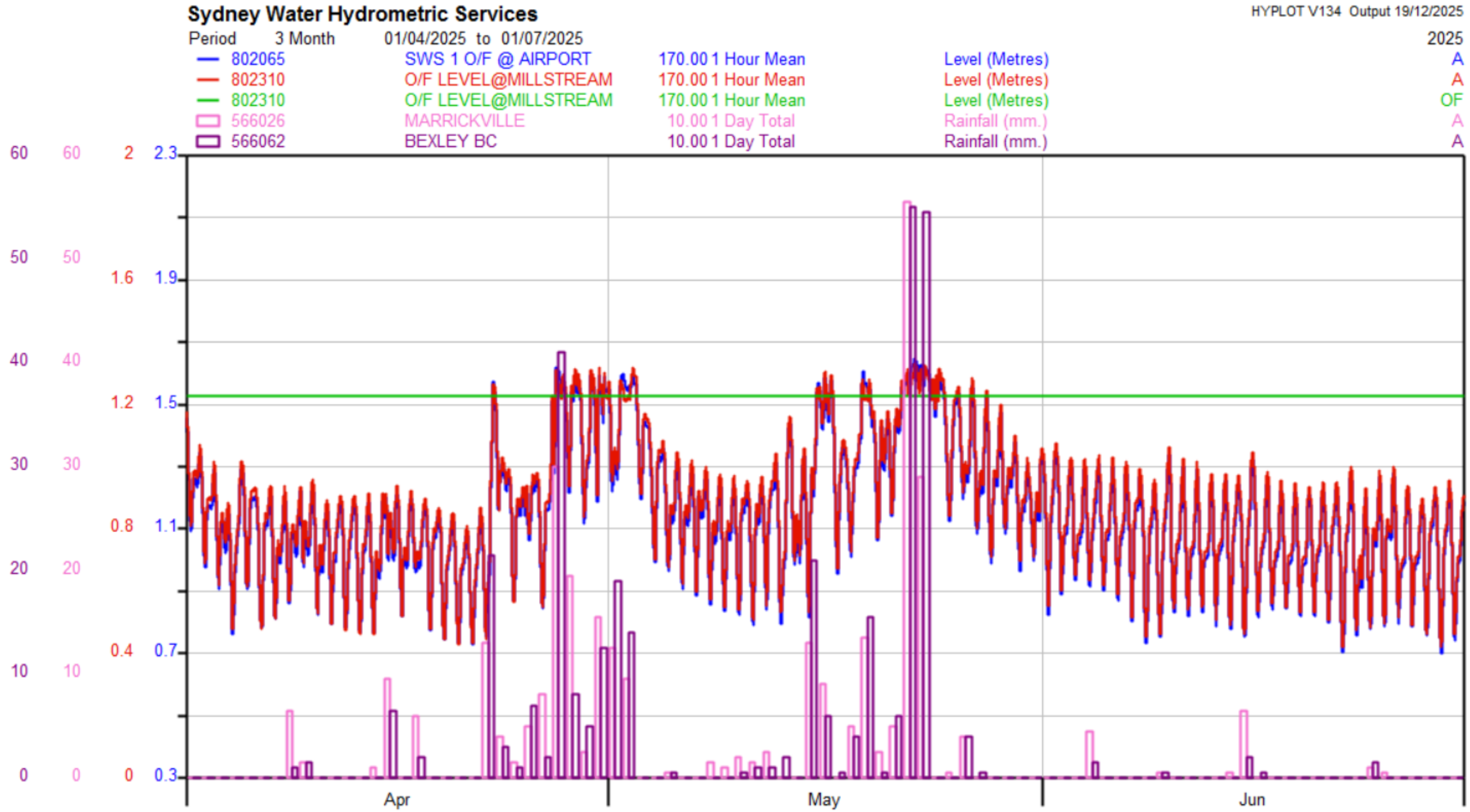
Report Status

Status	Version	Prepared by	Date	Checked by	Date	Change	Reason
Final	1.0	A. Schulz	12/01/2026	M. Assal	12/01/2026	--	--
Revised	1.1	I. Farrugia	16/01/2026	--	--	Dates on *Analysis Date & Time* column	Dates corrected

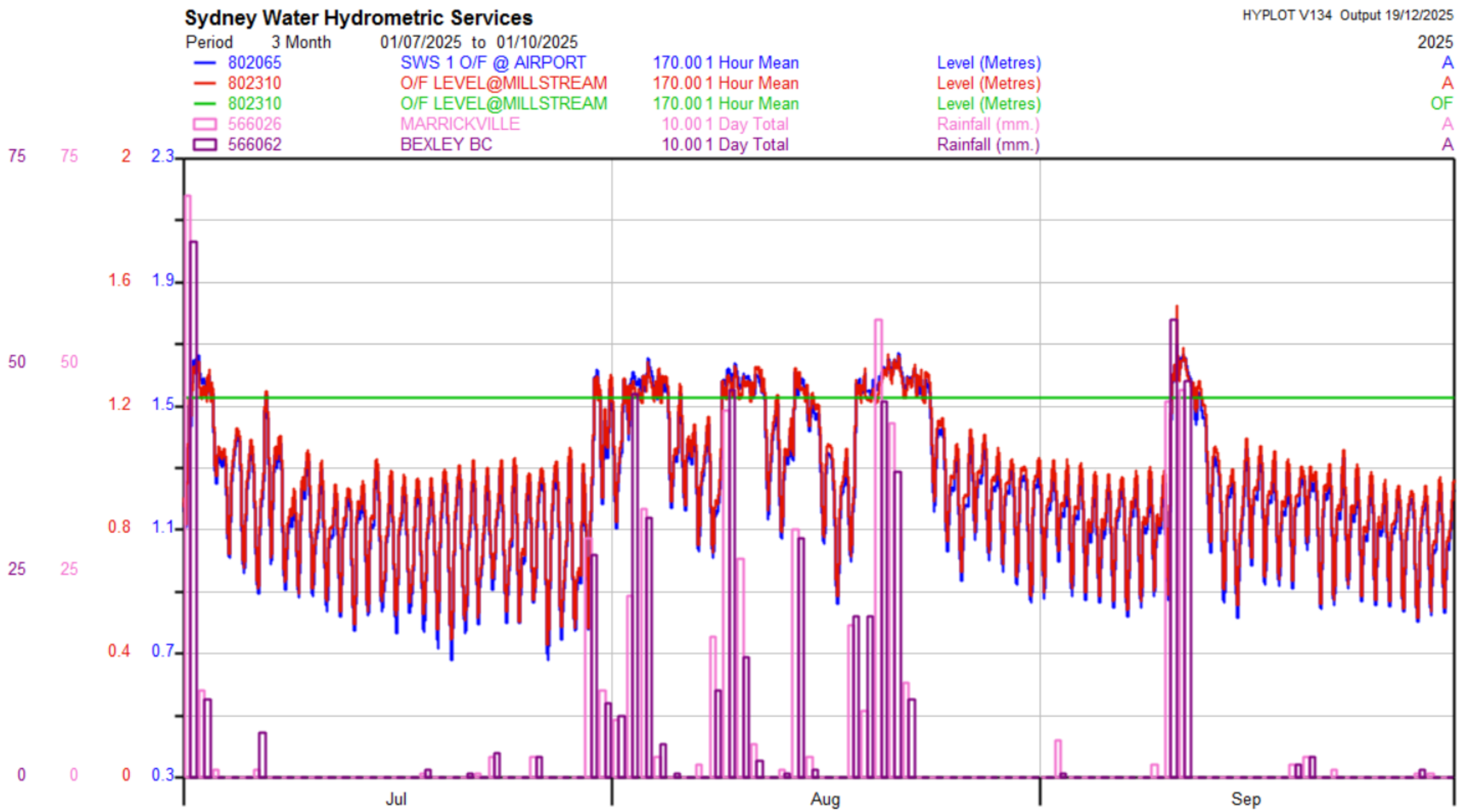
END OF DOCUMENT

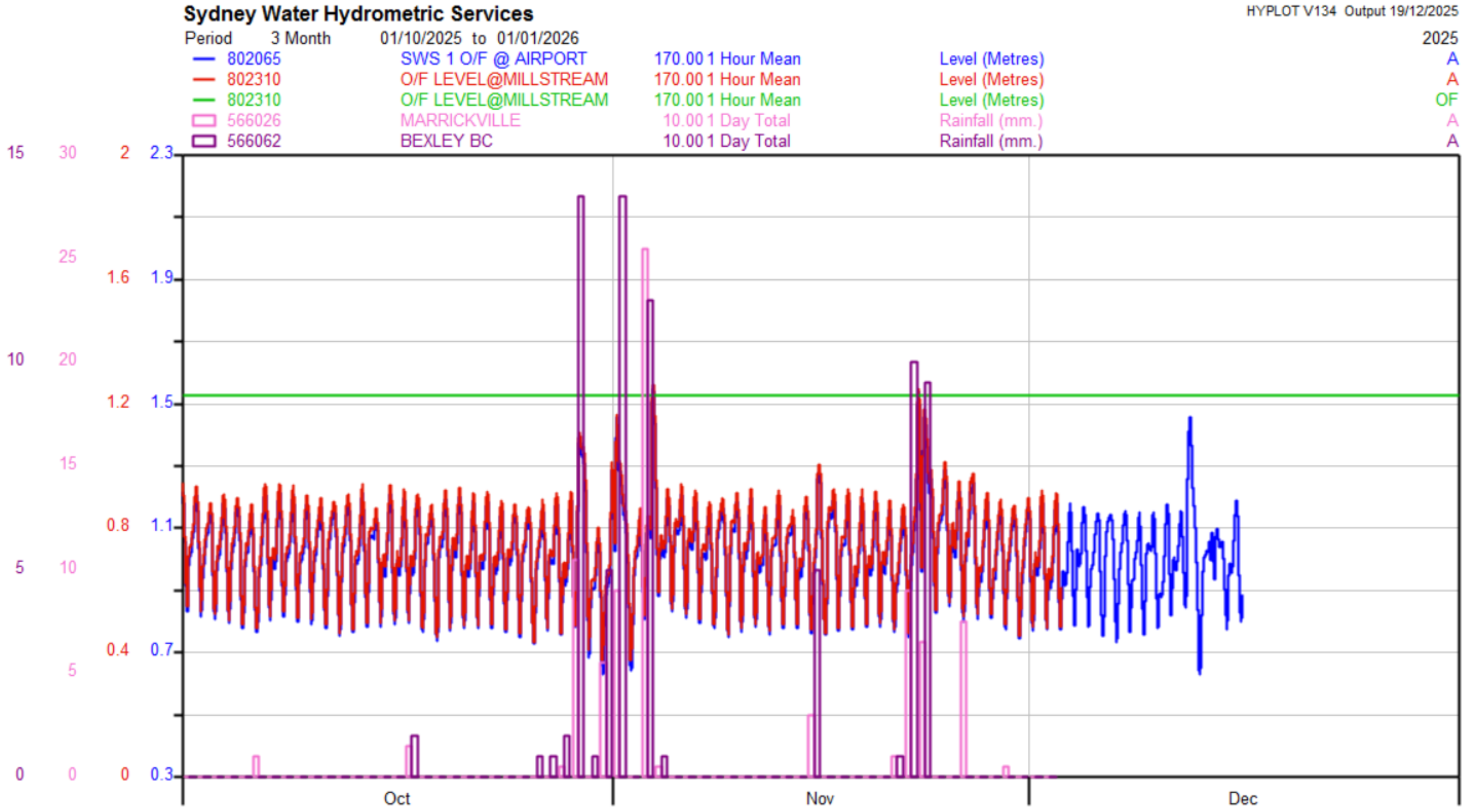
7.1.7 Appendix 7: Sydney Water Monitored ERS Gauge levels at Mill Stream Quarterly Periods Rainfall plots, Overflow Volumes and Sewer Levels



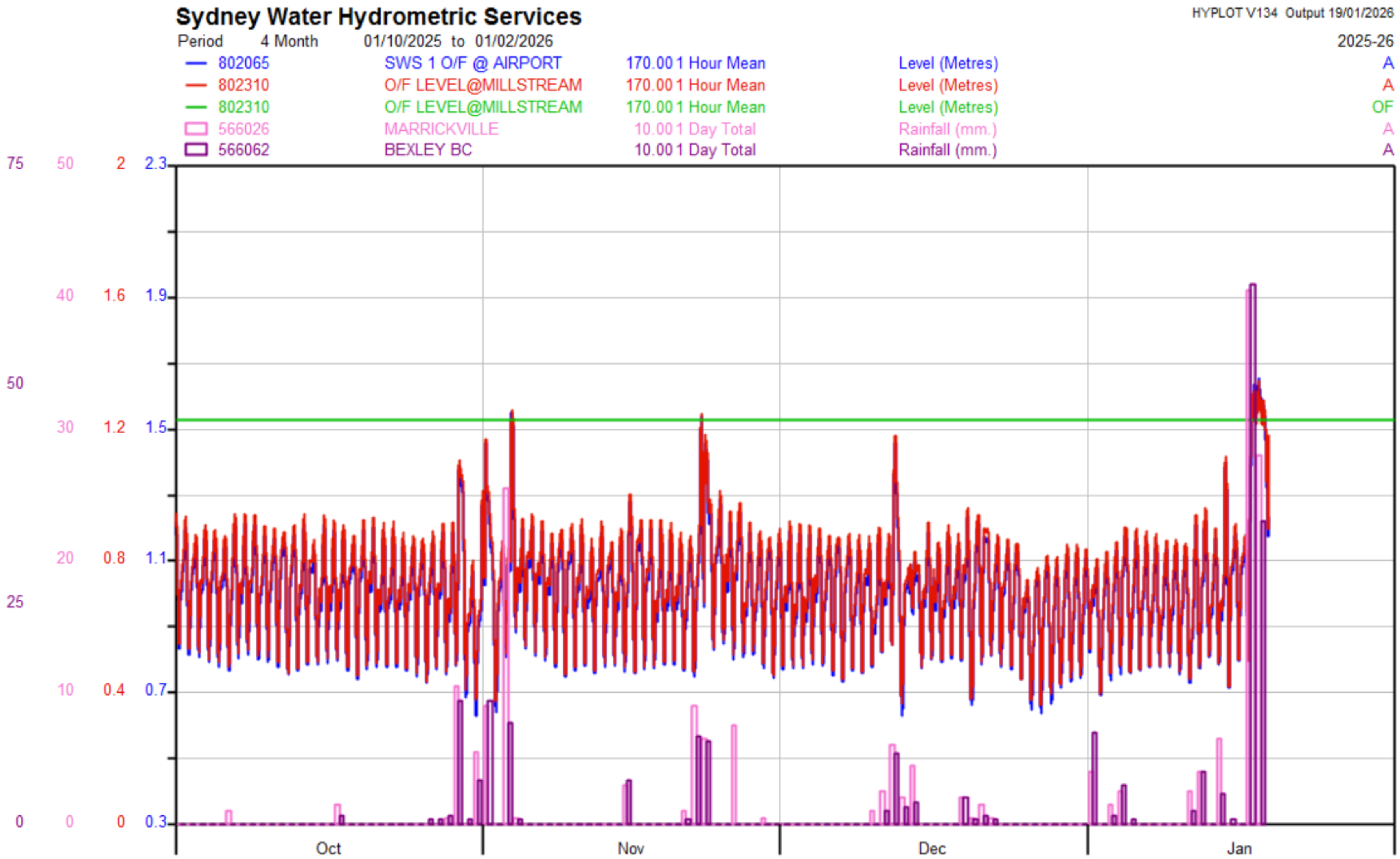


Sydney Water Hydrometric Services
HYPLOT V134 Output 19/12/2025
Period 3 Month 01/04/2025 to 01/07/2025
2025
802065 SWS 1 O/F @ AIRPORT 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) OF
566026 MARRICKVILLE 10.00 1 Day Total Rainfall (mm.) A
566062 BEXLEY BC 10.00 1 Day Total Rainfall (mm.) A
60 60 2 2.3
50 50
1.6 1.9
40 40
1.2 1.5
30 30
0.8 1.1
20 20
10 10
0.4 0.7
0 0 0 0.3
Apr
May
Jun


Sydney Water Hydrometric Services
HYPLOT V134 Output 19/12/2025
Period 3 Month 01/07/2025 to 01/10/2025
2025
802065 SWS 1 O/F @ AIRPORT 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) OF
566026 MARRICKVILLE 10.00 1 Day Total Rainfall (mm.) A
566062 BEXLEY BC 10.00 1 Day Total Rainfall (mm.) A
75 75 2 2.3
1.6 1.9
50 50
1.2 1.5
0.8 1.1
25 25
0.4 0.7
0 0 0 0.3
Jul
Aug
Sep



Sydney Water Hydrometric Services
HYPLOT V134 Output 19/12/2025
Period 3 Month 01/10/2025 to 01/01/2026
2025
802065 SWS 1 O/F @ AIRPORT 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) OF
566026 MARRICKVILLE 10.00 1 Day Total Rainfall (mm.) A
566062 BEXLEY BC 10.00 1 Day Total Rainfall (mm.) A
15 30 2 2.3
25
1.6 1.9
10 20
1.2 1.5
15
0.8 1.1
5 10
0.4 0.7
5
0 0 0 0.3
Oct
Nov
Dec


Sydney Water Hydrometric Services
HYPLOT V134 Output 19/01/2026
Period 4 Month 01/10/2025 to 01/02/2026
2025-26
802065 SWS 1 O/F @ AIRPORT 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) A
802310 O/F LEVEL@MILLSTREAM 170.00 1 Hour Mean Level (Metres) OF
566026 MARRICKVILLE 10.00 1 Day Total Rainfall (mm.) A
566062 BEXLEY BC 10.00 1 Day Total Rainfall (mm.) A
75 50 2 2.3
40 1.6 1.9
50
30 1.2 1.5
20 0.8 1.1
25
10 0.4 0.7
0 0 0 0.3
Oct
Nov
Dec
Jan

7.1.8 Appendix 8: Sydney Water Variation Request under Requirement 5.16(3) of the Airports (Environment Protection) Regulations 1997

Sydney WATER

Variation Request under Regulation 5.16(3) of the *Airports (Environment Protection) Regulations 1997*

Condition No.	Approved condition	Proposed amended condition (changes in red)	Reason variation is sought	Proposed update to Environmental Management Plan (EMP)	Period for which the variation is needed
2(b)	Annual EMP Compliance Report to the AEO by 31 January 2026, covering the period from 17 January 2025 to 17 January 2026	Annual EMP Compliance Report to the AEO by 28 February 2026, covering the period from 01 January 2025 to 31 December 2025	Sydney Water collects data in quarterly periods, with the fourth quarter of the year ending on 31 December. By reporting to 17 January each year, this creates difficulty for Sydney Water teams to collate and analyse the relevant data required for the annual report which also covers the fourth quarter. Due to limited staff and subject matter expert availability during the holiday period, Sydney Water also requests extending the submission deadline to 28 February 2026 to allow adequate time for data validation, internal review and reporting aligned with calendar year data. This approach was successfully trialled for the 2024 EMP Compliance Report.	Amend Table 4 - Mill Stream environmental management plan summary - 'Annual Compliance Report submitted by 28 February 2026'	Until end of Authorisation period – 31 March 2027
2(c)	Annual EMP Compliance Reports to the AEO by 31 January 2027, covering the period from 17 January 2026 to 17 January 2027	Annual EMP Compliance Reports to the AEO by 28 February 2027, covering the period from 01 January 2026 to 31 December 2026	As per 2(b).	Amend Table 4 - Mill Stream environmental management plan summary - 'Annual Compliance Report submitted by 28 February 2027'	
2(d)	Annual EMP Compliance Reports to the AEO by 31 March 2027, covering the period from 17 January 2027 to 17 March 2027	Annual EMP Compliance Reports to the AEO by 30 April 2027, covering the period from 01 January 2027 to 31 March 2027	The final report covering 01 January 2027– 31 March 2027 is proposed for submission by 30 April 2027 to allow sufficient time for data compilation and quality assurance and to align with the end of the current authorisation period.	Amend Table 4 - Mill Stream environmental management plan summary - 'Annual Compliance Report submitted by 30 April 2027'	
9	By 1 February 2025, 1 February 2026 and 1 February 2027 Sydney Water must provide an annual update on the progress of the implementation of the EMP at a community meeting to be held locally (e.g. Botany Town Hall).	By 1 February 2025, 1 March 2026 and 1 May 2027 Sydney Water must provide an annual update on the progress of the implementation of the EMP at a community meeting to be held locally (e.g. Botany Town Hall).	Community engagement meetings are proposed to shift to align with the proposed revised EMP Compliance Report schedule and ensure meaningful stakeholder communication. This approach was successfully trialled for the 2024 EMP Compliance Report.	NA.	

10	By 28 February 2025, 28 February 2026 and 28 February 2027 finalised copies of the Annual EMP Compliance Report must be provided to Bayside Council and published on the Sydney Water Website.	By 28 February 2025, 31 March 2026 and 31 May 2027 finalised copies of the Annual EMP Compliance Report must be provided to Bayside Council and published on the Sydney Water Website.	The publication deadline for EMP Compliance Reports is proposed to move to allow coordination with Bayside Council, and timely web publication.	NA.	
20	By 31 December 2024 Sydney Water must complete all operational works for the Botany Low Level Carrier Rehabilitation project.	By 31 December 2026 Sydney Water must complete all operational works for the Botany Low Level Carrier Rehabilitation project.	A number of complexities have been experienced in completing the operational works for the Botany Low Level Carrier Rehabilitation project, which have impacted delivery timeframes, and are anticipated to have an ongoing impact. These have now been estimated and incorporated into the delivery schedule. These complexities have included:: • Access constraints within Sydney Airport grounds requiring a formal access agreement; • Project delays stemming from prolonged negotiations and legal reviews of the Licence Access Agreement; • Technical challenges including debris obstruction, suspected pipe collapse, and heritage-listed tree root interference; • Environmental and asset condition; and • uncertainties impacting site investigations. Please refer to the attached for reference: • Stakeholder Reference Group Meeting Slides - 23 July 2025 (**Attachment A**), and • Project Control Group Meeting Slides - 15 August 2025 (**Attachment B**).	Amend the completion date for the Botany Low Level Carrier Rehabilitation project under section 6.1.5 and 'Table 4 Mill Stream environmental management plan summary', and update Appendix A 'Detailed delivery timeframes'.	
23	By 31 December 2026 Sydney Water must complete the construction and implementation of wastewater screening at Pump Station SP0038.	By 31 December 2026 Sydney Water must commence the construction and implementation of wastewater screening at Pump Station SP0038.	Sydney Water has redirected its focus toward an alternative solution to deliver	Amend the start of the wastewater screening construction and remove reference to completion date under section 6.4.2 and in 'Table 4 Mill Stream	

Sydney Water Corporation ABN 49 776 225 038
1 Smith Street, Parramatta, NSW 2150 | PO Box 399, Parramatta, NSW 2124
Telephone 13 20 92 **Media (24/7)** 8849 5151 **sydneywater.com.au**

			this project, which is progressing through the design phase. The preferred original design was scoped, however this option would have resulted in significant delays to project delivery due to heritage constraints and technical difficulties identified at Pump Station SP0038. Completion date of construction of the new design is estimated to be 31 December 2027 (to be determined in the next Authorisation period).	environmental management plan summary' and update Appendix A 'Detailed delivery timeframes'.	
24	By 31 March 2027, Sydney Water must complete at least 40% of the SWSOOS 2 desilting program	By 31 March 2027, Sydney Water must complete between 10-15% of the SWSOOS 2 desilting program.	Less than 1% of desilting has been completed as of September 2025. This is because the planned safe access approach to the SWSOOS 2 pipe to carry out the desilting required implementation of an isolation valve, and rectification of a collapsed section of overflow pipe. However, this access option risks resulting in minor leakage of dry weather sewage into the environment, which is a Non-Compliance under Sydney Water's Environment Protection License with the NSW Environment Protection Authority (EPA), and an offence under the Protection of the *Environment Operations Act 1997* (POEO Act). As a result, the project is currently on hold whilst Sydney Water ensures safe access and flow management constraints. An alternate strategy to assess other potential safe access solutions is also being undertaken in parallel.	Reflect new target for the desilting project under section 6.1.1, in 'Table 4 Mill Stream environmental management plan summary' and update Appendix A 'Detailed delivery timeframes'.	

7.1.9 Appendix 9: Mill Stream Odour Monitoring Report-September 2025

7.1.10 Appendix 10: Mill Stream Water Quality Report 2025- Mill Stream WQ Report 2025.pdf , Mill Stream App 7.3 WQ raw data.xlsx

7.1.11 Appendix 11: An Overview of Model Compliance with Condition L7.1- Millstream Overflow Performance Reporting Jan 2025 to Dec 2025 Ver1.pdf

Odour Monitoring at Mill Stream

September 2025

sydneywater.com.au

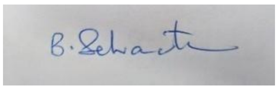
26 September 2025

Acknowledgement of Country

Sydney Water respectfully acknowledges the Traditional Custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.

Document Control

Prepared by:



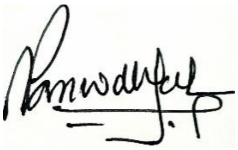
Bala Selvananthan

Planning Program Lead
Integrated Planning East, SP&LA

Date:

11/09/2025

Endorsed by:



Nilesh Panwalkar

Manager, Integrated Planning East
SP&LA

Date:

15/09/2025

Approved by:

Tim Hill

Environmental Regulatory Manager

Water, Environment and Infrastructure Performance

Date:

26/09/2025

Figures

Tables

No table of figures entries found.

1. Introduction

Sydney Water owns the Mill Stream Emergency Relief Structure (ERS) located within the grounds of Sydney Airport (**Figure 1**).

Emergency relief structures are an essential component of all wastewater systems. They are critical control points which are engineered to prevent damage to networks and protect public health by preventing wastewater surcharges and flooding of private property and public spaces during wet weather. The structures and discharges are commonly referred to as ‘overflows’ and most often occur at times of intense rainfall when the stormwater flows have infiltrated the wastewater system.

The Malabar wastewater system is the largest system that Sydney Water owns and operates. It covers approximately one third of Sydney and services nearly 1.8 million people. The South Western Suburbs Ocean Outfall Sewer (SWSOOS) conveys wastewater from the merging chamber at Arncliffe to Malabar Water Resource Recovery Facility (WRRF).

Sydney Water owns and operates eight ERSs on the SWSOOS that discharge wastewater to the Mill Stream during wet weather (known collectively as the Mill Stream ERS). The Mill Stream is located on the eastern side of Sydney Airport at Mascot. It is the last major ERS on the SWSOOS before the Malabar WRRF.

Odour in the past has been identified as a potential issue for the operation of the ERS due to complaints that have been received from the local community, particularly from residents in Botany to the east of the ERS. The Mill Stream Quarterly Compliance Reports have reported the below complaints since the odour monitoring commenced on 18 September 2024:

- For the quarterly reporting period of 1 July 2024 to 30 September 2024, there were no odour complaints received.
- For the quarterly reporting period of 1 October 2024 to 31 December 2024, a complaint was received on 17 December 2024. Sydney Water investigated this issue, however no odour was detected, and all Sydney Water assets were operating as normal. Sydney Water concluded that odour may have been coming from a vent stack nearby due to wind and heat. A second complaint was received on 23 October 2024, however it was related to the odour control unit (OCU) located near the Sydney Airport Control Tower (SY0041).
- For the quarterly reporting period of 1 January 2025 to 30 March 2025, there were no odour complaints received related to the Mill Stream ERS. One complaint was received on 7 January 2025 related to OCU SY0041.
- For the quarterly reporting period of 1 April 2025 to 30 June 2025, one complaint was received on 13 June 2025. The complainant reported odours emanating from the Mill Pond wastewater overflow facility located adjacent to Botany Public School at 1076 Botany Road, Botany. Sydney Water investigated this issue, and the odour was deemed to be potentially attributed to a private fault located in front of 1367 Botany Road, Botany.
- Any complaints received for the current reporting period (1 July 2025 – 30 September 2025) will be included in the next Quarterly Compliance Report and tabled at the next Mill Stream Stakeholder Reference Group meeting, to be held on 23 October 2025.

Figure 1: Location of Mill Stream Emergency Relief Structure

2. Odour monitoring

Sydney Water commissioned odour sampling of potential sources to better understand the potential odour impacts of the ERS. The sampling was initially carried out between July 2020 and March 2021 and aimed to quantify odour emissions from the Mill Stream ERS discharge point and up and downstream of the ERS, among other potential sources. The sampling was carried out in normal (dry weather), overflow and after overflow (wet weather) conditions.

2.1 Monitoring undertaken in Phase 1

Monitoring was conducted at the Airport Fence and Botany Public School over a twelve-month period from January 2021 and January 2022. The results indicate that the H_2S values at both sites were low, with a maximum concentration of 0.037 ppm at Botany Public School and 0.756 ppm at the Airport fence. The monitors were removed after consistently low level of H_2S recorded at both locations.

2.2 Monitoring undertaken in Phase 2

As part of the Environmental Management Plan (EMP) Section 6.5.5, Sydney Water installed four continuous air quality monitoring (H_2S) stations near Mill Stream overflows to capture periods of overflow discharge over a period of 12 months. The findings have complemented the monitoring that was conducted in 2020/21.

Monitors were installed on 18 September 2024, upstream of overflows near Botany Public School, at the Mill Stream overflows, and near the Botany container terminal along Foreshore Drive. These monitors have been in place for a period of nearly 12 months.

Please see the locations of monitoring sites in **Figure 2.**

During the monitoring period of 18 September 2024 to the 26 August 2025, a maximum of 0.006 ppm was detected on 18 August 2025 at Sydney Airport Fence, a level that was not detectable by the human nose. A maximum of 0.21 ppm was detected on 8 May 2025 at Foreshore Beach, a level that was detectable but a very low level and presents no danger to human health. A maximum of 0.43 ppm was detected on 7 December 2024, a level that was detectable by the human nose but a very low level and presents no danger to human health.

2.3 Recommendation

Based on the consistently low levels of H_2S recorded as part of phase 2 at the three sites mentioned above, it is recommended that monitoring be discontinued and the monitors removed.

Figure 2: Odour monitoring locations

3. Appendix

3.1 Monitoring data from Botany Public School, Foreshore Beach and ERS at Mill Stream

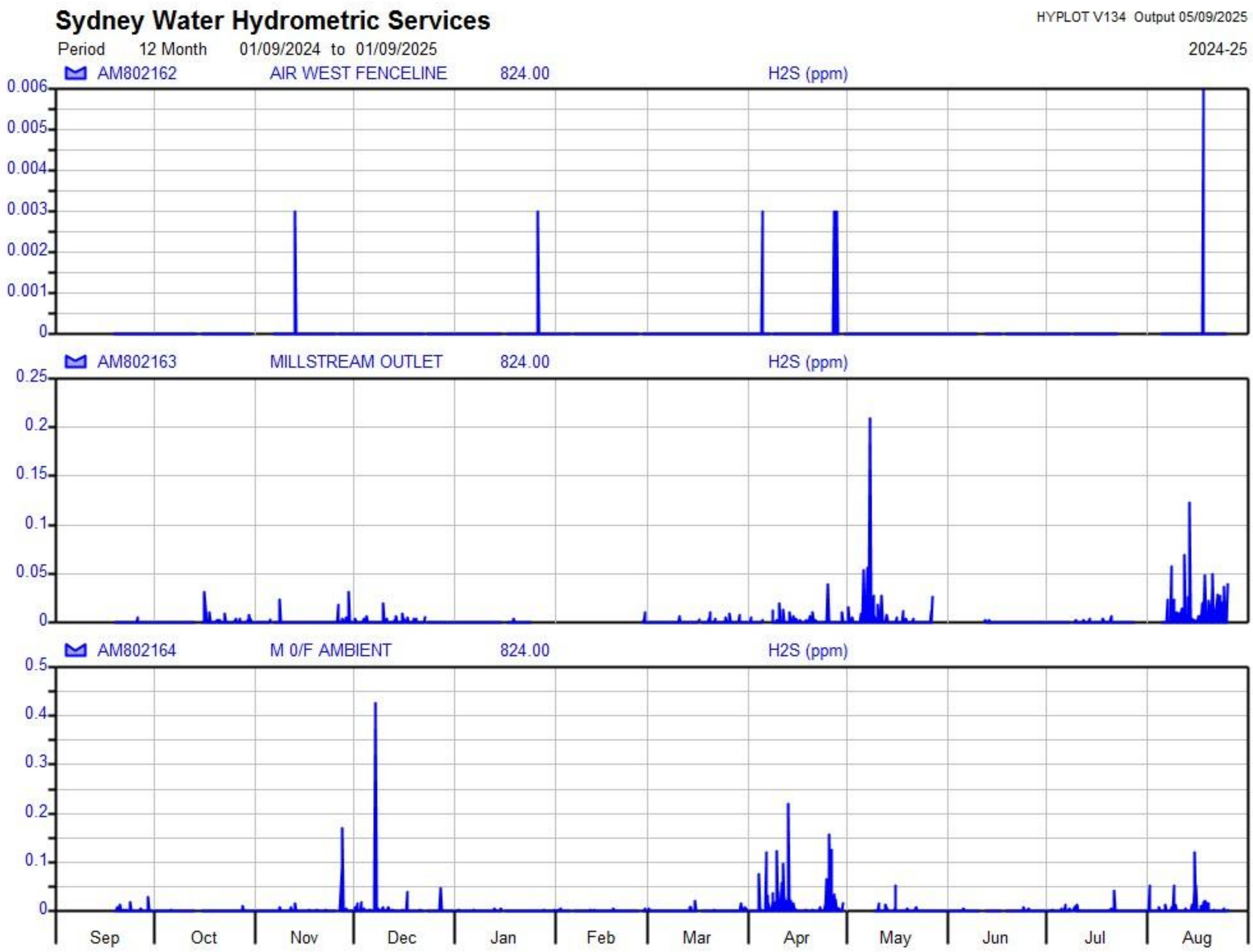


Figure 3: Monitoring data from Botany Public School, Foreshore Beach and ERS at Mill Stream

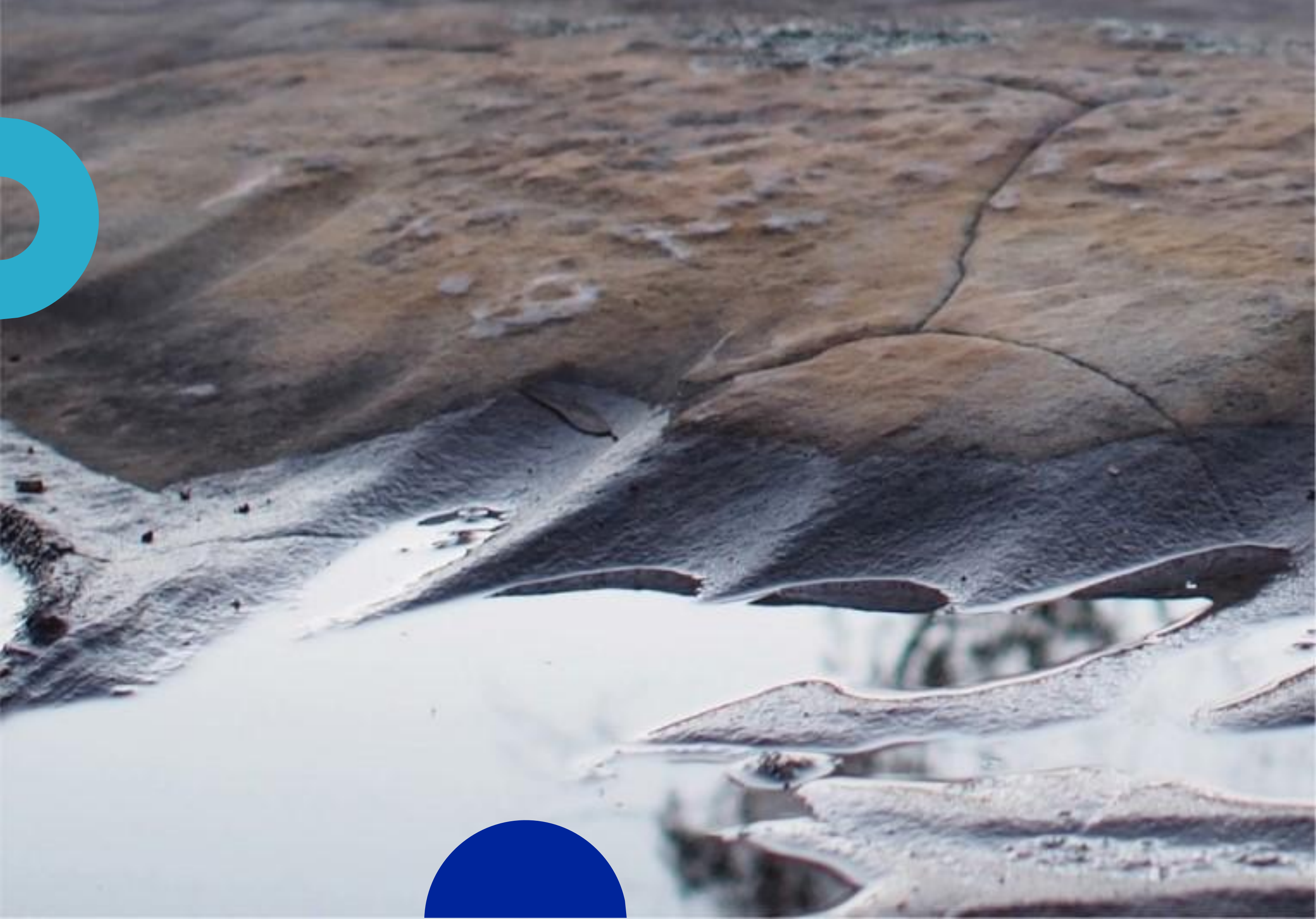
Mill Stream

Water Quality report under Authorisation No: 01/2024

Sydney WATER

Acknowledgement of Country

Sydney Water respectfully acknowledges the Traditional Custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.



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Executive Summary

Sydney Water was granted an Authorisation, subject to conditions, under regulation 5.09 of the *Airports (Environment Protection) Regulations 1997* (Cwth) (Regulations) to operate Emergency Relief Structures (ERSs) located on Sydney Airport land, and which discharge to Mill Stream. This report addresses condition 21(a) of that Authorisation, presenting the results of the Mill Stream water quality monitoring program. This report details the results of the monitoring conducted as part of the current Authorisation period as detailed in action 5.4 of the Mill Stream Environment Management Plan (EMP). This report includes the data from previous monitoring periods which were conducted in 2020 and 2023.

The water quality monitoring for the current authorisation period was conducted quarterly, beginning in April 2024 and wrapped up in February 2025. Each quarter involved a 5 day post overflow and a single day dry weather event. Previous sampling periods were conducted in a more condensed period within each year, following the same 5 day post overflow event sampling, however dry weather events were conducted over 2 days. The post overflow sampling events corresponded to relatively high discharge volume, that was comparable to conditions observed during the 2020 monitoring program, whereas 2023 captured smaller overflow discharge conditions.

The concentration of contaminants measured from the wastewater network prior to wet weather overflow discharge were generally lower in 2024 compared to the previous monitoring periods. Median effluent concentrations decreased in 2024 from the 2020 monitoring period, with the exception of PFOS, chlorophyll-α and sulphide. Comparison to 2023 is limited as only one sample was able to be collected during the monitoring period.

Results from the 2024 monitoring program indicate that receiving waters immediately downstream of the Mill Pond Weir and ERS experienced the greatest degradation of water quality in both wet weather overflow and dry weather conditions, as observed in 2020 and 2023. Bacteriological and nutrient actors (nitrogen and phosphorus) appear to be the most heavily influenced by ERS discharges as concentrations immediately downstream of the ERS were the greatest. Spatially there was substantial reduction in pollutant concentration observed at more distal locations likely induced by greater dilution, dispersion and decay. These results suggest that works Sydney Water are undertaking to decrease the volume and duration of wet weather overflow discharged at Mill Stream would also reduce the observable impact to water quality.

Chlorophyll-α did not appear to be noticeably impacted by ERS overflow as the upstream site routinely returned the highest concentration per sampling event in both dry and wet weather. The 2024 results follow the same trend as previous periods, with chlorophyll-a concentration being the highest at the upstream site, then reducing downstream.

There was minimal spatial variation in results for metals, organics, PFAS, sulphide and other physico-chemical parameters in dry and wet weather. This suggests less influence from specific ERS overflow events and likely reflective of the baseline stormwater condition and inputs.

Results from the monitoring program has informed how the Mill Stream overflows influence the receiving waterway and allowed characterisation against relevant guideline levels. The 2024-2025 monitoring has not provided additional insights beyond what was already evidenced from previous programs. Hence, Sydney Water has not identified opportunity for any additional actions *'to improve water quality at Mill Stream'* to those already detailed in the current Mill Stream Environmental Management Plan. However, there are opportunities to refine and improve the monitoring program design, including increased monitoring to capture stormwater events without ERS discharge and a review of the sample analytes and suitability of guideline levels.

1. Introduction

1.1 Context

Emergency relief structures (ERS) are an essential component of all wastewater systems. They are critical control points which are engineered to prevent damage to networks and protect public health by preventing wastewater surcharges and flooding of private property and public spaces during wet weather. The structures and discharges are commonly referred to as overflows and most often occur at times of intense rainfall when the stormwater flows have infiltrated the wastewater system.

The Malabar wastewater system displayed in Figure 1 is the largest system that Sydney Water owns and operates. It covers approximately one third of Sydney and services more than 2 million people. The South Western Suburbs Ocean Outfall Sewer (SWSOOS) listed on the New South Wales State Heritage Register in 2020, transports wastewater from the merging chamber at Arncliffe to Malabar Wastewater Resource Recovery Facility (WRRF).

Sydney Water owns and operates eight ERS on the SWSOOS that discharge wastewater to the Mill Stream during wet weather (known collectively as the Mill Stream ERS). The Mill Stream ERS is one of the largest in Sydney Water's network and is located on federally owned land at Sydney Airport and has potential impacts on the local environment. This requires Sydney Water to apply for an Authorisation under the *Airports (Environment Protection) Regulation (AEPR) 1997* from the Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts (DITRDCSA) to operate the ERS.

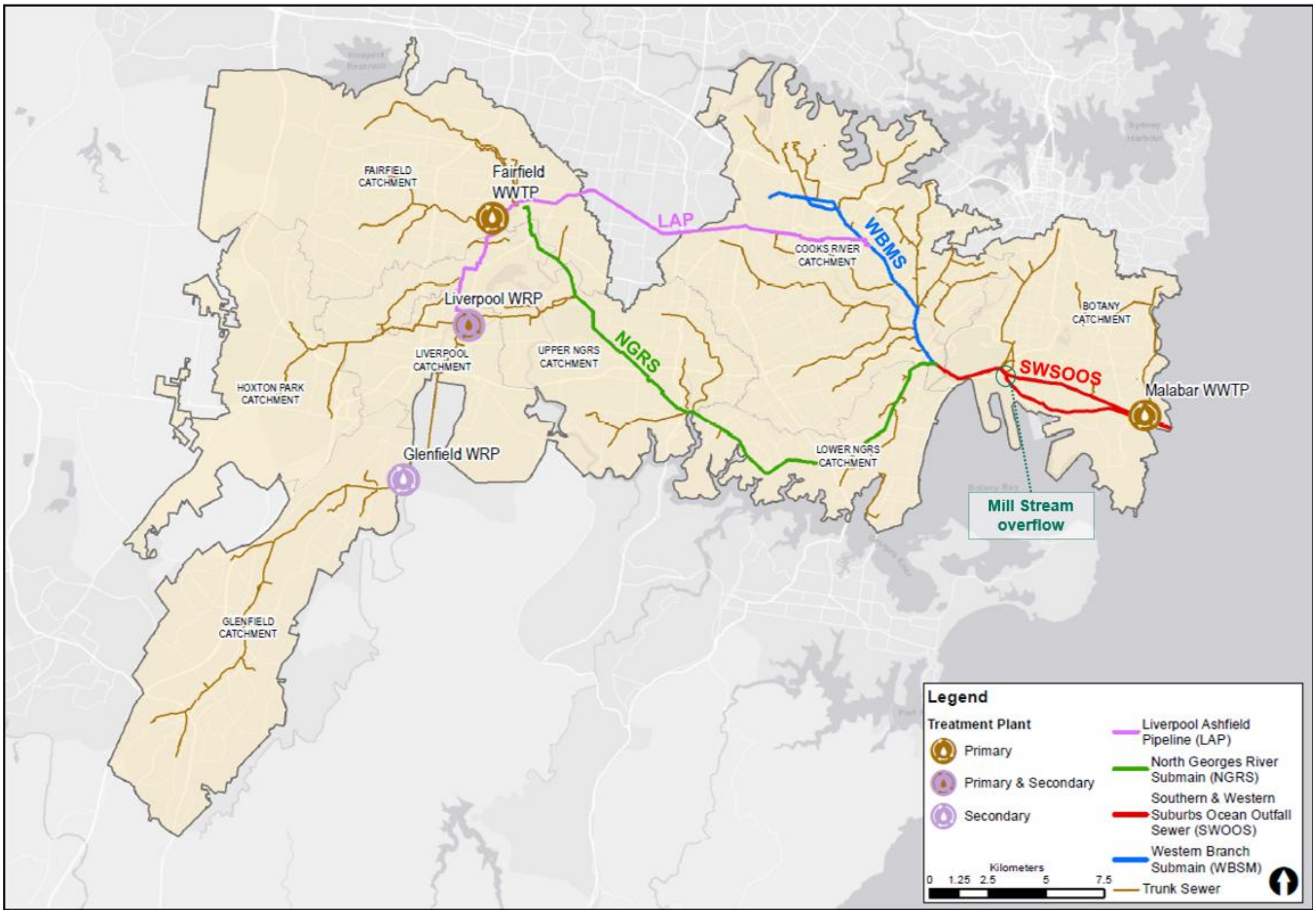

Figure 1 Malabar wastewater network and Mill Stream ERS location

1.2 Scope & objectives

The scope of this water quality monitoring report is to detail Sydney Waters monitoring of the Mill Stream and receiving waterways, satisfying condition 21(a) of the Mill Stream Authorisation No: 01/2024;

‘by 31 July 2025, submit a Water Quality Monitoring Report to the AEO that reports comprehensively on Sydney Water’s monitoring in Mill Stream and that sets out recommended actions for the improvement of water quality at Mill Stream and surrounding Botany Bay area’

The objectives of this report are:

- Compare monitoring results collected under authorisation No:01/2024 to previous monitoring periods
- Assess the influence of the Mill Stream ERS discharge on the receiving water quality of Mill Stream and Port Botany
- Identify pollutants of concern and assess results against the relevant guidelines and criteria
- Provide recommendations to be considered for future monitoring programs as part of the Mill Stream Authorisation.

Please note that this report builds on the analysis of previous water quality monitoring detailed in the below reports

- 2020 program - Mill Stream Emergency Relief Structures: Environmental and Ecological Assessment Report, Sydney Water. (2021).
- 2023 program - Mill Stream Water Quality Report, Sydney Water (2023)

2. Methodology

2.1 Quality Assurance

Quality control standards are satisfied by Sydney Water Laboratory Services NATA certified to ISO 9001:2015 Quality management systems; ISO 14001: 2015 Environmental Management Systems and AS/NZS 4801: 2001 Occupational Health & Safety Management System. All analytical work is performed to the requirements of AS ISO/IEC 17025: 2015 General requirements for the competence of testing and calibration laboratories. PFAS analysis in saline waters is currently not performed in-house at Sydney Waters Laboratories. Analysis was outsourced to the National Measurement Institute (NMI), a NATA accredited laboratory ensuring the use of approved methods, detection limits and reporting requirements.

2.2 Data preparation, analysis & presentation

Monitoring data was extracted from Sydney Water's databases, tidied and analysed using R statistical analysis software version: R.4.4.2. All data points were retained for analysis including descriptive summary statistics, and figures such as box and whisker plots.

Where the recorded measurement was below the laboratory limit of reporting (LOR), half the limit of reporting value was used as the recorded measurement for calculations and figures. In instances where laboratory LOR has been adjusted over time, the current LOR was used for the reporting of summary statistics.

Water quality data is presented as box and whisker plots to make comparisons across sample locations. Box and whisker plots graphed the 25th percentile value, median (50th percentile) and 75th percentile values as shown in Figure 2. The whiskers point to the maximum or minimum value within two times the interquartile range (IQR) from the median. Exceptions (outliers) are points with values between 2 and 3 times the IQR from the median.

Figures with y-axis values log10 scaled for ease of visualisation have been labelled and where applicable the water quality guidelines have been included.

The monitoring data obtained from 1st April 2024 to 28th February 2025 is labelled as period 2024 for simplicity. Sampling events in periods 2020 and 2023 were completed within respective calendar years.

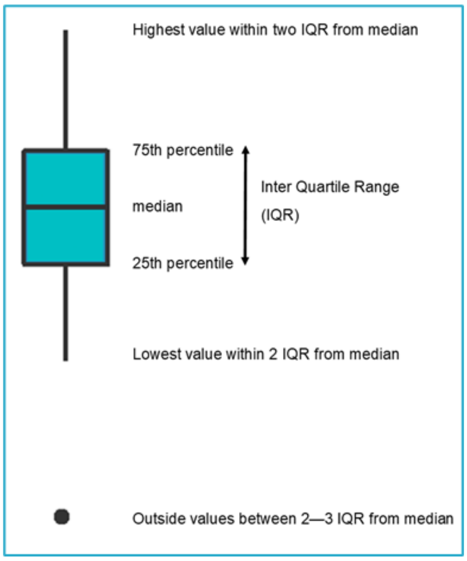

Figure 2 Example of box and whisker plot

Receiving water summary statistics are displayed as wet weather by individual monitoring periods (***2020***, ***2023*** and ***2024***) and ***overall dry*** for combined dry weather periods. Please note that wet weather monitoring is conducted when a confirmed ERS overflow event has commenced, dry weather monitoring is conducted when there has been <5mm in the preceding 72 hours, and <15mm and no overflows in the preceding 7 days.

Where appropriate Default Guideline Values (DGVs) are present, plot limit lines and summary statistic colourised comparisons are made against relevant highly disturbed system values (80% and 90%) for estuarine receiving waters, as suitable to the Mill Stream system (ANZG 2018). Colourised comparison to compliance with relevant guideline levels is included for median results only, however maximum and minimum results are included for data completeness. Site MS1 is freshwater, so while its data appears in tables and figures for a complete overview, direct comparisons to the displayed guideline levels are not appropriate; where relevant, reference to freshwater levels has been made in text.

Sydney Water has historically converted and measured all available ammonia species to the de-ionised form by pH manipulation in the lab, essentially reporting the total of both NH_3 and NH_4^+ concentrations as ammonia-nitrogen. As temperature and pH field measurements were taken at the time of sample collection, ammonium as nitrogen (NH_4^+-N) has been calculated according to the dissociation constant reported by ANZG enabling comparison to relevant limits. One limitation of this calculation is that the LOR for ammonia is 0.01 mg/L or 10 µg/L, above that of schedule 2 limit introducing error though rounding. It must also be noted that these calculations of ammonia and ammonium are not NATA accredited.

2.3 Relevant guidelines

To allow for an effective comparison to relevant guidelines, median concentrations were calculated across the monitoring periods for each site, separated by weather condition. This was done on data collected in the three monitoring periods 2020, 2023 and 2024-25. The median was then compared to the following guidelines, where guideline values were available and applicable:

- **Airports (Environment Protection) Regulations 1997 - Schedule 2**

  The Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts (DITRDCSA) is responsible for the administration of the airport environmental regulatory regime at 22 federally-leased airports around Australia. These airports are managed under an environmental regulatory framework established by the Airports Act 1996 and the *Airports (Environment Protection) Regulations 1997*. This regulatory framework applies to the management of all on-ground environmental issues, including air, soil, water (***Schedule 2***), noise and chemical pollution on-airport. As the federally-leased airports are located on Commonwealth land, state and territory laws do not apply. Relevant guideline values are presented in Table 1.

- **Australian and New Zealand guidelines for fresh and marine water quality**

  The Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018 and ANZECC 2000) are recognised as the accepted standard and best-practice guidelines for assessing receiving water quality impacts in Australia. These guidelines can be applied to the receiving waters in Mill Stream and Botany Bay. Relevant guideline values are presented in Table 1, and include specific default guideline levels, % species protection levels and lower and upper limits.

- **PFAS National Environmental Management Plan - Version 3.0**

  The per- and poly-fluoroalkyl substances (PFAS) National Environmental Management Plan (NEMP) 1.0 was released in January 2018, including the draft PFAS default guidelines values (DGVs) for species protection from the Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality. The consultation of NEMP 3.0 commenced in December 2022, before the August 2023 revised draft ANZG PFOS DGVs for aquatic ecosystem protection were released and hence were not included as part of the review and release of PFAS NEMP 3.0 in 2025.

  Due to the higher reliability of the revised ANZG PFOS DGVs than the previous draft guidelines, they will be used in place of the NEMP 3.0 values for this assessment and are presented in Table 2.

Table 1 Schedule 2 and ANZG guidelines for estuarine systems

				ANZG						
Analyte	**LOR**	**Units**	**Sched 2**	**Default Trigger**	**80%**	**90%**	**95%**	**99%**	**Low limit**	**Upper limit**
Ammonia NH3 -N	<0.01	mg/L			1.7	1.2	0.91	0.5		
Ammonium (as N)		mg/L	0.005	0.015						
BOD5	<2	mg/L								
Chemical Oxygen Demand	<5	mg/L								
Chlorophyll - a	<0.2	µg/L	1	4						
Dissolved Oxygen	<0.1	mg/L	6							
Enterococci	<1	CFU/100mL							35*	230**
Faecal Coliform	<1	CFU/100mL	150						150*	1000**
Nitrate Nitrogen NO3-N	<0.01	mg/L		0.015						
Nitrite Nitrogen NO2-N	<0.001	mg/L								
Nonylphenol ethoxylate	<5	µg/L			360	220	140	50		
Oxidised Nitrogen NOx-N	<0.01	mg/L								
Percent Dissolved Oxygen	<0.1	SAT%							80	110
Soluble Reactive Phosphorus	<0.002	mg/L		0.005						
Sulphide	<30	µg/L	2	1						
Temperature Sample		°C								
Total Copper	<0.5	µg/L	5		8	3	1.3	0.3		
Total Lead	<0.1	µg/L	5		12	6.6	4.4	2.2		
Total Mercury	<0.01	µg/L	0.1		1.4	0.7	0.4	0.1		
Total Nickel	<0.2	µg/L	15		560	200	70	7		
Total Silver	<0.1	µg/L	1		2.6	1.8	1.4	0.8		
Total Zinc	<1	µg/L	50		21	12	8	3.3		
Total Nitrogen	<0.05	mg/L		0.3						
Total Phosphorus	<0.002	mg/L	0.005	0.03						
Total Suspended Solids	<2	mg/L								
Turbidity HACH White Light	<0.2	NTU							0.5	10
conductivity	<7	µS/cm								
di(2-ethylhexyl) phthalate	<10	µg/L	0.6							
pH	<0.1	pH								
PFOS	<0.02	µg/L			17	2.7	0.48	0.0091		

ANZG *primary and **secondary contact waterway guidelines

Table 2 NEMP 3.0 PFAS guidelines

PFAS Isomer	**LOR**	**Units**	**80%**	**90%**	**95%**	**99%**
PFOS	<0.02	µg/L	31	2	0.13	0.00023
PFOA	<0.01	µg/L	1824	632	220	19

2.4 Monitoring Locations

Monitoring locations have remained constant from the initial monitoring conducted in 2020 and are described in Table 3 and presented in Figure 3. Receiving water locations were selected based on feasibility to sample by boat and experimental design constituting a baseline (MS1), potential pollution source (MSERS), immediate mixing zone (MSFSR) and subsequent downstream waters influenced by dilution (MSNFB, MS4 and MSRW). It should be noted that site MS1 is located in freshwater. Due to the location of the Mill Stream ERS discharge point being directly below the weir that separates freshwater and estuary, it is not possible to have a comparable upstream estuarine site.

In dry conditions, monitoring was scheduled in advance when sampling could occur at high tide to ensure boat access to receiving waters within Mill Stream was possible. Wet weather monitoring was reactive, meaning tide cycles were not always favourable or environmental conditions prevented safe boat use (i.e. high winds and swell). Events which were unable to be sampled by boat were conducted on foot at alternate locations*.

Table 3 Receiving waterway locations

Site	Site code	Site description	Latitude	Longitude
Mill Stream upstream	MS1	Upstream of the Mill Stream ERS and weir in the Mill Stream Pond	-33.94472	151.18995
Mill Stream ERSs	MSERS*	Sample of wastewater effluent prior to discharge (within pipe)	-33.94457	151.18943
Mill Stream immediately downstream of Foreshore Rd	MSFSR*	Mill Stream from Foreshore Road	-33.94588	151.18850
Mill Stream Mid-stream	MSNFB*	Mill Stream – Northern most extent of Foreshore Beach	-33.95265	151.19190
Foreshores Beach	MS4*	Mill Stream/ Botany Bay – near Mill Stream look out	-33.95508	151.19362
Botany Bay Runway	MSRW*	Between the end of the runway and the New Botany Wharf	-33.97213	151.19894

*MSFSR alternate location by foot from Sir Joseph Bank Park, immediately upstream of Foreshore Road

*MSNFB alternate location by foot from Northern most extent of Foreshore Beach

*MS4 alternate location by foot from Eastern most extent of Mill Stream lookout break wall

*MSRW alternate location by foot from Southern most extent of Foreshore boat ramp break wall

Figure 3 Mill Stream monitoring locations

3. Water Quality

3.1 Monitored Events

A summary from the three monitoring periods is detailed in Table 4. Monitoring conducted in 2020 and 2023 was completed in a condensed timeframe within a few months. Dry weather monitoring in each campaign was two events consisting of two consecutive days, while wet weather monitoring consisted of three events each spanning five consecutive days. The 2024 monitoring campaign was completed over a year spaced quarterly consisting of four dry, single day monitoring events and four wet weather events each spanning five consecutive days. Wet weather monitoring events were conducted following a confirmation of overflow discharge from any of the Mill Stream overflows. Dry weather monitoring was conducted according to the following criteria: <5mm in the preceding 72 hours AND <15mm of rain and no overflow activity within the preceding 7 days. A summary of the daily conditions is presented in Appendix 7.1 and hydrographic gauging of daily rainfall and ERS discharge volumes have been included in Appendix 7.2.

Table 4 Summary of monitored events across three periods

Event	Event dates	Rainfall (mm)	Tidal Condition	Overflow volume (ML) & duration
2020				
Wet event #1	14/07 – 18/07	8.8	Variable tidal condition (ebb, incoming, high and low tide)	31.8 - 7 hours
Dry event #1	23/07 – 24/07	0	High tides	NA
Wet event #2	26/07 – 30/07	65.8	Variable tidal condition (high, incoming, low and medium ebb tide)	418.4 - 62 hours
Dry event #2	4/08/ - 5/08	0	Variable tidal condition (high, incoming and ebb tide)	NA
Wet event #3	8/08 – 12/08	30.4	Variable tidal condition (high, incoming, low and ebb tide)	309.3 - 49.5 hours
2023				
Wet event #1	31/08 – 4/09	8.6	Incoming or high tides	8.6 - 2 hours
Dry event #1	22/08 – 23/08	0	Incoming tides	NA
Wet event #2	5/11 – 9/11	57	Variable tidal condition (high, incoming and ebbing tides)	94.5 - 12 hours
Dry event #2	26/09 – 27/09	0	Low and ebbing tides	NA
Wet event #3	10/11 – 14/11	12.4	Variable tidal condition (high, incoming and ebbing tides)	15.3 - 4 hours
2024 - 2025				
Wet event #1	5/04 – 9/04	164.8	Variable tidal condition (high, ebb, runout and low tide)	649.2* - 64.7 hours
Dry event #1	24/05	0	High tides	NA
Wet event #2	27/09 – 1/10	31.8	Variable tidal condition (low and ebbing tides)	18.7^ – 11.5 hours
Dry event #2	6/08	0	High tides	NA
Wet event #3	30/11 – 4/12	89.4	Variable tidal condition (incoming, high and ebb)	54.2*^ – 23.8 hours
Dry event #3	31/09	0	High tides	NA
Wet event #4	16/01 – 20/01	56.3	Variable tidal condition (incoming, low, high and runout tide)	59.2*^ - 23.5 hours
Dry event #4	28/02	0	High tides	NA

* Intermittent overflows - during sampling, a second overflow occurred after a gap of >1 day from when the previous overflow ceased.

^ Overflow started the day prior to the first event date.

3.2 ERS effluent quality

Summary statistics for concentrations measured in ERS effluent within the network prior to discharge during the 2020, 2023 and 2024 monitoring periods are displayed in Table 5 and plots from Figure 5 to Figure 10. Comparison of analyte concentrations have not been made with schedule 2 or ANZG/ANZECC guidelines as these are intended for measuring impact within waterbodies and application to ERS effluent quality does not consider dilution from upstream flows or tidal flushing.

ERS discharge volumes are calculated as the cumulative volume from four gauges (IDs:802063, 802064, 802065 & 802310) (Figure 4). Rainfall is measured from Sydney Airport meteorological station ID:066037. The average discharge volume and rainfall corresponding to overflow event sampling is presented below:

- 2020: Average 35mm rainfall, average 253.2 ML discharge
- 2023: Average 26mm rainfall, average 39.8 ML discharge
- 2024: Average 59mm rainfall, average 195.3 ML discharge

ERS median effluent concentrations decreased in 2024 from the 2020 monitoring period except for PFOS, chlorophyll-α and sulphide. There are multiple factors and complexity that would determine wastewater quality (concentrations and presence) at the time that samples are collected. This would include but not be limited to the scale of rainfall event, stormwater inflow and infiltration, nature of ERS operation (syphon vs gravity), time of day, sediment/silt bed load within the network and when in an overflow event samples are collected (first pulse to tail end).

ERS median effluent concentrations of PFOS, *Enterococci*, nonylphenol ethoxylate and biochemical oxygen demand increased in 2024 from the 2023 monitoring period. However, only one ERS effluent sample could be collected during the 2023 monitoring period as sampled events were shorter and discharge had mostly ceased by the time field staff could get to the site.

Figure 4 Location of key wastewater assets at Mill Stream, including gauged overflows

Table 5 ERS summary statistics for monitored events

	2020				2023*				2024			
Analyte	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
PFAS												
PFOA (335-67-1) [µg/L]	5	**<0.01**	<0.01	0.01	1	**0.01**	0.01	0.01	4	**<0.01**	<0.01	0.02
PFOS (1763-23-1) [µg/L]	5	**<0.05**	<0.05	<0.05	1	**<0.02**	<0.02	<0.02	4	**0.03**	<0.02	0.24
Bacteriology												
Enterococci [CFU/100mL]	5	**2100000**	1200000	3800000	1	**1000000**	1000000	1000000	5	**830000**	100000	970000
Faecal Coliform [CFU/100mL]	5	**6300000**	3700000	12000000	1	**1000000**	1000000	1000000	5	**1000000**	100000	7000000
Chlorophyll												
Chlorophyll - a [µg/L]	5	**1.1**	0.4	1.6	-	**-**	-	-	5	**3.2**	1.3	20.67
Metals												
Total Copper [µg/L]	5	**89.4**	66.8	111	1	**96.8**	96.8	96.8	5	**54.5**	24.9	89.6
Total Lead [µg/L]	5	**10.5**	7.32	11.8	1	**10.6**	10.6	10.6	5	**4.9**	4	20.9
Total Mercury [µg/L]	5	**0.03**	0.02	0.15	1	**0.14**	0.14	0.14	5	**0.03**	<0.01	0.05
Total Nickel [µg/L]	5	**3.7**	3.3	4.6	1	**4.4**	4.4	4.4	5	**2.8**	1.1	3.8
Total Silver [µg/L]	5	**<0.1**	<0.1	1.5	1	**<0.1**	<0.1	<0.1	5	**<0.1**	<0.1	0.2
Total Zinc [µg/L]	5	**146**	127	199	1	**158**	158	158	5	**103**	42	186
Nutrients												
Ammonia NH3 -N [mg/L]	4	**23.35**	18.6	24.6	1	**29.5**	29.5	29.5	5	**15.6**	6.06	35.2
Ammonium_Nitrogen [µg/L]	4	**24400**	19500	25800	1	**30500**	30500	30500	4	**25100**	6400	36300
Nitrate Nitrogen NO3-N [mg/L]	-	**-**	-	-	-	**-**	-	-	2	**0.06**	0.02	0.09
Nitrite Nitrogen NO2-N [mg/L]	-	**-**	-	-	-	**-**	-	-	2	**0.1**	0.01	0.2
Soluble Reactive Phosphorus [mg/L]	5	**2.49**	2	3.45	1	**2.72**	2.72	2.72	5	**2.16**	0.53	4.04
Total Nitrogen [mg/L]	5	**34**	33	42.9	1	**38.7**	38.7	38.7	5	**30**	9.77	41.7
Total Phosphorus [mg/L]	5	**4.45**	3.65	4.62	1	**5**	5	5	5	**2.86**	1.18	5.36
Physical Chemistry												
Conductivity [uS/cm]	5	**631**	618	709	1	**632**	632	632	4	**638**	276	1039
Dissolved Oxygen [mg/L]	5	**6.2**	2.7	7.6	1	**4**	4	4	4	**5.15**	1.2	7.8
Percent Dissolved Oxygen [%]	5	**70.6**	55.6	79.9	1	**44.6**	44.6	44.6	4	**60**	13.2	91.1
Temperature Sample [°C]	5	**17.7**	17.2	18.3	1	**21.6**	21.6	21.6	4	**23.25**	23	23.5
Total Suspended Solids [mg/L]	5	**170**	110	190	1	**190**	190	190	5	**140**	77	180
Turbidity HACH White Light [NTU]	5	**140**	94	170	1	**120**	120	120	4	**89**	39	110
pH [pH units]	5	**7.59**	7.47	7.64	1	**7.74**	7.74	7.74	4	**7.31**	7.06	7.73
Organics												
Nonylphenol ethoxylate [µg/L]	5	**658**	89	2250	1	**7**	7	7	5	**496**	114	1380
Octylphenol ethoxylate [µg/L]	5	**<5**	<5	<5	1	**<5**	<5	<5	5	**<5**	<5	14
di(2-ethylhexyl) phthalate [µg/L]	5	**<10**	<10	<10	1	**<10**	<10	<10	5	**<10**	<10	<10
Other												
BOD5 [mg/L]	5	**230**	190	310	1	**150**	150	150	5	**160**	62	190
Oil & Grease [mg/L]	5	**26**	11	53	1	**30**	30	30	5	**16**	9	31
Sulphide [µg/L]	5	**50**	<30	156	1	**265**	265	265	5	**158**	63	246

*Only one ERS sample was obtained during the 2023 monitoring period as discharges had generally ceased by field sampling arrival to site.

- no monitoring results available.

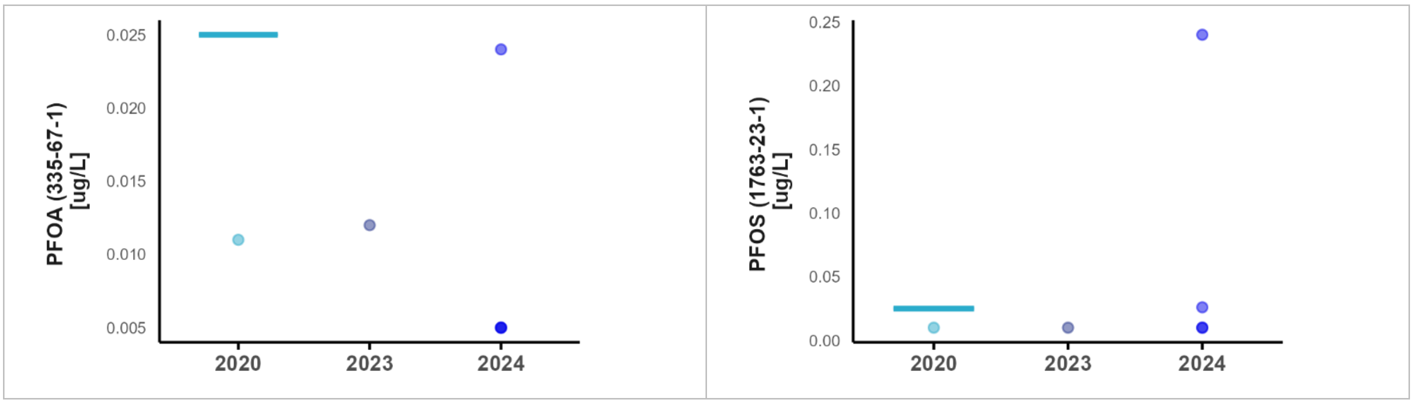

Figure 5 PFAS concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

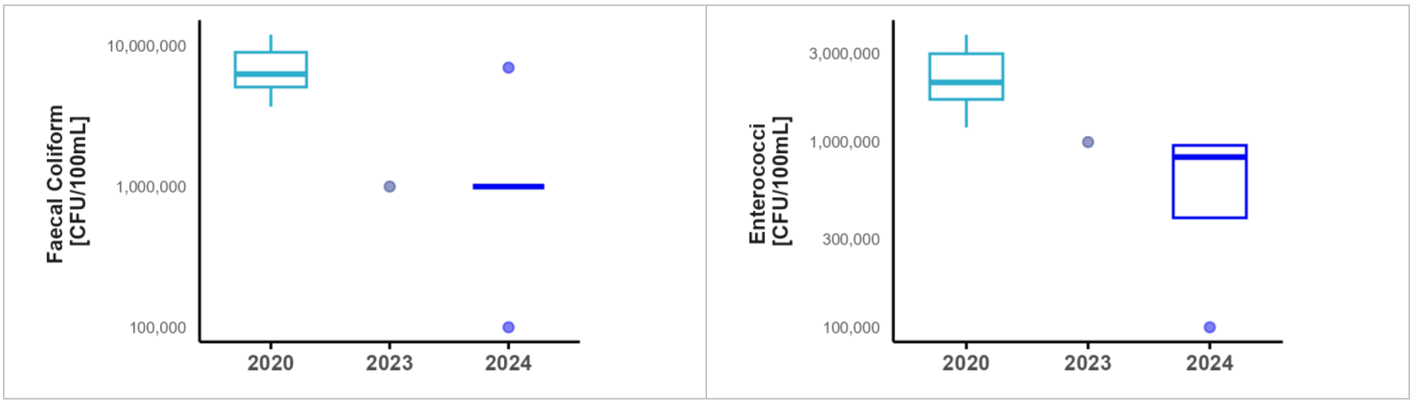

Figure 6 Bacteriological concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

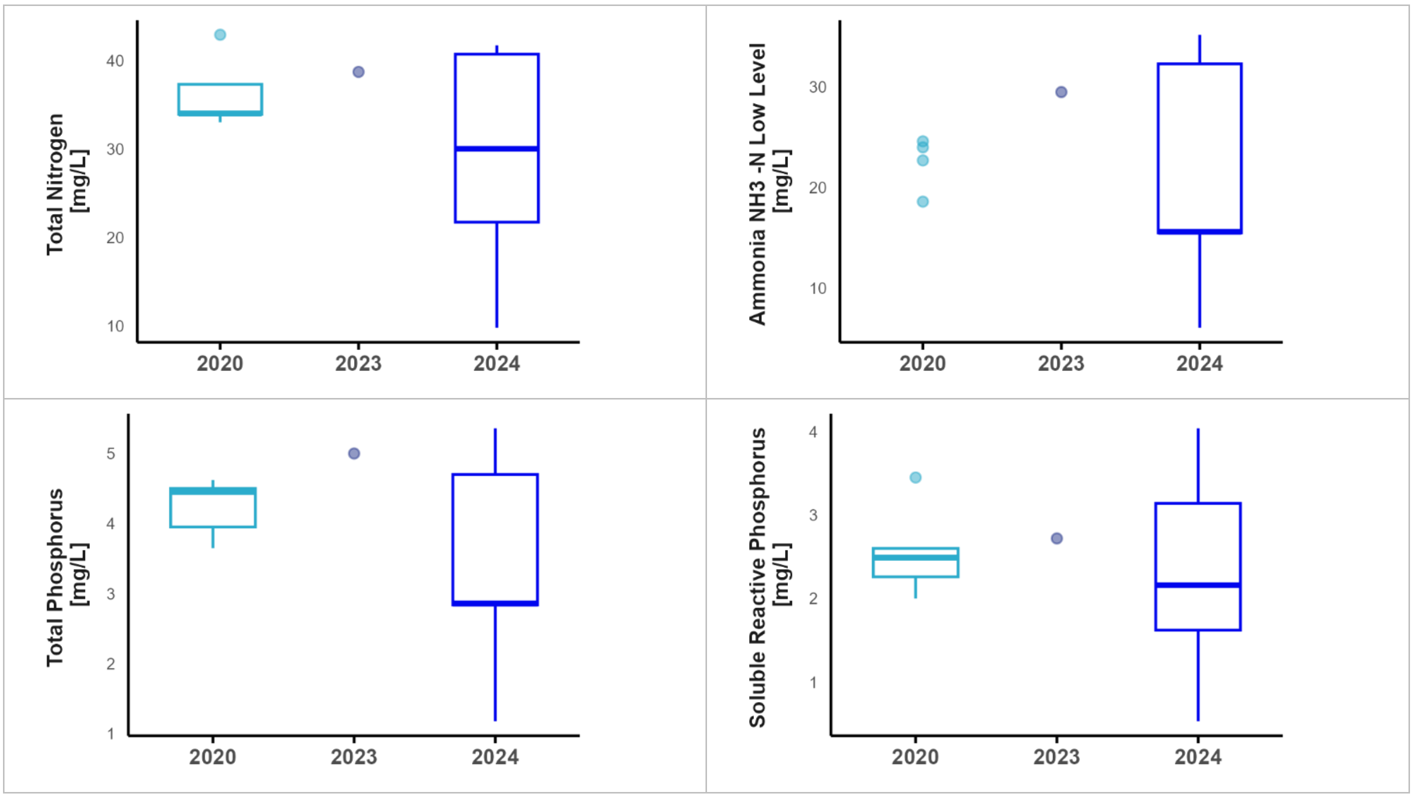

Figure 7 Nutrient concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

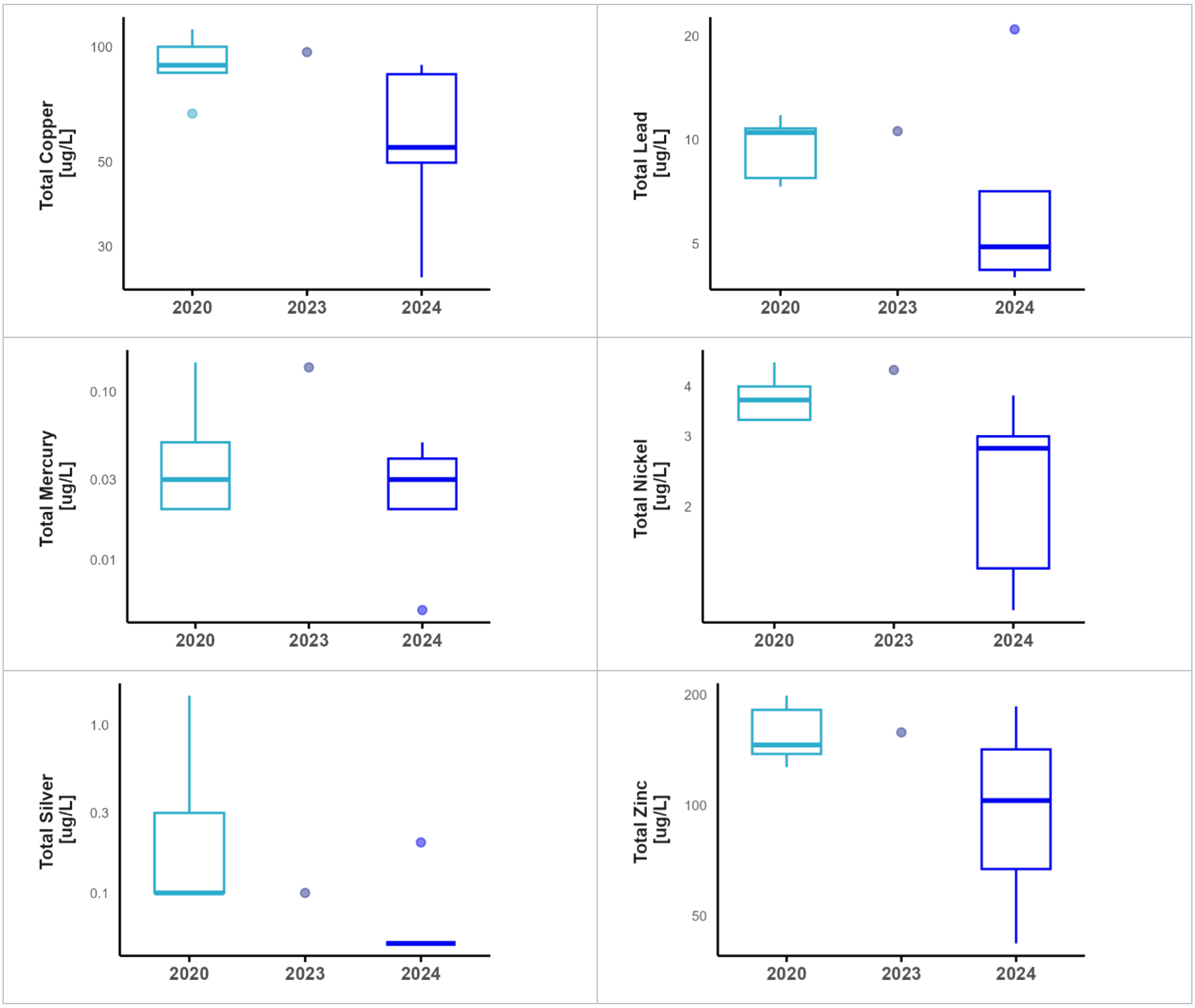

Figure 8 Metal concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

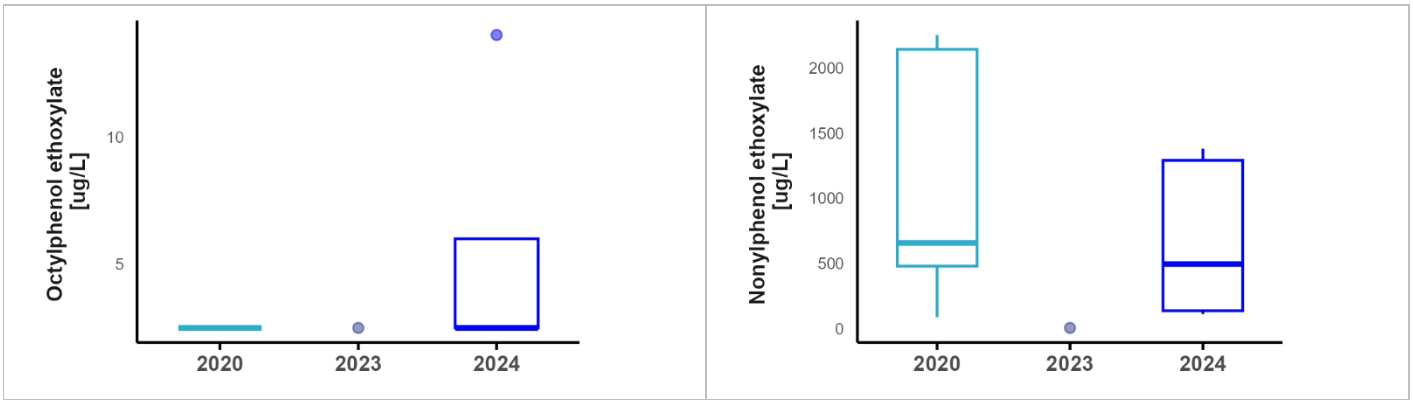

Figure 9 Surfactant concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

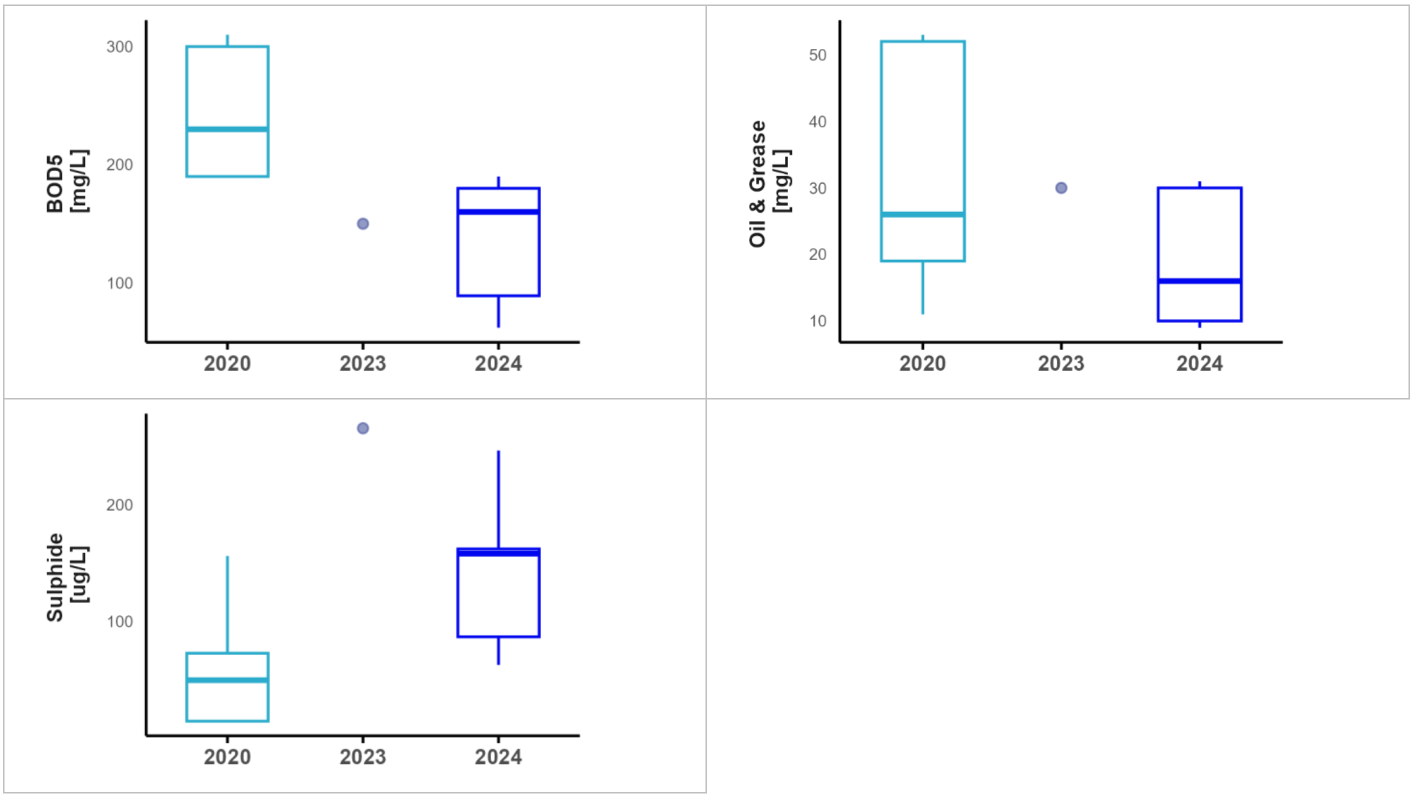

Figure 10 Additional concentrations recorded in ERS discharges from 2020, 2023 and 2024 monitoring periods

3.3 Receiving water quality

3.3.1 General observations

General observations are required when the Field Sampling Team visits each site to collect samples. These observations include odour, scum, visual pollution (with site photos), fauna and any other general comments of relevance.

Scum and visual pollution were given a rating from 0 to 3 (0 = not present, 1 = low, 2 = moderate, 3 = high). For reporting purposes, scores of 1 or above are considered as present and are summarised in Table 6 and Table 7. Visual turbidity assessment data was recorded through general comments that describe different levels of turbidity. Any mention of turbidity was captured and summarised in the tables below.

For summary Table 6 and Table 7, the sampling sites were grouped per event and if one or more sites noted a particular observation, it was counted as present for that event. Field observations can be subjective and may vary between samplers.

Table 6 Summary of Dry event general observations. "-" indicates no record.

Sampling event	Sampling dates	Odour	Scum	Visual Pollution	Turbid or clear
Dry Event 1	24/05/2024	Present (MSFR)	-	Present	Clear
Dry Event 2	6 /09/2024	-	-	-	Turbid / Clear
Dry Event 3	31/10/2024	-	-	Present	Clear
Dry Event 4	28/02/2025	-	-	-	Clear

During Dry Event 1, a 'foul ambient odour' was observed at MSFR, accompanied by organic debris and domestic rubbish, which were likely the sources of the odour. No odour was detected at any of the other sampling sites during the event.

During overflow events in the 2024–2025 period, odour was consistently present on the first day and dissipated by the fourth day. MS1 had no recorded odour and three days of visual pollution. MSFSR observed eight days with odour including a dry event and 12 instances of visual pollution. MS4 recorded 10 instances of visual pollution and five occurrences of odour. MSRW experienced only one day of odour on 5/04.

Table 7 Summary of overflow event general observations in days. "-" no data measured.

Sampling event	Sampling dates	Odour	Scum	Visual Pollution	Turbid
Overflow Event 1	5/04/2024 – 9/04/2024	4 days	-	-	5 days
Overflow Event 2	27/09/2024 – 1/10/2024	1 day	1 day	4 days	3 days
Overflow Event 3	30/11/2024 – 4/12/2024	2 days	5 days	5 days	2 days
Overflow Event 4	16/01/2025 – 20/01/2025	3 days	2 days	4 days	5 days

3.3.2 Receiving water monitoring results

Per- and poly-fluoroalkyl substances (PFAS)

The unique properties of PFAS have led to its wide usage for many decades, it is also highly resistant to physical, chemical and biological degradation. As there are no schedule 2 limits for PFAS isomers, NEMP 3.0 PFOA species protection guidelines (SPG) and ANZG PFOS default guideline values (DGVs) have been used from Table 1 and Table 2.

Summary statistics for PFAS concentrations in the receiving water is displayed in Table 8, including the 80, 90, 95 and 99% SPG's. As DGVs do not account for bioaccumulation, ANZG recommends applying the 99% DGV for PFOS in slightly-to-moderately disturbed ecosystems to consider higher trophic level organisms likely at greater risk. Comparisons of median concentrations within Table 8 have been made to higher guideline values owing to the bioaccumulation risk.

Median PFOA concentrations were below the NEMP 3.0 99% SPG of 19 µg/L at all receiving water sites in all conditions and monitoring periods.

The PFOS 99% ANZG DGV of 0.0091 µg/L is below the laboratory LOR of 0.05 (2020) and 0.02 µg/L (2023 and 2024) that has been used for sample analysis from the three monitoring periods, this has limited assessment against that DGV. However, MSFSR and MSNFB median concentrations were above the 99% ANZG DGV for most sampling periods and conditions. Median PFOS concentrations were below the ANZG 95% DGV of 0.48 µg/L at all receiving water sites in dry weather and the three wet weather periods. The maximum PFOS concentration recorded was 0.46 µg/L in dry weather at MSFSR, below the ANZG 95% DGV.

Table 8 Summary PFAS concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
PFOA (335-67-1) [µg/L] NEMP 3.0: 80%:1824, 90%:632, 95%:220, 99%:19																
MS1	15	**<0.05**	<0.01	<0.05	15	**<0.01**	<0.01	0.01	20	**<0.01**	<0.01	0.01	12	**<0.01**	<0.01	0.01
MSFSR	15	**<0.05**	<0.05	<0.05	15	**0.01**	<0.01	0.03	20	**<0.01**	<0.01	0.01	12	**0.01**	<0.01	0.02
MSNFB	15	**<0.05**	<0.05	<0.05	15	**<0.01**	<0.01	0.01	20	**<0.01**	<0.01	0.03	12	**<0.01**	<0.01	0.01
MS4	15	**<0.05**	<0.05	<0.05	15	**<0.01**	<0.01	<0.01	20	**<0.01**	<0.01	<0.01	12	**<0.01**	<0.01	<0.05
MSRW	15	**<0.05**	<0.05	<0.05	15	**<0.01**	<0.01	<0.01	20	**<0.01**	<0.01	<0.01	12	**<0.01**	<0.01	0.02
PFOS (1763-23-1) [µg/L] ANZG: 80%:17, 90%:2.7, 95%:0.48, 99%:0.0091																
MS1	15	**<0.05**	<0.05	0.04	15	**0.03**	<0.02	0.08	20	**0.02**	<0.02	0.05	12	**0.05**	<0.05	0.08
MSFSR	15	**<0.05**	<0.05	0.21	15	**0.24**	0.03	0.34	20	**0.07**	<0.02	0.17	12	**0.13**	0.09	0.46
MSNFB	15	**0.08**	<0.05	0.15	15	**0.09**	<0.02	0.24	20	**0.05**	<0.02	0.20	12	**0.08**	<0.05	0.28
MS4	15	**<0.05**	<0.02	0.16	15	**<0.02**	<0.02	0.12	20	**0.04**	<0.02	0.13	12	**<0.02**	<0.02	0.12
MSRW	15	**<0.05**	<0.02	0.05	15	**<0.02**	<0.02	0.07	20	**<0.02**	<0.02	0.07	12	**<0.02**	<0.02	0.37

Note: ANZG DGV or NEMP SPG 99% exceeded

Bacteriological

Faecal coliforms (FC) and *Enterococci* (Ent) bacteria are the most common biological indicators used to assess water quality to inform human health risk. The presence of faecal coliforms and Enterococci in water may indicate the presence of more harmful pathogens, like enteric viruses or protozoa such as Cryptosporidium or Giardia. Stormwater and wastewater overflows are common sources of FC and Ent in urban waters (Marsalek & Rochfort, 2004; Soller et al, 2015). Schedule 2 defines an adverse effect because entry of a substance into waters when:

a. *median faecal coliform count is above 150 CFU, or*

b. *more than 20% of 5 samples taken at regular intervals in a month exceed 600 CFU*

ANZG guidelines for recreational water quality recommend applying 150 CFU/100 mL FC count and 35 CFU/100 mL Ent as threshold to primary contact waterways (PCW) suitable for activities such as swimming. Secondary contact waterways (SCW) such as boating and kayaking bacteriological thresholds are 1,000 FC and 230 Ent CFU/100 mL. Recreational water quality guidelines have been developed with the intent of providing an indication of risk swimmers or other water users may have in developing an illness from contact with the water, applying site specific guidelines related to waterway use. Applying this risk-based approach to the monitoring locations based on public use or restriction; MS4 would likely be defined as primary contact owing to its proximity to Foreshore Beach while MSRW likely a secondary contact zone, due to extensive recreational boating use.

Summary statistics for bacteriological results and comparisons to ANZG guidelines are presented in Table 9. Accompanying FC and Ent analyte boxplots are displayed in Figure 11 and Figure 12.

In dry weather median faecal and Ent counts at MS1, MS4 and MSRW were below primary waterway guidelines, while MSFSR and MSNFB were between PCW and SCW guidelines.

In wet weather, median concentrations for FC and Ents were above schedule 2 and ANZG PCW guidelines at all sites in 2024. SCW guidelines were exceeded at all sites downstream of the Mill Stream ERS, except Ents counts at MSRW.

Table 9 Summary bacteriological concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Enterococci [CFU/100mL] ANZECC primary: 35, secondary: 230																
MS1	15	**84**	2	5000	15	**14**	<1	4300	20	**45.5**	4	11000	12	**8**	<1	8900
MSFSR	15	**3000**	430	650000	15	**3000**	110	500000	20	**3050**	320	250000	12	**210**	15	5200
MSNFB	15	**2800**	380	160000	15	**1100**	11	260000	20	**735**	43	570000	12	**70**	10	670
MS4	15	**3400**	60	170000	15	**19**	<1	55000	20	**1400**	20	240000	12	**5**	<1	520
MSRW	15	**2700**	24	310000	15	**<1**	<1	590	20	**98.5**	<1	33000	12	**<1**	<1	3
Faecal Coliform [CFU/100mL] ANZECC primary: 150, secondary: 1000																
MS1	15	**110**	15	4100	15	**65**	15	5900	19	**470**	43	18000	12	**37.5**	5	300
MSFSR	15	**28000**	4400	5400000	15	**3500**	110	1000000	20	**12000**	2300	1000000	12	**600**	20	5200
MSNFB	15	**50000**	1900	630000	15	**3500**	17	1000000	20	**85500**	1400	1100000	12	**220**	20	3900
MS4	15	**80000**	860	640000	15	**68**	<1	100000	20	**74000**	460	1100000	12	**5.5**	<1	3100
MSRW	15	**35000**	10	1000000	15	**12**	<1	22000	20	**11150**	48	1000000	12	**<1**	<1	14

Note: ANZG PCW exceeded, ANZG SCW exceeded

Comparing results spatially, both FC and Ent results are consistent with there being a source of bacteriological contamination between sites MS1 and MSFSR. Untreated effluent has FC and Ent concentration of ~10,000,000 CFU, indicating that the Mill Stream ERS is the predominant source of the observed bacteriological counts. While counts are significantly lower in dry weather when the ERS isn't active, a similar trend is observed. It is possible that other sources of contamination occur and reduced tidal flushing in upper Mill Stream results in elevated counts.

Bacteriological results for downstream waters in 2024 resemble data obtained from 2020. There was a notable decrease in bacteriological counts in 2023. Comparison of average rainfall and ERS discharge volumes across the three monitoring periods suggest that the lower counts in 2023 were reflective of lower overflow volumes and rainfall during monitoring.

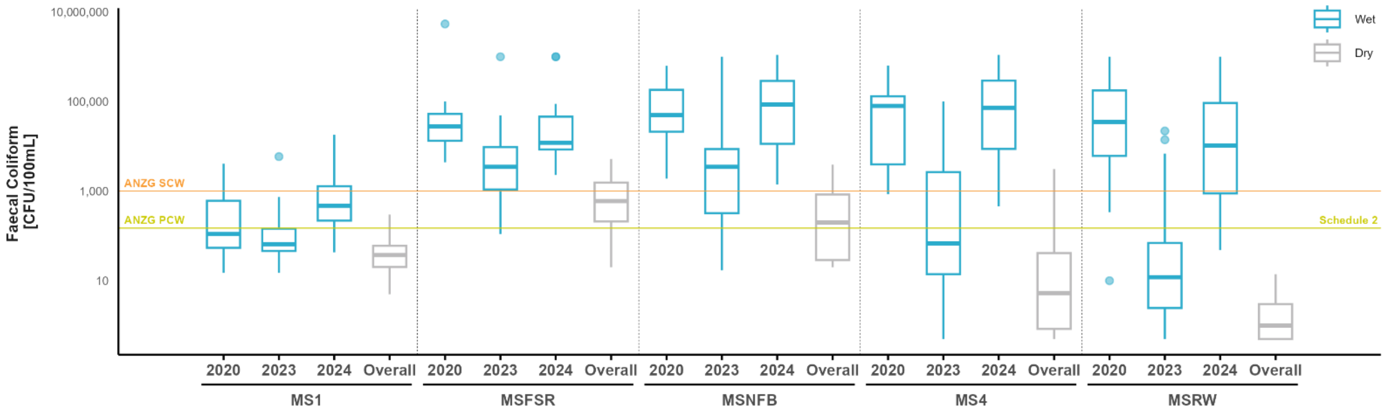

Figure 11 Faecal coliform counts at Mill Stream waterway sites

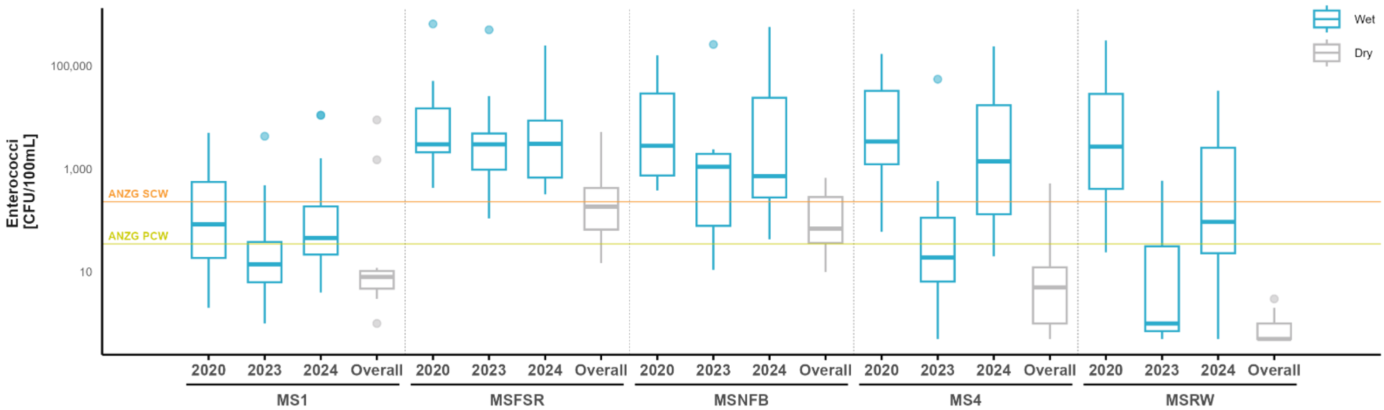

Figure 12 *Enterococci* counts at Mill Stream waterway sites

Nutrients

Nitrogen and phosphorus are the key essential nutrients required for the growth of photosynthetic organisms such as weed or algae and can enter waterways from geological sources, controlled or uncontrolled discharges, urban runoff, agricultural run-off and submarine groundwater discharge (Weinstein et al 2011). As nitrogen availability often limits the primary productivity of many ecosystems, large changes in the availability of nitrogen can lead to severe alterations of the nitrogen cycle in ecosystems. Likely activities relevant to significantly impacting the nitrogen cycle in the Mill Stream are ammonification from wastewater discharges and runoff of nitrogen-based fertilizers both increasing the amount of biologically available nitrogen. While ammonia is attributed to toxicity, nitrification as described in the nitrogen cycle is the process of converting ammonia to nitrite then to nitrate and can lead to an increase in biotic growth potentially causing eutrophication (Bernhard 2010).

The drainage basin contributing to Mill Stream covers Botany, Mascot, Randwick and Kensington with Centennial Parklands at the furthest edge. It is expected fertilisers, animal waste, sediments, organic material, roadways and vehicular biproducts originating from stormwater would routinely attribute to nutrient loads in addition to periodic wet weather discharges from the Mill Stream ERS. Nitrogen and phosphorus actors give an indication as to availability of nutrients in the water column, potentially leading to eutrophic conditions.

Summary statistics for nitrogen based nutrient analytes and comparisons to respective guidelines are presented in Table 10. Accompanying total nitrogen, ammonia, ammonium, nitrite and nitrate boxplots are displayed from Figure 13 to Figure 17.

Table 10 Summary nitrogen based nutrient concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Total Nitrogen [mg/L] - ANZG default trigger: 0.3																
MS1	15	**0.92**	0.72	1.08	15	**0.64**	0.43	0.86	20	**0.92**	0.61	1.16	12	**0.84**	0.44	1.84
MSFSR	15	**1.82**	0.57	18.7	15	**0.81**	0.47	13.7	20	**1**	0.62	3.96	12	**0.79**	0.49	1.32
MSNFB	15	**1.34**	0.63	5.54	15	**0.55**	0.25	11.3	20	**1.04**	0.28	10.8	12	**0.52**	0.32	1.14
MS4	15	**1.14**	0.27	5.93	15	**0.24**	0.2	4.92	20	**0.9**	0.29	6.42	12	**0.23**	0.15	0.42
MSRW	15	**1.01**	0.18	6.53	15	**0.21**	0.17	0.62	20	**0.5**	0.21	2.11	12	**0.19**	0.13	0.3
Ammonia NH3-N [mg/L] - ANZG trigger values for marine water species protection: 80%:1.7, 90%:1.2, 95%:0.91, 99%:0.5																
MS1	11	**0.08**	0.04	0.12	15	**<0.01**	<0.01	0.24	20	**0.07**	<0.01	0.19	12	**<0.01**	<0.01	0.06
MSFSR	11	**0.16**	0.1	1.58	15	**0.16**	0.06	9.89	20	**0.14**	0.03	2.47	12	**0.14**	<0.01	0.53
MSNFB	11	**0.54**	0.11	3.82	15	**0.11**	<0.01	8.09	20	**0.31**	<0.01	7.54	12	**0.12**	0.02	0.37
MS4	11	**0.73**	0.03	3.22	15	**0.02**	<0.01	3.59	20	**0.25**	<0.01	4.57	12	**<0.01**	<0.01	0.17
MSRW	11	**0.58**	0.02	4.24	15	**0.02**	<0.01	0.2	20	**0.12**	<0.01	1.16	12	**<0.01**	<0.01	0.02
Ammonium-Nitrogen [µg/L] –Schedule 2: 5 / ANZG default trigger: 15																
MS1	11	**84**	42	126	15	**11**	5	253	19	**73**	5	201	12	**16**	5	61
MSFSR	11	**170**	105	1662	15	**170**	63	10387	19	**150**	31	2593	12	**150**	11	557
MSNFB	11	**570**	115	4022	15	**120**	5	8506	19	**380**	5	7924	12	**120**	20	389
MS4	11	**770**	31	3376	15	**20**	10	3779	19	**320**	5	4739	12	**15**	5	173
MSRW	11	**600**	20	4447	15	**20**	10.	206	19	**130**	5	1216	12	**10**	5	20

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Nitrite Nitrogen NO_2-N [mg/L]																
MS1	-	-	-	-	-	-	-	-	15	**0.008**	0.002	0.020	4	**0.009**	0.003	0.016
MSFSR	-	-	-	-	-	-	-	-	15	**0.011**	0.005	0.024	4	**0.006**	0.002	0.020
MSNFB	-	-	-	-	-	-	-	-	15	**0.013**	<0.001	0.121	4	**0.004**	0.003	0.032
MS4	-	-	-	-	-	-	-	-	15	**0.008**	<0.001	0.066	4	**0.002**	<0.001	0.014
MSRW	-	-	-	-	-	-	-	-	15	**0.003**	<0.001	0.014	4	**<0.001**	<0.001	0.002
Nitrate Nitrogen NO_3-N [mg/L] –Schedule 2: 0.01																
MS1	-	-	-	-	-	-	-	-	15	**0.14**	0.02	0.53	4	**0.26**	<0.01	0.8
MSFSR	-	-	-	-	-	-	-	-	15	**0.22**	0.05	1.07	4	**0.12**	0.02	0.39
MSNFB	-	-	-	-	-	-	-	-	15	**0.10**	0.01	0.48	4	**0.07**	0.02	0.27
MS4	-	-	-	-	-	-	-	-	15	**0.08**	<0.01	0.36	4	**0.02**	<0.01	0.16
MSRW	-	-	-	-	-	-	-	-	15	**0.06**	<0.01	0.12	4	**<0.01**	<0.01	<0.01

Note: Schedule 2 exceeded, ANZG default trigger or 90% SPG exceeded

Total nitrogen

Total nitrogen is the sum of all nitrogen-based actors primarily ammonia (NH3), nitrates (NO3), nitrite (NO2) and nitrous oxides (NxO). The schedule 2 total nitrogen freshwater limit is 0.1 mg/L and there is no specified marine limit. The ANZG default trigger value for south-east Australian estuarine waters is 0.3 mg/L and 0.35 mg/L for lowland rivers in NSW.

Median concentration values for total nitrogen have exceeded the respective ANZG default trigger values at MS1, MSFSR and MSNFB in each of the three wet weather monitoring campaigns and in encompassing dry weather. MS4 and MSRW was below the ANZG default trigger value in dry weather and during 2023 in wet weather. The highest total nitrogen median and maximum concentrations were observed at site MSFSR in 2020 and 2023, however in 2024 this occurred at MSNFB.

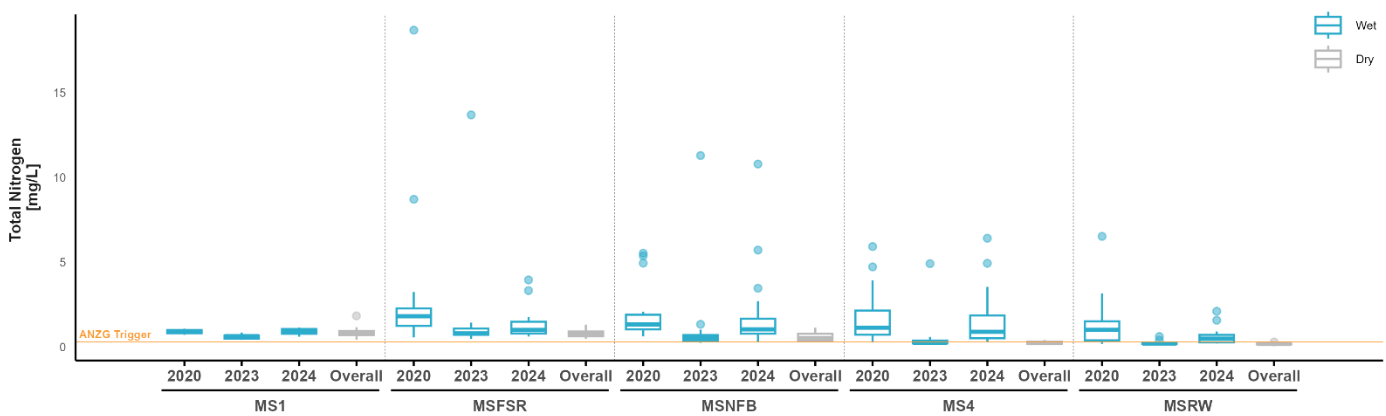

Figure 13 Total nitrogen concentration at Mill Stream waterway sites

Ammonia and ammonium

The term 'ammonia' refers to two chemical species of ammonia that are in equilibrium in water: the un-ionised ammonia, NH_3, and the ionised ammonium ion, NH_4^+. The proportion of the two chemical forms in water varies with the physico-chemical properties of the water, particularly pH and temperature.

The schedule 2 ammonium limit is 5 µg/L for estuarine and coastal waters while ANZG has set a default trigger limit of 15 µg/L. ANZG additionally lists a 95% species protection marine trigger value for total ammonia-nitrogen of 0.91 mg/L (0.910 µg/L) based on toxicity of ammonium at a calculated pH of 8.0. These comparatively low limits of ammonium to ammonia is representative of the greater toxicity unionised ammonia possesses and the ionisation pH equilibrium in relevant aquatic environments displayed in Table 11.

Table 11 ANZG 95% marine species protection for total ammonia-N at varying pH

pH	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5
NH_3-N (µg/L)	3910	3560	3200	2840	2490	2150	1850	1560	1320	1100	910	750	620	510	420	350

Total ammonia

Median total ammonia concentrations at all sites in dry weather were below the ANZG 95% species protection level of 0.91 mg/L based on a pH of 8.0. In wet weather median total ammonia concentrations were below the ANZG 95% species protection level at all sites. Median ammonia concentrations at MS1 exceeded the schedule 2 freshwater limit of 0.02 mg/L in wet weather during 2020 and 2024.

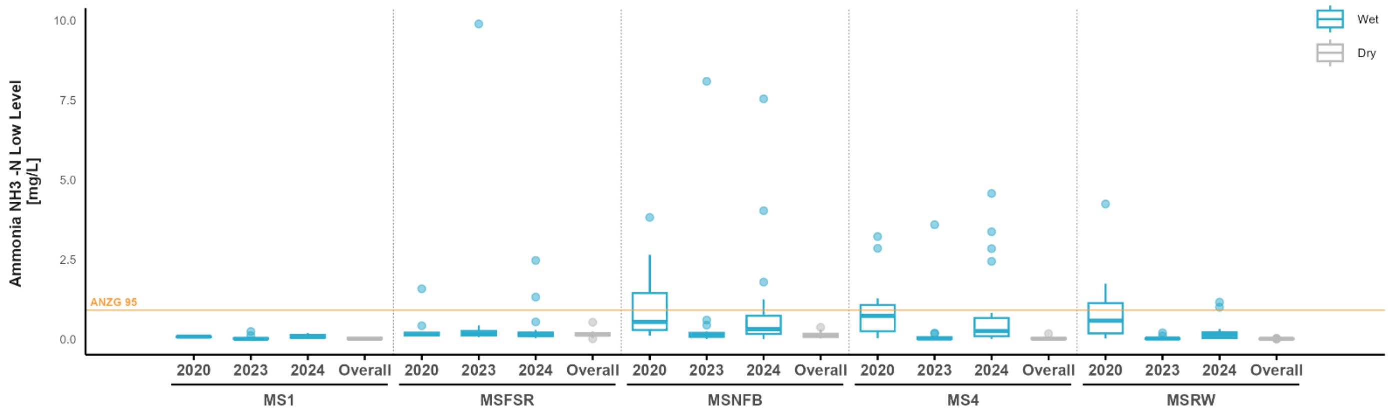

Figure 14 Total ammonia-nitrogen concentrations at Mill Stream waterway sites

Calculated ammonium

The schedule 2 marine limit for ammonium is 5 µg/L, respective ANZG default trigger values for estuarine and lowland rivers are 15 and 20 µg/L.

Median ammonium concentrations calculated from total ammonia, pH and temperature were above the schedule 2 marine limit of 5 µg/L at all sites in dry weather and wet weather. Median ammonium concentrations also exceeded estuarine ANZG default trigger MS4 and MSRW in dry weather. Median ammonium concentrations at MS1 exceeded the lowland river ANZG default trigger in wet weather during 2020 and 2024.

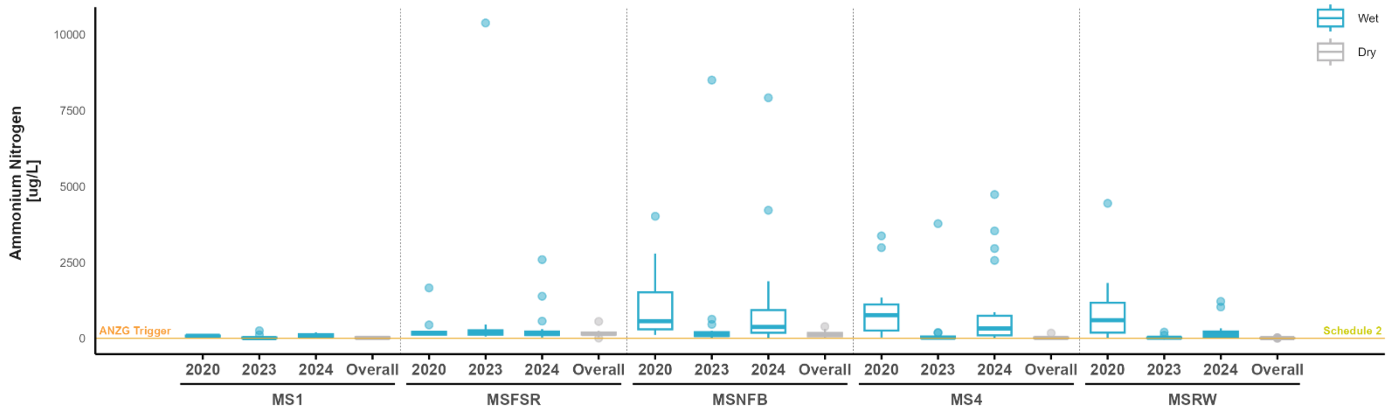

Figure 15 Calculated ammonium-nitrogen concentrations at Mill Stream waterway sites

Nitrites / Nitrates

Nitrites are the first intermediate compound in the nitrification process converting ammonia to nitrate, carried out by microorganisms known as ammonia-oxidisers. Nitrite monitoring as an analyte commenced during the 2024 monitoring period and there is no schedule 2 or ANZG limits listed for nitrite concentration in estuarine waterways. Median nitrite concentrations in dry weather were highest in the upstream, decreasing down Mill Stream. In dry weather median nitrite concentrations were found to be highest in the first two receiving water sites.

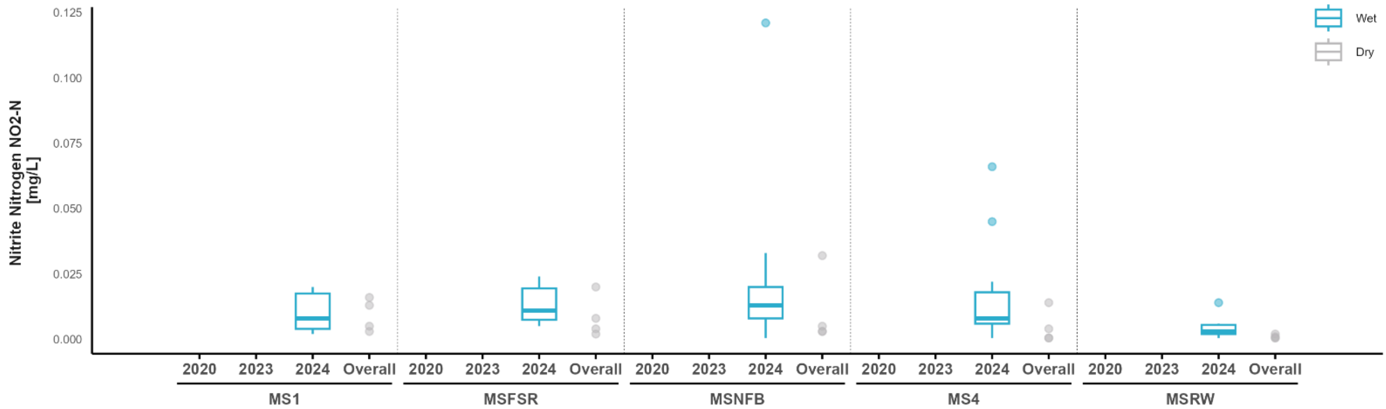

Figure 16 Nitrite concentrations at Mill Stream waterway sites

The second step in nitrification is the oxidation of nitrite to nitrate carried out by a separate group of microorganisms known as nitrite-oxidising bacteria. Nitrate monitoring as an analyte commenced during the 2024 monitoring period and the LOR is 0.01 mg/L. The estuarine schedule 2 limit for nitrate is 10 µg/L where the previous ANZECC 2000 default trigger value for nitrate (15 µg/L) was found to be erroneous and has subsequently been retracted. A recent technical brief (ANZG 2025) found nitrate toxicity in freshwater largely influenced by water hardness. For reference comparing the relative 80% and 99% DGVs, 'soft' (low ion concentration) freshwater is 2.3 and 0.64 mg/L, while 'hard' seawater (high ion concentration) is 56 and 18 mg/L respectively.

Median nitrate concentrations exceeded the schedule 2 limit at all sites in 2024 except for MSRW in dry weather. In dry weather nitrate concentrations decrease from the upstream to downstream-bay locations. This decreasing trend was also observed in median nitrate wet weather concentrations although the MSFSR had an increase from MS1.

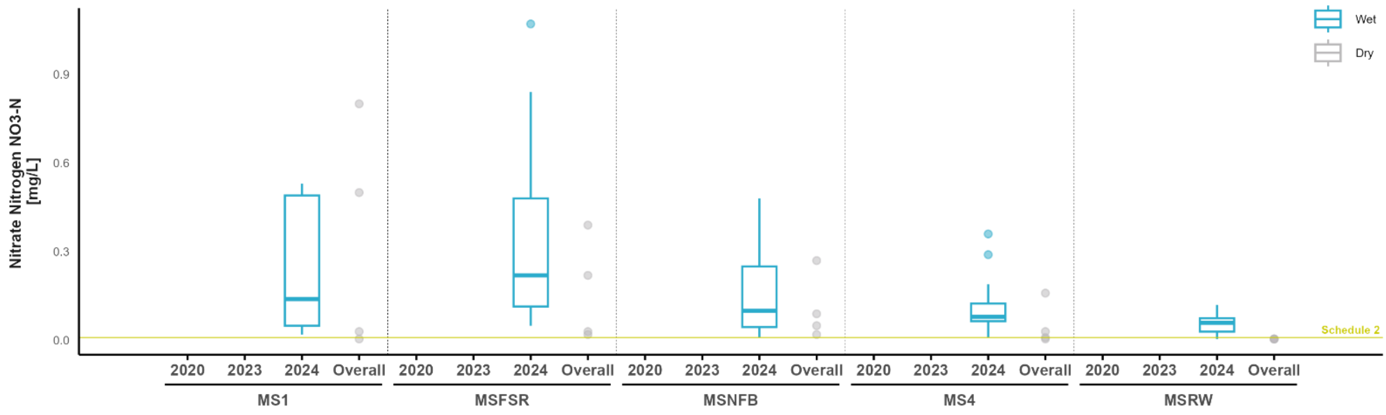

Figure 17 Nitrate concentrations at Mill Stream waterway sites

Phosphorus

The two laboratory methods of phosphorus analysis performed on samples obtained from the three monitoring periods are total phosphorus and soluble reactive phosphorus. Total phosphorus is the total content of phosphorus in an unfiltered, digested aliquot to measure the entire phosphorus element concentration as P. Soluble reactive phosphorus (SRP) is a measure of orthophosphate, the labile form of phosphorus directly used by plant cells and often attributed to eutrophication and water quality degradation (Minesota Stormwater Manual).

Summary statistics for phosphorus based nutrient analytes and comparisons to respective guidelines are presented in Table 12. Accompanying total phosphorus and SRP analyte boxplots are displayed in Figure 18 and Figure 19.

Table 12 Summary phosphorus based nutrient concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Total Phosphorus [mg/L] - Schedule 2: 0.005 / ANZG estuarine default trigger: 0.03																
MS1	15	**0.03**	0.02	0.04	15	**0.03**	0.01	0.04	20	**0.05**	0.02	0.11	12	**0.02**	0.01	0.09
MSFSR	15	**0.12**	0.04	2.12	15	**0.07**	0.02	1.58	20	**0.07**	0.05	0.75	12	**0.07**	0.03	0.1
MSNFB	15	**0.1**	0.03	0.52	15	**0.06**	0.02	1.17	20	**0.08**	0.04	1.22	12	**0.05**	0.03	0.09
MS4	15	**0.13**	0.02	0.53	15	**0.03**	0.02	0.48	20	**0.09**	0.02	0.6	12	**0.02**	0.01	0.04
MSRW	15	**0.07**	0.02	0.54	15	**0.02**	0.01	0.09	20	**0.04**	0.02	0.27	12	**0.02**	0.01	0.02
Soluble Reactive Phosphorus [mg/L] – ANZG estuarine default trigger: 0.005																
MS1	15	**<0.002**	<0.002	<0.002	15	**<0.002**	<0.002	<0.002	20	**<0.002**	<0.002	0.01	12	**<0.002**	<0.002	0.01
MSFSR	15	**0.02**	0.01	1.71	15	**0.02**	0.01	0.94	20	**0.02**	<0.002	0.16	12	**0.03**	0.02	0.05
MSNFB	15	**0.05**	0.01	0.33	15	**0.02**	<0.002	0.66	20	**0.03**	<0.002	0.65	12	**0.02**	0.01	0.04
MS4	15	**0.03**	<0.002	0.26	15	**0.01**	<0.002	0.23	20	**0.02**	<0.002	0.32	12	**0.01**	<0.002	0.02
MSRW	15	**0.03**	0.01	0.32	15	**0.01**	<0.002	0.04	20	**0.02**	<0.002	0.1	12	**0.01**	<0.002	0.01

Note: Schedule 2 exceeded, ANZG default trigger or 90% SPG exceeded

The schedule 2 limit for phosphates (as P) of 0.005 mg/L in estuarine waters is assumed to encompass all phosphorus containing actors (ie total phosphorus), similar to the freshwater phosphorus limit of 0.01 mg/L. The ANZG estuarine and lowland river default trigger guidelines for total phosphorus are 0.03 and 0.05 mg/L respectively.

Total phosphorus median concentrations exceed interpreted schedule 2 limits at all sites in both weather conditions. In dry weather median total phosphorus concentrations at MSFSR and MSNFB exceeded the ANZG default trigger limit. In wet weather, median total phosphorus concentrations in receiving waters exceeded estuarine ANZG default trigger limits at all sites except MS4 and MSRW during 2023.

The ANZG default trigger for SRP is 0.005 mg/L for estuarine waters and 0.02 mg/L for lowland rivers. The LOR for SRP is 0.002 mg/L. SRP median concentrations at MS1 were below the LOR and subsequent ANZG trigger value in wet and dry conditions. SRP median concentrations at all receiving water sites exceeded the ANZG estuarine default trigger value in wet and dry weather conditions.

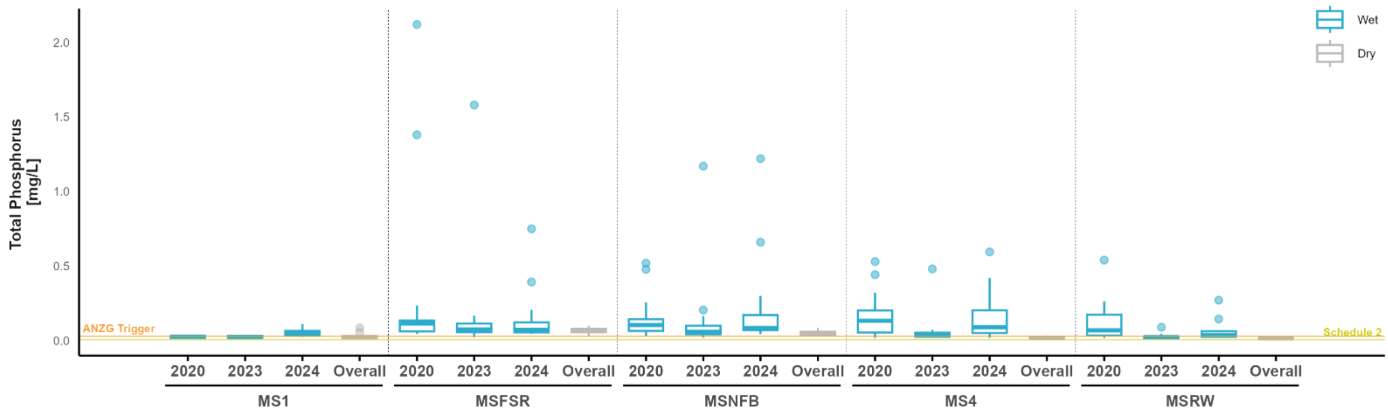

Figure 18 Total phosphorus concentrations at Mill Stream waterway sites.

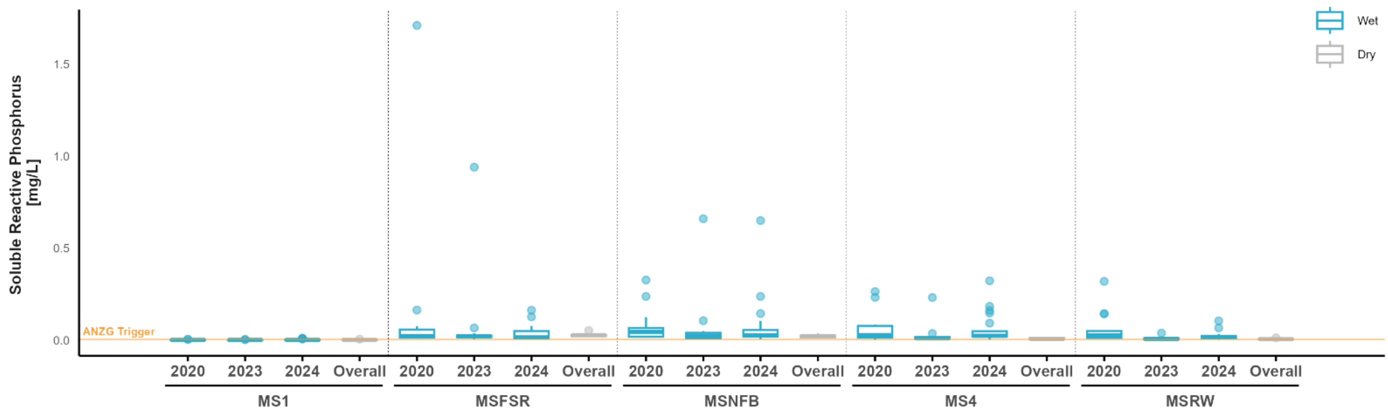

Figure 19 Soluble reactive phosphorus concentrations at Mill Stream waterway sites.

Chlorophyll–α

Nutrient monitoring is conducted as a measure of pressure input into the system. Nitrogen and phosphorus actors give an indication as to availability of nutrients in the water column, allowing biota to grow potentially causing eutrophication. Chlorophyll-a (Chl-α) is the primary photosynthetic pigment in algae and cyano-bacteria giving its green colour (Sudradjat et al, 2024). Whilst not directly a pollutant, Chl-α is used as a surrogate to measure biota concentration an indication of stress on the ecosystem leading to eutrophication. One assumption of using Chl-α as an indicator to ecosystem stress is that biota growth is a result of nutrient availability.

Summary statistics for Chl-α and comparison to relevant guidelines are presented in Table 13, with accompanying boxplot displayed in Figure 20.

The schedule 2 limit for Chl-α is 1 µg/L in estuarine waters compared to the ANZG default trigger guideline of 4 µg/L in estuaries and 3 µg/L for lowland rivers. Median Chl-α concentrations exceed the schedule 2 limit at all sites, over each monitoring period and in both weather conditions.

In dry weather the Chl-α ANZG limits are exceeded at MS1 (freshwater) and MSFSR before median concentrations at the remaining three receiving water sites drop below the 4 µg/L limit. In wet weather, 2024 median Chl-α results follow the same trend as previous periods where Chl-α concentration is highest upstream then subsequently reducing downstream, with MSRW the only site below the ANZG limit.

Table 13 Summary Chlorophyll-a concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Chlorophyll – a [µg/L] –Schedule 2: 1 / ANZG default trigger for estuaries: 4																
MS1	15	**8**	2.4	19.6	15	**8.6**	2.2	20	20	**21.59**	8.2	37.17	12	**9.15**	5	53.2
MSFSR	15	**6**	1.6	70	15	**3.3**	1.1	8.9	20	**15.86**	2.3	31.5	12	**7.58**	1.3	16.4
MSNFB	15	**3.8**	1.2	18.8	15	**2**	0.7	4.7	20	**7.06**	1.6	23.13	12	**1.75**	1.2	18.5
MS4	15	**3.2**	1.5	17.7	15	**2.2**	1.1	4.6	20	**5.59**	0.9	44.4	12	**1.9**	1.2	5.7
MSRW	15	**1.5**	0.7	3.6	15	**1.9**	1.2	4.7	20	**2.65**	0.9	76.72	12	**1.48**	0.5	6.3
Note: Schedule 2 exceeded, ANZG default trigger exceeded																

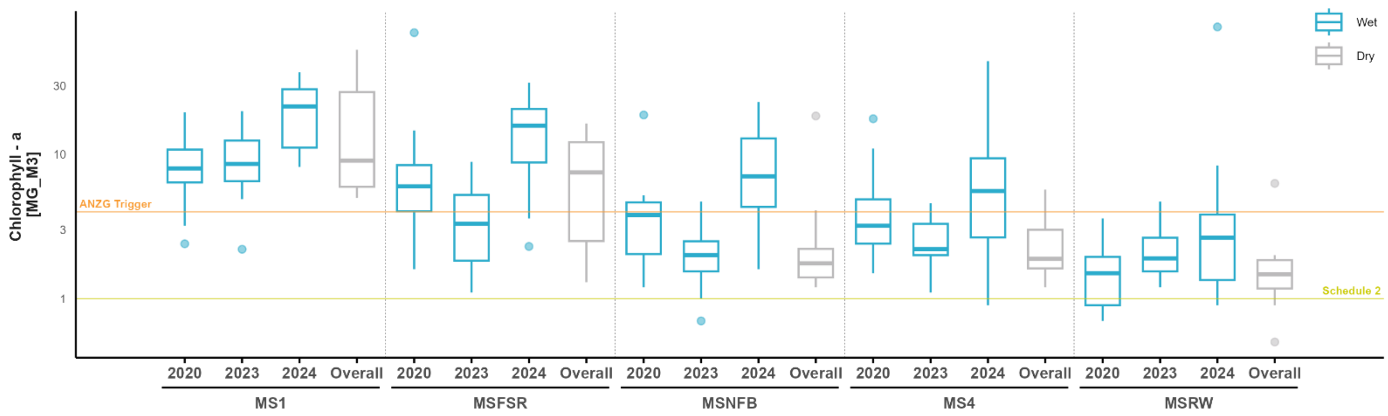

Figure 20 Chlorophyll-a concentrations at Mill Stream waterway sites

Metals

Heavy metals have the capacity to have a toxic effect on marine biota, especially in high concentration and waterways receiving anthropogenic pollution (ANZG, 2000). Domestic chemicals and biproducts, natural sediments, motor vehicles, and road dust entering the bay via stormwater and wastewater overflows are all likely sources of trace metal pollution. Studies on the sources of heavy metal pollutants in and around Sydney Harbour have shown that copper, lead and zinc are the greatest concern due their elevated concentrations and potential toxicity to marine organisms (Hatje et al, 2001, Hatje et al, 2003). Hatje et al, (2001) suggests that metals like zinc and nickel are uniform in their distribution throughout the harbour whereas copper and lead are significantly influenced by anthropogenic inputs.

Summary statistics for metal analytes and comparisons to respective guidelines are presented in Table 14. Accompanying copper, lead, mercury, nickel, silver and zinc boxplots are displayed from Figure 21 to Figure 26.

Table 14 Summary Metal concentrations at Mill Stream waterway sites

	2020				2023				2024				Overall Dry			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Total Copper [µg/L] –Schedule 2: 5 / ANZG trigger values for marine water: 80%:8, 90%:3, 95%:1.3, 99%:0.3																
MS1	15	**2.4**	1.5	3.8	15	**1.9**	1.5	4	20	**2.2**	1.7	8.4	12	**1.5**	0.7	2.4
MSFSR	15	**7.0**	2.6	95.7	15	**1.5**	0.6	27.5	20	**2.5**	1.2	23.3	12	**1.05**	<0.5	10.9
MSNFB	15	**3.7**	1.7	18.2	15	**1.3**	<0.5	17.6	20	**2.9**	<0.5	19.2	12	**0.95**	<0.5	4.2
MS4	15	**2.8**	0.7	20.1	15	**1.0**	0.6	9.2	20	**2.2**	<0.5	27.5	12	**<0.5**	<0.5	1.6
MSRW	15	**2.2**	<0.5	10.3	15	**0.7**	<0.5	1.3	20	**1.1**	0.6	2.7	12	**<0.5**	<0.5	0.9
Total Lead [µg/L] –Schedule 2: 5 / ANZG trigger values for marine water: 80%:12, 90%:6.6, 95%:4.4, 99%:2.2																
MS1	15	**2.2**	1.49	3.09	15	**1.2**	0.7	2.4	20	**2.7**	1.7	12.4	12	**1.5**	0.9	2.6
MSFSR	15	**2.6**	1.61	58.4	15	**0.9**	0.6	4.2	20	**2.5**	0.9	18.6	12	**1.0**	0.5	7.2
MSNFB	15	**1.6**	0.95	4.83	15	**0.8**	0.3	3.6	20	**2.1**	0.2	7.2	12	**0.7**	0.29	3.8
MS4	15	**1.5**	0.18	5.66	15	**0.5**	0.2	3	20	**1.9**	0.3	34.1	12	**0.5**	0.13	1.1
MSRW	15	**0.9**	0.11	3.57	15	**0.4**	<0.1	0.7	20	**0.5**	0.2	2	12	**0.3**	<0.1	1.2
Total Mercury [µg/L] –Schedule 2: 0.1 / ANZG trigger values for marine water: 80%:1.4, 90%:0.7, 95%:0.4, 99%:0.1																
MS1	15	**<0.01**	<0.01	0.02	15	**<0.01**	<0.01	0.06	20	**<0.01**	<0.01	<0.01	12	**<0.01**	<0.01	<0.01
MSFSR	15	**<0.01**	<0.01	0.23	15	**<0.01**	<0.01	0.08	20	**<0.01**	<0.01	<0.01	12	**<0.01**	<0.01	0.02
MSNFB	15	**<0.01**	<0.01	0.03	15	**<0.01**	<0.01	0.06	20	**<0.01**	<0.01	0.02	12	**<0.01**	<0.01	<0.01
MS4	15	**<0.01**	<0.01	0.02	15	**<0.01**	<0.01	0.06	20	**<0.01**	<0.01	0.02	12	**<0.01**	<0.01	<0.01
MSRW	15	**<0.01**	<0.01	0.02	15	**<0.01**	<0.01	0.06	20	**<0.01**	<0.01	<0.01	12	**<0.01**	<0.01	<0.01

		2020				2023				2024				Overall Dry		
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Total Nickel [µg/L] –Schedule 2: 15 / ANZG trigger values for marine water: 80%:560, 90%:200, 95%:70, 99%:7																
MS1	15	**0.3**	0.3	0.5	15	**0.4**	<0.2	1.2	20	**0.4**	<0.2	0.9	12	**0.4**	<0.2	0.4
MSFSR	15	**0.9**	0.5	6.8	15	**0.5**	0.3	2.0	20	**0.6**	0.3	4.2	12	**0.4**	<0.2	1.0
MSNFB	15	**0.5**	0.4	1.6	15	**0.3**	<0.2	1.4	20	**0.5**	<0.2	1.4	12	**0.3**	<0.2	0.5
MS4	15	**0.5**	<0.2	1.4	15	**<0.2**	<0.2	1.0	20	**0.5**	<0.2	2.4	12	**<0.2**	<0.2	0.3
MSRW	15	**0.4**	<0.2	0.9	15	**<0.2**	<0.2	0.4	20	**0.3**	<0.2	0.5	12	**<0.2**	<0.2	1.8
Total Silver [µg/L] –Schedule 2: 1 / ANZG trigger values for marine water: 80%:2.6, 90%:1.8, 95%:1.4, 99%:0.8																
MS1	15	**<0.1**	<0.1	<0.1	15	**<0.1**	<0.1	0.7	20	**<0.1**	<0.1	0.9	12	**<0.1**	<0.1	0.2
MSFSR	15	**<0.1**	<0.1	<0.1	15	**<0.1**	<0.1	1.1	20	**<0.1**	<0.1	0.3	12	**<0.1**	<0.1	0.4
MSNFB	15	**<0.1**	<0.1	<0.1	15	**0.2**	<0.1	0.6	20	**<0.1**	<0.1	0.6	12	**<0.1**	<0.1	0.9
MS4	15	**<0.1**	<0.1	<0.1	15	**0.3**	<0.1	0.9	20	**<0.1**	<0.1	0.9	12	**<0.1**	<0.1	0.5
MSRW	15	**<0.1**	<0.1	<0.1	15	**0.2**	<0.1	3.4	20	**<0.1**	<0.1	2.2	12	**<0.1**	<0.1	0.7
Total Zinc [µg/L] –Schedule 2: 50 / ANZG trigger values for marine water: 80%:21, 90%:12, 95%:8, 99%:3.3																
MS1	15	**12**	9	26	15	**7**	3	13	20	**9**	5	30	12	**7**	2	15
MSFSR	15	**33**	10	474	15	**8**	3	79	20	**13**	4	152	12	**6**	3	34
MSNFB	15	**15**	7	58	15	**5**	2	36	20	**11**	2	39	12	**4**	2	13
MS4	15	**12**	3	52	15	**3**	<1	23	20	**9**	2	116	12	**2**	<1	8
MSRW	15	**8**	2	25	15	**3**	<1	7	20	**4**	<1	12	12	**<1**	<1	2

Note: Schedule 2 exceeded, ANZG default trigger 90% exceeded, ANZG default trigger 80% exceeded

Copper

The schedule 2 marine and freshwater limits for copper are 5 µg/L and 2 µg/L respectively. ANZG 80% and 90% species protection guidelines (SPG) in marine waters are 8 and 3 µg/L, corresponding freshwater guidelines are 2.5 and 1.8 µg/L. The copper LOR is 0.5 µg/L.

In dry weather median copper concentration was below schedule 2 and 90% SPG at all sites. Median copper concentrations for 2024 in wet weather was below schedule 2 and 90% SPG at all sites except MS1 which exceeded the freshwater schedule 2 and 90% SPG. Median copper concentrations in 2024 were higher than 2023 however a notable improvement from 2020 results where MSFSR and MSNFB exceeded the 90% SPG including respective schedule 2 limit exceedances at MS1 and MSFSR.

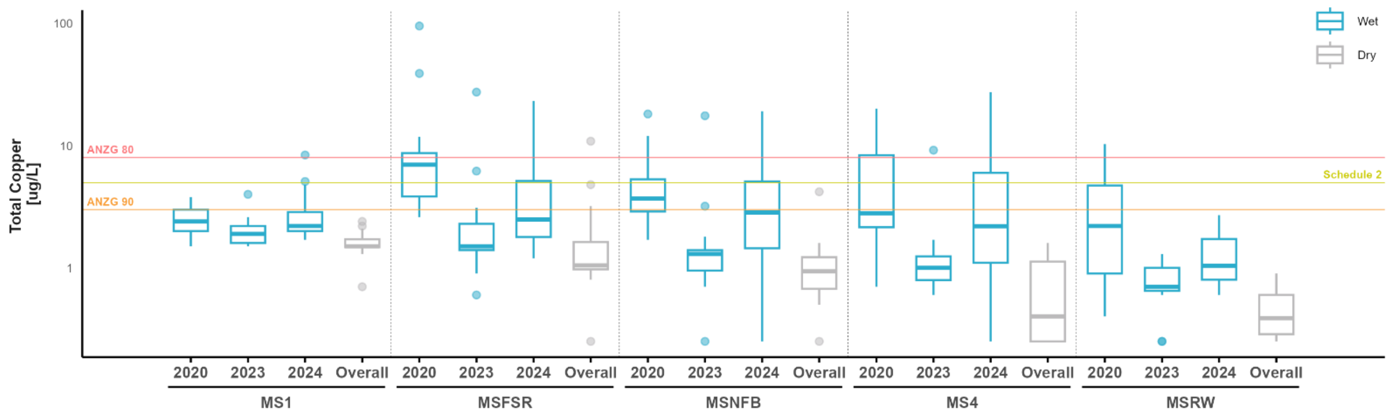

Figure 21 Total copper concentrations at Mill Stream waterway sites. Axis $\log_{10}$ transformed

Lead

The schedule 2 marine and freshwater limits for lead are 5 and 1 µg/L respectively. ANZG 80%, and 90% SPG are 12 and 6.6 µg/L, corresponding freshwater guidelines are 9.4 and 5.6 µg/L. The lead LOR is 0.1µg/L.

In dry weather median lead concentrations were below schedule 2 marine limits and respective 90% SPGs at all sites, the freshwater schedule 2 limit was exceeded at MS1.

In wet weather, median lead concentrations were below 90% SPG limits at all sites. Median lead concentrations at receiving waters were below schedule 2 marine limits, however MS1 exceeded the freshwater limit across all periods.

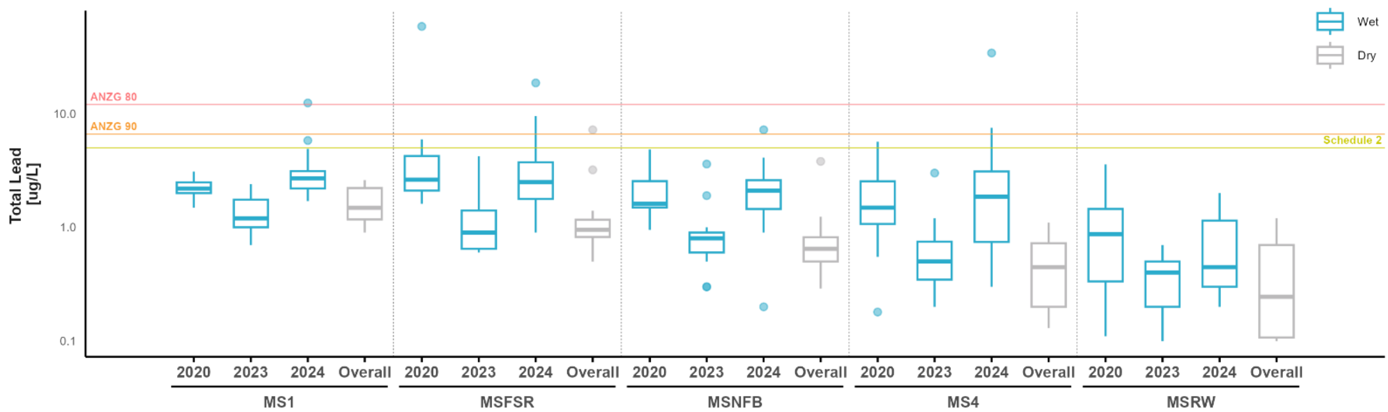

Figure 22 Total lead concentrations at Mill Stream waterway sites. Axis $\log_{10}$ transformed

Mercury

The schedule 2 marine and freshwater limit for mercury is 0.1 µg/L. ANZG 80% and 90% SPGs are 1.4 and 0.7 µg/L, corresponding freshwater guidelines are 5.4 and 1.9 µg/L. The mercury LOR is 0.01 µg/L.

Median mercury concentrations were below the 0.01 µg/L LOR at all sites in dry weather and across the three wet weather periods.

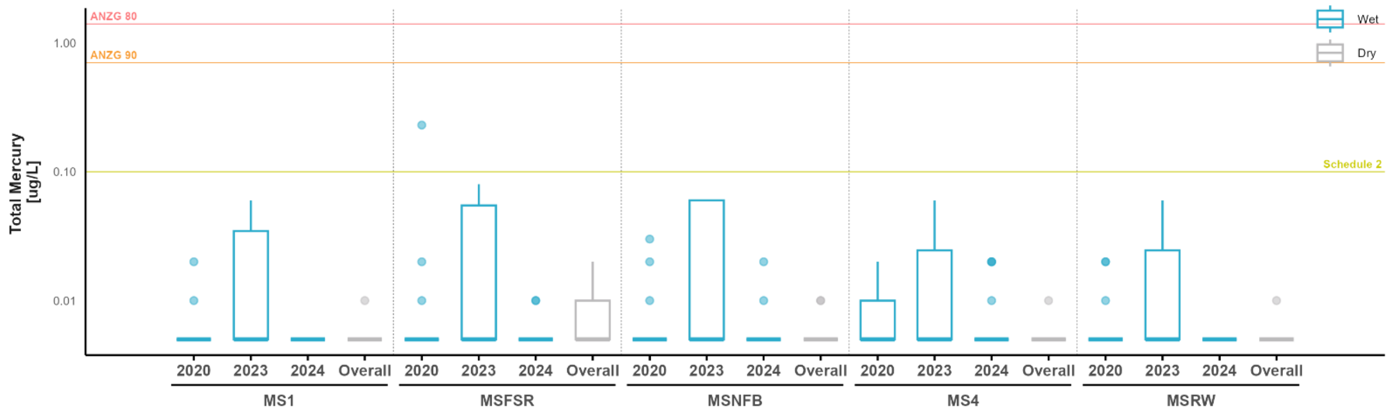

Figure 23 Total mercury concentrations at Mill Stream waterway sites. Axis log_{10} transformed

Nickel

The schedule 2 marine and freshwater limit for nickel is 15 µg/L. ANZG 80% and 90% SPGs are 560 and 200 µg/L, corresponding freshwater guidelines are 17 and 13 µg/L. The nickel LOR is 0.2 µg/L.

Median nickel concentrations were below the 90% SPGs and schedule 2 limits at all sites in dry weather and across the three wet weather periods.

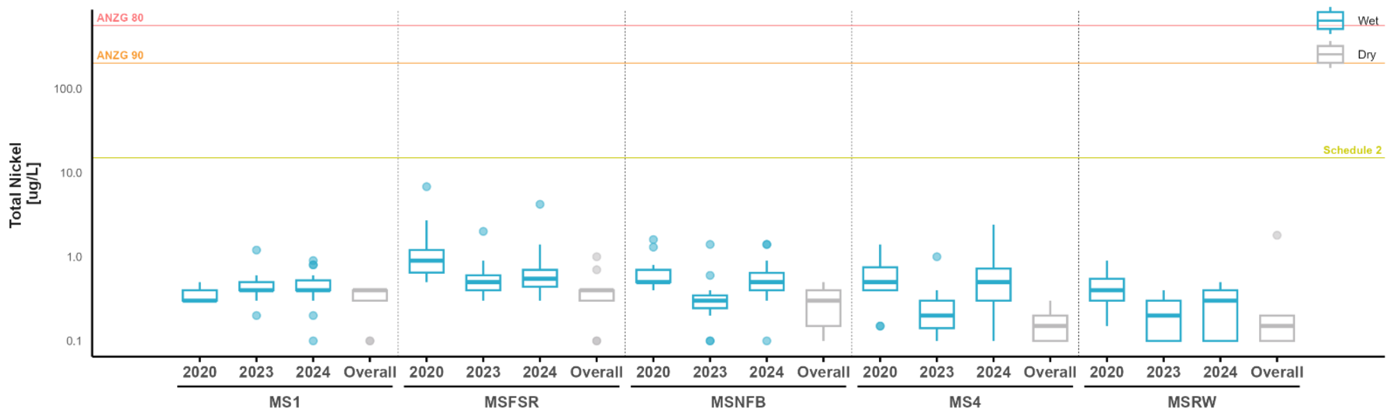

Figure 24 Total nickel concentrations at Mill Stream waterway sites. Axis log_{10} transformed

Silver

The schedule 2 marine and freshwater limits for silver are 1 and 0.1 µg/L respectively. ANZG 80% and 90% SPGs are 2.6 and 1.8 µg/L, corresponding freshwater guidelines are 0.2 and 0.1 µg/L. The silver LOR is 0.1 µg/L.

Median silver concentrations were below the 90% SPGs and schedule 2 limits at all sites in dry weather and across the three wet weather periods.

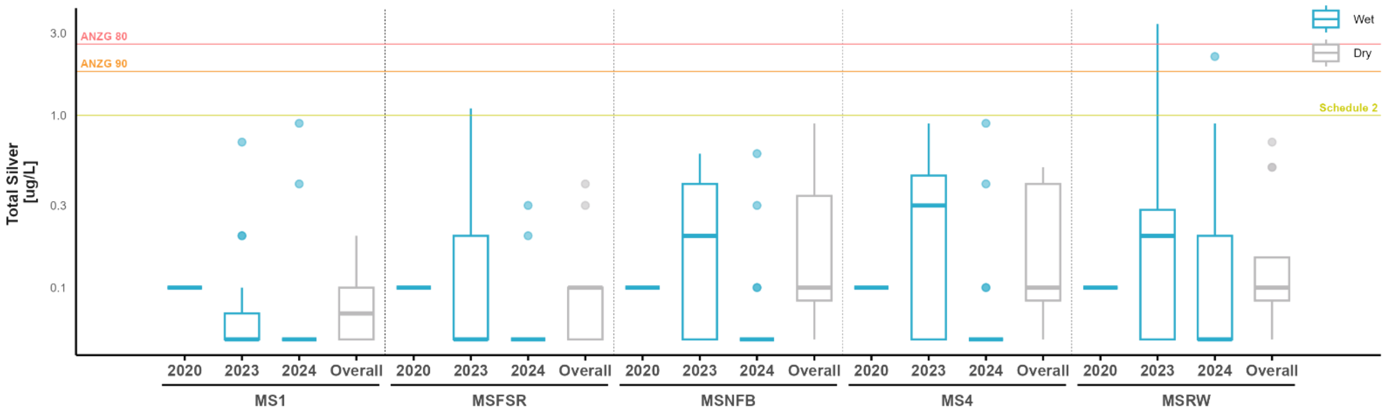

Figure 25 Total silver concentrations at Mill Stream waterway sites. Axis log_{10} transformed

Zinc

The schedule 2 marine and freshwater limits for zinc are 50 and 5 µg/L respectively. ANZG 80% and 90% SPGs are 21 and 12 µg/L, corresponding freshwater guidelines are 31 and 15 µg/L. The zinc LOR is 1 µg/L.

In dry weather median zinc concentrations were below schedule 2 marine limits and respective 90% SPGs at all sites, the freshwater schedule 2 limit was exceeded at MS1.

In wet weather, zinc median concentrations in 2024 exceeded the 90% SPG at MSFSR at 12.5 µg/L. Median zinc concentrations were higher in 2024 than 2023 yet improved from 2020, where MSFSR exceeded the 80% SPG and MSNFB exceeded the 80% SPG. The freshwater schedule 2 limit was exceeded at MS1 in all wet periods.

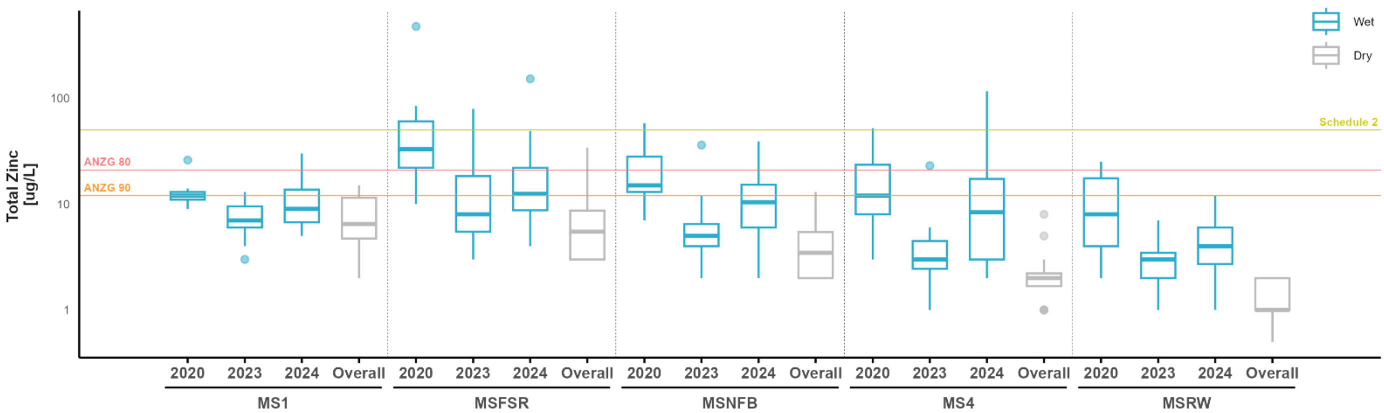

Figure 26 Total zinc concentrations at Mill Stream waterway sites. Axis log_{10} transformed

Physicochemical

There are two types of physical stressors that are broadly categorised as *directly* or *indirectly* effecting an ecosystem. Stressors directly effecting biota are distinguished by their directly toxic affect while others can indirectly result in ecosystem changes such as pH (metal release), temperature (physiological rates) etc.

Summary statistics for physicochemical parameters and comparisons to respective guidelines are presented in Table 15 Accompanying conductivity, dissolved oxygen, pH, temperature, total suspended solids, and turbidity are displayed from Figure 27 to Figure 33.

Table 15 Summary Physicochemical parameters at Mill Stream waterway sites

	2020				2023				2024				Overall			
Site	n	Median	Min	Max	n	Median	Min	Max	n	Median	Min	Max	n	Median	Min	Max
Conductivity [uS/cm]																
MS1	15	**167**	128	240	15	**214**	101	353	20	**187.5**	83	271	12	**241**	201	300
MSFSR	15	**753**	191	11100	15	**23100**	325	42300	20	**1827.5**	103	38200	12	**30950**	17400	46000
MSNFB	15	**6150**	490	45400	15	**43300**	492	53400	20	**17100**	279	51300	12	**43050**	18800	53300
MS4	15	**32600**	3130	51300	15	**51900**	3320	53600	20	**31000**	1337	51500	12	**52850**	41800	54000
MSRW	15	**43200**	23200	52900	15	**53000**	45300	53500	20	**47050**	25500	52900	12	**53550**	49900	53900
Dissolved Oxygen [mg/L] –Schedule 2: 6 mg/L																
MS1	15	**9.6**	9.0	10.3	15	**7.8**	6.2	9.8	20	**8.0**	5.6	11.2	12	**9.9**	7.9	10.8
MSFSR	15	**9.4**	5.9	10.1	15	**6.0**	2.8	9.7	20	**8.0**	4.0	10.8	12	**5.9**	0.2	8.1
MSNFB	15	**8.5**	5.8	10.2	15	**6.7**	3.1	9.2	20	**7.1**	1.6	9.0	12	**6.4**	3.4	8.6
MS4	15	**9.2**	6.2	10.3	15	**8.0**	4.6	10	20	**7.6**	5.7	8.7	12	**7.9**	5.6	10
MSRW	15	**8.1**	4.7	10.1	15	**7.7**	4.4	9.8	20	**7.2**	6.3	8.1	12	**8.1**	6.7	10.1
Percent Dissolved Oxygen [%] – ANZG default trigger for estuarine: 80 – 110 %																
MS1	15	**94.1**	85.8	98.3	15	**89.2**	72.2	122	20	**89.8**	70	122	12	**100.5**	94.7	116
MSFSR	15	**95.0**	59.1	99.9	15	**70.1**	37.3	108	20	**91.1**	53.3	118	12	**69.9**	2.4	92.3
MSNFB	15	**87.8**	55	100	15	**80.1**	40.2	101	20	**83.2**	18.6	101	12	**78.5**	38.1	92.1
MS4	15	**97.2**	59.3	102	15	**99.6**	56.8	118	20	**96.1**	65.3	109	12	**98.6**	79.1	106
MSRW	15	**93.9**	44.2	98.5	15	**99.1**	88.8	106	20	**95.6**	77.4	102	12	**100.5**	95.7	105
Temperature Sample [°C]																
MS1	15	**13.9**	11.8	16.1	15	**21.2**	16.8	26.5	20	**21.15**	15.8	26.4	12	**17.15**	13.3	28.4
MSFSR	15	**14.8**	12.5	16.3	15	**21**	15.3	26.4	20	**21.3**	17.1	27	12	**17.8**	13.9	25.1
MSNFB	15	**13.8**	12.4	16.4	15	**20**	14	23.8	20	**21.05**	16.7	25.5	12	**17**	13.1	24
MS4	15	**14.5**	13.2	16.4	15	**20.6**	16.1	25.1	20	**21.2**	16.4	25.1	12	**17.3**	14.7	23.5
MSRW	15	**14.1**	12.8	15.8	15	**20**	16.1	21.9	20	**20.95**	16.5	23.7	12	**17.1**	15.1	24.2

	2020				2023				2024				Overall			
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
Total Suspended Solids [mg/L]																
MS1	15	**3**	<2	6	15	**3**	<2	7	20	**7**	3	110	12	**3.5**	<2	9
MSFSR	15	**8**	<2	260	15	**7**	<2	42	20	**10.5**	3	96	12	**6**	3	25
MSNFB	15	**7**	<2	37	15	**9**	5	27	20	**9.5**	3	29	12	**6**	3	31
MS4	15	**16**	<2	96	15	**9**	<2	19	20	**11**	<2	160	12	**7**	<2	33
MSRW	15	**7**	<2	28	15	**9**	4	19	20	**6.5**	<2	19	12	**5**	<2	15
Turbidity HACH White Light [NTU] – ANZG default trigger for estuarine: 0.5 – 10 NTU																
MS1	15	**3.6**	1.7	6.7	15	**2.1**	1.3	7.9	20	**6.85**	2.9	33	12	**2.3**	0.9	4.8
MSFSR	15	**7**	3.9	66	15	**4.2**	2.8	49	20	**7.85**	3.6	32	12	**5.75**	2.9	34
MSNFB	15	**8.7**	4.7	37	15	**3.7**	1.5	30	20	**6.55**	2.9	25	12	**2.55**	1.5	36
MS4	15	**11**	1.5	41	15	**2.2**	1.1	22	20	**5.6**	1.1	60	12	**1.35**	0.7	8.8
MSRW	15	**4.9**	0.6	20	15	**1.0**	0.6	2.2	20	**1.6**	0.6	13	12	**0.8**	0.5	1.7
pH [pH units] – ANZG default trigger for estuarine: 7.0 – 8.5																
MS1	15	**7.32**	7.13	7.63	15	**7.27**	7.00	8.69	19	**7.32**	6.65	8.13	12	**7.53**	7.24	9.18
MSFSR	15	**7.33**	7.07	7.53	15	**7.35**	7.09	7.58	19	**7.25**	6.77	7.72	12	**7.59**	7.08	7.9
MSNFB	15	**7.45**	7.28	8.09	15	**7.73**	7.11	8.1	19	**7.35**	7.00	8.11	12	**7.82**	7.13	8.04
MS4	15	**7.83**	7.50	8.16	15	**8.08**	7.19	8.2	19	**7.78**	7.19	8.1	12	**8.12**	7.92	8.18
MSRW	15	**8.02**	7.59	8.14	15	**8.07**	7.87	8.15	19	**8.03**	7.38	8.12	12	**8.14**	8.05	8.2

Note: Schedule 2 exceeded, ANZG default trigger exceeded

Dissolved Oxygen

Rapidly moving water tends to contain higher concentrations of dissolved oxygen, while stagnant water contains very little. If surface waters are moving sufficiently fast, they will generally have 100% dissolved oxygen saturation due to free exchange within the atmosphere. Bacteria and/or organic matter consume dissolved oxygen in water, therefore when in excess, they can cause oxygen depletion and aquatic life experiences competition for available oxygen. This is more likely to occur in the summer when there is a seasonal low in dissolved oxygen, as increasing temperatures decrease the ability of water to hold dissolved oxygen (Baird 1997).

Dissolved oxygen is measured in two ways: concentration (mg/L) as an *absolute* expression of the weight of oxygen dissolved in water, or as percent saturation (% DO) *relative* to the maximum dissolved oxygen content at a given temperature and pressure. Schedule 2 uses the *absolute* measurement defining an adverse effect when dissolved oxygen content of water to falls:

a. *below 6 mg/L, or*

b. *to 80% average saturation level for a 24-hour period*

ANZG default trigger values are set based on *relative* DO content listing south-east Australian estuaries lower and upper saturation limits at 80% and 110% respectively. Due to the monitoring design an average saturation level for each site is too variable to define and as such comparison will be made to the 6 mg/L absolute and 80-110 % relative guideline levels.

Median dissolved oxygen concentration was above the schedule 2 limit at all sites, periods and weather conditions, except MSFSR in 2024 dry conditions where it fell just below the limit (5.9mg/L). The lowest median dissolved oxygen concentration in wet weather was observed at MSFSR in 2023 (6.0 mg/L).

Similar results were observed with dissolved oxygen saturation (%) results. In dry weather median dissolved oxygen saturation at MSFSR and MSNFB were both below the lower ANZG default trigger value. In wet weather conditions the median dissolved oxygen saturation at MSFSR in 2023 was the only site below the lower ANZG default trigger value.

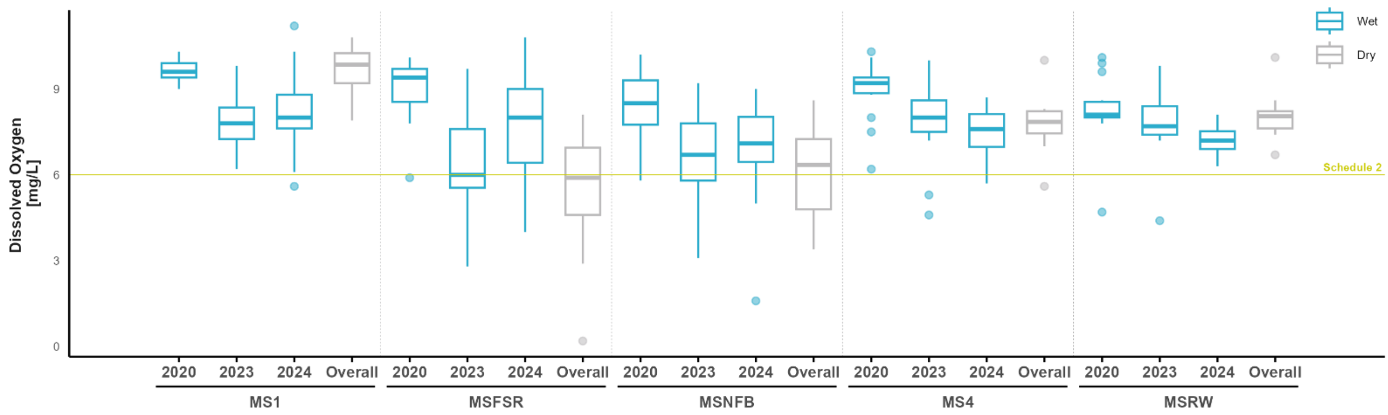

Figure 27 Dissolved oxygen at Mill Stream waterway sites

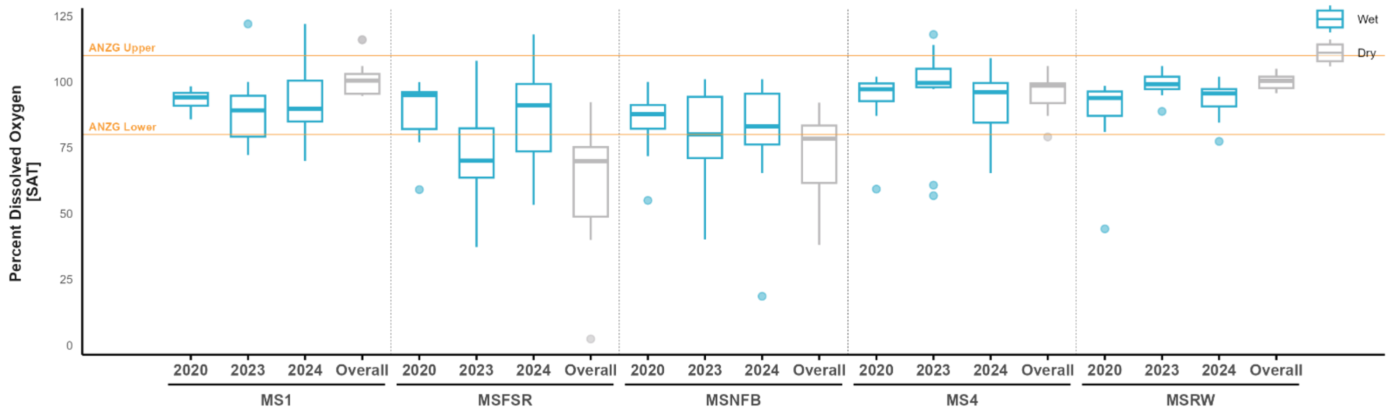

Figure 28 Dissolved oxygen saturation at Mill Stream waterway sites

pH

Schedule 2 defines an adverse effect when the pH of marine waters rises by more than 0.2 whereas the ANZG guideline for NSW estuarine systems is pH is 7.0 – 8.5. Owing to the design of the monitoring program and complexity of the Mill Stream estuarine system, comparison to schedule 2 limits is not suitable so ANZG guidelines have been applied.

Median pH values in dry and wet weather are all within ANZG guidelines for each monitoring period. In both dry and wet weather monitoring, an increasing trend in pH from the freshwater upstream site through to MS4 and MSRW is observed. This is likely due to dilution of the upstream freshwater flow through the tidally influenced estuarine system and into the bay where sea water buffering occurs stabilising the pH at 8.1.

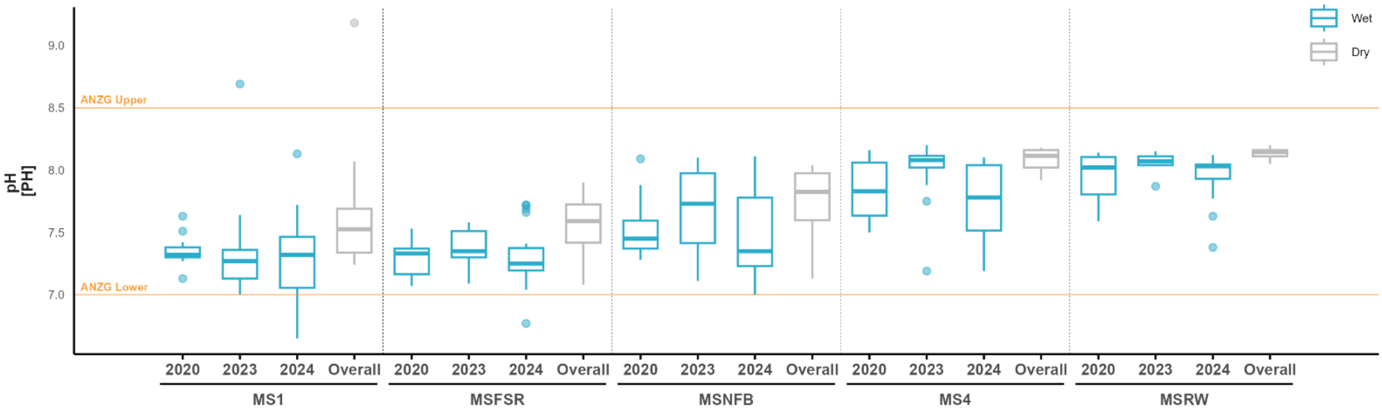

Figure 29 pH concentrations at Mill Stream waterway sites

Conductivity

Millstream is a tidally influenced estuarine system as observed in the dry weather monitoring data. We see an increasing conductivity trend as distance from the upstream freshwater site MS1 increases, terminating at MSRW where conductivity is comparable with standard ocean water (~53 mS/cm) in dry weather. Lower conductivity is observed at monitored locations during wet weather as additional non-saline (stormwater) inputs enter the estuarine system.

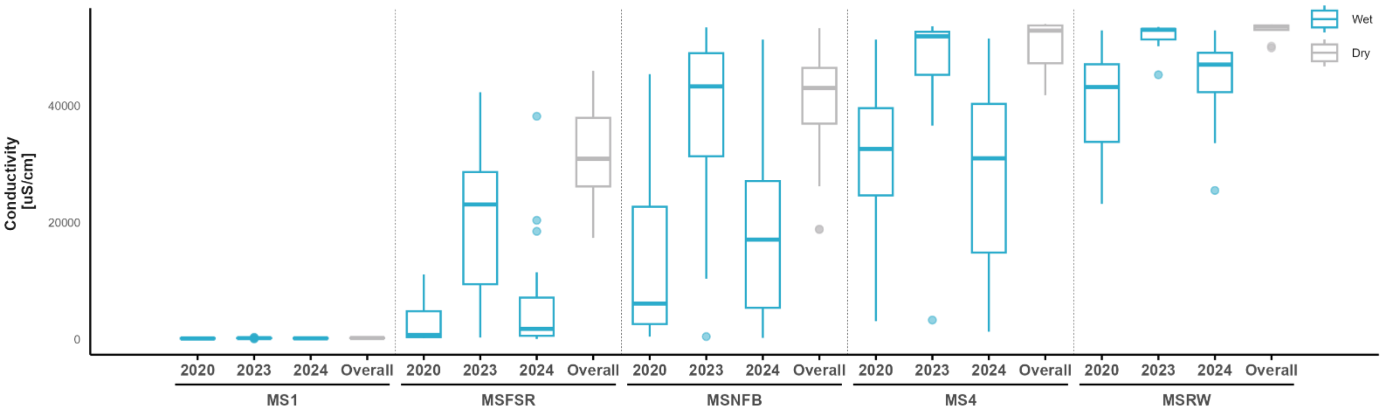

Figure 30 Conductivity at Mill Stream waterway sites

Temperature

Owing to the design of the monitoring program, no assessment against schedule 2 criteria has been made. Schedule 2 defines a *two-degree change in temperature is an influence*, however the temperature within the Mill Stream receiving waters are likely the result of stormwater inputs and the tidal cycle at the time of monitoring.

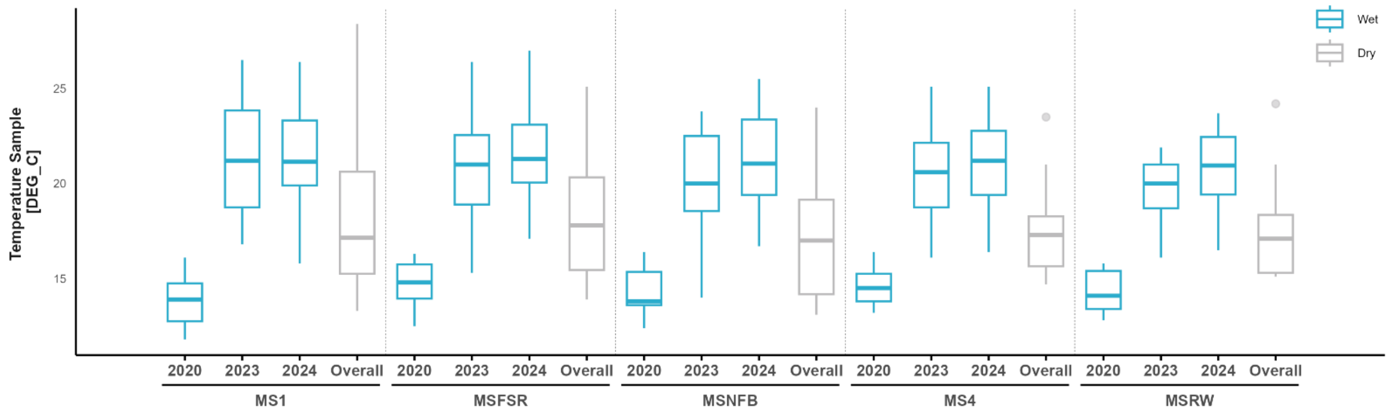

Figure 31 Temperature at Mill Stream waterway sites

Total Suspended Solids & Turbidity

Total suspended solids (TSS) is the concentration of suspended solid particles such as silt, organic matter, algae and microscopic organisms measured in the laboratory by filtering a known volume of sample and recording its dried mass. Turbidity allows field measurement of water clarity by its optical properties and does not necessarily correlate to water quality. Although different methods, TSS and turbidity give insight into similar water quality characteristics and affect temperature, photosynthesis, nutrient concentration and microbiology (EPA 2021).

Schedule 2 defines an adverse effect because entry of a substance into waters:

c. *Total suspended solids concentration changes by >10% from the seasonal mean, or*
d. *Visual clarity (inverse of turbidity) is reduced by >10% from the seasonal mean*

Owing to the configuration of the monitoring program, no assessment against schedule 2 criteria for TSS or turbidity against a seasonal mean can be made. The ANZG default trigger values for south-east estuarine and marine turbidity is 0.5-10 NTU, there is no guideline levels for TSS.

Median turbidity values in dry weather were all within the lower and upper ANZG trigger values. MS4 in 2020 was the only median turbidity to exceed the trigger values, at 11 NTU, in wet weather.

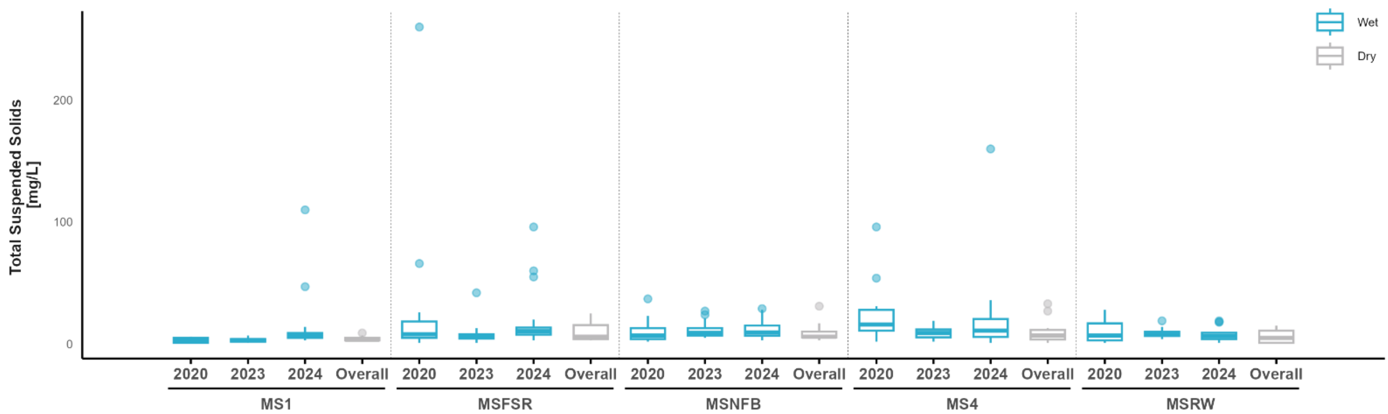

Figure 32 Total suspended solids at Mill Stream waterway sites

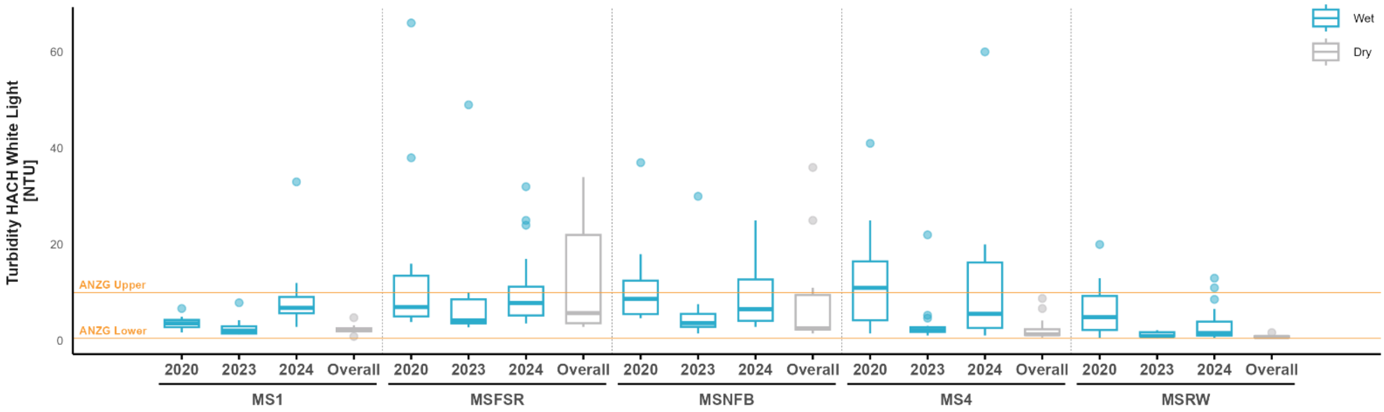

Figure 33 Turbidity at Mill Stream waterway sites

Additional Analytes

Summary statistics for additional analytes and comparisons to respective guidelines are presented in Table 16. Accompanying biochemical oxygen demand, oil & grease and sulphide boxplots are displayed from Figure 34 to Figure 36.

Table 16 Summary additional parameters at Mill Stream waterway sites

		2020				2023				2024				Overall		
Site	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**	**n**	**Median**	**Min**	**Max**
BOD$_5$ [mg/L]																
MS1	15	**<2**	<2	6	15	**<2**	<2	94	20	**<2**	<2	9	12	**<2**	<2	7
MSFSR	15	**4**	<2	69	15	**<2**	<2	49	20	**3**	<2	50	12	**5**	<2	15
MSNFB	15	**3**	<2	22	15	**<2**	<2	22	20	**<2**	<2	24	12	**<2**	<2	3
MS4	15	**4**	<2	27	15	**<2**	<2	12	20	**<2**	<2	14	12	**<2**	<2	10
MSRW	15	**<2**	<2	19	15	**<2**	<2	8	20	**<2**	<2	10	12	**<2**	<2	15
Oil & Grease [mg/L]																
MS1	15	**<5**	<5	<5	15	**<5**	<5	<5	20	**<5**	<5	<5	12	**<5**	<5	<5
MSFSR	15	**<5**	<5	9	15	**<5**	<5	<5	20	**<5**	<5	24	12	**<5**	<5	<5
MSNFB	15	**<5**	<5	9	15	**<5**	<5	<5	20	**<5**	<5	<5	12	**<5**	<5	<5
MS4	15	**<5**	<5	10	15	**<5**	<5	<5	20	**<5**	<5	<5	12	**<5**	<5	<5
MSRW	15	**<5**	<5	6	15	**<5**	<5	<5	20	**<5**	<5	<5	12	**<5**	<5	<5
Sulphide [µg/L] –Schedule 2: 2.0																
MS1	15	**<30**	<30	<30	15	**<30**	<30	<30	20	**<30**	<30	50	12	**<30**	<30	50
MSFSR	15	**<30**	<30	339	15	**<30**	<30	183	20	**<30**	<30	50	12	**<30**	<30	1160
MSNFB	15	**<30**	<30	38	15	**<30**	<30	<30	20	**<30**	<30	50	12	**<30**	<30	174
MS4	15	**<30**	<30	40	15	**<30**	<30	<30	20	**<30**	<30	88	12	**<30**	<30	50
MSRW	15	**<30**	<30	<30	15	**<30**	<30	<30	20	**<30**	<30	50	12	**<30**	<30	50
Note: Schedule 2 exceeded																

Biochemical Oxygen Demand

Microorganisms in aerobic waters consume dissolved oxygen in digesting organic material from the surrounding water body as part of their cellular cycle. This microbial metabolism creates an oxygen demand which is measured in the laboratory over five days known as biochemical oxygen demand (BOD$_5$). In some circumstances biochemical oxygen demand can be greater than the contribution from autotrophic actors (algae, macrophytes) and natural atmospheric diffusion potentially leading to anoxic conditions.

No schedule 2 or ANZG aquatic ecosystem protection guideline values exist for BOD$_5$.

In dry weather the median BOD$_5$ concentration at MSFSR was above the 2 mg/L LOR. In wet weather median BOD$_5$ concentrations at MSFSR, MSNFB and MS4 during 2020 and MSFSR during 2024 were above the LOR. All other median BOD$_5$ concentrations were below the LOD.

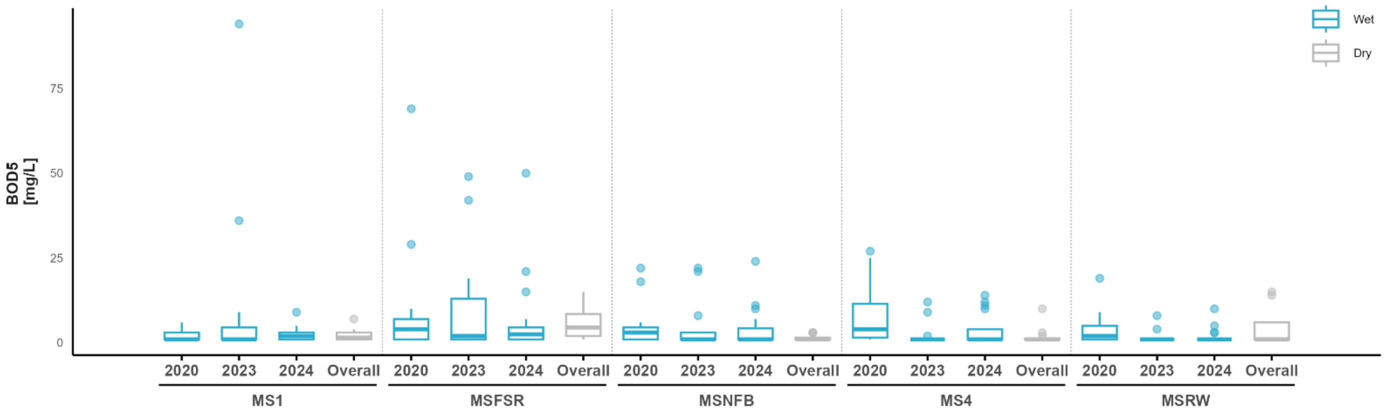

Figure 34 Biochemical oxygen demand concentration at Mill Stream waterway sites

Oil & Grease

Oil and grease (O&G) is the group of organic substances defined by their low affinity to water such as hydrocarbons, fatty acids, soaps, lipids and waxes. Organic substances are hydrophobic in nature and generally less dense than water, leading to formation of thin films on the water's surface potentially limiting light penetration or atmospheric oxygen (Pintor et al 2016).

No schedule 2 or ANZG aquatic ecosystem protection guideline values exist for O&G. In dry weather all measured concentrations were below the 5 mg/L LOR. In wet weather median O&G concentrations were below 5 mg/L. In the 2024 monitoring period, MSFSR was the only receiving water site to observe an O&G concentration above the LOR at 24 mg/L.

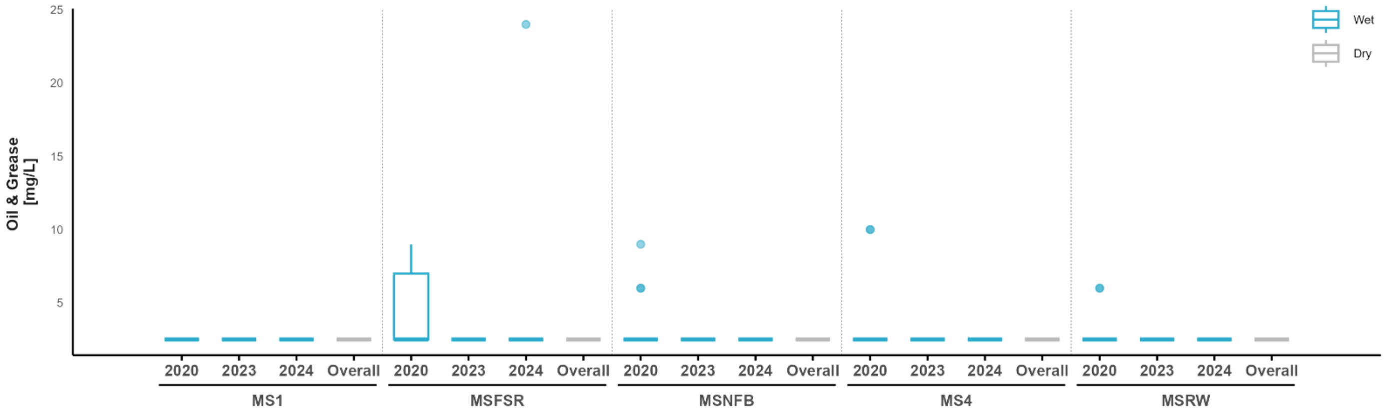

Figure 35 Oil and grease concentrations at Mill Stream waterway sites

Sulphide

Reduced oxygen availability in natural aquatic and sedimentary environments is often correlated to increased sulphide production. Anthropogenic eutrophication leading to organic enrichment and subsequent anoxia from decomposition of algal matter are generally from the discharge of organic-rich effluents (e.g. sewage) and enrichment of nutrients (fertiliser, detergent run-off).

The schedule 2 limit for sulphide is 2 µg/L, slightly above the ANZG low reliability marine trigger value of 1 µg/L specific to unionised hydrogen sulphide (H_2S). Median concentrations for sulphide were below the LOR (<30 µg/L) for all upstream and downstream sites in dry and wet weather. The analysis method used measures total sulphide, while not specifically applicable to the given limits if total sulphide concentration is below guideline values then so is the unionised sulphide concentration.

In dry weather, sulphide concentrations above detection limit have been observed at all sites, with MSFSR observing the maximum receiving water concentration of 1160 µg/L. In wet weather maximum sulphide concentrations observed were at MS4 in 2024 at 88 µg/L whilst in 2020 and 2023 the maximum receiving water concentrations were observed at MSFSR with 339 and 183 µg/L respectively.

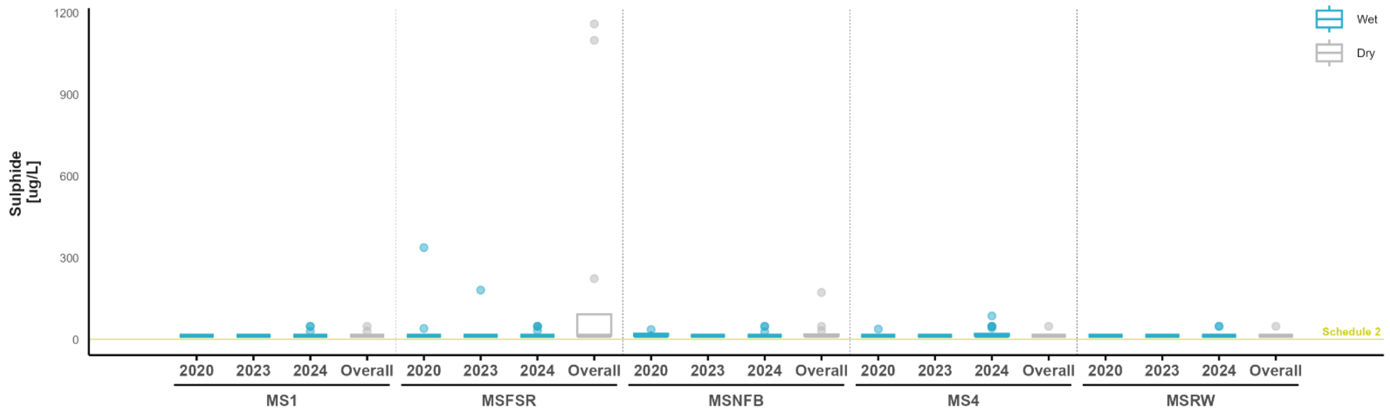

Figure 36 Sulphide concentrations at Mill Stream waterway sites

Organics

Summary statistics for organic analytes and comparisons to respective guidelines are presented in Table 17, with accompanying nonylphenol ethoxylate boxplots displayed in Figure 37.

Table 17 Summary organics concentrations at Mill Stream waterway sites

	2020				2023				2024				Dry Overall			
Site	n	Median	Min	Max	n	Median	Min	Max	n	Median	Min	Max	n	Median	Min	Max
Nonylphenol ethoxylate [µg/L] - ANZG default trigger for freshwater: 80%:360, 90%:220, 95%:140, 99%:50																
MS1	15	<5	<5	9	15	<5	<5	<5	20	<5	<5	15	12	<5	<5	19
MSFSR	15	<5	<5	888	15	<5	<5	<5	20	<5	<5	85	12	<5	<5	19
MSNFB	15	9	<5	58	15	<5	<5	9	20	<5	<5	250	12	<5	<5	9
MS4	15	11	<5	58	15	<5	<5	<5	20	<5	<5	89	12	<5	<5	18
MSRW	15	6	<5	185	15	<5	<5	<5	20	<5	<5	20	12	<5	<5	9
Octylphenol ethoxylate [µg/L]																
MS1	15	<5	<5	<5	15	<5	<5	<5	20	<5	<5	<5	12	<5	<5	<5
MSFSR	15	<5	<5	<5	15	<5	<5	<5	20	<5	<5	<5	12	<5	<5	<5
MSNFB	15	<5	<5	<5	15	<5	<5	<5	20	<5	<5	<5	12	<5	<5	<5
MS4	15	<5	<5	<5	15	<5	<5	<5	20	<5	<5	<5	12	<5	<5	<5
MSRW	15	<5	<5	<5	15	<5	<5	<5	20	<5	<5	<5	12	<5	<5	<5
di(2-ethylhexyl) phthalate [µg/L]																
MS1	15	<10	<10	<10	15	<10	<10	<10	20	<10	<10	<10	12	<10	<10	<10
MSFSR	15	<10	<10	<10	15	<10	<10	<10	20	<10	<10	<10	12	<10	<10	<10
MSNFB	15	<10	<10	<10	15	<10	<10	<10	20	<10	<10	<10	12	<10	<10	<10
MS4	15	<10	<10	<10	15	<10	<10	<10	20	<10	<10	<10	12	<10	<10	<10
MSRW	15	<10	<10	<10	15	<10	<10	<10	20	<10	<10	<10	12	<10	<10	<10

Surfactants

Nonylphenol ethoxylate (NPE) and octylphenol ethoxylate (OPE) are non-ionic surfactants used for reducing surface tension facilitating the wetting process, are used in detergents, paints and pesticides. Both NPE and OPE are classified as endocrine disrupters and can interfere with the hormonal system of organisms (Soares et al, 2008). Due to its low solubility and high hydrophobicity, surfactants tend to accumulate within sewage sludge and sediments.

There is no specific limits for NPE or OPE under schedule 2 or ANZG, however alcohol ethoxylated surfactant ANZG freshwater trigger values for 80% and 90% SPG of 360 and 220 µg/L was used in previous Mill Stream reporting, and so is included in this report.

Median NPE concentrations were below the 90% SPG at all sites in dry weather and across the three wet weather periods. Since 2023, wet weather median NPE concentrations were less than the 5 µg/L LOR.

Median, min and max concentrations of OPE were less than the 5 µg/L LOR at all sites, hence no figure has been included for reporting. There were two samples detected to contain OPE both from the ERS on the 5th and 6th of April 2025 at 14 and 6 µg/L respective.

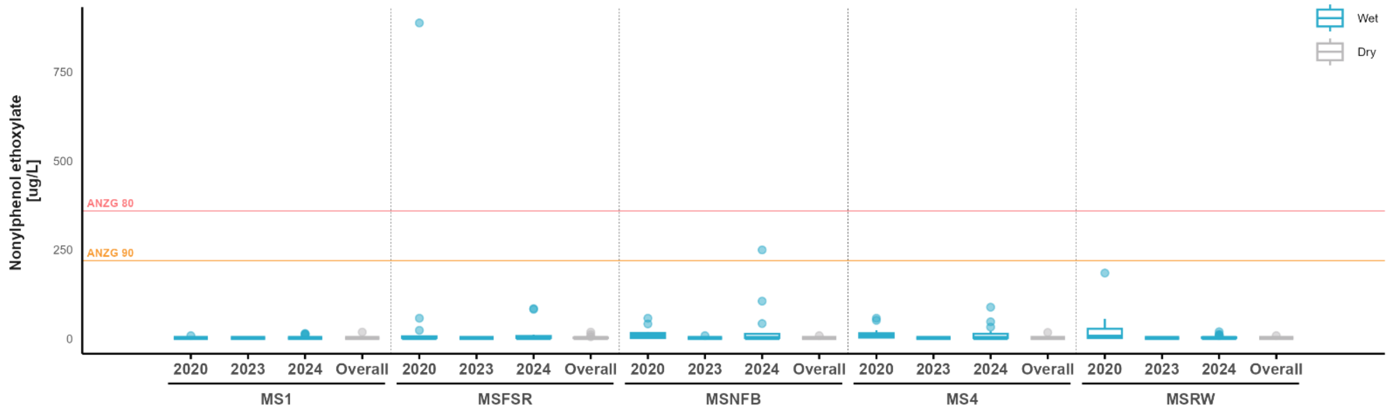

Figure 37 Nonylphenol ethoxylate concentrations at Mill Stream waterway sites

Phthalate esters

Di-(2-Ethylhexyl) phthalate (DEHP) primary use is as a plasticiser making plastics more flexible. Like most organic compounds, it is colourless and insoluble in pure water although can be transported into aquatic environments via acid solubilisers. DEPH in particle phase is subject to breakdown by small organisms in surface water or soils, causing a level of bioaccumulation higher to that of surrounding waters (DCCEEW). Higher level food chain animals are able to breakdown DEHP so tissue levels are generally low.

The schedule 2 accepted limit for DEHP is 0.6 µg/L compared to ANZG 80% and 90% trigger values for freshwater species protection of 1300 and 1100 µg/L respectively. As limited data for marine species these figures are recommended as an indicative interim working level only.

DEHP was not found present at concentrations above the 10 µg/L LOR in any samples analysed across the three Millstream monitoring periods and hence no figure has been included for reporting.

4. Conclusions

Waters immediately downstream of the Mill Stream ERS generally experienced the greatest degradation of water quality with respect to monitored pollutants. Spatial interpretation of the three monitoring periods indicated analytes impacting the estuarine Mill Stream receiving waters originating from both measured upstream wetland flow (MS1) and the ERS discharge (ERS). Temporally, 2023 monitoring results were generally lower in pollutant concentrations compared to 2020 and 2024 monitoring periods, reflecting the lower rainfall and overflow volume monitored.

Median concentrations of PFOA were below NEMP 99% SPG at all receiving water sites across the three monitoring periods. The median PFOA concentration at MSFSR in 2023 was the only site that returned a median above the LOR, although there was occasional samples from other sites that were above the LOR. Median PFOS concentrations fell between ANZG 95% and 99% DGVs at all sites during wet weather monitoring in all periods, however, please note that median concentrations at some sites were below the LOR. PFOS concentrations were generally higher in 2023 and during dry weather monitoring when compared to the wet weather monitoring in 2020 and 2024.

Spatially, both FC and Ent results indicate the input of a considerable microbial source between sites MS1 and MSFSR. Median concentrations of FC and Ent generally exceeded ANZG secondary contact guidelines in wet weather. Exceptions to this trend were observed at the more distal sites MS4 and MSRW during 2023, and specifically for Ent at MSRW in 2024 where only primary contact guidelines were exceeded.

Spatially, nitrogen and phosphorus results indicate the input of a considerable nutrient source between sites MS1 and MSFSR. All receiving water sites experience episodic high-concentration events exceeding the least stringent ANZG trigger values, indicating potential short-term risks to aquatic ecosystems. Median total nitrogen consistently exceeded ANZG default trigger values at MS1, MSFSR, and MSNFB across all monitoring periods, including dry weather. Additionally in 2020 and 2024, median values at the more distal sites MS4 and MSRW, also exceeded the ANZG default trigger value. Median total phosphorus concentrations exceed schedule 2 limits at all sites while ANZG trigger values were exceeded at all receiving water sites except for MS4 and MSRW during 2023 and dry weather. Median SRP concentrations exceed ANZG trigger values at all receiving water sites while MS1 was below LOR across all periods. The absence of SRP at MS1 suggests phosphorus originating from upstream is inert or deposited as non-soluble debris such as sediment or cell tissue. Temporally, median total phosphorus and SRP concentrations appear to have decreased since 2020, indicating a reduction of additional phosphorus input despite consistent concentration from MS1.

Median ammonia concentrations are below ANZG 95% marine water species protection at all sites across all monitoring periods. During the wetter 2020 and 2024 periods, higher median concentrations were observed beyond the immediate input zone at MSNFB and MS4 compared to MSFSR. Calculated median ammonium concentrations exceeded the schedule 2 and ANZG default trigger values at all receiving water sites in wet weather. As concentration data was calculated from ammonia with minor temperature and pH considerations, spatial trends are repeated.

The bacteriological and nutrient results evidence the impact that the Mill Stream overflows had on water quality during and following wet weather overflow discharge. As previously discussed, the data from 2023 was collected from overflows with shorter duration and volume and the results indicate reduced influence on water quality than the 2020 and 2024 periods which captured larger overflow events. These results suggest that works Sydney Water are undertaking to decrease the volume and duration of wet weather overflow discharged at Mill Stream would also reduce the potential impact to water quality at Mill Stream posed by the overflows.

Median Chl-α concentrations exceed schedule 2 limits at all sites. Spatially, the highest median Chl-α concentrations are consistently recorded at MS1, upstream of the ERS discharge suggesting Mill Pond is the significant source of Chl-α to the Mill Stream. Temporally, 2024 showed a significant increase in Chl-α concentrations at all sites from the previous 2020 and 2023 monitoring periods.

In 2024 median concentrations of copper, lead, mercury, nickel, silver and zinc did not exceed the marine schedule 2 limit criteria at any sample site. Median copper concentrations were below ANZG 90% marine trigger value for all weather periods except MSFSR and MSNFB during wet weather in 2020. Median lead, mercury, nickel and silver concentrations were below schedule 2 and ANZG 90% marine trigger values at all sites. Median zinc concentrations were below ANZG 90% marine trigger value for all weather periods except MSFSR in 2024 and MSFSR and MSNFB in 2020. Median zinc concentration at MSFSR in 2020 was the only occurrence of exceeding an ANZG 80% marine trigger value for metals.

Median dissolved oxygen concentration was above the schedule 2 limit at all sites in wet weather. Median dissolved oxygen concentration at MSFSR in dry weather was the only schedule 2 limit exceedance. Median dissolved oxygen saturation was within the ANZG default range for estuarine waters at all sites in wet weather except MSFSR in 2023. Median dissolved oxygen saturation at MSFSR and MSNFB in dry weather was below the lower ANZG default limit. Median turbidity was within the ANZG default range for estuarine waters at all sites in wet weather except MS4 in 2020. Median pH was within the ANZG default range for estuarine waters at all sites in wet weather.

Median BOD_5 concentrations are typically low or below LOR at all sites for all monitoring periods with no guideline values available for comparison. Episodic high-concentration events were observed at MS1 and MSFSR, indicating potential short-term risks to aquatic ecosystems. Median oil and grease concentration was below the LOR at all sites for all monitoring periods with no guideline values available for comparison. Median sulphide concentrations exceeded the schedule 2 limit at all sites despite being below the LOR. Median sulphide concentrations are consistently below detection. The high LOR relative to schedule 2 limits suggests that concentrations likely exceed while not explicitly detected. Episodic high-concentration events were observed at all sites exceeding the Schedule 2 limit.

Median NPE concentrations are consistently below LOR and the ANZG 90% freshwater trigger value for alcohol ethoxylated surfactants. Recorded OPE concentrations within receiving waters are all below LOR with no guideline values available for comparison. Recorded DEHP concentrations are all below LOR with no guideline values available for comparison. It is a recommendation to remove this analyte from future monitoring.

5. Recommendations

As reported, the Mill Stream overflows impact water quality when in operation, in particular this is noticeable in the bacteriological and nutrient results. Condition 21 (a) of the current Authorisation requires that this report, in part, sets out recommended actions for the improvement of water quality at Mill Stream and surrounding Botany Bay area. Sydney Water has undertaken extensive planning studies to assess the feasibility and deliverability of actions that can improve the frequency, volume and quality of overflow discharge at Mill Stream. These actions are detailed in the Mill Stream Environmental Management Plan (EMP) 2024-27 and present the most suitable options for Sydney Water to contribute to the improvement of water quality at Mill Stream and Botany Bay. Results from the monitoring program has informed how the Mill Stream overflows influence the receiving waterway and allowed characterisation against relevant guideline levels, however this monitoring period has not provided insights beyond what was already evidenced and hence no additional actions have been recommended to *'improve water quality at Mill Stream'*. However, there are recommendations for future water quality monitoring, and these are included below.

Future Monitoring

The following recommendations should be considered for future Mill Stream water quality monitoring programs:

- The addition of wet weather (rainfall) monitoring events, without Mill Stream ERS discharge, should be added to the monitoring program. This will allow further understanding of the baseline stormwater conditions during rainfall without influence from Mill Stream overflows.
- Water quality results should continue to be assessed against the current reference guideline levels from schedule 2 and ANZG 2018 as presented in this report and incorporate any future amendments made to the relevant water quality guidelines.
- Review of the current water quality parameters and collection methods - additional analytes and data sources may provide greater understanding of the influence of the Mill Stream overflows and other catchment sources.
- Investigate the possibility of standardised monitoring approaches for the routine (Environmental) and reactive (Emergency Response) monitoring programs to enhance the available data for analysis and reporting. This would need to consider regulatory and resourcing requirements during incident/event sampling.
- There should be a targeted approach to overflow event sampling to ensure overflows of different scales are monitored, when possible:
    - Larger events are required to collect ERS discharge samples (in-pipe wastewater quality), smaller events cease before sampling teams can attend the site (see 2023 monitoring period)
    - Capture variation in receiving environment water quality as a result of short and long overflow durations, and multiple events over the 5 monitoring days (see appendix 7.2)

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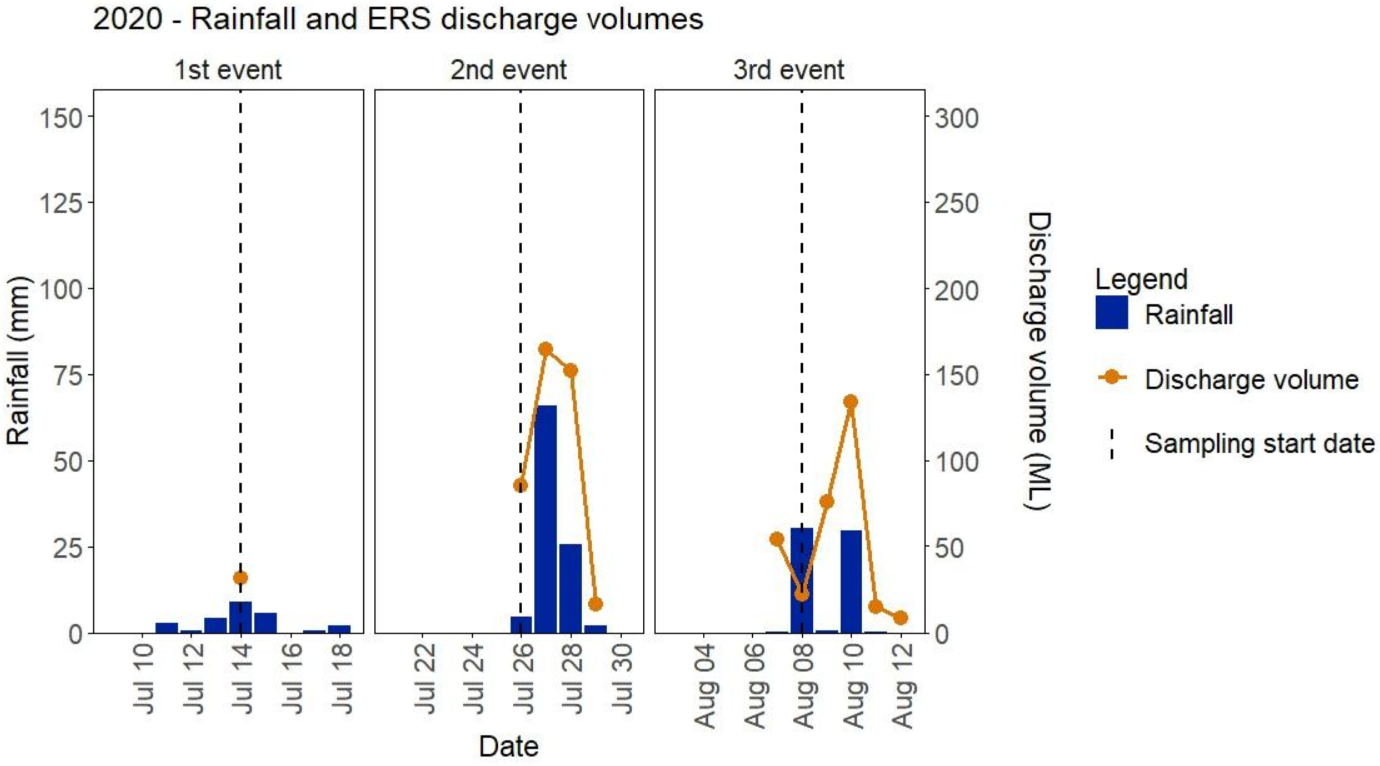
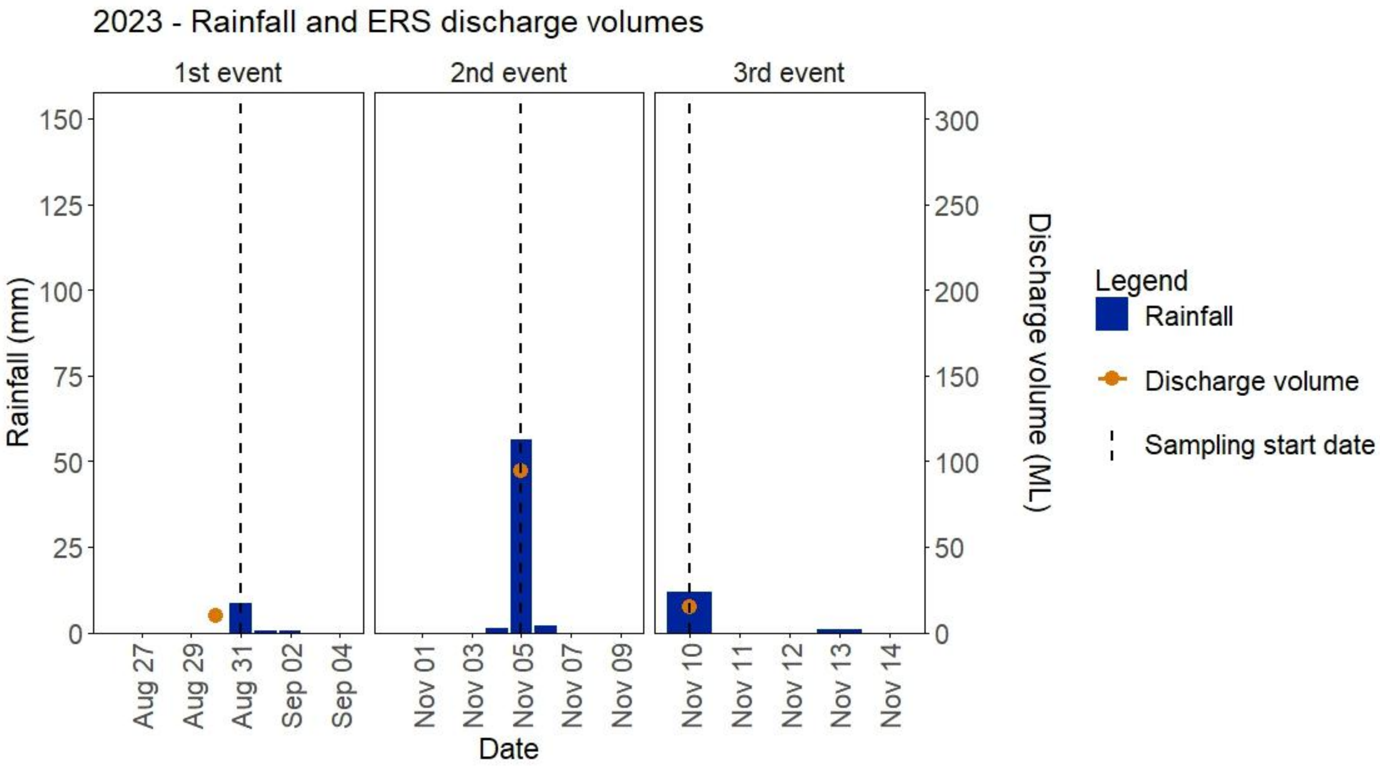
7. Appendices

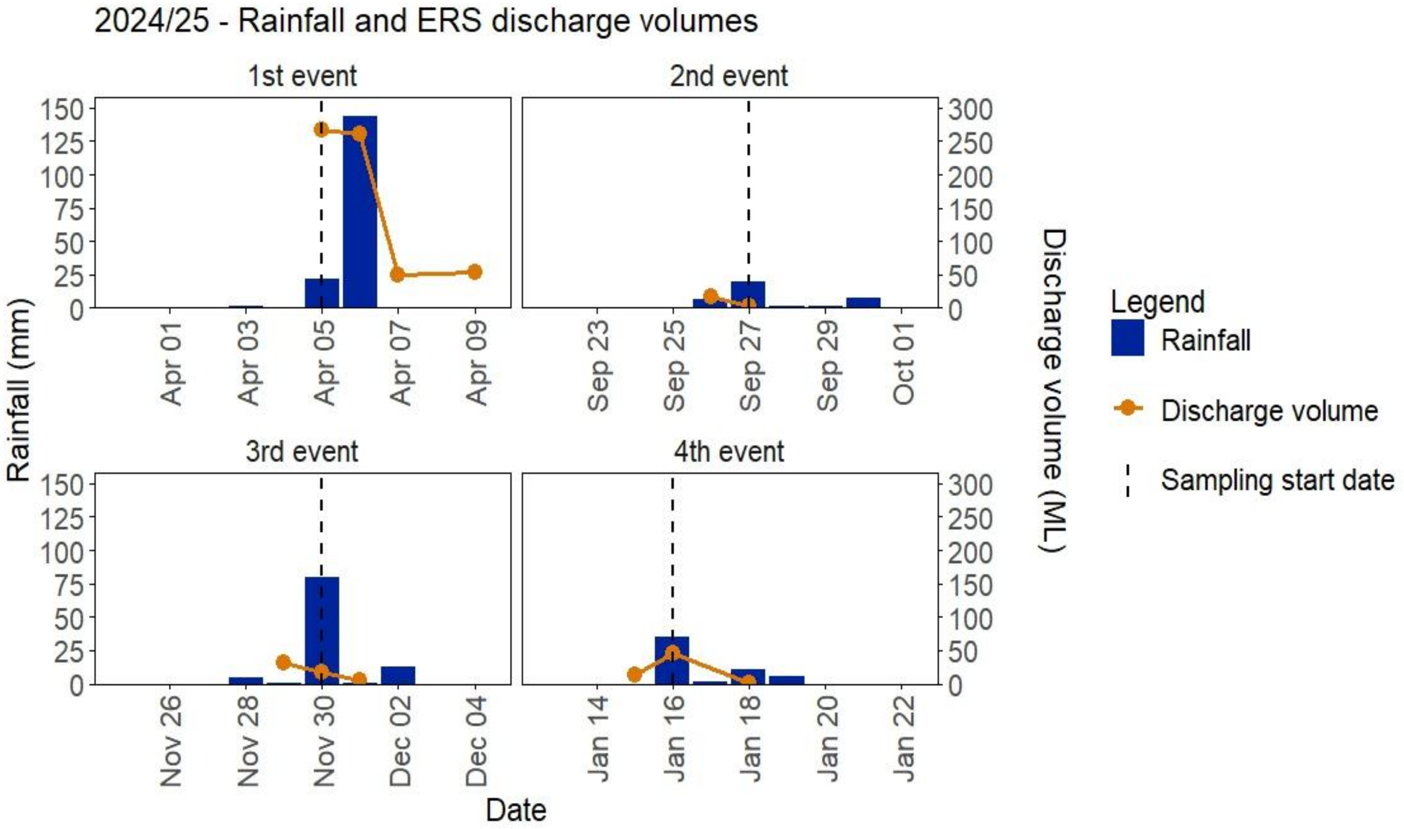
7.1 Monitored event daily condition summary

Sampling event	Sampling dates	24 hr Rain(mm)	Sampling method	Tide	Wind
Overflow Event 1	Friday, 5 April 2024	21.4	Road	Mid to low	SE @ 26 km/h
	Saturday, 6 April 2024	143.4	Boat	Mid to low	NNW @ 15 km/h
	Sunday, 7 April 2024	0	Boat	Mid to low	NM @ 9 km/h
	Monday, 8 April 2024	0	Road	Mid to low	S @ 17 km/h
	Tuesday, 9 April 2024	0	Boat	High to mid	SW @ 11 km/h
Dry Event 1	Friday, 24 May 2024	0*	Boat	High to mid	NW @ 13 km/h
Dry Event 2	Friday, 6 September 2024	0*	Boat	High	NW @ 4 km/h
Overflow Event 2	Friday, 27 September 2024	20.2	Road	Low	SSE @ 35 km/h
	Saturday, 28 September 2024	1.2	Road	Low	SSE @ 15 km/h
	Sunday, 29 September 2024	1.8	Road	Mid to low	WNW @ 9 km/h
	Monday, 30 September 2024	8	Road	Mid to low	SSW @ 24 km/h
	Tuesday, 1 October 2024	0.6	Road	Mid to low	WNW @ 7 km/h
Dry Event 3	Thursday, 31 October 2024	0*	Boat	High	SSW @ 11 km/h
Overflow Event 3	Saturday, 30 November 2024	74.4	Boat	High to mid	NE @ 24 km/h
	Sunday, 1 December 2024	0.4	Boat	High	WNW @ 17 km/h
	Monday, 2 December 2024	14.6	Road	High to mid	NW @ 17 km/h
	Tuesday, 3 December 2024	0	Road	High	NNE @ 13 km/h
	Wednesday, 4 December 2024	0	Road	High	S @ 26 km/h
Overflow Event 4	Thursday, 16 January 2025	35.6	Road	Low	S @ 50 km/h
	Friday, 17 January 2025	1.6	Road	Mid to high	SSW @ 44 km/h
	Saturday, 18 January 2025	11	Road	Mid to high	SSE @ 44 km/h
	Sunday, 19 January 2025	5.4	Road	Mid to high	S @ 30 km/h
	Monday, 20 January 2025	0	Road	Mid to high	SSW @ 17 km/h
Dry Event 4	Friday, 28 February 2025	0	Boat	High to mid	NW @ 13 km/h

7.2 Daily rainfall and ERS discharge volumes






2024/25 - Rainfall and ERS discharge volumes
1st event
2nd event
3rd event
4th event
Rainfall (mm)
Discharge volume (ML)
Date
Legend
Rainfall
Discharge volume
Sampling start date

7.3 Monitoring Data

Data to be included as excel attachment

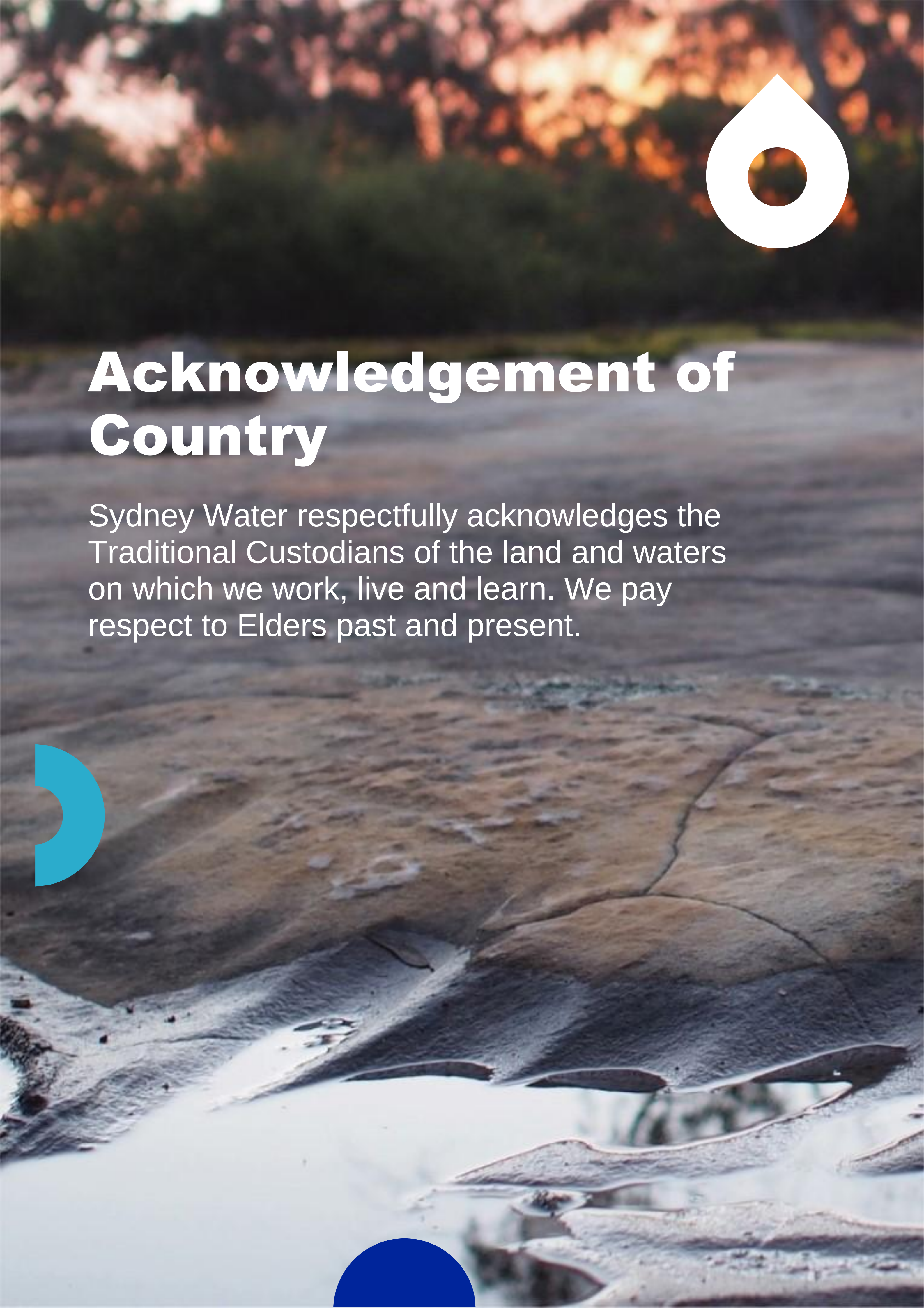
Millstream Overflow Performance Reporting

June 2025 to Dec 2025

Sydney WATER

sydneywater.com.au

xx/2023



Acknowledgement of Country

Sydney Water respectfully acknowledges the Traditional Custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.

Figures

Tables

Attachments

Document control

Version	Date	
V1	13 January 2026	Submitted for review

Approval

Author:

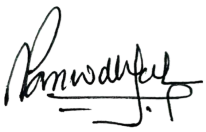
Signature | Date

Milroy Jayaveerasingam
Lead Planner
System Planning & Land Acquisition (SP&LA) Water & Environment Services

22/01/2026

Approved by:

Signature



Nilesh Panwalkar
Integrated Planning Manager, Area East
SP&LA) Water & Environment Services

22/01/2026

1. Introduction

1.1 Background

The Mill Stream ERS discharge is located on and potentially impacts air, land and waters of the Kingsford Smith Airport Site. Given this, it requires authorisation (Licencing) under Federal Legislation (Airport Act) and Airport Environment Protection Regulations. The Licence has a period of 3 years. At the end of 3 years a further Licence must be requested.

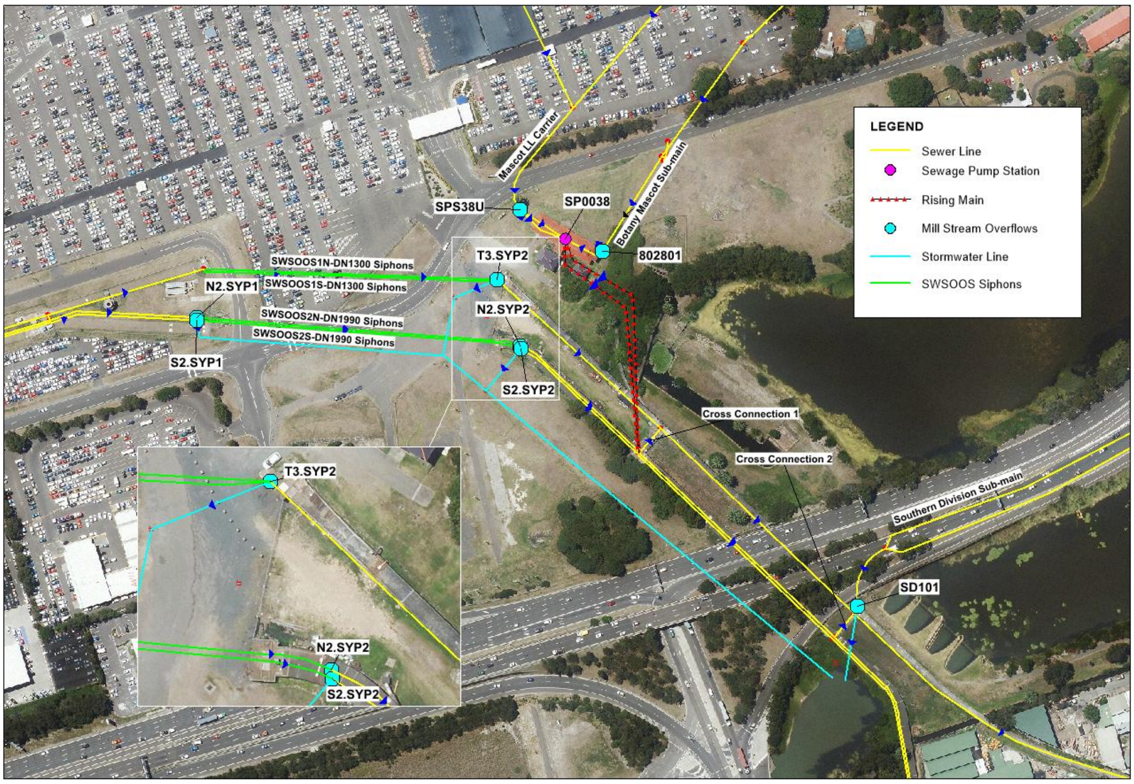
There are currently eight sewer overflows from SWSOOS1, SWSOOS2N, SWSOOS2S and SP0038 that discharge wet weather overflow into Mill Stream via stormwater channels. These overflow discharge frequency and volumes are causing issues where the Environment Protection Authority (EPA) and the Airport Authority are expressing great concerns.

The ERSs are located on federally owned land at Sydney Airport and has potential air and water impacts. This requires Sydney Water to gain an authorisation under the Airports (Environment Protection) Regulation (AEPR) 1997, issued by the Department of Infrastructure, Transport, Regional Development and Communications (DITRC) to operate this ERS.

The locations of the eight overflows designed to discharge to Mill Stream are shown in **Figure 1** Millstream overflow location map

.

Figure 1 Millstream overflow location map



1.1 Millstream Overflow performance

The modelled overflow performance is an average, calculated against an existing time series of rainfall that represents a range of weather conditions (10 years, 1985 – 1994). This time series is used by Sydney Water to provide a consistent and comparable assessment of the wastewater system performance as the system is changed through maintenance activities, upgrades, and ongoing development/population growth. The model is also calibrated with data sourced from flow gauges, level and pressure sensors, that continually monitor the network. This method is consistent with the process Sydney Water uses for reporting compliance with our Environment Protection Licences regulated and assessed by the NSW EPA. However, it is an averaged metric and cannot be used to compare to overflow activity observed during smaller weather periods, particularly more extreme periods such as flooding or drought. To address that Figure 1-3, represents how that average performance sits within the seasonal variability accounted for in the modelled time series, and as could be directly observed year to year at Mill Stream.

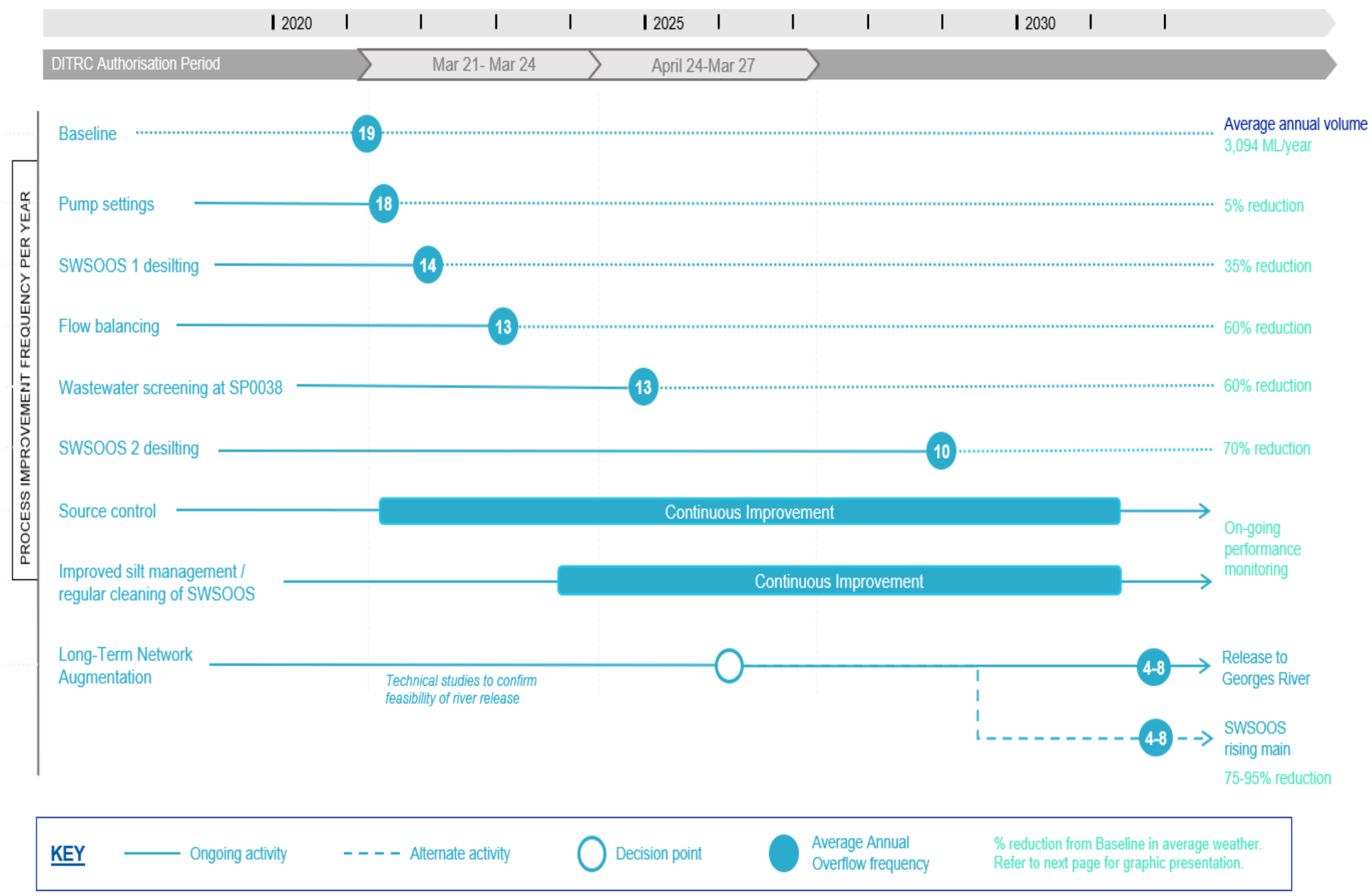


Figure 2 Millstream plan on a page (1), indicating overflow performance from asset works

Please note: performance beyond 2023 is an estimate based on assumed benefit from future works

Figure 3 Mill Stream plan on page (2) indicating seasonal variability in performance

2. Hydraulic modelling

The Malabar network model run code (MALHNG) was used for recalibration to assess the performance of the Millstream overflow for the period January 2025 to December 2025.

2.1 Flow Monitoring

A list of flow gauges used are provided in **Table 2-1**. A location plan of the gauging network is **Figure 2-1** and schematic diagrams showing the required network are provided in **Error! Reference source not found.** and **Figure 2-3.**

Table 1 SWSOOS Flow Gauges List

Gauge	Conduit	Data Recorded		
		Level	Velocity	Flow
802310	Southern Division Submain End	Yes		
802065	SWSOOS 1 Syphon Upper leg	Yes		
802001	SWSOOS 1	Yes	Yes	Yes
802051S	SWSOOS 2S	Yes	Yes	Yes
802051N	SWSOOS 2N	Yes	Yes	Yes
802064	SWSOOS 2N upper leg	Yes		

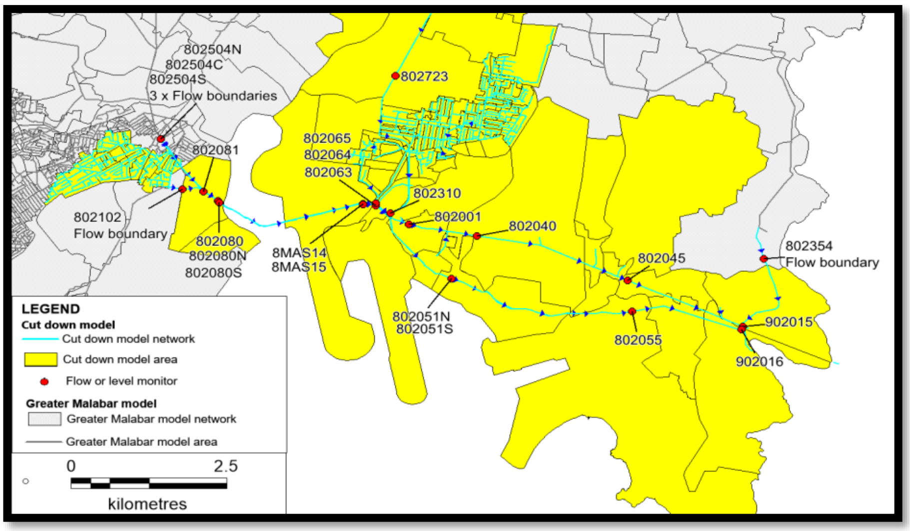


Figure 4 SWSOOS Gauge Location Plan

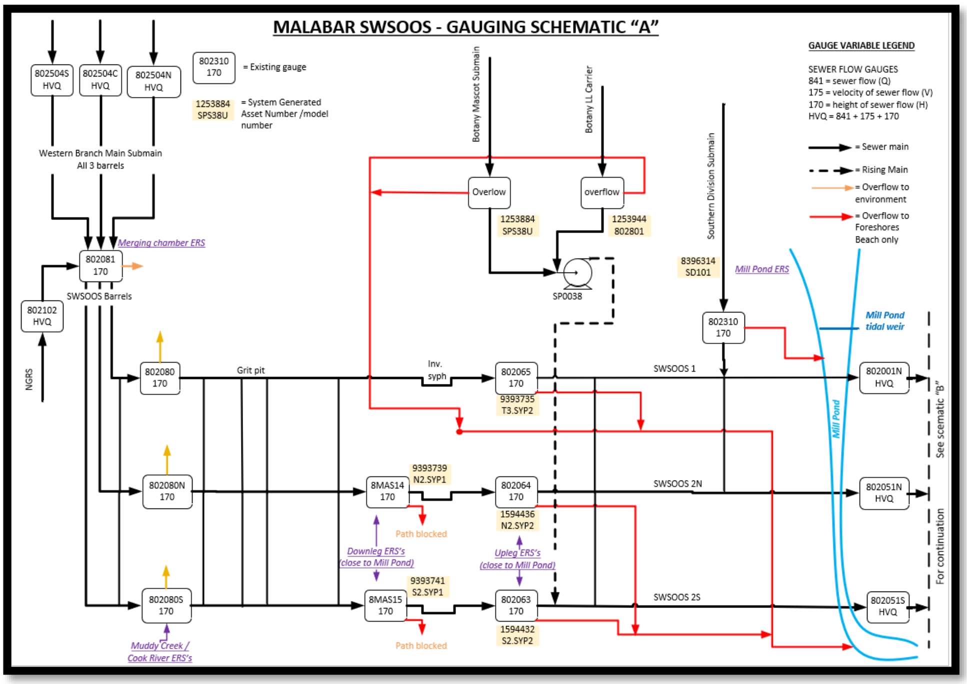


Figure 5 SWSOOS Flow Gauging Schematic A

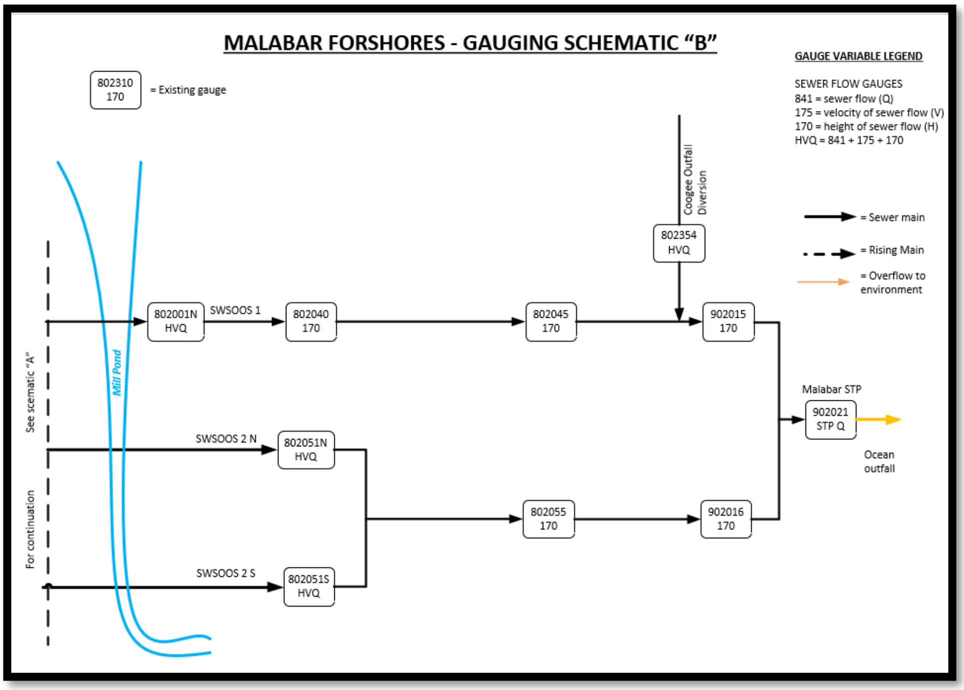


Figure 6 SWSOOS Flow Gauging Schematic B

2.2 Model calibration

The model was calibrated for the period January 2025 to December 2025. The calibration plots are in **Attachment A**.

2.3 Calibration Method

The model calibration process has been developed and implemented to meet Environmental Protect Licence (EPL) requirements. The following procedures have been developed for model calibration and technical management review of the model calibration and overflow performance reporting:

- WWNP0007 – Model update, Re-calibration and Annual reporting procedure.
- WWNP0008 – Electronic data file management
- WWNP0009 – Technical Management Review and Decision framework

The model calibration and overflow performance reporting involves the following six steps:

- Step 1 involves reviewing gauge data as well as identification of changes to the system (PRP101.2 3.3.1).
- Step 2 involves identifying significant changes to the system and incorporating them into the model (PRP101.2 3.3.1).
- Step 3 involves testing the updated model for bias using the model validation acceptance criteria (PRP101.1 3.5).
- Step 4 involves defining a recalibration plan identifying the scope of model changes and data required for recalibration (PRP101.2 5.3.2–5.3.3).
- Step 5 involves the model recalibration (PRP101.2 5.3.2–5.3.3)..
- Step 6 involves the model being run using the 10-year rainfall time series from 1985 to 1994, analysis of the results and reported as required by the licence (PRP101.2 5.3.4).

2.4 Hydraulic sewer system model compliance

This section details the compliance of the hydraulic sewer system model with condition L7.1 (**Attachment 3)**. Further information in *Appendix B* outlines the performance indicators and acceptance criteria to ensure that the model(s) are appropriately calibrated for accurate reporting.

2.5 Quality Management System

The Quality Management System (QMS) is a framework that describes how Sydney Water works by documenting role accountabilities, business processes, policies, and procedures. The QMS defines a standardised way of working across the organisation so teams can consistently deliver high-quality products and services while reducing duplication and making work easier. It also helps Sydney Water continuously monitor performance and identify opportunities for improvement.

Sydney Water's QMS is certified to ISO 9001 (**Attachment 6**), providing assurance to stakeholders and customers that the organisation can reliably meet its commitments.

The QMS includes key quality elements—captured in processes and procedures—that define the standardised Sydney Water ways of working.

Figure 7 Quality Management System

2.5.1 Quality assurance

To comply with condition L7.1(a) to L7.1(d)**,** Sydney Water implements a quality management system (QMS) certified to ISO 9001:2015 for the hydraulic sewer system modelling processes. Quality assurance includes surveillance audits for select procedures and a technical management review of all models. The hydraulic sewer model being used to predict the overflows for the reticulation system must be adjusted to reflect changes in the real world and recalibrated if significant changes have occurred. The new model is checked for accuracy and classified in accordance with the accuracy achieved.

The hydraulic sewer system model should have no temporal or magnitude bias in either flow volume or water levels at the licence gauges as referenced in the document titled "PRP101.1 System Model Performance Indicators, September 2000" (**Attachment 5**) and subsequent modifications made by the Criteria Review Committee (**Attachment 7).** The model calibration plots are provided **in Attachment 2 and Attachment 3**

Table 2 Model verification using Bias test for Licence Gauges

NO	Gauge ID (Licence)	Sewer/ Overflow (S/OF)	SWAGMAN Compliance						Pass/Fail	Comments
			Depth			Flow				
			R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)	R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)		
1	802001	S	0.87	Y	Y	0.82	Y	Y	Pass	The DW Temporal Bias was due to the silt build up in the SWSOOS2 Barrels.
2	802051N	S	0.86	Y	Y	0.85	Y	Y	Pass	
3	802051S	S	0.86	Y	Y	0.83	Y	Y	Pass	
4	802310	S	0.86	Y	Y	-	Level only	-	Pass	
Long Term Gauges										
5	802063	S/OF	0.88	Y	Y		Level only		Pass	
6	802064	S/OF	0.86	Y	Y		Level only		Pass	
7	802065	S/OF	0.87	Y	Y		Levels only		Pass	

Table 3 Model verification using Additional Gauges

Additional Gauges									
Licence - OF Gauges SWAGMAN Compliance									
		Initial Test				Sensitivity Teat			Comments
No	OF Gauge	Lower Depth (m)	Upper Depth (m)	Weir Crest Depth(m)	Overflow Index	Weir Crest Depth(m)	Overflow Index	WC Lowering by (mm)	
1	802310	1.00	1.60	1.20	1.000				Sensitivity Test was not performed as the predicted Overflow Index at the Weir Crest is beyond expectation.
2	802063	1.40	2.20	1.70	0.913				
3	802064	1.40	2.20	1.70	0.957				
4	802065	1.00	1.60	1.30	1.000				

2.5.2 Technical management review

A technical management review is conducted to ensure the model is developed in accordance with the modelling procedures and that the model meets minimum quality requirements stipulated in the quality system. Refer **Attachment 1** for technical management review conducted for the Millstream overflow performance reporting model. Millstream Overflow Performance

The performance of the Millstream overflows is represented by the number of wet weather overflows per 10 years by the sewer hydraulic model and compared to 2021 "benchmark" year. A schematic representation of the modelling development and testing process for the Millstream overflows is included in **Figure 7**.

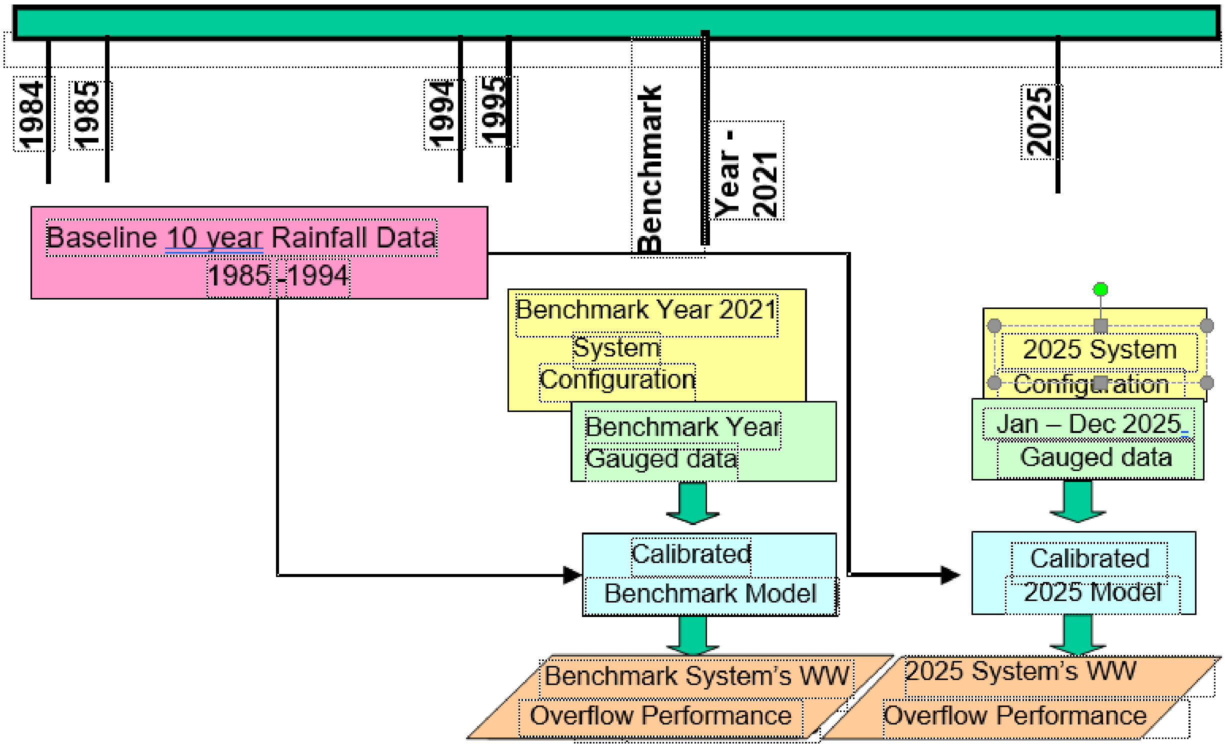


Figure 8 Comparison of Overflow Performance between Bench mark (2021) and 2025

The baseline set in the March 2021 authorisation under the Airports (Environment Protection) Regulation (AEPR) 1997, issued by the Department of Infrastructure, Transport, Regional Development and Communications (DITRC) is overflow frequency/year of 19 and overflow volume of 3094 ML/year.

The following short-term options are currently in progress in the period January 2025 to Dec 2025:

1. De-silting of SWSOOS 2
2. Source control work.
3. Wastewater screening

The recalibrated model was simulated using the rainfall time series 1985 to 1994 used for Environmental Protection Licence (EPL). **Table 2** provides the comparison of the overflow performance of all 8 Emergency Relief Structures (ERS) discharging into Millstream against the 2021 baseline.

Table 4 Millstream overflow performance comparison between Baseline and December 2025

Overflow Location	Conduit	Baseline (2021)		December 2025 Performance	
		Frequency/year	Volume (ML/Year)	Frequency	Volume (ML/Year)
N2.SYP1	SWSOOS 2N (Syphon Upper leg)	7	0.2	7	0.2
S2.SYP1	SWSOOS 2S (Syphon Upper leg)	9	0.3	9	0.3
T3.SYP2	SWSOOS 1	18	771	13	76.9
N2.SYP2	SWSOOS 2N (Syphon Lower leg)	7	119	12	306.1
S2.SYP2	SWSOOS 2S (Syphon Lower leg)	8	133	12	335.0
SD101	Southern Branch weir	19	34	13	5.8
SD101	Southern Brach Syphon	16	2037	10	514.3
SPS38U	Botany Low Level Carrier	0	0	0	0
802801	Botany Mascot Submain	0	0	0	0
Total		**19**	**3094**	**13**	**1238**

Attachment 1 Technical Management Review 2025 Botany Catchment

Technical Management Review 2025 Botany Catchment (PALMS Malabar STS Model)

Sydney WATER

Review Information for the Year 2025 Malabar STS Model (PALMS Botany Catchment):	
Benchmark Year:	Malabar (2021)
Last Available Review:	Malabar TMR 2021
Curent Acceptance Status :	Conforming ~~/ Non-Conforming~~
Number of outstanding OI & PARS:	04
Modeller in Charge	Mahmood Hossain
Project Manager	Milroy Jayaveerasingam
Assignement Manager	Milroy Jayaveerasingam
TMR Reveiner	Jovan Titus

Review Dates				
Section A-C	09/01/2026	Accepted: YES ~~/ NO~~	Completed:	12/01/2026
Section D1	09/01/2026	Accepted: YES ~~/ NO~~	Completed:	12/01/2026
Section D2	12/01/2026	Accepted: YES / ~~NO~~	Completed:	12/01/2026
Section E	12/01/2026	Accepted: YES / ~~NO~~	Completed:	12/01/2026
Section F	12/01/2026	Accepted: YES / ~~NO~~	Completed:	12/01/2026

Review Summary- Year 2025

- Has the Model been re-calibrated in accordance with "Good Modelling Practice": YES / ~~NO~~
- Has the Model been found to be suitable for reporting purposes: YES / ~~NO~~
- Is the current model compatible with the benchmark model: YES / ~~NO~~

  If No, specify proposed alternative benchmark year: XXXX
- Number of PARs / OIs issued 04
- Has been given the acceptance status of:
  - Conforming
  - ~~Non-Conforming~~

Reviewer: **Jovan Titus** **Date:** **09/01/2026**

Are you, the Project Manager, satisfied the conclusions drawn from the technical review are an accurate description of the Year 2025 status of the Botany Catchment, of Malabar STS Model (Palms).

Project Manager: **Milroy Jayaveerasingakm** **Date:** **13/01/2026**

Review Section A- Improvement Options & Outstanding PAR Compliance

(Section F of the year 2021 Review) ***Refer the Section F for model improvement suggestion for the Future.***

OI: Opportunity for Improvement

Improvement Option	Justification	PAR No.	Already Resolved (Y/N)

Comments

Review Section B- Model Update & Good Modelling Practice:

Review Objective	Check (Y/N/OI)	Comments	New PAR No.
Project Co-ordination Folder:			
- is it available	Y	Maintain electronically	
- does it contain the appropriate sections	Y	Folder location - R:\WWDIH\PALMS\STS\Malabar	
Archiving:			
- is the filing system for hardcopies appropriate	NA	Maintaining electronically	
- is the filing system for electronic items appropriate	Y	R:\WWDIH\PALMS\STS\Malabar	
- is the log sheet updated as appropriate	Y		
Model Update:			
- property Id file available for the system	Y	BY_Property_2025	
- evidence of residential “Zero” water consumption filled in with average residential water consumption.	Y		
- have population data been updated	Y	281,308 (2024)	
- have rainfall data been updated	Y	Data Base : MA24-25	
- MapInfo file created for current rain gauges	Y	Table : C_BY_RG_2024	
- has gauge information been updated	Y		
- MapInfo file created for current sewer gauges	Y	Table: C_BY_FM_2024	
- have operators been consulted to identify asset changes	Y	Correspondence/meetings	
- have changes to asset data been updated	Y	Detailed model build using latest HYDRA data	

- will there be chances that the model update will influence the overflow performance of the system?	Y	Detail model has included all overflows	
Additional Information:			
- have all available Trunk gauges been identified	Y		
- is the Trunk gauge coverage adequate	Y		
- is there a need to adopt additional Trunk gauges	Y		
- is there a need to include SCAMP gauges	OI		
- does this system require flow monitor rationalisation for future modelling?	Y	Refer the Strategic Sewer Gauge Review Report 2021	
Model Checks:			
- is the model coverage adequate	OI	May need to add SCAMP Catchments for the future modelling.	
- is the level of catchment delineation adequate	Y		
- does model geometry match actual system geometry	Y		
- have catchment load points been checked	Y		
- have all trunk overflows been included	Y		
- has the use of reticulation overflows been justified	OI	Retic Overflows could be avoided by adding detailed SCAMP models wherever required.	
- have all operational issues been resolved	Y		

Review Section C- Additional Reviewer Recommendations:

*Note: S Rating: serious implications for model and /or calibration accuracy,
M Rating: minor issue with limited implication on model and /or calibration accuracy

Recommendation	Rating(S/M)*	Justification	New PAR No.	Date Resolved

Review Section A-C Summary:

- Have all outstanding PARs been resolved? YES ~~/ NO~~
- Has the Modeller followed "Good Modelling Practices"? YES ~~/ NO~~
- Have additional OI/PARs been raised in Review Sections B & C? ~~YES~~ / NO

Reviewer: **Jovan Titus** **Date:** **09/01/2026**

Project Manager: **Milroy Jayaveerasingam** **Date:** **13/01/2026**

Review Section D1- Initial Model Validation: (Refer Section D2 for Calibration Review Information)

SWAGMAN Verification:

- Has the Year 2025 Botany Catchment (PALMS) Malabar STS model been updated in accordance with procedures? YES / ~~NO~~
- List number of Licensed/Long Term Gauges (Gauges in the extended model area only):

NO	Gauge ID (Licence)	Sewer/ Overflow (S/OF)	SWAGMAN Compliance						Pass/Fail	Comments
			Depth			Flow				
			R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)	R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)		
1	802001	S	0.87	Y	Y	0.82	Y	Y	Pass	The DW Temporal Bias on Level was due to the silt build up in the SWSOOS2 Barrels.
2	802051N	S	0.86	Y	Y	0.85	Y	Y	Pass	
3	802051S	S	0.86	Y	Y	0.83	Y	Y	Pass	
4	802310	S	0.86	Y	Y	-	Level only	-	Pass	
Long Term Gauges										
5	802063	S/OF	0.88	Y	Y	-	Level only	-	Pass	The DW Temporal Bias on Level was due to the silt build up in the SWSOOS2 Barrels.
6	802064	S/OF	0.86	Y	Y	-	Level only	-	Pass	
7	802065	S/OF	0.87	Y	Y	-	Levels only	-	Pass	

Additional Gauges									
				Licence - OF Gauges SWAGMAN Compliance					
No	OF Gauge	Initial Test				Sensitivity Teat			Comments
		Lower Depth (m)	Upper Depth (m)	Weir Crest Depth(m)	Overflow Index	Weir Crest Depth(m)	Overflow Index	WC Lowering by (mm)	
1	802310	1.00	1.60	1.20	1.000				Sensitivity Test was not performed as the predicted Overflow Index at the Weir Crest is beyond expectation.
2	802063	1.40	2.20	1.70	0.913				
3	802064	1.40	2.20	1.70	0.957				
4	802065	1.00	1.60	1.30	1.000				

Lower depth = depth from pipe IL to PDWF * Cannot be determined; # sites are possibly silt effected

Upper Depth = depth range from pipe IL to between WC and PWWF

WC Depth – depth from pip IL to WC

Gauge Compliance:

- No. Licensed Sewer Gauges: 3 (Only the HVQ Gauges on the SWSOOS Mains were considered)
- No. of Compliant Licensed Sewer Gauges: 3 % Compliance: 100%
- No. of Licensed Overflow Gauges: 4
- No. of Compliant Licensed Overflow Gauges: 4 % Compliance: 100%

Model Acceptance:

- Conforming Model (>75% pass for Licensed Sewer Gauges)

- ~~Non-Conforming Model (<75% pass for Licensed Sewer Gauges)~~

Year 2025 Botany STS Model Status:

- Does Updated Per Capacity Contribution Comply with "GMP"? YES / ~~NO~~
- Does Updated Average Return Factors "GMP"? YES / ~~NO~~
- Is Re-calibration of the Model Required? YES / ~~NO~~ (This model requires Review and Re-Calibration annually)
- If Yes (proceed to section D2), has a Re-calibration Plan been Developed? YES / ~~NO~~

Reviewer: **Jovan Titus** **Date: 09/01/2026**

- If No (proceed to section E), is the Modeller Advised to do Reporting? ~~YES~~ / NO

Project Manager: **Milroy Jayaveerasingam** **Date: 13/01/2026**

Review Section D2- Model Calibration Check & Model Validation:

Calibration & Verification Periods:			
Event ID	**Start Date**	**Stop Date**	**Duration**
Dry Weather Period 1	24/02/2025	03/03/2025	7 Days
Dry Weather Period 2	29/09/2025	05/10/2025	7 Days
Dry Weather Period 3	09/07/2025	16/07/2025	7 Days
Duration of wet event 1	25/07/2025	31/08/2025	37 days (Three Rain Periods covered)
Duration of wet event 2	16/03/2025	11/04/2025	26 days (Three Rain Periods covered)
Duration of wet event 3	24/01/2025	16/03/2025	51 days (Three Rain Periods covered)
SWAGMAN Verification Period	01/01/2025	10/11/2025	10 Months
10-year Time Series Period	01/01/1985	31/12/1995	10 Years

Dry Weather Calibration:	Check (Y/N/OI)	New PAR No.	Comments
- is the available gauge information sufficient for model calibration	Y		
- are the chosen calibration periods suitable for model calibration	Y		3 Dry weeks
if no, specify alternative period(s)			
- has the dry weather calibration procedure been followed	Y		
- are per capita contributions justified	Y		System Avg 214 L/EP/day
- are return factors justified	Y		Catchments in the Randwick and Maroubra area has higher ARF, Needed Review

- are baseflow contributions justified	Y		Average BF 14.9%
- are bed roughness values justified	Y		Lower Manning Numbers were used in SWSOOSs to reflect the Siltation. (Needed de-Silting)
- are peak velocities justified	Y		
- are visual calibration results acceptable	Y		Dry Weather Model Levels are Low and were accepted taking into the account of severe Siltation that the SWSOOS 2 Barrels are experiencing.
- have DWF calibration plots been made available for review	Y		
- have DWF calibration plots been signed and filed in folder	NA		Maintain electronically
- have DWF calibration plots soft copies available in server	Y		P:\Mill Stream_Overflow Assessment\2025_Botany/Calibration Plots _ DW _ Botany Bay Catchment 2025
Wet Weather Calibration:			
- is the available gauge information sufficient for model calibration	Y		
- are the chosen calibration periods suitable for model calibration	Y		
if no, specify alternative period(s)			
- has the wet weather calibration procedure been followed	Y		
- are wet weather parameters justified	Y		
- are top roughness values justified	Y		Justified on the basis of the siltation issue that the SWSOOS2 Barrels are experiencing.
- are peak velocities justified	Y		
- are visual calibration results acceptable	Y		Wet weather Flow and Levels are in good calibration with the Measured records.
- have WWF calibration plots been made available for review	Y		
- have WWF calibration plots been signed and filed in folder	Y		Maintaining electronically.

- have WWF calibration plots soft copies available in the server	Y		P:\Mill Stream_Overflow Assessment\2025_Botany/Calibration Plots _ WW _ Botany Bay Catchment 2025
- has the procedure for time series modelling been followed	Y		
- are changes in overflow frequencies justified	Y		

Review Section D2- Model Re-Calibration & Model Validation:

Review Objective	Check (Y/N/OI)	New PAR No.	Comments
SWAGMAN Analysis:			
- is the available gauge information sufficient for model validation	Y		
- has the entire data period been used for model validation	Y		
if no, justify omissions			
- has the SWAGMAN verification procedure been followed	Y		
- have SWAGMAN verification plots been made available for review	Y		Maintaining electronically
- have SWAGMAN verification plots been signed and filed in folder	Y		P:\Mill Stream_Overflow Assessment\2025_Botany\Pre_Calibration\SWAGMAN/Swagman Model Report NA_Pre-Calibration.doc
Model Status:			
- have all catchment issues been resolved	Y		
- have all population data issues been resolved	Y		
- have all system geometry issues been resolved	Y		

- have all overflow information issues been resolved	Y		
- have all other asset information issues been resolved	Y		
- have all operational issues been resolved	Y		
- have all rainfall data issues been resolved	Y		
- have all gauge issues been resolved	N/A		
- have all issues identified in Section – C been addressed	N/A		
System Status – Year 2021 (last Re-Calibrated Year) to 2025 Comparison:			
- can model updates be rated as significant	Y		The Cross Connection 1 and 2 (Between SWSOOS1 and SWSOOS2) were removed
- can changes to model parameters be rated as significant	N		
- can signs of system deterioration be rated as significant	Y		
- can changes in overflow volumes be rated as significant	N		Overflow volume changed about 1%
-can changes in individual overflow frequency rated as significant	N		
- in case of overflow frequency of individual overflow change by more than 5-10%, this has to be discussed with the Project Manager. Evidence of such discussion sighted	N/A		
- is current benchmark year still applicable	Y		

<u>Statistics for Year 2021/2025 STS Model Palms (Botany Catchment) Malabar Update:</u> (compare benchmark year and current year)

Population (2021/2025):	278,118 / 281,308	% change: +1.15% (But the DW Flow decreased by 2.2%, 1106.2 l/s to 1082.7 l/s)
Catchment Area (2021/2025):	7,111 / 7,111 ha	% change: 0.0%
Sewer Length (2021/2025):	179 / 179 km	% change: 0.0%
No. Constructed Overflows (2021/2025):	47 / 47	% change: 0.0 %
No. Reticulation Overflows (2021/2025):	7 / 7	% change: 0.0 %
No. Pump Stations (2021/2025):	4 / 4	% change: 0.0 %

Review Section D2 Summary:

- Has correct calibration and verification procedures been followed? YES / ~~NO~~
- Have additional OI/PARs been raised in Review Section D2? ~~YES~~ / NO

Review Section D2 – Model Re-Calibration & Model Validation:

Gauge Compliance : Refer the Table D1 for SWAGMAN Assissent Outcome.

NO	Gauge ID (Licence)	Sewer/ Overflow (S/OF)	SWAGMAN Compliance						Pass/Fail	Comments
			Depth			Flow				
			R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)	R^2	Temporal Bias Acceptable (Y/N)	Magnitude Bias Acceptable (Y/N)		
1	802001	S								
2	802051N	S								
3	802051S	S								
4	802310	S								
Long Term Gauges										
5	802063	S/OF								
6	802064	S/OF								
7	802065	S/OF								

Additional Gauges									
Licence - OF Gauges SWAGMAN Compliance									
		Initial Test				Sensitivity Teat			Comments
No	OF Gauge	Lower Depth (m)	Upper Depth (m)	Weir Crest Depth(m)	Overflow Index	Weir Crest Depth(m)	Overflow Index	WC Lowering by (mm)	
1	802310			1.20					
2	802063			1.70					
3	802064			1.70					
4	802065			1.30					

- No. of Licensed Sewer Gauges: 3
- No. of Compliant Licensed Sewer Gauges: 3 % Compliance: 100%
- No. of Licensed Overflow Gauges: 4
- No. of Compliant Licensed Overflow Gauges: 4 % Compliance: 100%
- No. of Additional Gauges: N/A
- No. of Compliant Additional Gauges: N/A % Compliance: N/A

Model Acceptance:

- Conforming Model (>75% pass for Licensed Sewer Gauges)
- ~~Non-Conforming Model (<75% pass for Licensed Sewer Gauges)~~

Benchmark Status:

- Is the Current Benchmark Year is still Applicable: YES / ~~NO~~

If No, specify recommended alternative benchmark year: XXXX

- Is the modeller advised to proceed to reporting? YES ~~/ NO~~
  (not applicable for year 2001 model reviews)

Reviewer:	**Jovan Titus**	**Date:**	**12/01/2026**
Project Manager:	**Milroy Jayaveerasingam**	**Date:**	**13/01/2026**

Review Section E - Reporting:

Review Objective	Check (Y/N/OI)	New PAR No.	Comments
Have model verifications been completed	Y		
Have Load Based License Inputs been completed	N/A		
Has the EPA Summary Report been completed	N/A		
Have all files been archived appropriately	Y		P:\Mill Stream_Overflow Assessment\2025_Botany R:\WWDIH\PALMS\STS\Malabar
Has the CIM Report been completed	N/A		

Review Section E Summary:

- Has the Year 2025 reporting been finalised? YES ~~/ NO~~
- Have additional OI/PARs been raised in Review Section E? ~~YES /~~ NO

Reviewer: **Jovan Titus** **Date:** **12/01/2026**

Project Manager: **Milroy Jayaveerasingam** **Date:** **13/01/2026**

Section F- Improvement Options & outstanding PARs to be carried forward to 2026.

Improvement Option	Justification	PAR No.	Already Resolved (Y/N)
Extend the Model to accommodate the Missing SCAMP Catchments, thus removing the Reticulation Overflows from the Model.	Actual Model Representation	OI	N
De-Silting in SWOOS2 Barrels is strongly recommended.	Regain the hydraulic Capacity lost in the SWSOOS2	OI	N
Re-Calibrate the Model after the de-silting is completed.	Reliability in System Capacity and confidence in system performance.	OI	N
Reliable Gauging performance. Ie Reduction in Missing gauge data during Wet Weather, especially the Gauges 802102 (NGRS) and 802504N,C,S (Western Main Sewer, Three Barrels) which are used as Boundary Condition flows for the Botany catchment Model Calibration.	Quality / More data for Model Calibration and Validation	OI	N

Review Section F Summary:

- Does the Year 2025 Model Re-Calibration comply with "Good Modelling Practices"? YES / ~~NO~~
- Does this conclude the Year 2025 Model Verification? YES / ~~NO~~

This concludes the Year 2025 Technical Management Review. Any outstanding issues are to be carried forward and resolved as part of the Year 2026 Model Re-calibration.

Reviewer: **Jovan Titus** **Date: 12/01/2026** **Project Manager:** **Milroy Jayaveerasingam** **Date: 13/01/2026**

Attachment 2 Calibration Plots – Dry Weather Flow

**Calibration Plots	Botany Bay Catchment _ Malabar System 2025**

Dry Weather Events:

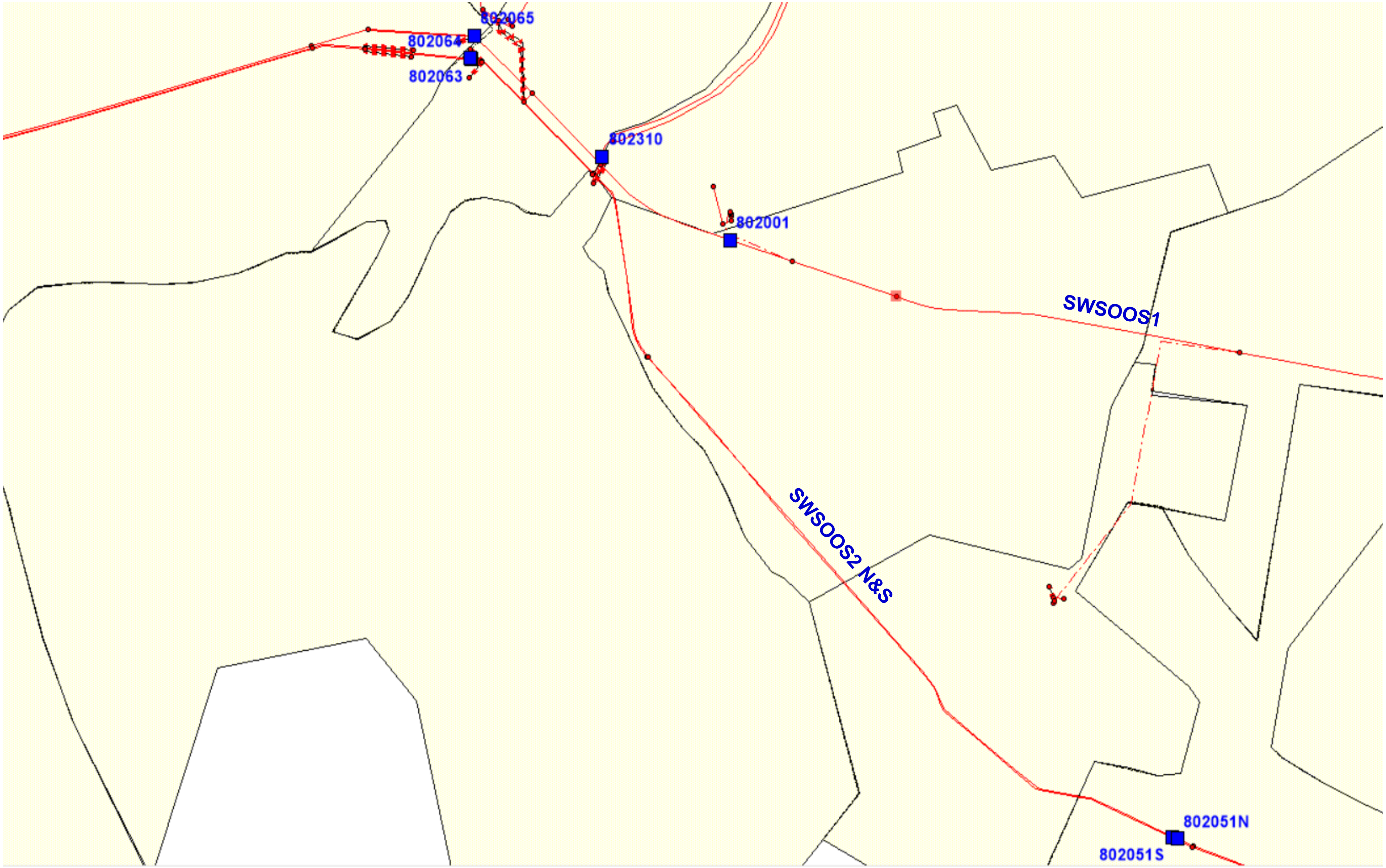
**Dry Week 1	:	24/02 - 03/03/2025**

**Dry Week 2	:	29/09 – 05/10/2025**

**Dry Week 3	:	09 – 16 / 07 / 2025**

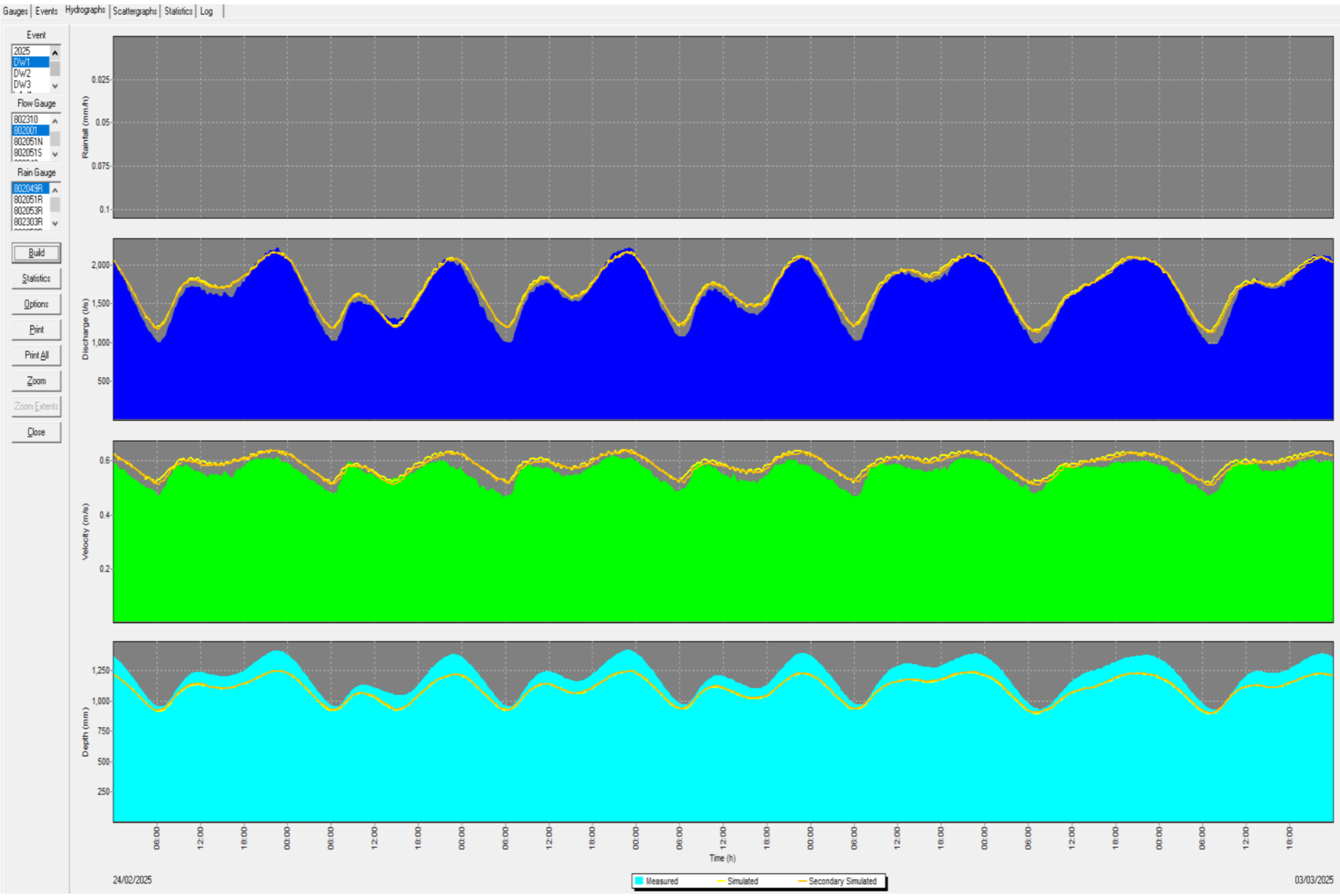
Gauges Assessed:

Gauge	Comment
802001	SWSOOS 1, HVQ Licence Gauge
802051N	SWSOOS2 N, HVQ Licence Gauge
802051S	SWSOOS2 S, HVQ Licence Gauge
802063	SWSOOS 2S (S2.SYP2), Level Only, Licence Gauge
802064	SWSOOS 2N (N2.SYP2), Level Only, Licence Gauge
802065	SWSOOS 1 (T3.SYP2), Level Only, Licence Gauge
802310	Southern Division Sewer, Level Only, Licence Gauge



Sewer Gauge Layout – Botany Bay Catchment

802001 DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	994252.85	Peak measured flow (l/s)	2224.58	Mean measured flow (l/s)	1641.49
Total simulated volume (cu.m)	029722.15	Peak simulated flow (l/s)	2164.40	Mean simulated flow (l/s)	1709.56
Ratio	1.04	Ratio	0.97	Ratio	1.04

Velocity

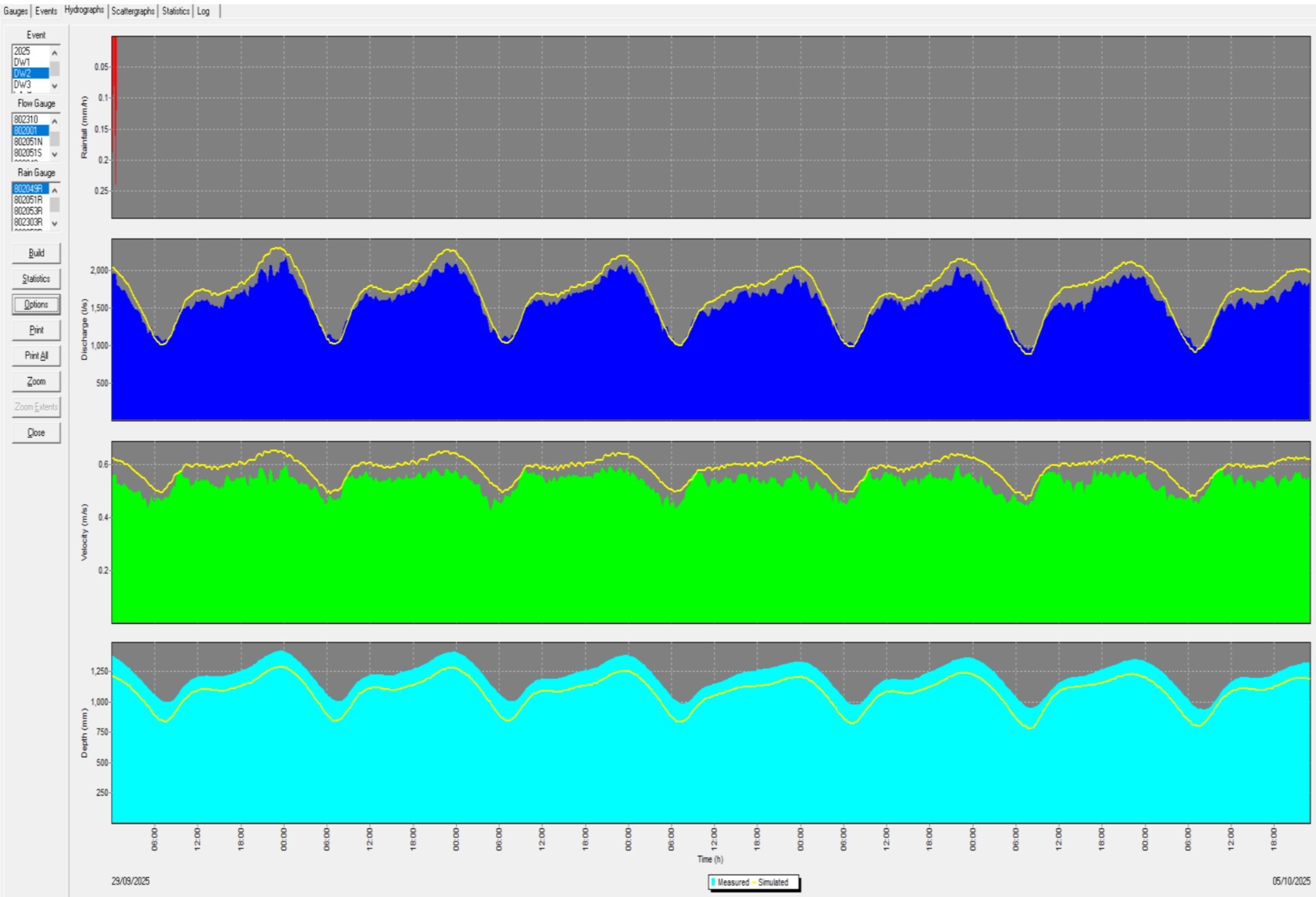
Peak measured velocity (m/s)	0.62	Mean measured velocity (m/s)	0.56
Peak simulated velocity (m/s)	0.64	Mean simulated velocity (m/s)	0.59
Ratio	1.04	Ratio	1.06

Depth

Peak measured depth (mm)	1418	Mean measured depth (mm)	1200
Peak simulated depth (mm)	1247	Mean simulated depth (mm)	1094
Ratio	0.88	Ratio	0.91

Close

802001 DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.13	Peak measured intensity (mm/h)	0.28	Mean measured intensity (mm/h)	0.0008

Discharge

Total measured volume (cu.m)	949946.67	Peak measured flow (l/s)	2184.19	Mean measured flow (l/s)	1577.72
Total simulated volume (cu.m)	014802.44	Peak simulated flow (l/s)	2309.60	Mean simulated flow (l/s)	1684.79
Ratio	1.07	Ratio	1.06	Ratio	1.07

Velocity

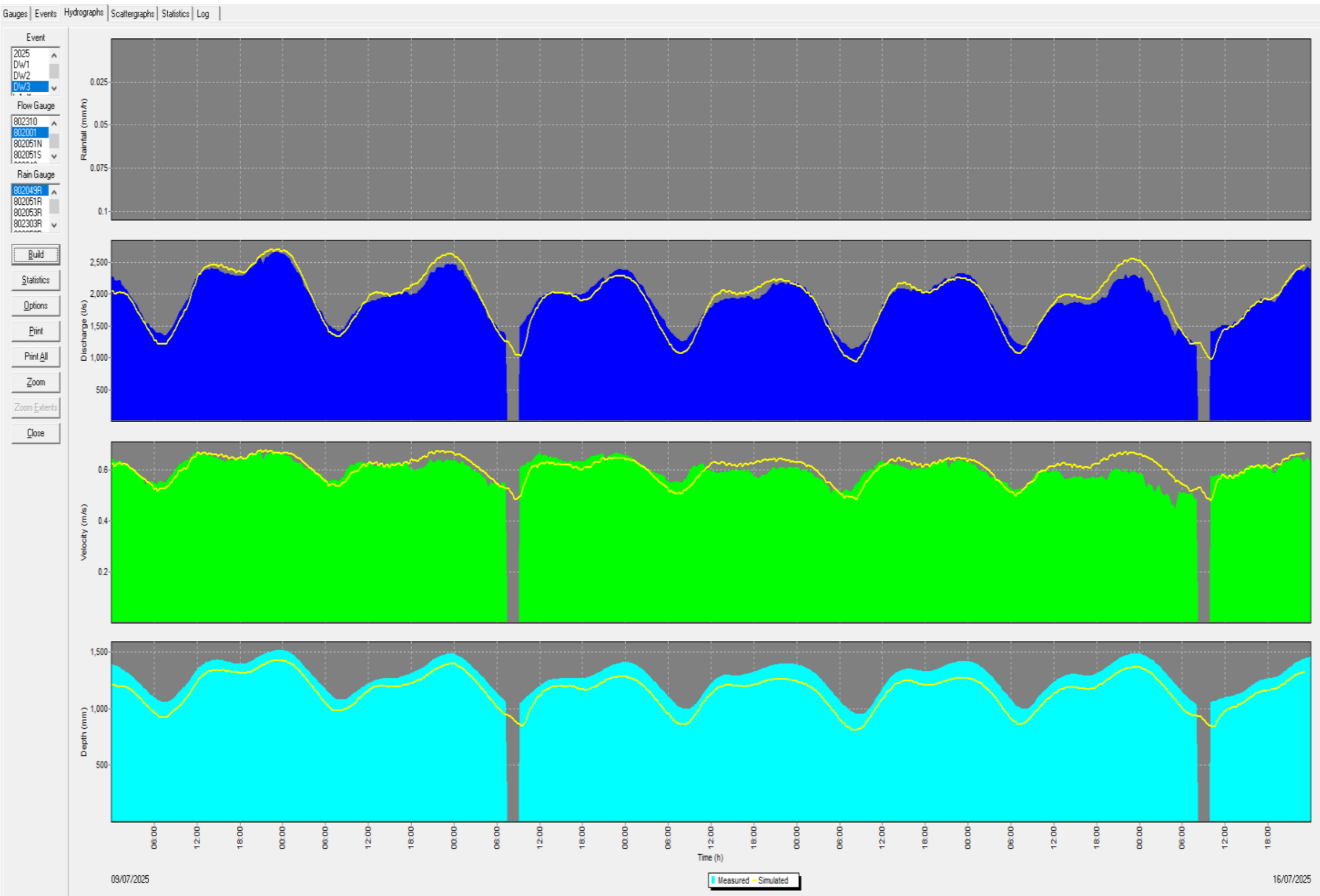
Peak measured velocity (m/s)	0.60	Mean measured velocity (m/s)	0.53
Peak simulated velocity (m/s)	0.65	Mean simulated velocity (m/s)	0.59
Ratio	1.09	Ratio	1.10

Depth

Peak measured depth (mm)	1421	Mean measured depth (mm)	1209
Peak simulated depth (mm)	1291	Mean simulated depth (mm)	1084
Ratio	0.91	Ratio	0.90

Close

802001 DW3



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	137256.39	Peak measured flow (l/s)	2666.85	Mean measured flow (l/s)	1877.59
Total simulated volume (cu.m)	143061.24	Peak simulated flow (l/s)	2706.40	Mean simulated flow (l/s)	1897.73
Ratio	1.01	Ratio	1.01	Ratio	1.01

Velocity

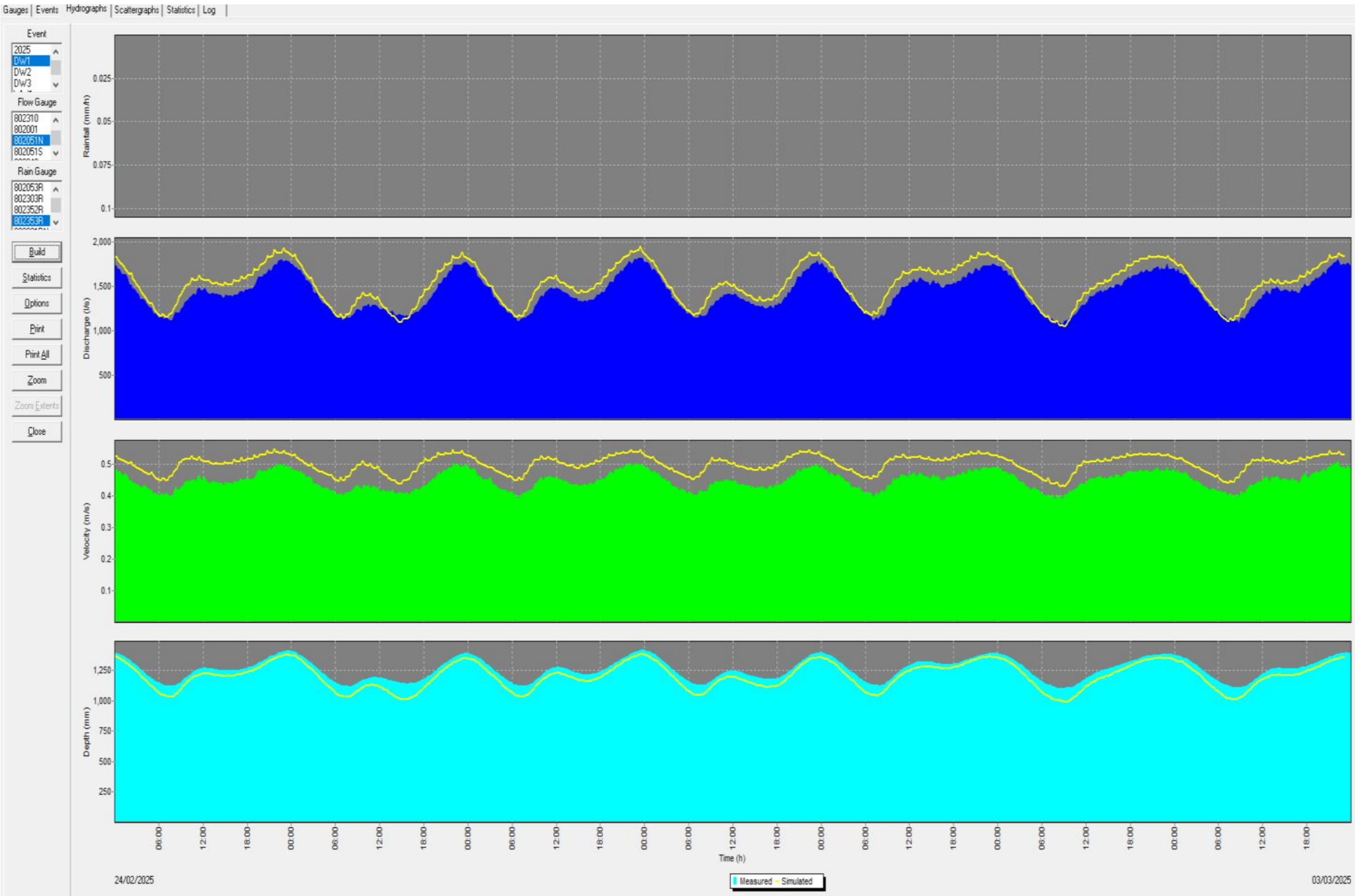
Peak measured velocity (m/s)	0.67	Mean measured velocity (m/s)	0.59
Peak simulated velocity (m/s)	0.68	Mean simulated velocity (m/s)	0.61
Ratio	1.00	Ratio	1.03

Depth

Peak measured depth (mm)	1518	Mean measured depth (mm)	1251
Peak simulated depth (mm)	1430	Mean simulated depth (mm)	1156
Ratio	0.94	Ratio	0.92

Close

802051N DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	871129.17	Peak measured flow (l/s)	1820.77	Mean measured flow (l/s)	1438.22
Total simulated volume (cu.m)	919603.73	Peak simulated flow (l/s)	1947.30	Mean simulated flow (l/s)	1526.74
Ratio	1.06	Ratio	1.07	Ratio	1.06

Velocity

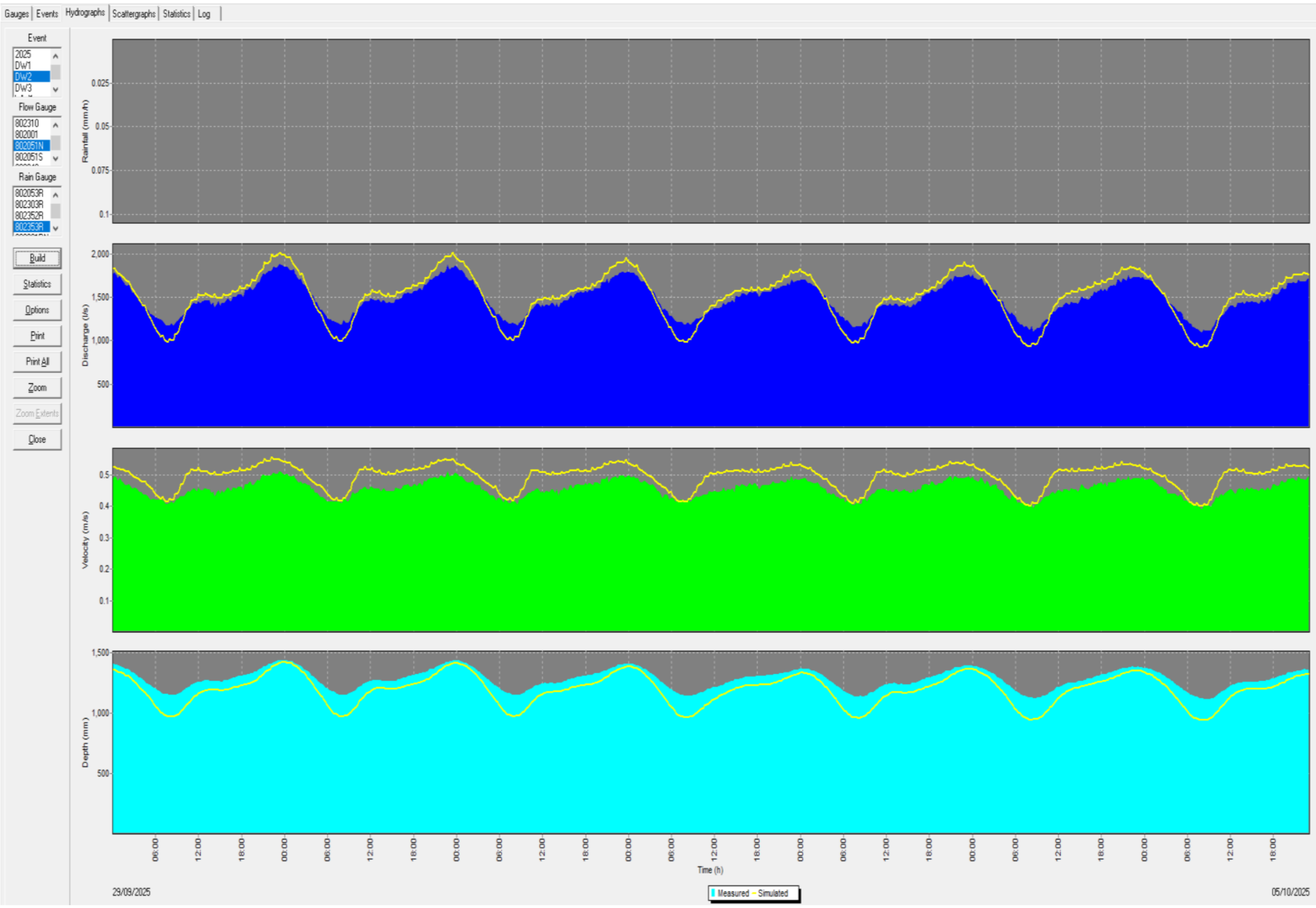
Peak measured velocity (m/s)	0.51	Mean measured velocity (m/s)	0.45
Peak simulated velocity (m/s)	0.55	Mean simulated velocity (m/s)	0.50
Ratio	1.07	Ratio	1.11

Depth

Peak measured depth (mm)	1417	Mean measured depth (mm)	1258
Peak simulated depth (mm)	1382	Mean simulated depth (mm)	1202
Ratio	0.98	Ratio	0.96

Close

802051N DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	894388.52	Peak measured flow (l/s)	1891.14	Mean measured flow (l/s)	1485.45
Total simulated volume (cu.m)	905794.10	Peak simulated flow (l/s)	2014.90	Mean simulated flow (l/s)	1503.82
Ratio	1.01	Ratio	1.07	Ratio	1.01

Velocity

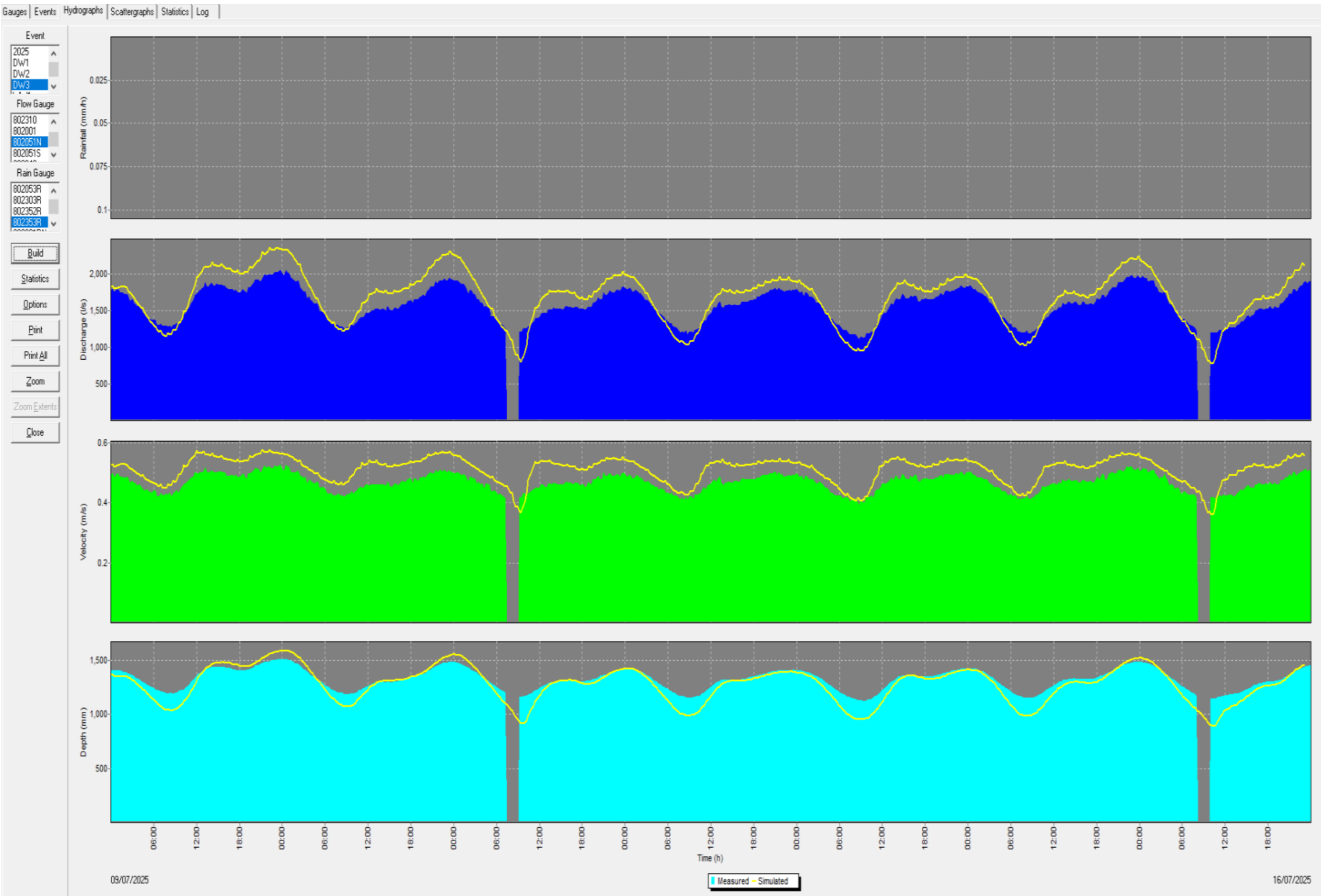
Peak measured velocity (m/s)	0.51	Mean measured velocity (m/s)	0.46
Peak simulated velocity (m/s)	0.56	Mean simulated velocity (m/s)	0.50
Ratio	1.08	Ratio	1.09

Depth

Peak measured depth (mm)	1443	Mean measured depth (mm)	1280
Peak simulated depth (mm)	1422	Mean simulated depth (mm)	1193
Ratio	0.99	Ratio	0.93

Close

802051N DW3



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	938681.52	Peak measured flow (l/s)	2048.68	Mean measured flow (l/s)	1549.75
Total simulated volume (cu.m)	008141.75	Peak simulated flow (l/s)	2352.20	Mean simulated flow (l/s)	1673.74
Ratio	1.07	Ratio	1.15	Ratio	1.08

Velocity

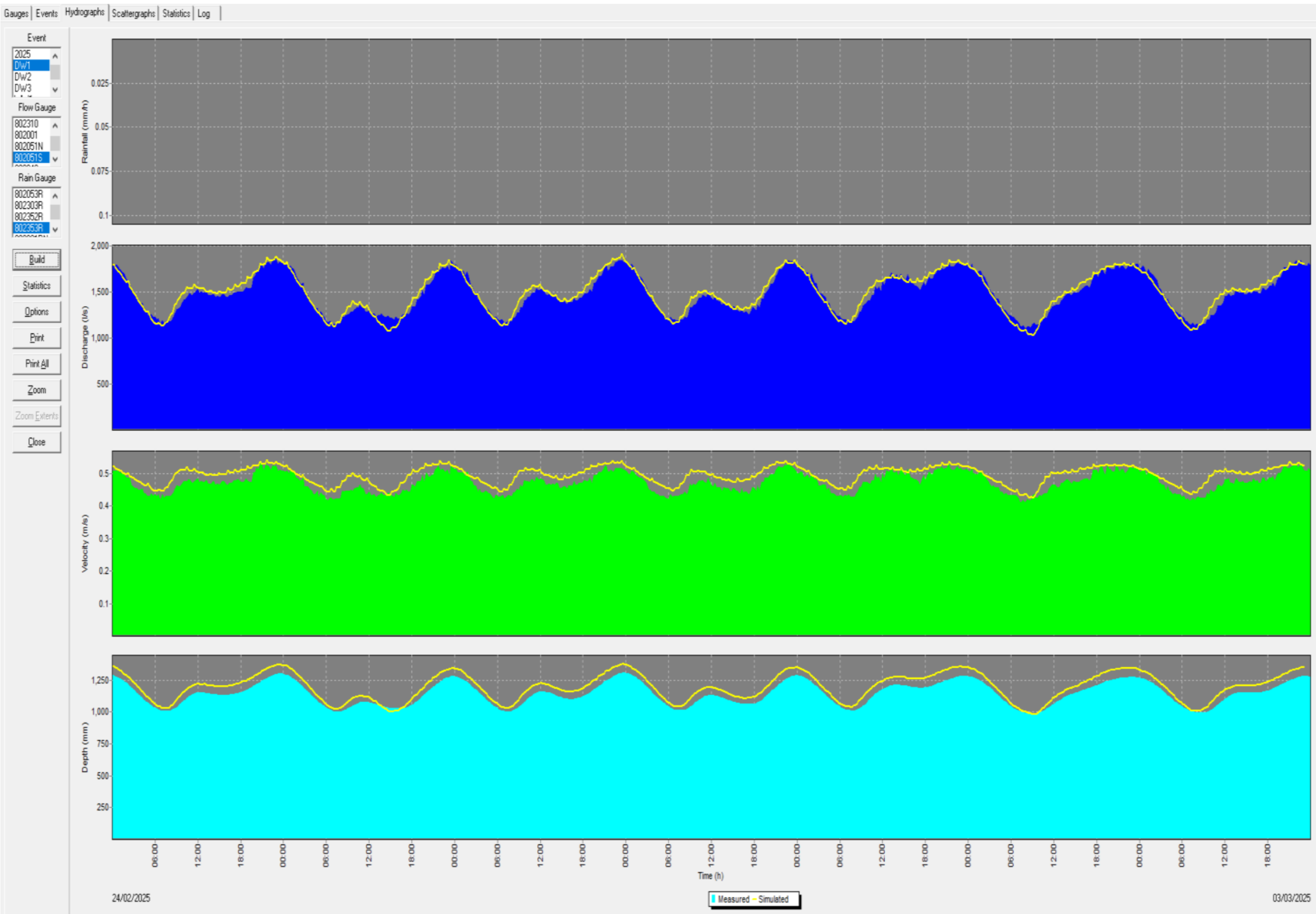
Peak measured velocity (m/s)	0.53	Mean measured velocity (m/s)	0.46
Peak simulated velocity (m/s)	0.58	Mean simulated velocity (m/s)	0.51
Ratio	1.09	Ratio	1.12

Depth

Peak measured depth (mm)	1510	Mean measured depth (mm)	1295
Peak simulated depth (mm)	1592	Mean simulated depth (mm)	1275
Ratio	1.05	Ratio	0.98

Close

802051S DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	901710.26	Peak measured flow (l/s)	1871.05	Mean measured flow (l/s)	1488.71
Total simulated volume (cu.m)	904051.66	Peak simulated flow (l/s)	1915.20	Mean simulated flow (l/s)	1500.92
Ratio	1.00	Ratio	1.02	Ratio	1.01

Velocity

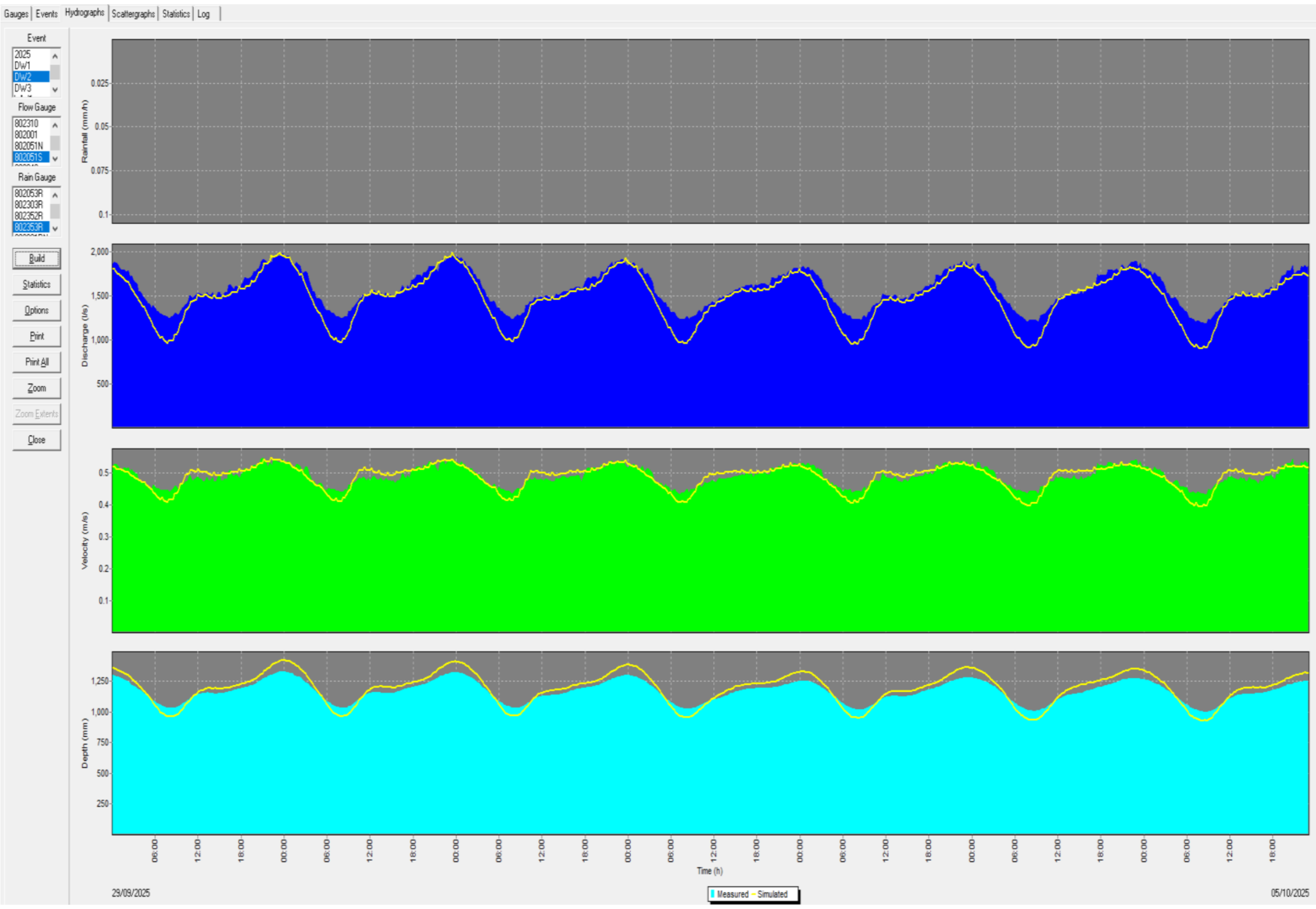
Peak measured velocity (m/s)	0.53	Mean measured velocity (m/s)	0.47
Peak simulated velocity (m/s)	0.54	Mean simulated velocity (m/s)	0.50
Ratio	1.01	Ratio	1.05

Depth

Peak measured depth (mm)	1308	Mean measured depth (mm)	1146
Peak simulated depth (mm)	1378	Mean simulated depth (mm)	1199
Ratio	1.05	Ratio	1.05

Close

802051S DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	947926.23	Peak measured flow (l/s)	1984.61	Mean measured flow (l/s)	1574.37
Total simulated volume (cu.m)	890056.48	Peak simulated flow (l/s)	1982.40	Mean simulated flow (l/s)	1477.69
Ratio	0.94	Ratio	1.00	Ratio	0.94

Velocity

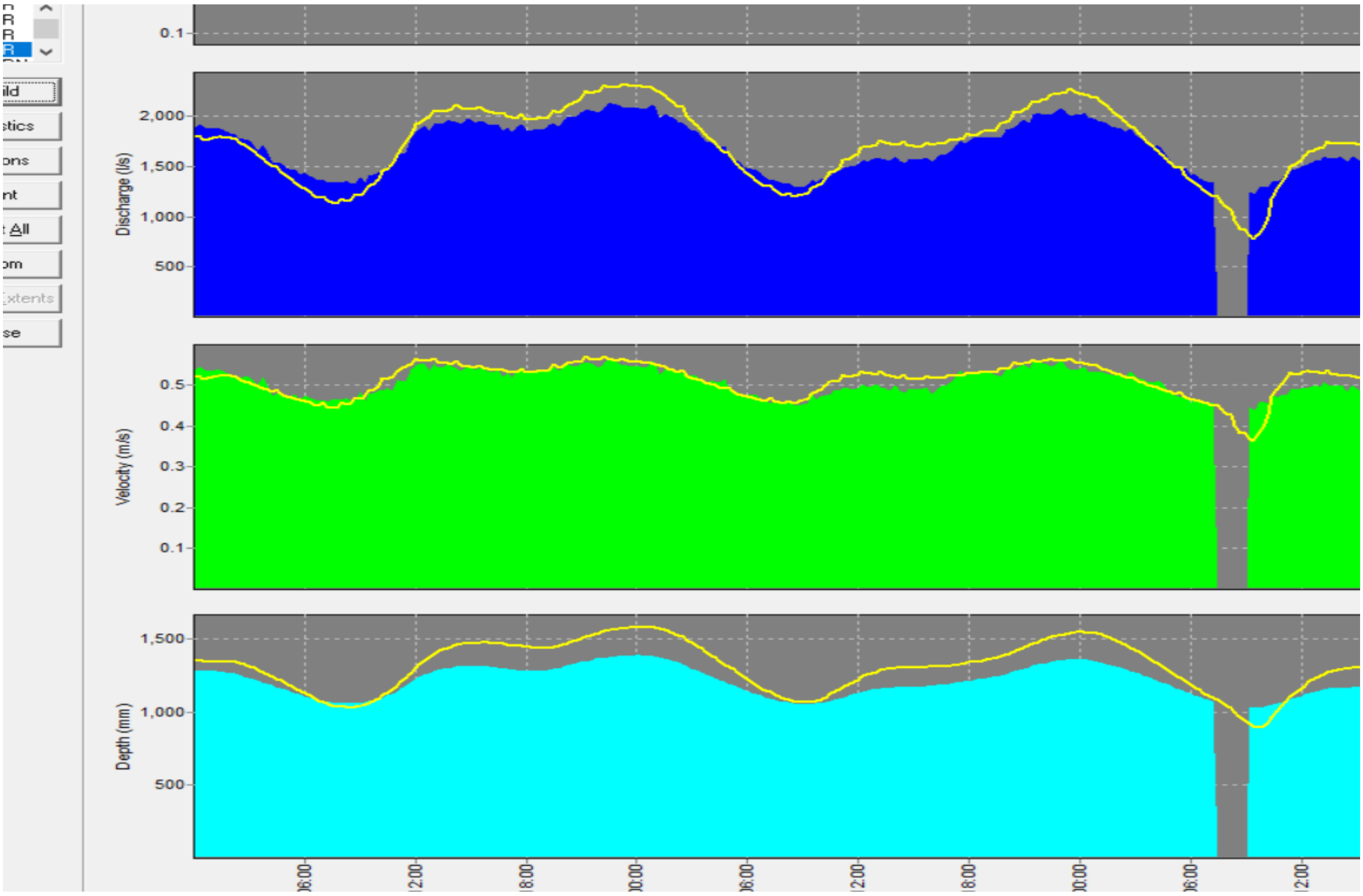
Peak measured velocity (m/s)	0.55	Mean measured velocity (m/s)	0.49
Peak simulated velocity (m/s)	0.55	Mean simulated velocity (m/s)	0.49
Ratio	1.00	Ratio	1.00

Depth

Peak measured depth (mm)	1328	Mean measured depth (mm)	1166
Peak simulated depth (mm)	1419	Mean simulated depth (mm)	1189
Ratio	1.07	Ratio	1.02

Close

802051S DW3



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	862175.43	Peak measured flow (l/s)	2144.54	Mean measured flow (l/s)	1618.20
Total simulated volume (cu.m)	867185.20	Peak simulated flow (l/s)	2321.10	Mean simulated flow (l/s)	1637.71
Ratio	1.01	Ratio	1.08	Ratio	1.01

Velocity

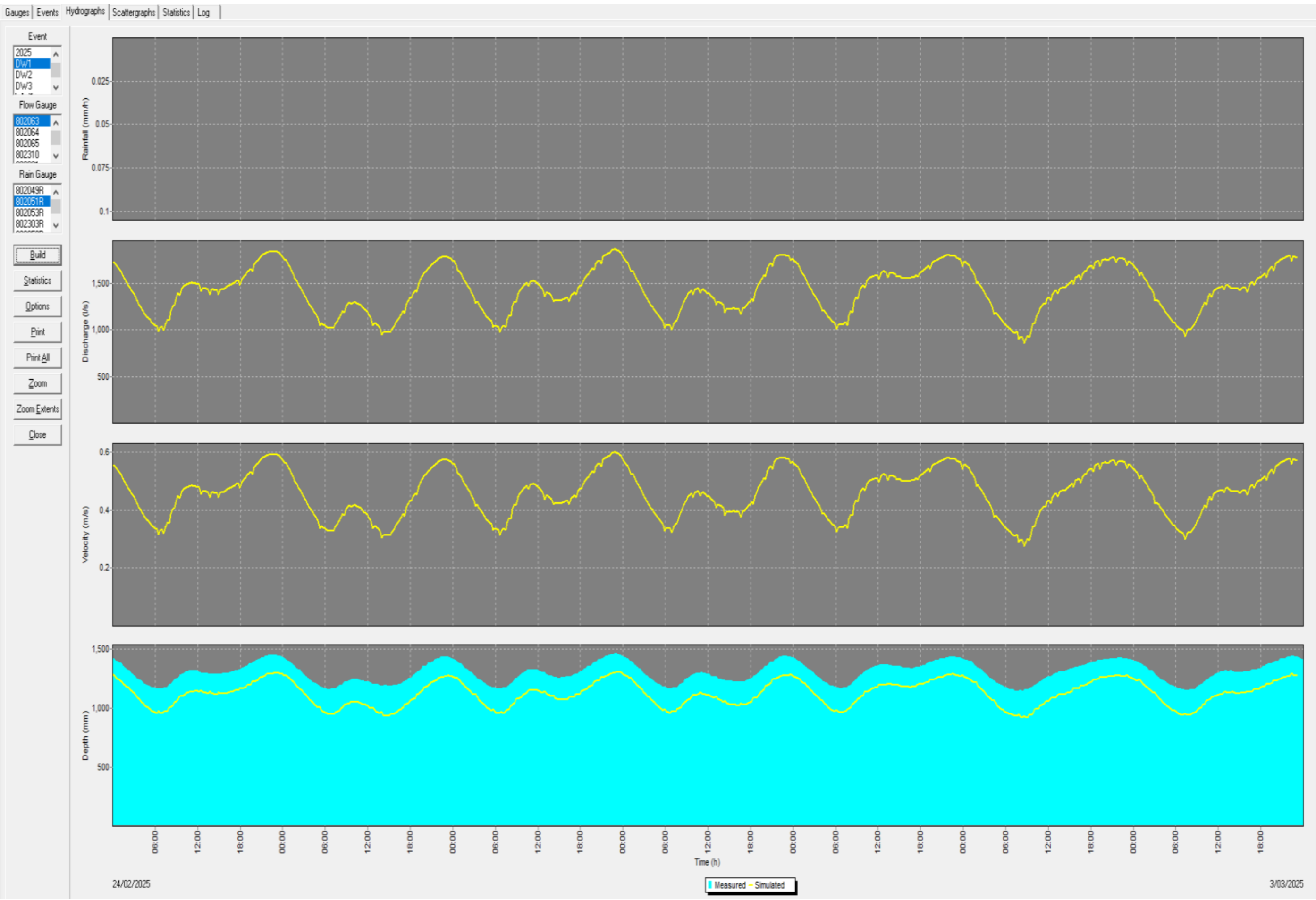
Peak measured velocity (m/s)	0.57	Mean measured velocity (m/s)	0.49
Peak simulated velocity (m/s)	0.57	Mean simulated velocity (m/s)	0.50
Ratio	1.00	Ratio	1.03

Depth

Peak measured depth (mm)	1390	Mean measured depth (mm)	1169
Peak simulated depth (mm)	1589	Mean simulated depth (mm)	1268
Ratio	1.14	Ratio	1.08

Close

802063 DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	861673.43	Peak simulated flow (l/s)	1869.60	Mean simulated flow (l/s)	1430.57
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

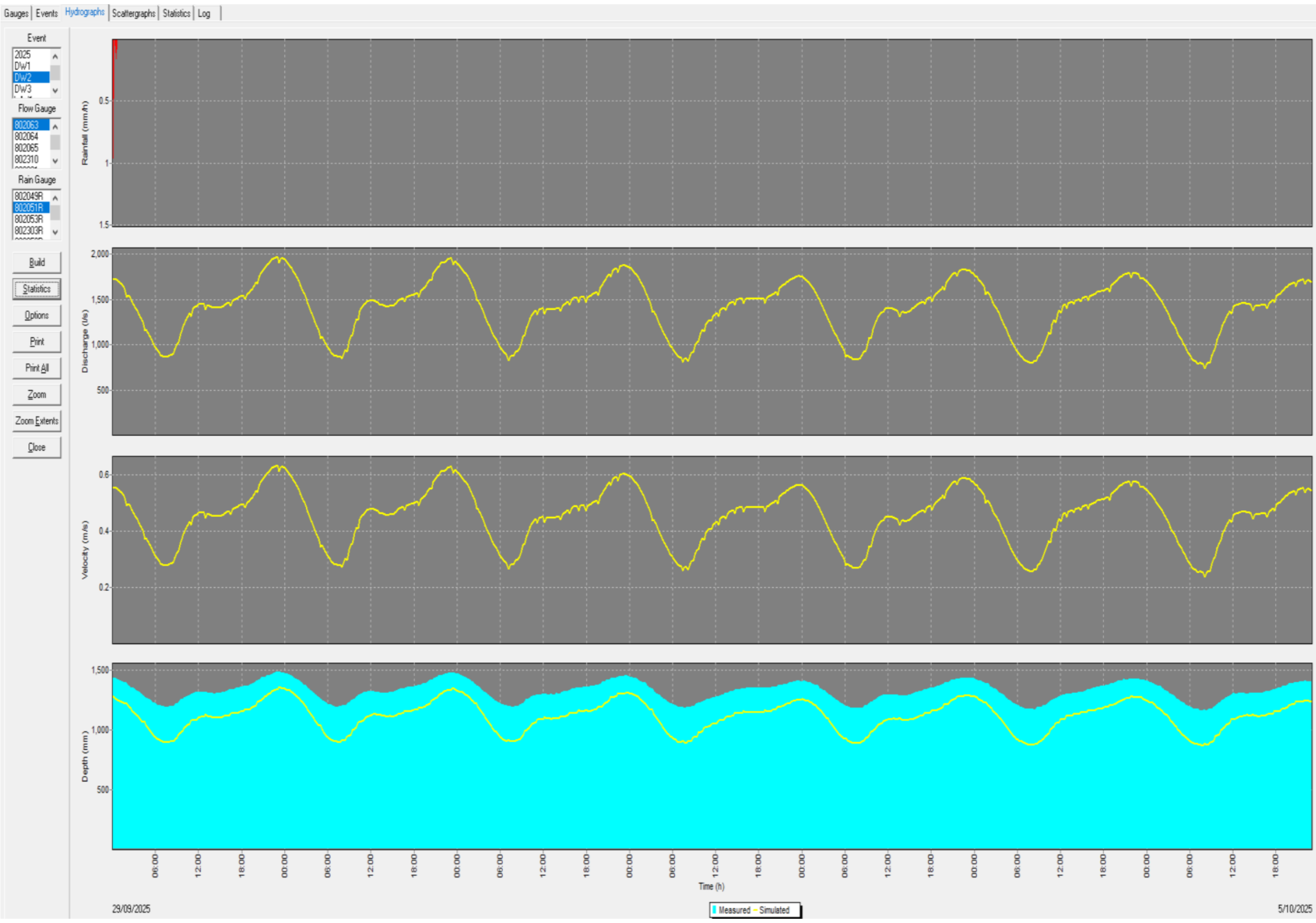
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.60	Mean simulated velocity (m/s)	0.46
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1463	Mean measured depth (mm)	1304
Peak simulated depth (mm)	1308	Mean simulated depth (mm)	1124
Ratio	0.89	Ratio	0.86

Close

802063 DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.40	Peak measured intensity (mm/h)	1.44	Mean measured intensity (mm/h)	0.0024

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	847402.79	Peak simulated flow (l/s)	1970.60	Mean simulated flow (l/s)	1406.87
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

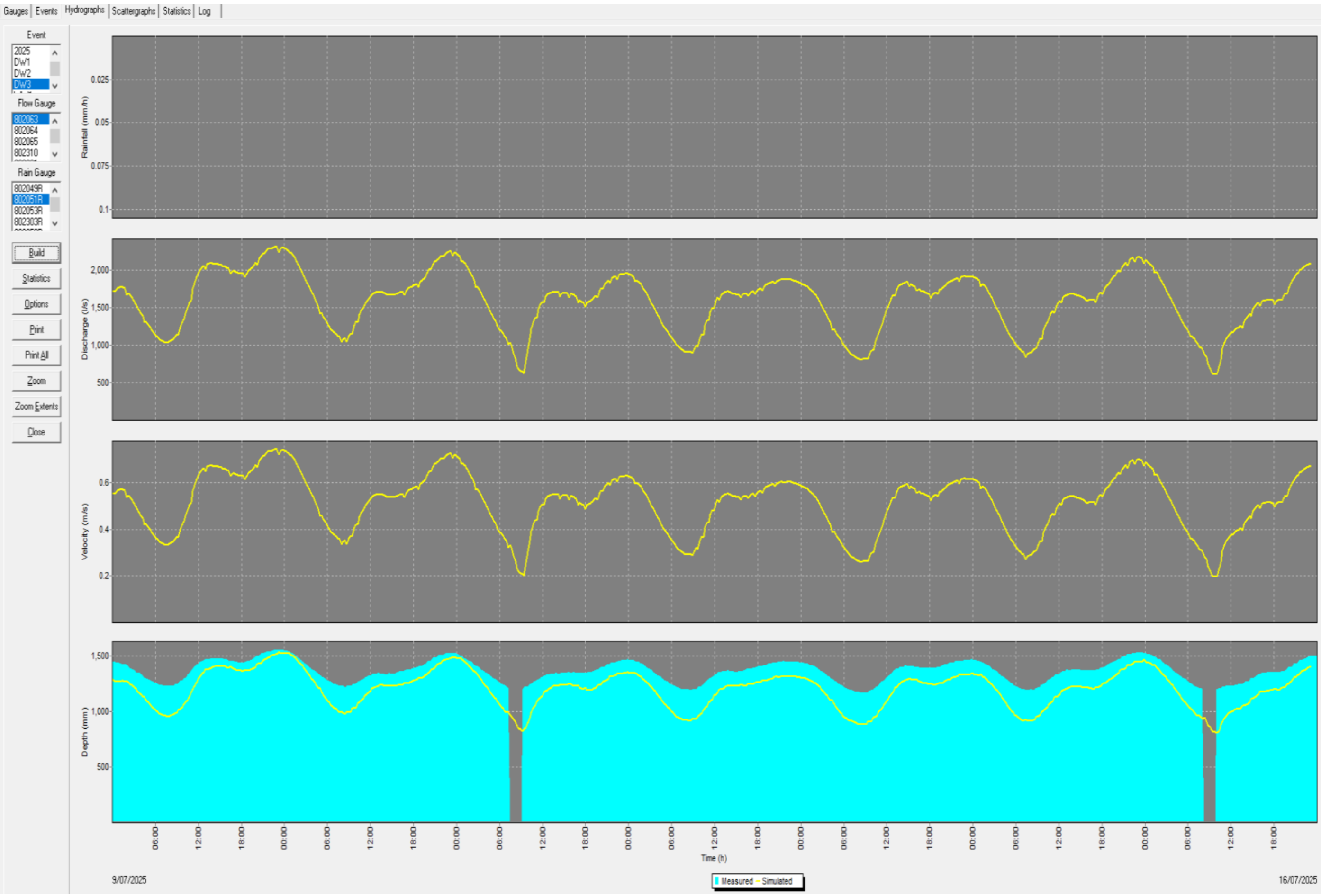
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.63	Mean simulated velocity (m/s)	0.45
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1487	Mean measured depth (mm)	1327
Peak simulated depth (mm)	1363	Mean simulated depth (mm)	1116
Ratio	0.92	Ratio	0.84

Close

802603 DW3



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	958706.28	Peak simulated flow (l/s)	2308.80	Mean simulated flow (l/s)	1591.66
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

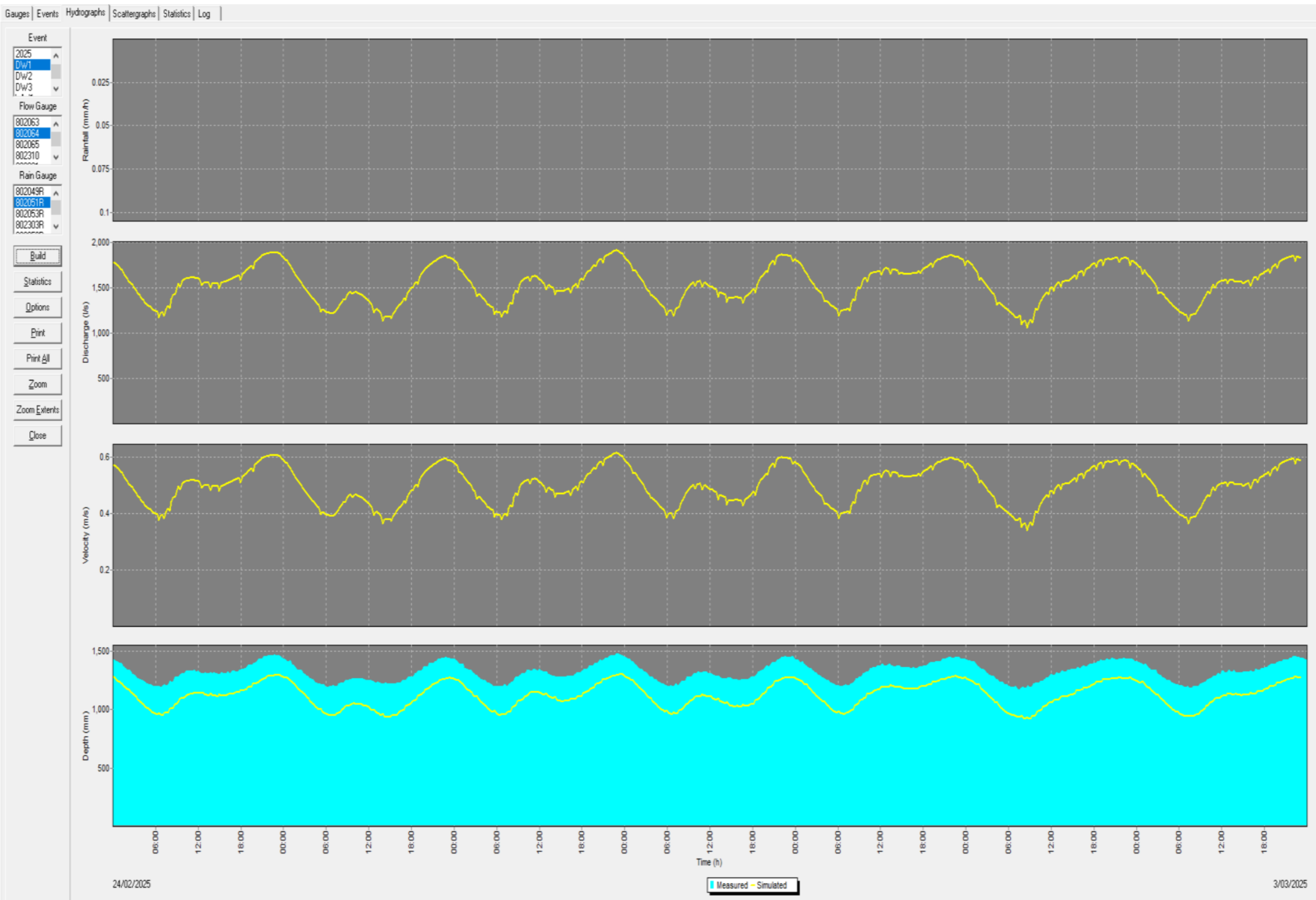
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.74	Mean simulated velocity (m/s)	0.51
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1550	Mean measured depth (mm)	1335
Peak simulated depth (mm)	1532	Mean simulated depth (mm)	1199
Ratio	0.99	Ratio	0.90

Close

802064 DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	934928.27	Peak simulated flow (l/s)	1916.30	Mean simulated flow (l/s)	1552.19
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

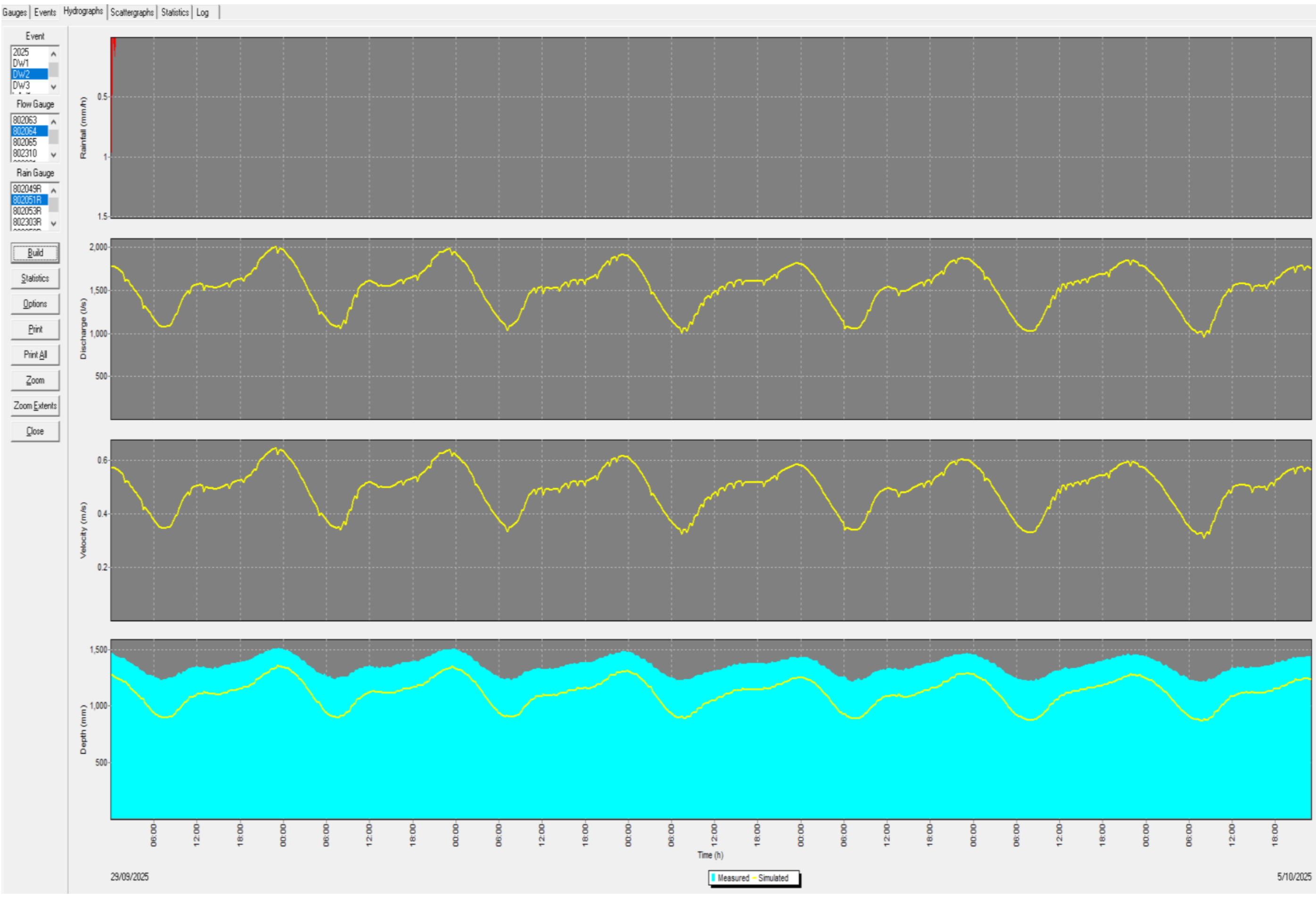
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.62	Mean simulated velocity (m/s)	0.50
Ratio	Undefined	Ratio	Undefined

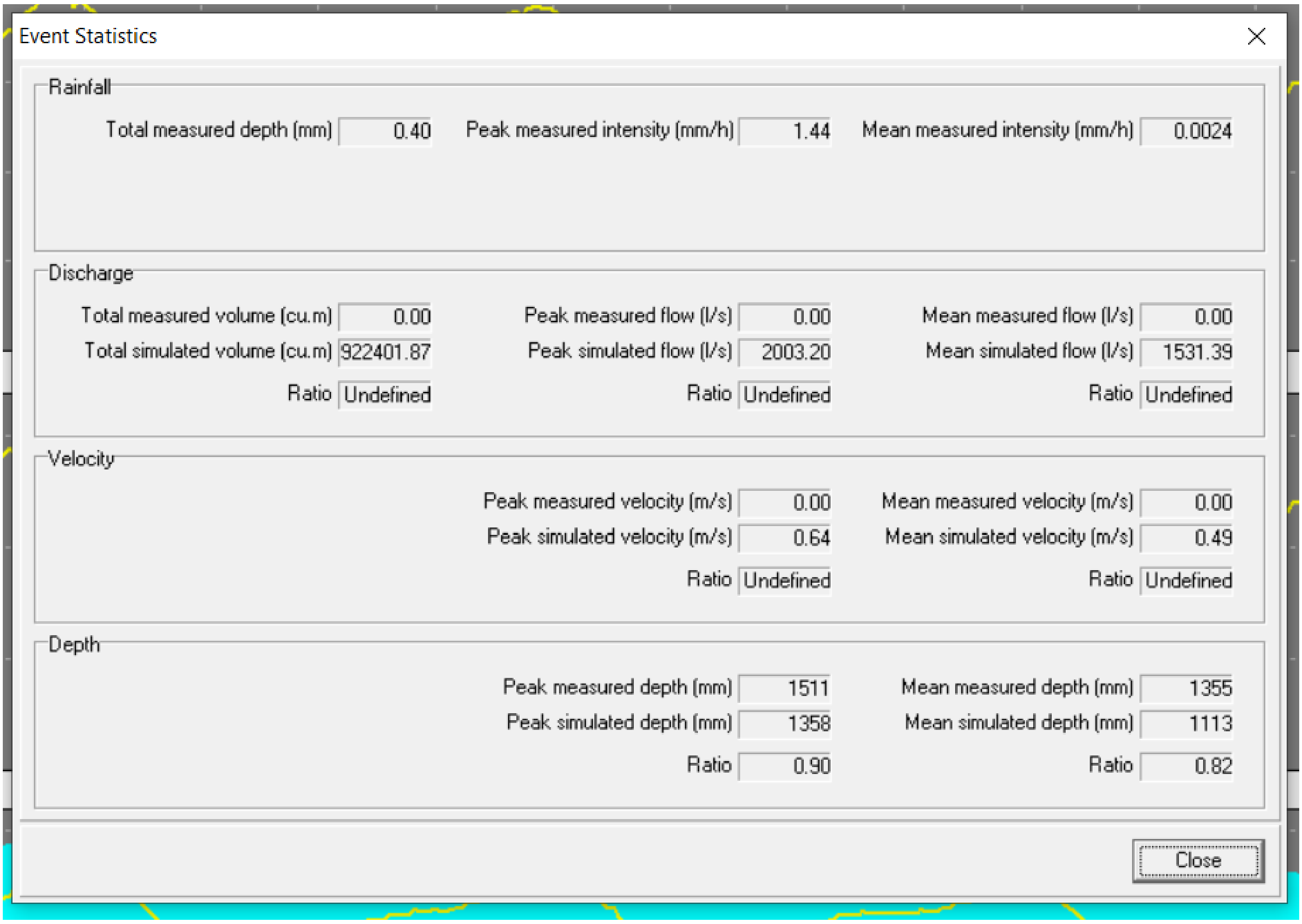
Depth

Peak measured depth (mm)	1475	Mean measured depth (mm)	1324
Peak simulated depth (mm)	1304	Mean simulated depth (mm)	1121
Ratio	0.88	Ratio	0.85

Close

802064 DW2




Event Statistics

Rainfall

Total measured depth (mm)	0.40	Peak measured intensity (mm/h)	1.44	Mean measured intensity (mm/h)	0.0024

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	922401.87	Peak simulated flow (l/s)	2003.20	Mean simulated flow (l/s)	1531.39
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

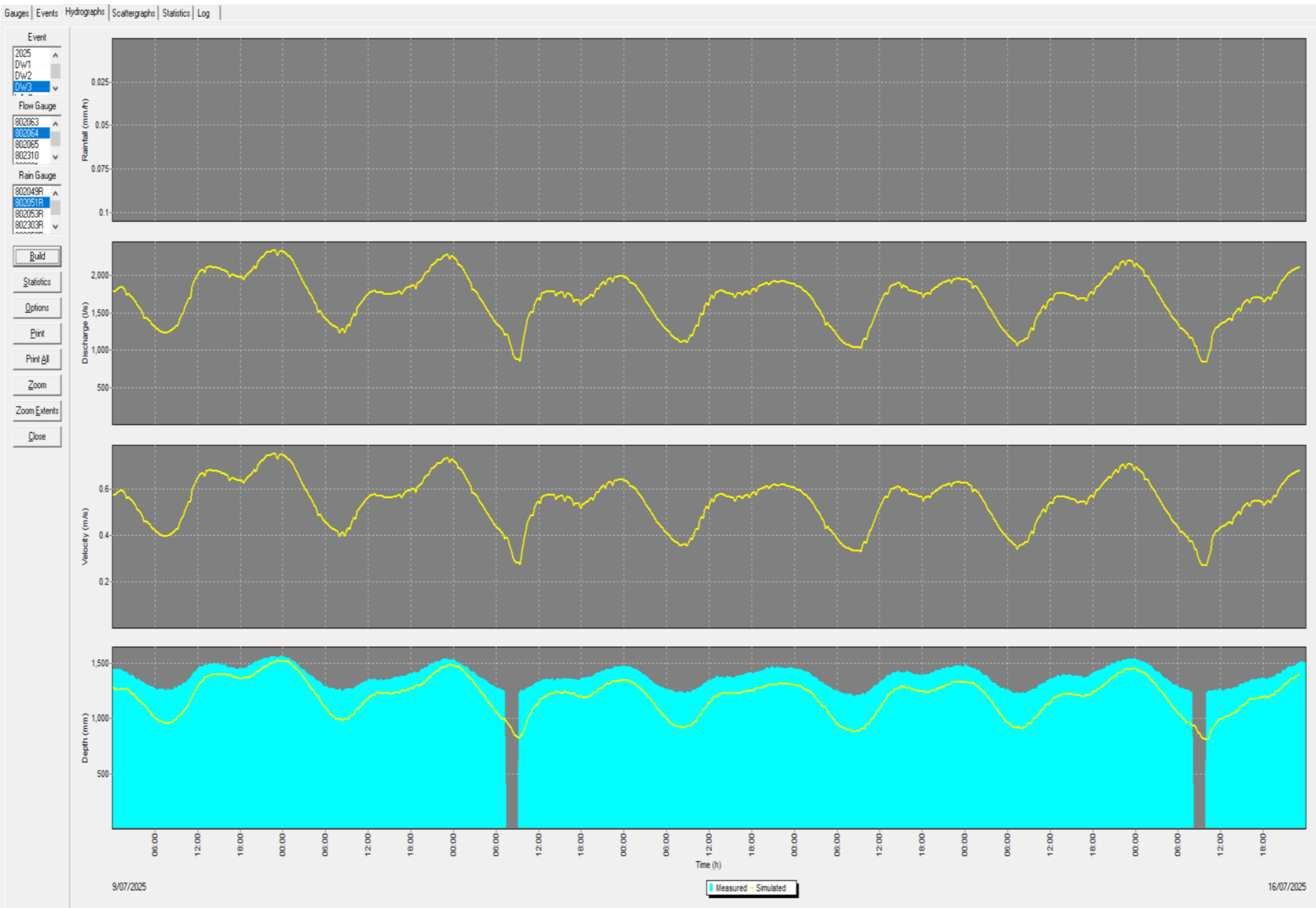
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.64	Mean simulated velocity (m/s)	0.49
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1511	Mean measured depth (mm)	1355
Peak simulated depth (mm)	1358	Mean simulated depth (mm)	1113
Ratio	0.90	Ratio	0.82

Close

802064 DW3



Event Statistics

Rainfall

Total measured depth (mm)	Peak measured intensity (mm/h)	Mean measured intensity (mm/h)
0.00	0.00	0.0000

Discharge

	Volume	Peak flow (l/s)	Mean flow (l/s)
Measured	Total measured volume (cu.m) 0.00	Peak measured flow (l/s) 0.00	Mean measured flow (l/s) 0.00
Simulated	Total simulated volume (cu.m) 015594.19	Peak simulated flow (l/s) 2331.90	Mean simulated flow (l/s) 1686.11
Ratio	Undefined	Undefined	Undefined

Velocity

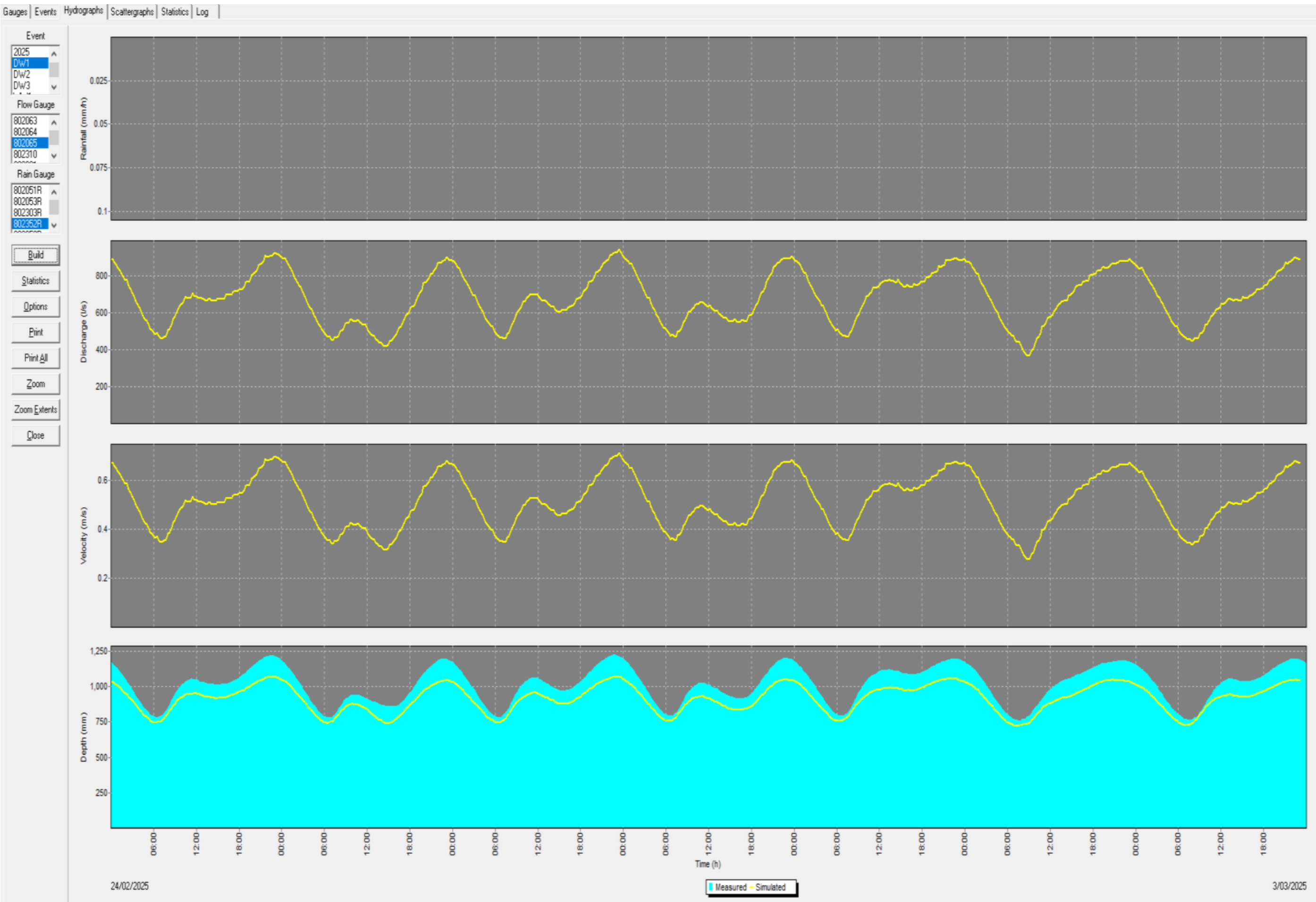
	Peak velocity (m/s)	Mean velocity (m/s)
Measured	Peak measured velocity (m/s) 0.00	Mean measured velocity (m/s) 0.00
Simulated	Peak simulated velocity (m/s) 0.75	Mean simulated velocity (m/s) 0.54
Ratio	Undefined	Undefined

Depth

	Peak depth (mm)	Mean depth (mm)
Measured	Peak measured depth (mm) 1565	Mean measured depth (mm) 1351
Simulated	Peak simulated depth (mm) 1527	Mean simulated depth (mm) 1195
Ratio	0.98	0.88

Close

802065 DW1



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	411096.70	Peak simulated flow (l/s)	944.70	Mean simulated flow (l/s)	682.51
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

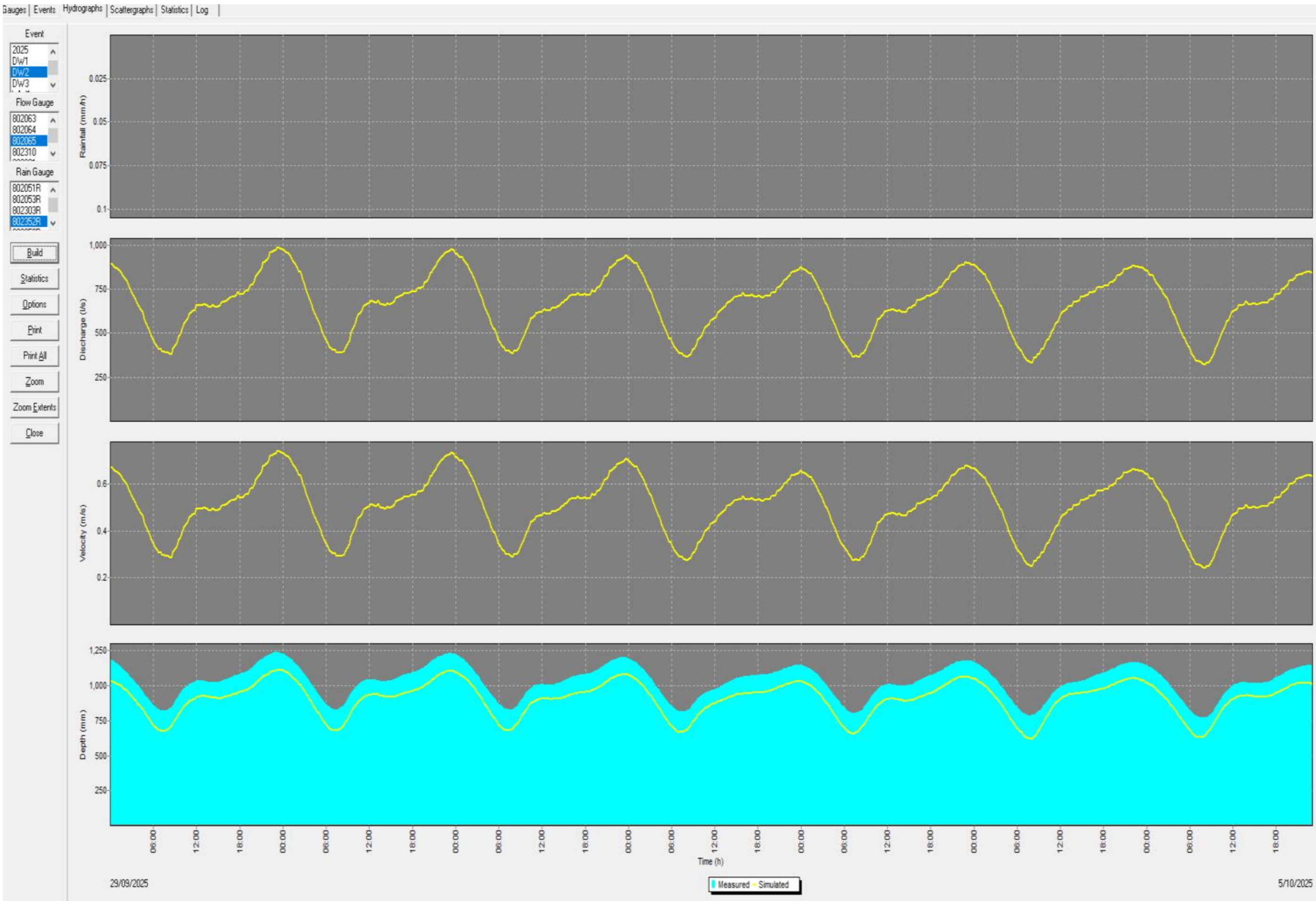
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.71	Mean simulated velocity (m/s)	0.51
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1226	Mean measured depth (mm)	1016
Peak simulated depth (mm)	1072	Mean simulated depth (mm)	917
Ratio	0.87	Ratio	0.90

Close

802065 DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	403358.56	Peak simulated flow (l/s)	987.40	Mean simulated flow (l/s)	669.66
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

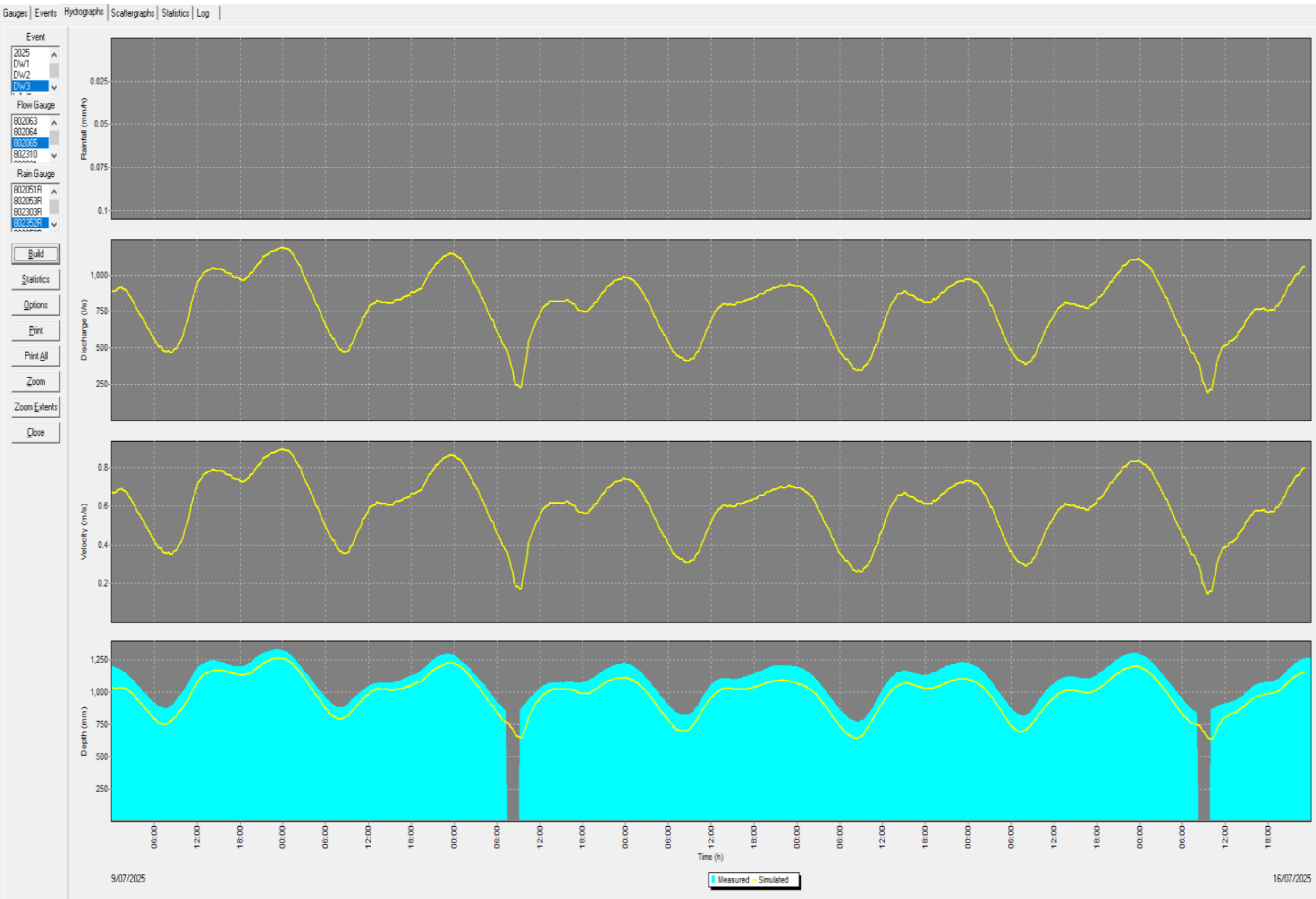
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.74	Mean simulated velocity (m/s)	0.50
Ratio	Undefined	Ratio	Undefined

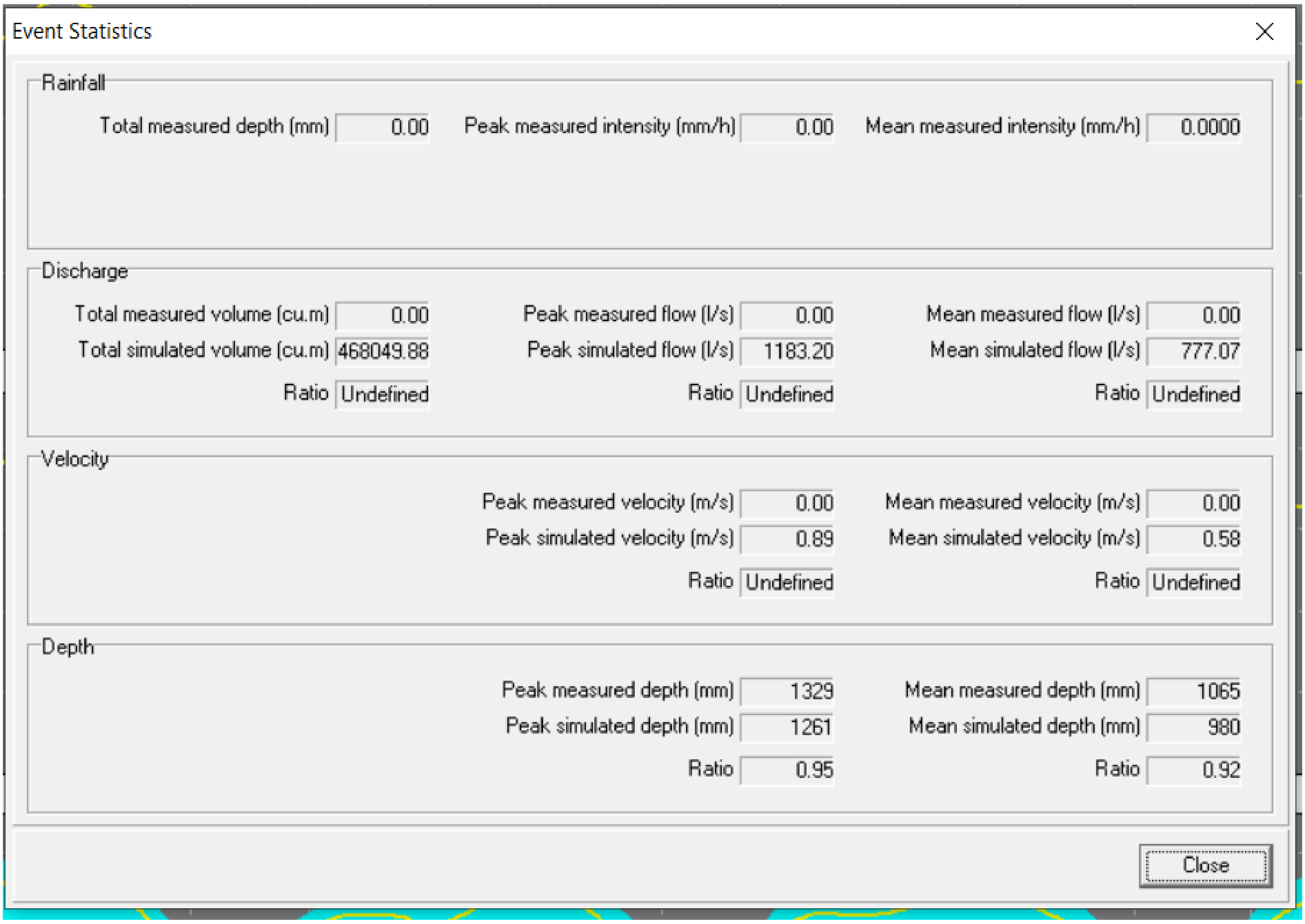
Depth

Peak measured depth (mm)	1240	Mean measured depth (mm)	1031
Peak simulated depth (mm)	1116	Mean simulated depth (mm)	907
Ratio	0.90	Ratio	0.88

Close

802065 DW3





Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	468049.88	Peak simulated flow (l/s)	1183.20	Mean simulated flow (l/s)	777.07
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

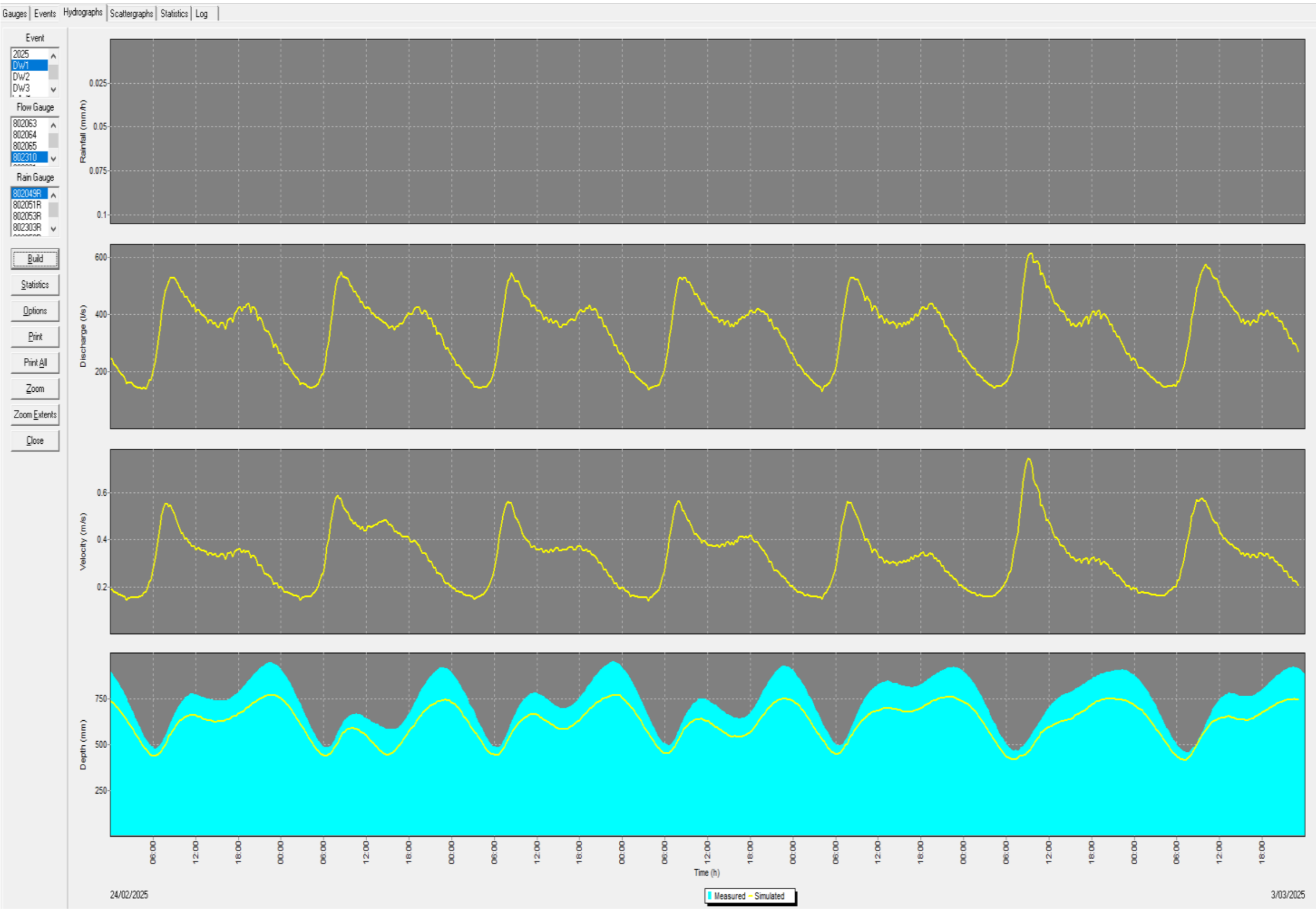
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.89	Mean simulated velocity (m/s)	0.58
Ratio	Undefined	Ratio	Undefined

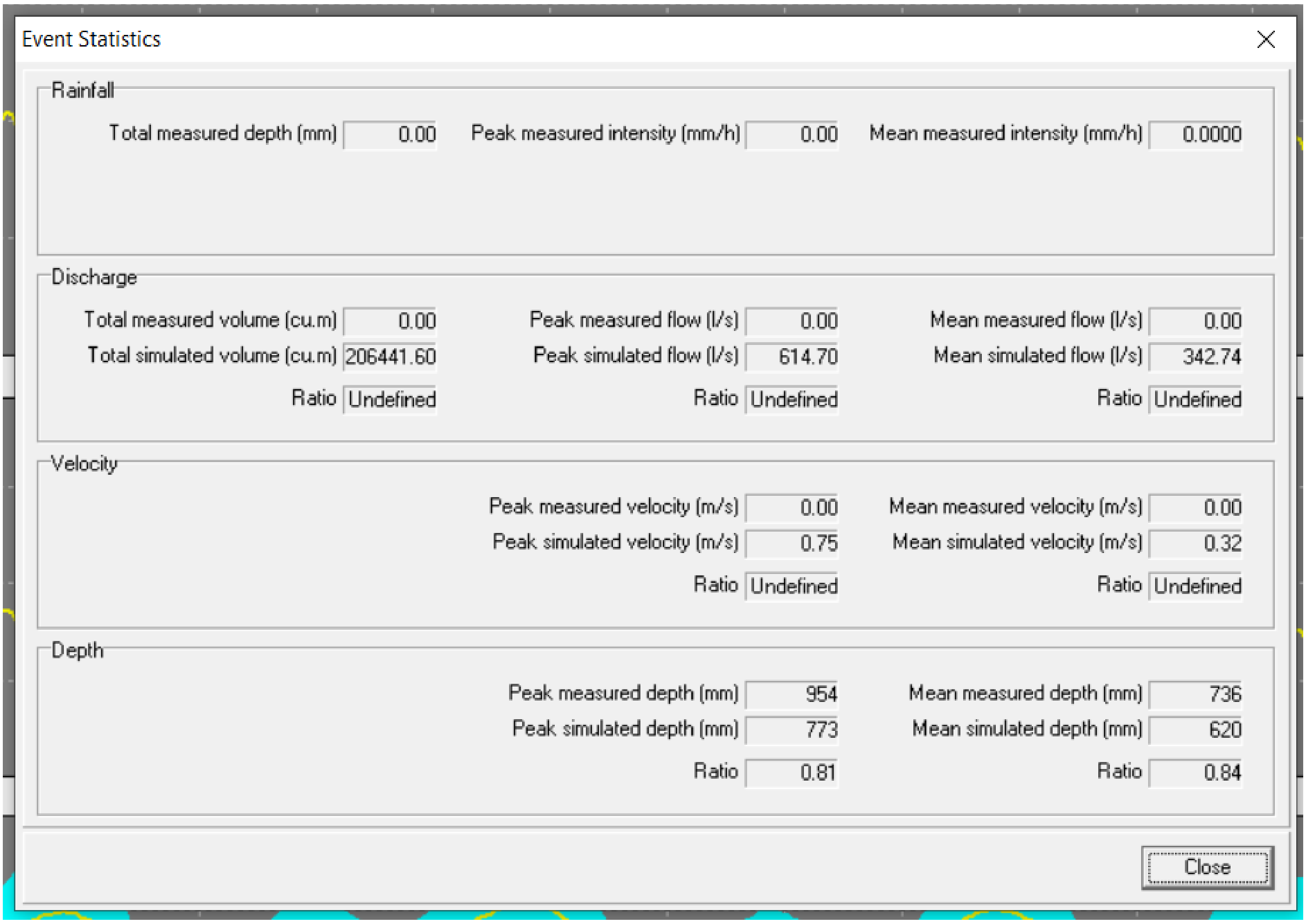
Depth

Peak measured depth (mm)	1329	Mean measured depth (mm)	1065
Peak simulated depth (mm)	1261	Mean simulated depth (mm)	980
Ratio	0.95	Ratio	0.92

Close

802310 DW1





Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	206441.60	Peak simulated flow (l/s)	614.70	Mean simulated flow (l/s)	342.74
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

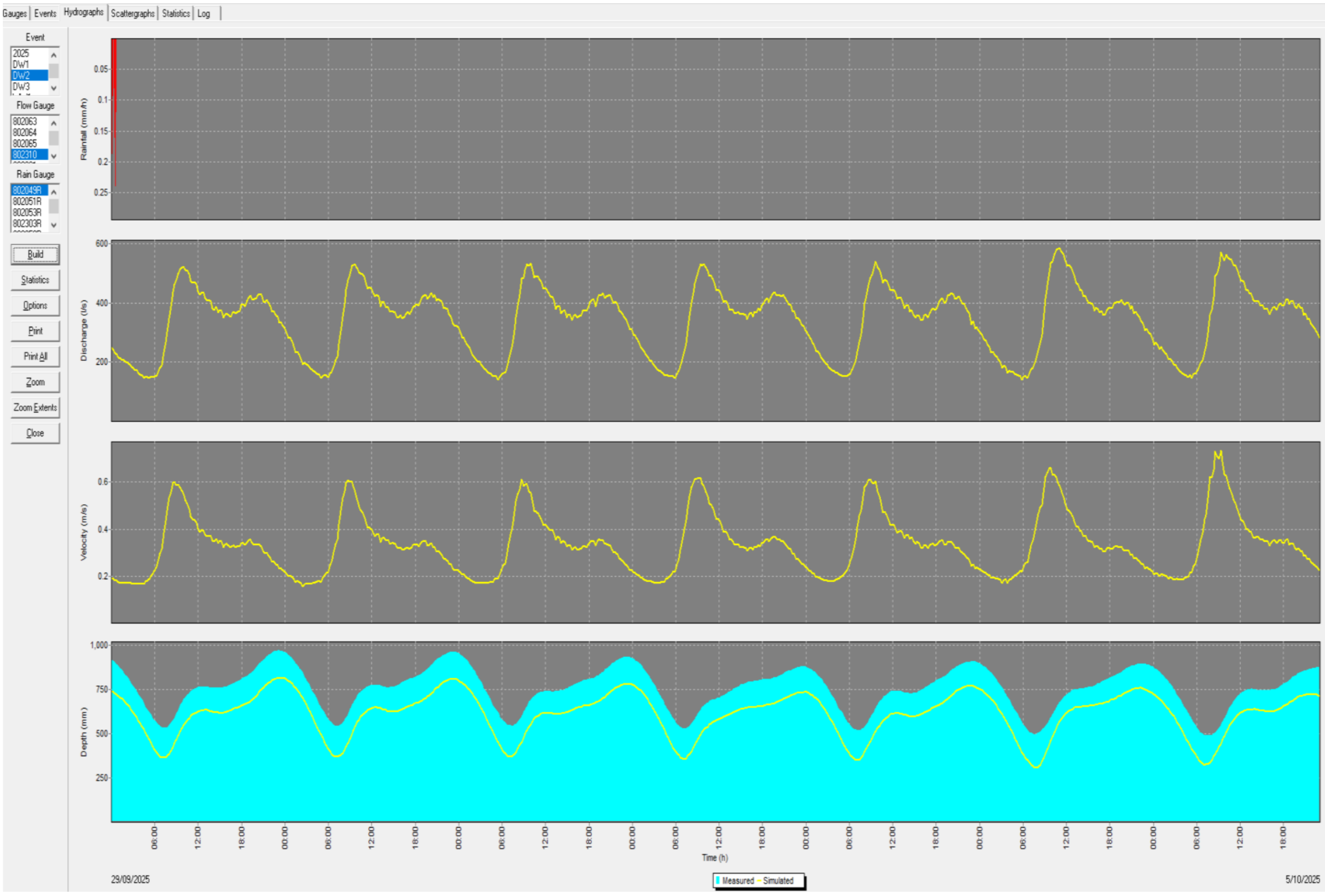
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.75	Mean simulated velocity (m/s)	0.32
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	954	Mean measured depth (mm)	736
Peak simulated depth (mm)	773	Mean simulated depth (mm)	620
Ratio	0.81	Ratio	0.84

Close

802310 DW2



Event Statistics

Rainfall

Total measured depth (mm)	0.13	Peak measured intensity (mm/h)	0.28	Mean measured intensity (mm/h)	0.0008

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	206275.19	Peak simulated flow (l/s)	582.60	Mean simulated flow (l/s)	342.46
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

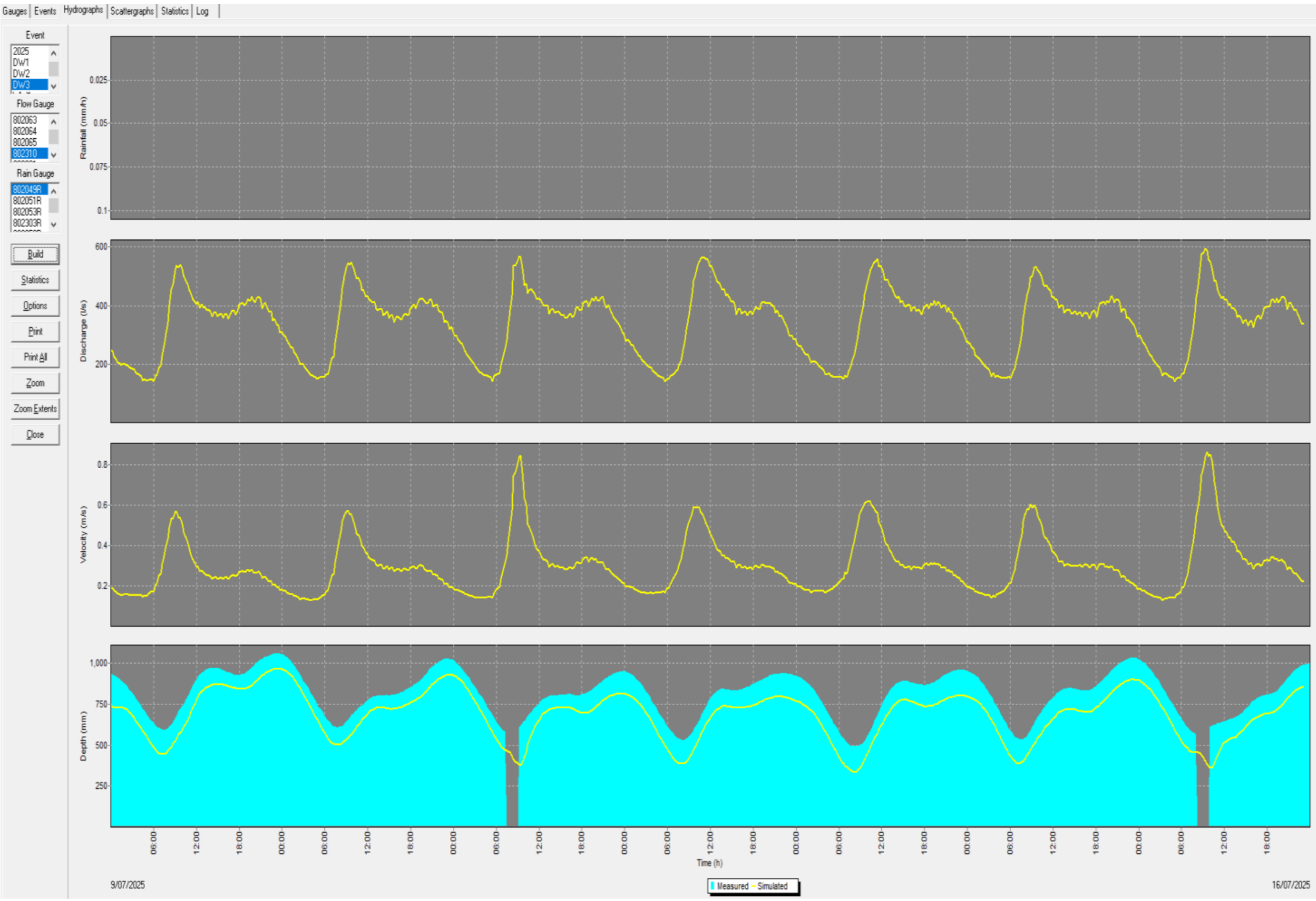
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.73	Mean simulated velocity (m/s)	0.33
Ratio	Undefined	Ratio	Undefined

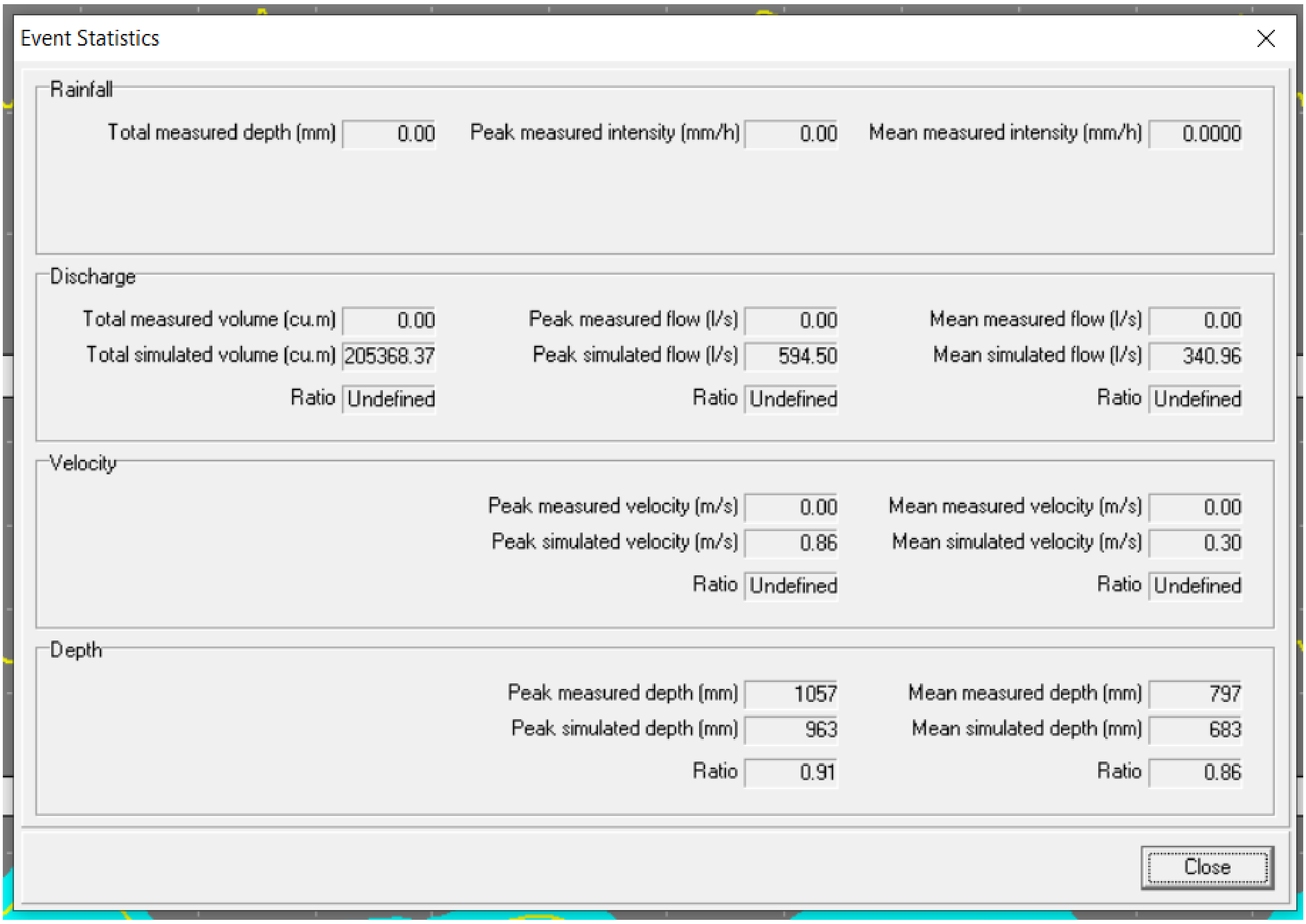
Depth

Peak measured depth (mm)	972	Mean measured depth (mm)	755
Peak simulated depth (mm)	818	Mean simulated depth (mm)	610
Ratio	0.84	Ratio	0.81

Close

802310 DW3





Event Statistics

Rainfall

Total measured depth (mm)	0.00	Peak measured intensity (mm/h)	0.00	Mean measured intensity (mm/h)	0.0000

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	205368.37	Peak simulated flow (l/s)	594.50	Mean simulated flow (l/s)	340.96
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.86	Mean simulated velocity (m/s)	0.30
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1057	Mean measured depth (mm)	797
Peak simulated depth (mm)	963	Mean simulated depth (mm)	683
Ratio	0.91	Ratio	0.86

Close

Attachment 3 Calibration Plots – Wet Weather Flow

Calibration Plots Botany Bay Catchment _ Malabar System 2025

Wet Weather Events:

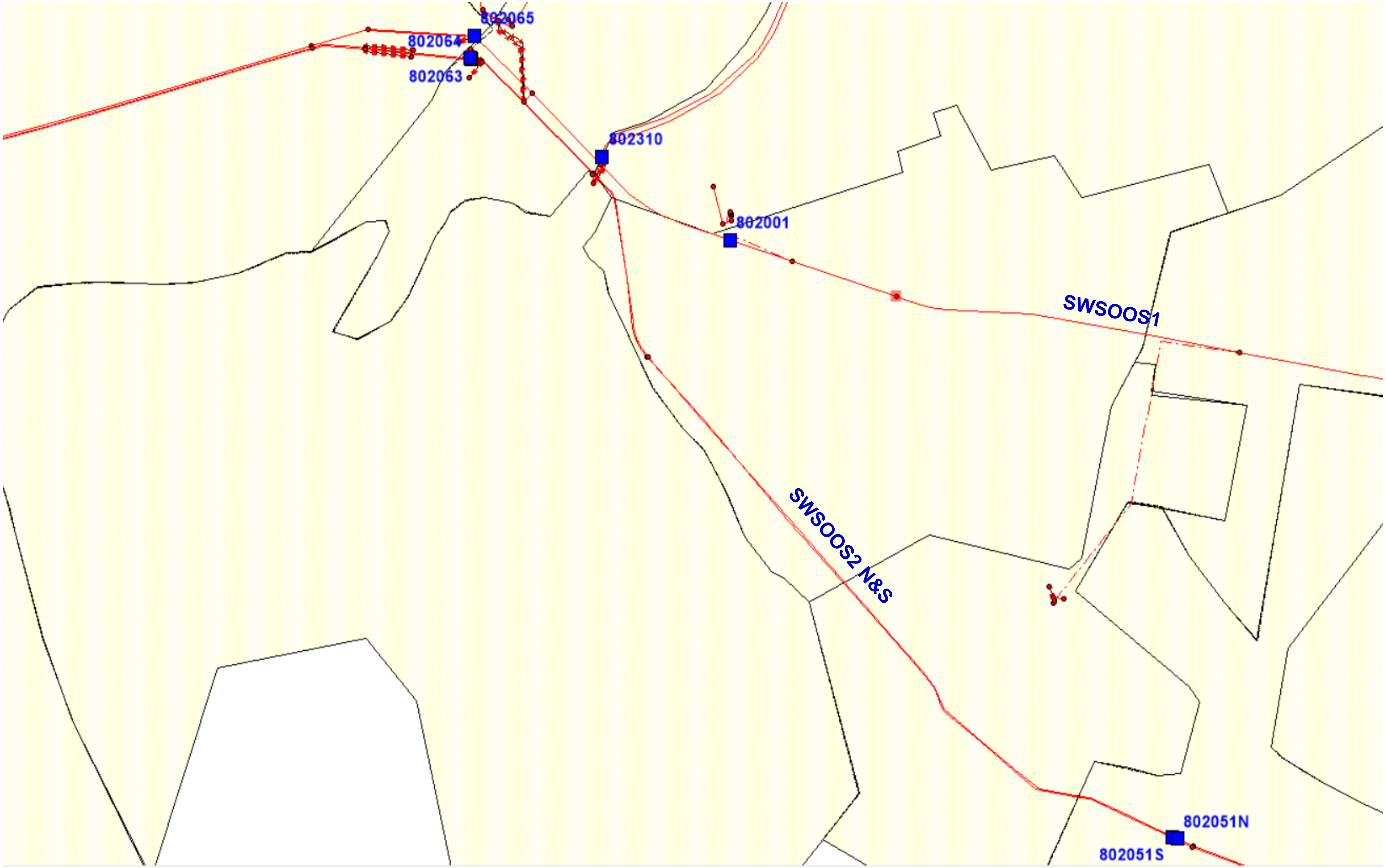
WW Event 1 : 25/07 - 31/08/2025 (Three Rain Periods covered)

WW Event 2 : 16/03 - 11/04/2025 (Three Rain Periods covered)

WW Event 3 : 24/01 - 16 / 03 / 2025 (Three Rain Periods covered)

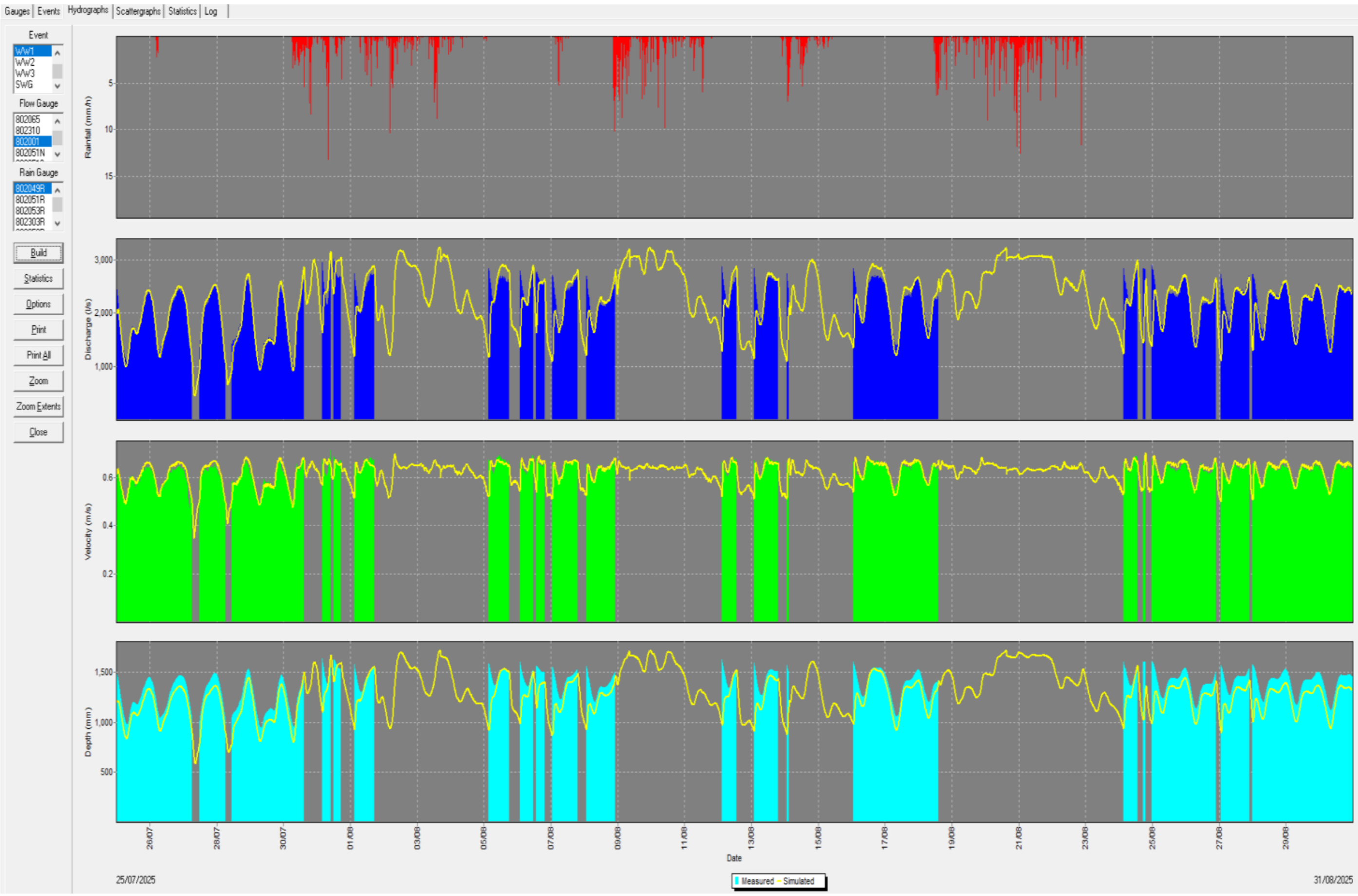
Gauges Assessed:

Gauge	Comment
802001	SWSOOS 1, HVQ Licence Gauge
802051N	SWSOOS2 N, HVQ Licence Gauge
802051S	SWSOOS2 S, HVQ Licence Gauge
802063	SWSOOS 2S (S2.SYP2), Level Only, Licence Gauge
802064	SWSOOS 2N (N2.SYP2), Level Only, Licence Gauge
802065	SWSOOS 1 (T3.SYP2), Level Only, Licence Gauge
802310	Southern Division Sewer, Level Only, Licence Gauge



Sewer Gauge Layout – Botany Bay Catchment

802001 WW1



Event Statistics

Rainfall

Total measured depth (mm)	443.13	Peak measured intensity (mm/h)	18.60	Mean measured intensity (mm/h)	0.4989

Discharge

Total measured volume (cu.m)	645431.06	Peak measured flow (l/s)	3034.62	Mean measured flow (l/s)	1140.02
Total simulated volume (cu.m)	128945.45	Peak simulated flow (l/s)	3229.40	Mean simulated flow (l/s)	2231.28
Ratio	1.96	Ratio	1.06	Ratio	1.96

Velocity

Peak measured velocity (m/s)	0.71	Mean measured velocity (m/s)	0.33
Peak simulated velocity (m/s)	0.70	Mean simulated velocity (m/s)	0.62
Ratio	0.98	Ratio	1.91

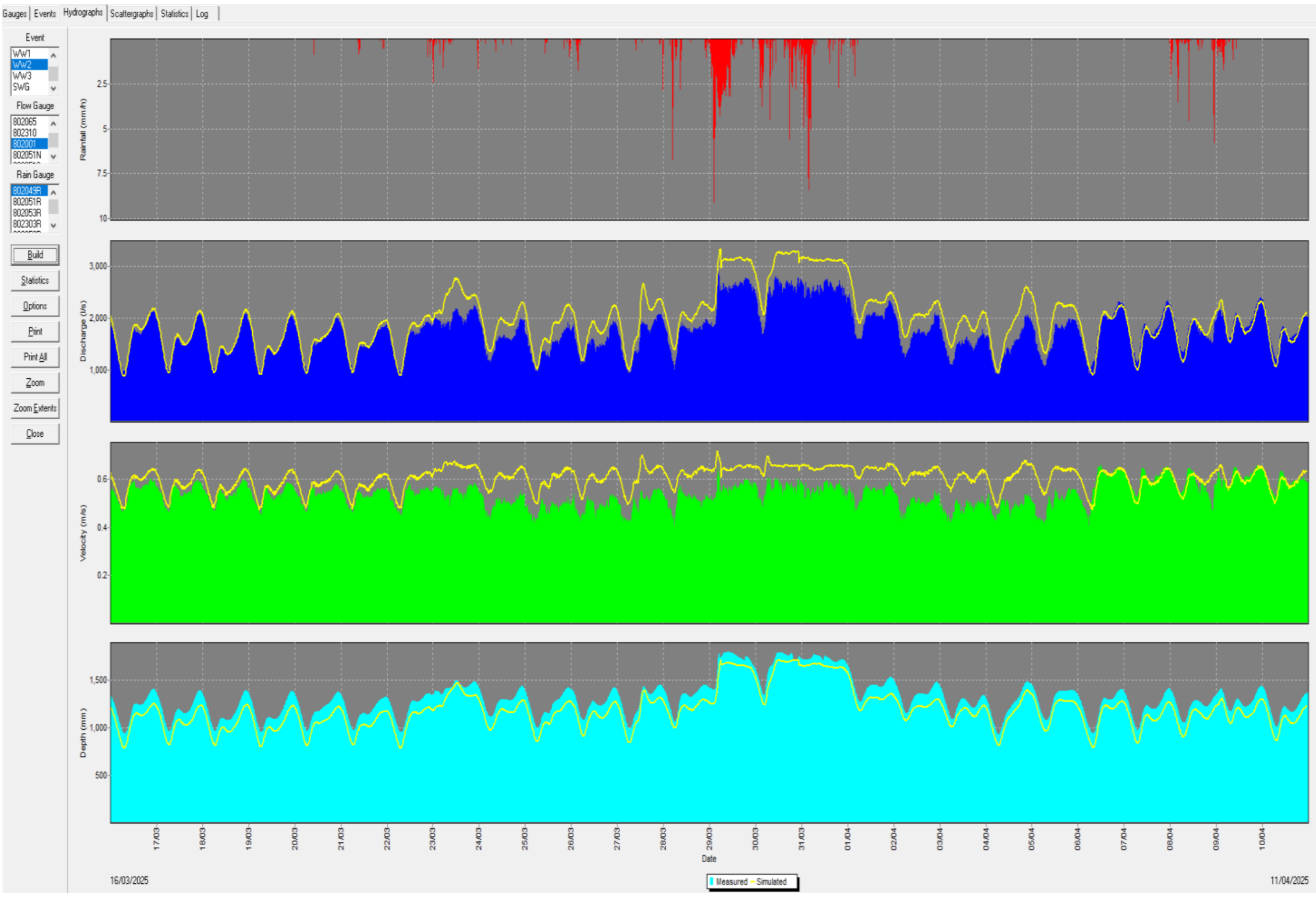
Depth

Peak measured depth (mm)	1643	Mean measured depth (mm)	714
Peak simulated depth (mm)	1720	Mean simulated depth (mm)	1292
Ratio	1.05	Ratio	1.81

Close

Due to Missing Gauge Data, the Statistics Average couldn’t be evaluated.

802001 WW2



Event Statistics

Rainfall

Total measured depth (mm)	115.83	Peak measured intensity (mm/h)	9.60	Mean measured intensity (mm/h)	0.1856

Discharge

Total measured volume (cu.m)	964011.10	Peak measured flow (l/s)	2992.78	Mean measured flow (l/s)	1763.90
Total simulated volume (cu.m)	392245.25	Peak simulated flow (l/s)	3325.40	Mean simulated flow (l/s)	1957.59
Ratio	1.11	Ratio	1.11	Ratio	1.11

Velocity

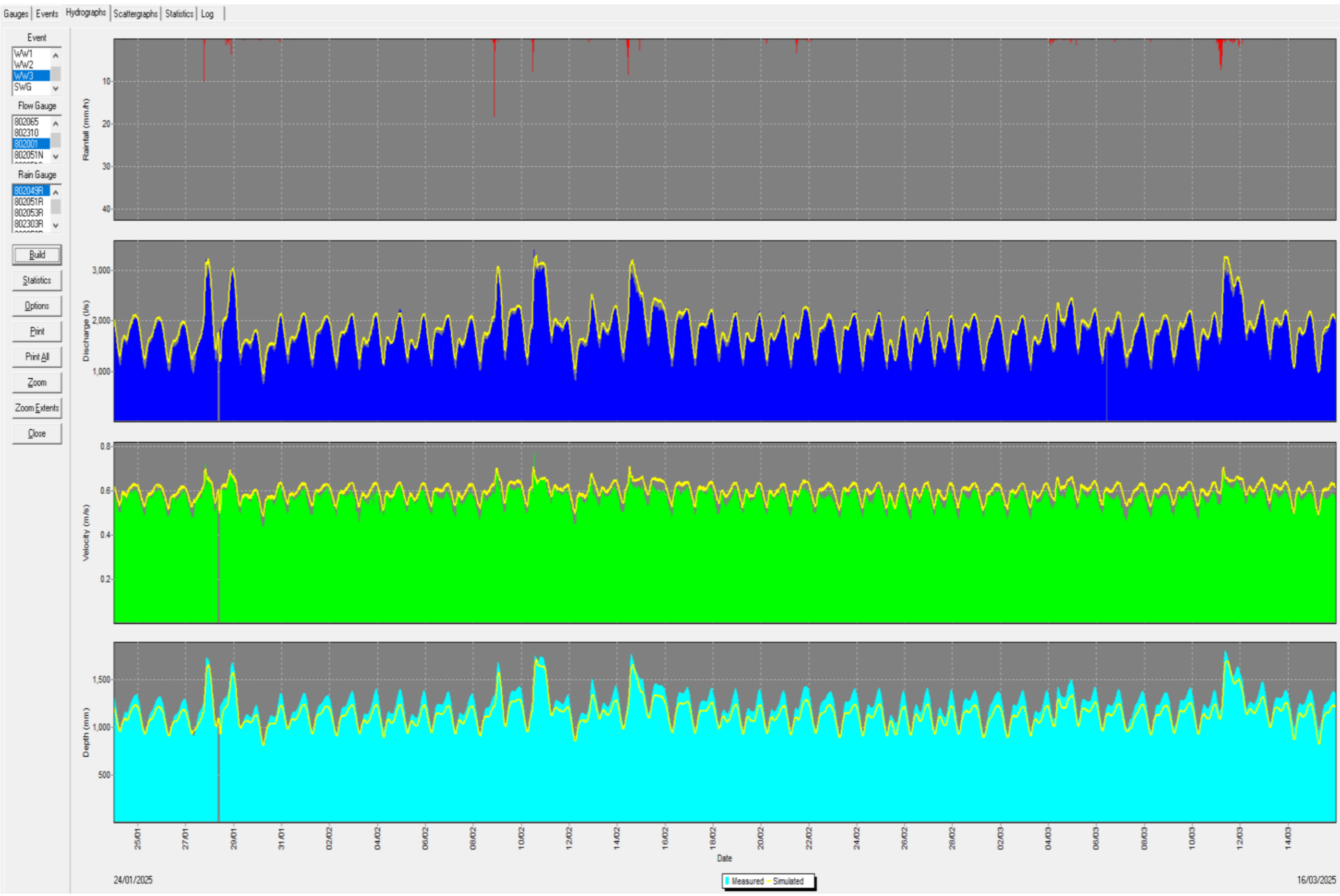
Peak measured velocity (m/s)	0.66	Mean measured velocity (m/s)	0.54
Peak simulated velocity (m/s)	0.72	Mean simulated velocity (m/s)	0.60
Ratio	1.09	Ratio	1.12

Depth

Peak measured depth (mm)	1801	Mean measured depth (mm)	1305
Peak simulated depth (mm)	1717	Mean simulated depth (mm)	1185
Ratio	0.95	Ratio	0.91

Close

802001 WW3



Event Statistics

Rainfall

Total measured depth (mm)	121.82	Peak measured intensity (mm/h)	40.64	Mean measured intensity (mm/h)	0.0995

Discharge

Total measured volume (cu.m)	670663.12	Peak measured flow (l/s)	3411.36	Mean measured flow (l/s)	1740.44
Total simulated volume (cu.m)	125616.70	Peak simulated flow (l/s)	3281.80	Mean simulated flow (l/s)	1844.80
Ratio	1.06	Ratio	0.96	Ratio	1.06

Velocity

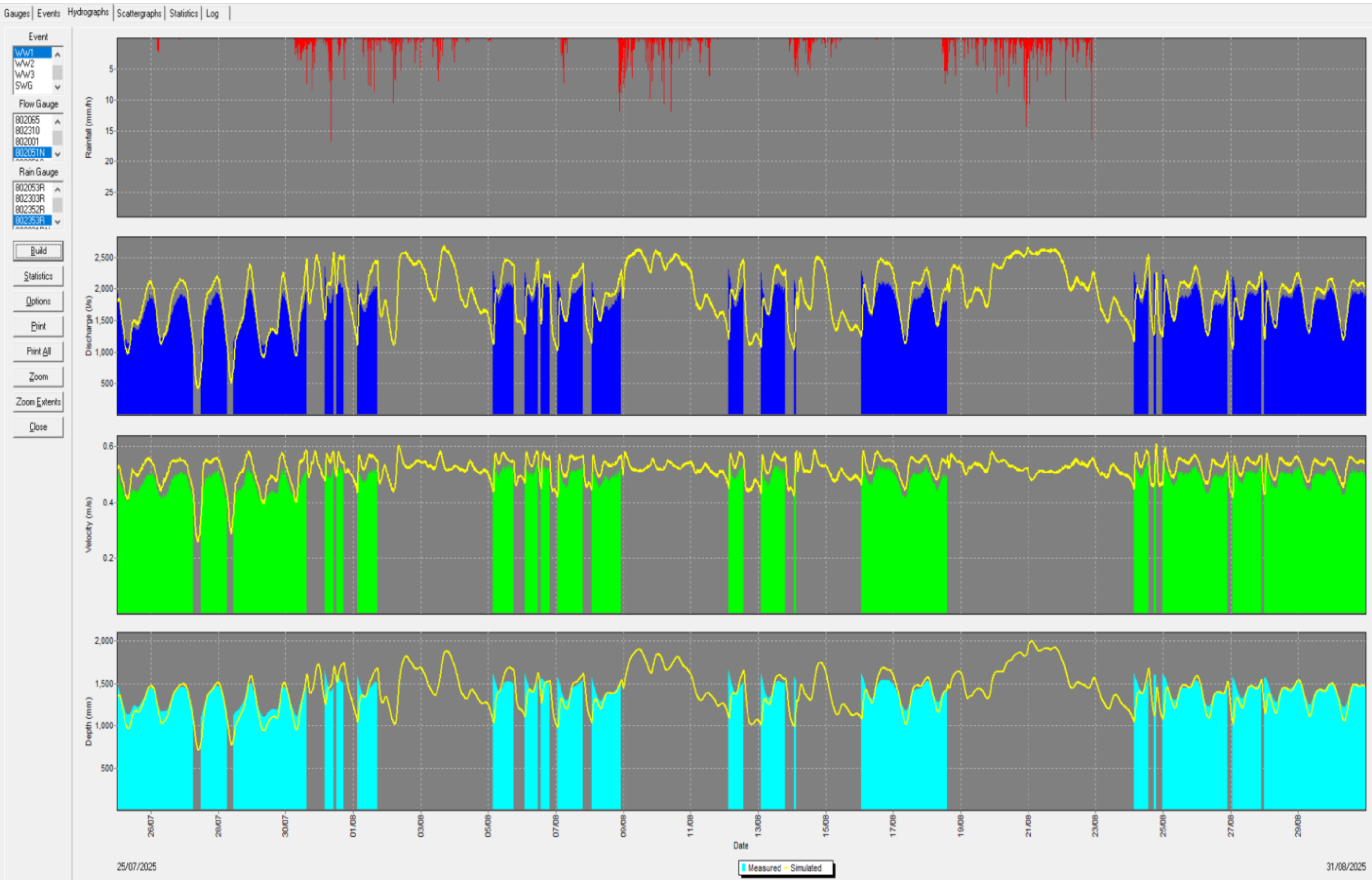
Peak measured velocity (m/s)	0.78	Mean measured velocity (m/s)	0.57
Peak simulated velocity (m/s)	0.71	Mean simulated velocity (m/s)	0.60
Ratio	0.91	Ratio	1.06

Depth

Peak measured depth (mm)	1805	Mean measured depth (mm)	1236
Peak simulated depth (mm)	1716	Mean simulated depth (mm)	1143
Ratio	0.95	Ratio	0.92

Close

802051N WW1



Event Statistics

Rainfall

Total measured depth (mm)	492.87	Peak measured intensity (mm/h)	27.52	Mean measured intensity (mm/h)	0.5549

Discharge

Total measured volume (cu.m)	938157.94	Peak measured flow (l/s)	2359.60	Mean measured flow (l/s)	918.83
Total simulated volume (cu.m)	108087.15	Peak simulated flow (l/s)	2691.80	Mean simulated flow (l/s)	1911.76
Ratio	2.08	Ratio	1.14	Ratio	2.08

Velocity

Peak measured velocity (m/s)	0.55	Mean measured velocity (m/s)	0.25
Peak simulated velocity (m/s)	0.61	Mean simulated velocity (m/s)	0.52
Ratio	1.11	Ratio	2.05

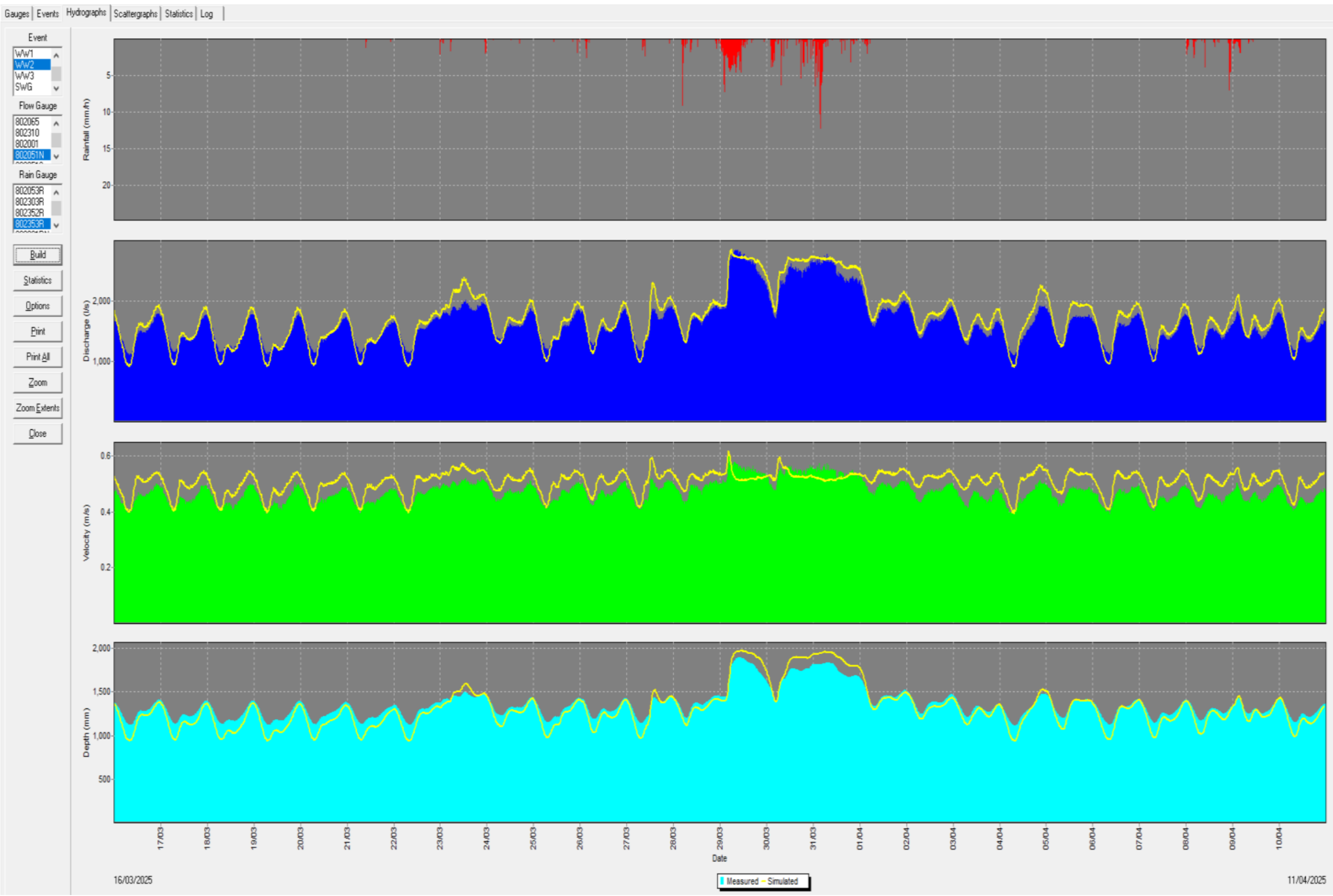
Depth

Peak measured depth (mm)	1670	Mean measured depth (mm)	729
Peak simulated depth (mm)	2003	Mean simulated depth (mm)	1413
Ratio	1.20	Ratio	1.94

Close

Due to Missing Gauge Data, the Statistics Average couldn't be evaluated.

802051N WW2



Event Statistics

Rainfall

Total measured depth (mm)	131.31	Peak measured intensity (mm/h)	23.52	Mean measured intensity (mm/h)	0.2103

Discharge

Total measured volume (cu.m)	707215.77	Peak measured flow (l/s)	2852.41	Mean measured flow (l/s)	1649.63
Total simulated volume (cu.m)	855451.77	Peak simulated flow (l/s)	2857.40	Mean simulated flow (l/s)	1718.35
Ratio	1.04	Ratio	1.00	Ratio	1.04

Velocity

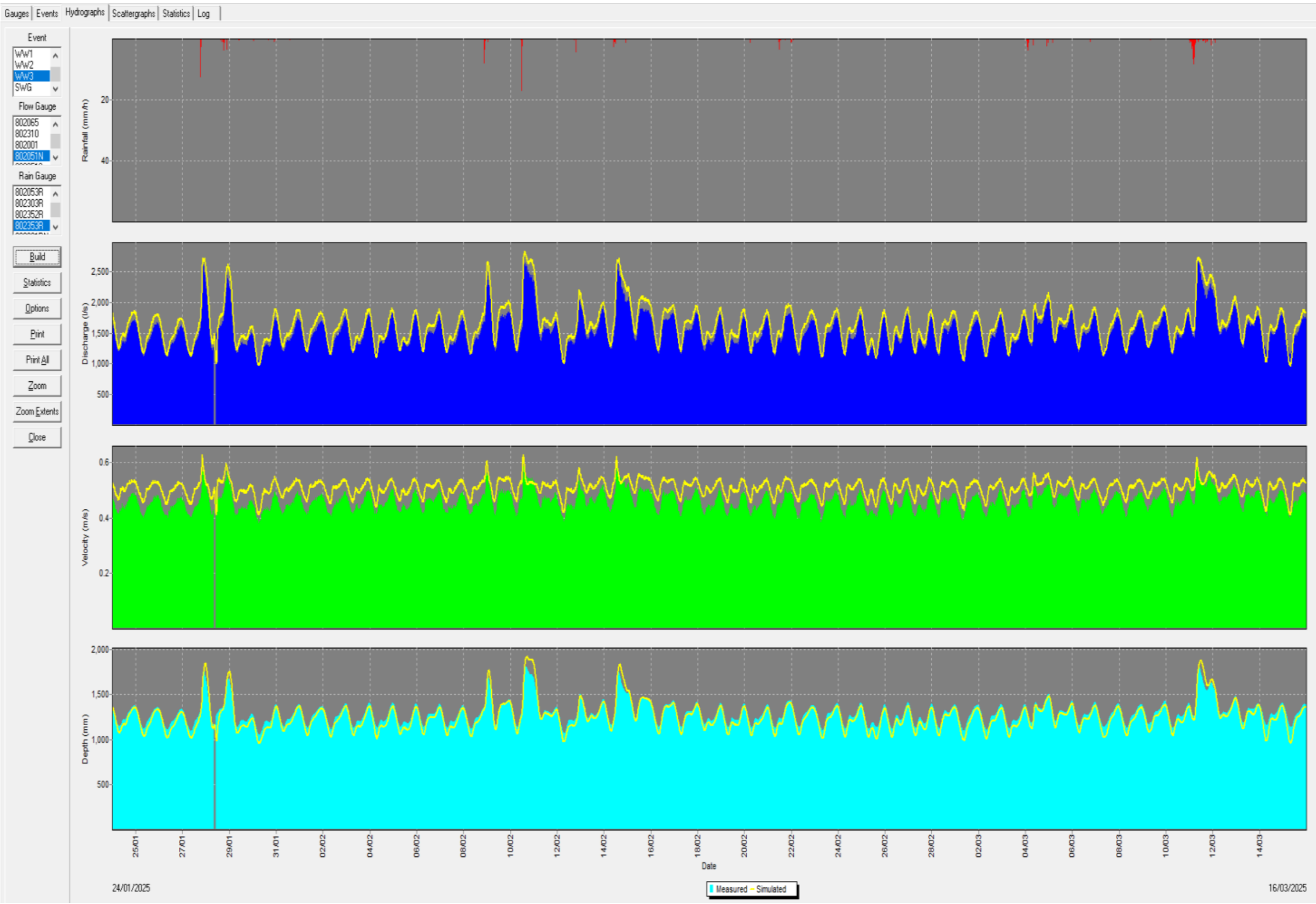
Peak measured velocity (m/s)	0.61	Mean measured velocity (m/s)	0.47
Peak simulated velocity (m/s)	0.62	Mean simulated velocity (m/s)	0.51
Ratio	1.02	Ratio	1.08

Depth

Peak measured depth (mm)	1894	Mean measured depth (mm)	1356
Peak simulated depth (mm)	1971	Mean simulated depth (mm)	1311
Ratio	1.04	Ratio	0.97

Close

802051N WW3



Event Statistics

Rainfall

Total measured depth (mm)	131.78	Peak measured intensity (mm/h)	57.24	Mean measured intensity (mm/h)	0.1076

Discharge

Total measured volume (cu.m)	748428.06	Peak measured flow (l/s)	2687.09	Mean measured flow (l/s)	1531.19
Total simulated volume (cu.m)	183678.32	Peak simulated flow (l/s)	2830.80	Mean simulated flow (l/s)	1630.95
Ratio	1.06	Ratio	1.05	Ratio	1.07

Velocity

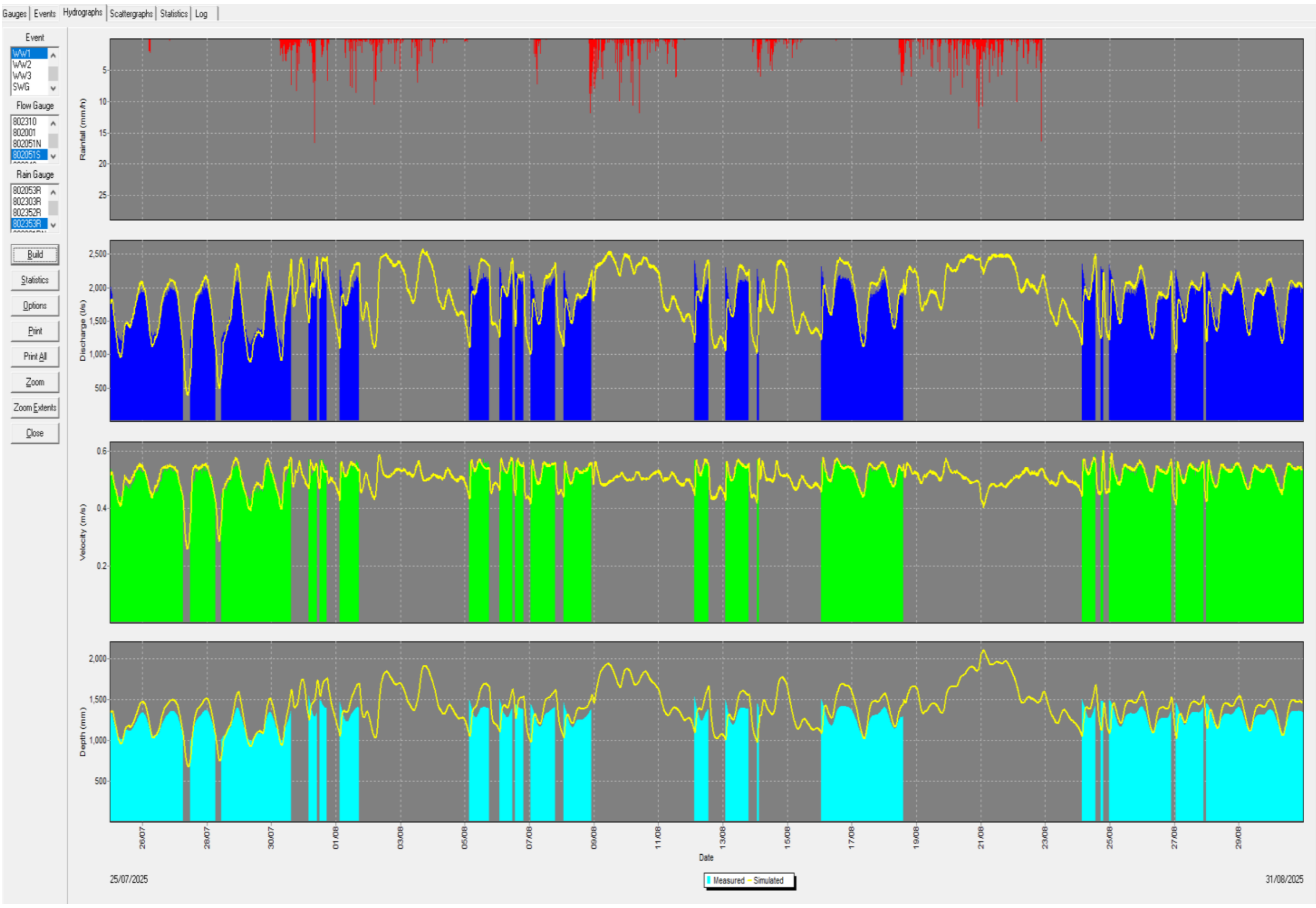
Peak measured velocity (m/s)	0.60	Mean measured velocity (m/s)	0.46
Peak simulated velocity (m/s)	0.63	Mean simulated velocity (m/s)	0.51
Ratio	1.04	Ratio	1.10

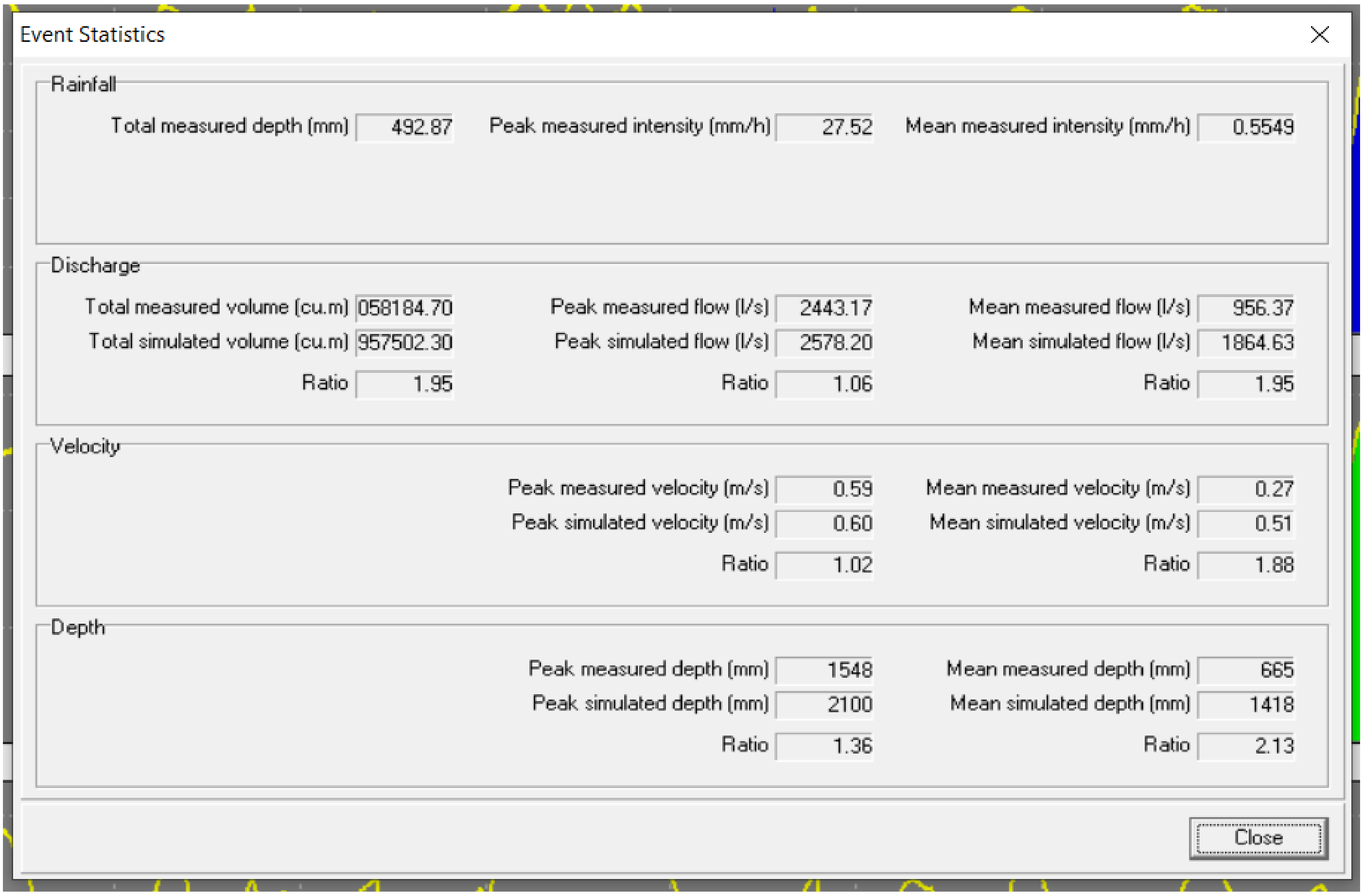
Depth

Peak measured depth (mm)	1807	Mean measured depth (mm)	1296
Peak simulated depth (mm)	1919	Mean simulated depth (mm)	1256
Ratio	1.06	Ratio	0.97

Close

802051S WW1





Event Statistics

Rainfall

Total measured depth (mm)	492.87	Peak measured intensity (mm/h)	27.52	Mean measured intensity (mm/h)	0.5549

Discharge

Total measured volume (cu.m)	058184.70	Peak measured flow (l/s)	2443.17	Mean measured flow (l/s)	956.37
Total simulated volume (cu.m)	957502.30	Peak simulated flow (l/s)	2578.20	Mean simulated flow (l/s)	1864.63
Ratio	1.95	Ratio	1.06	Ratio	1.95

Velocity

Peak measured velocity (m/s)	0.59	Mean measured velocity (m/s)	0.27
Peak simulated velocity (m/s)	0.60	Mean simulated velocity (m/s)	0.51
Ratio	1.02	Ratio	1.88

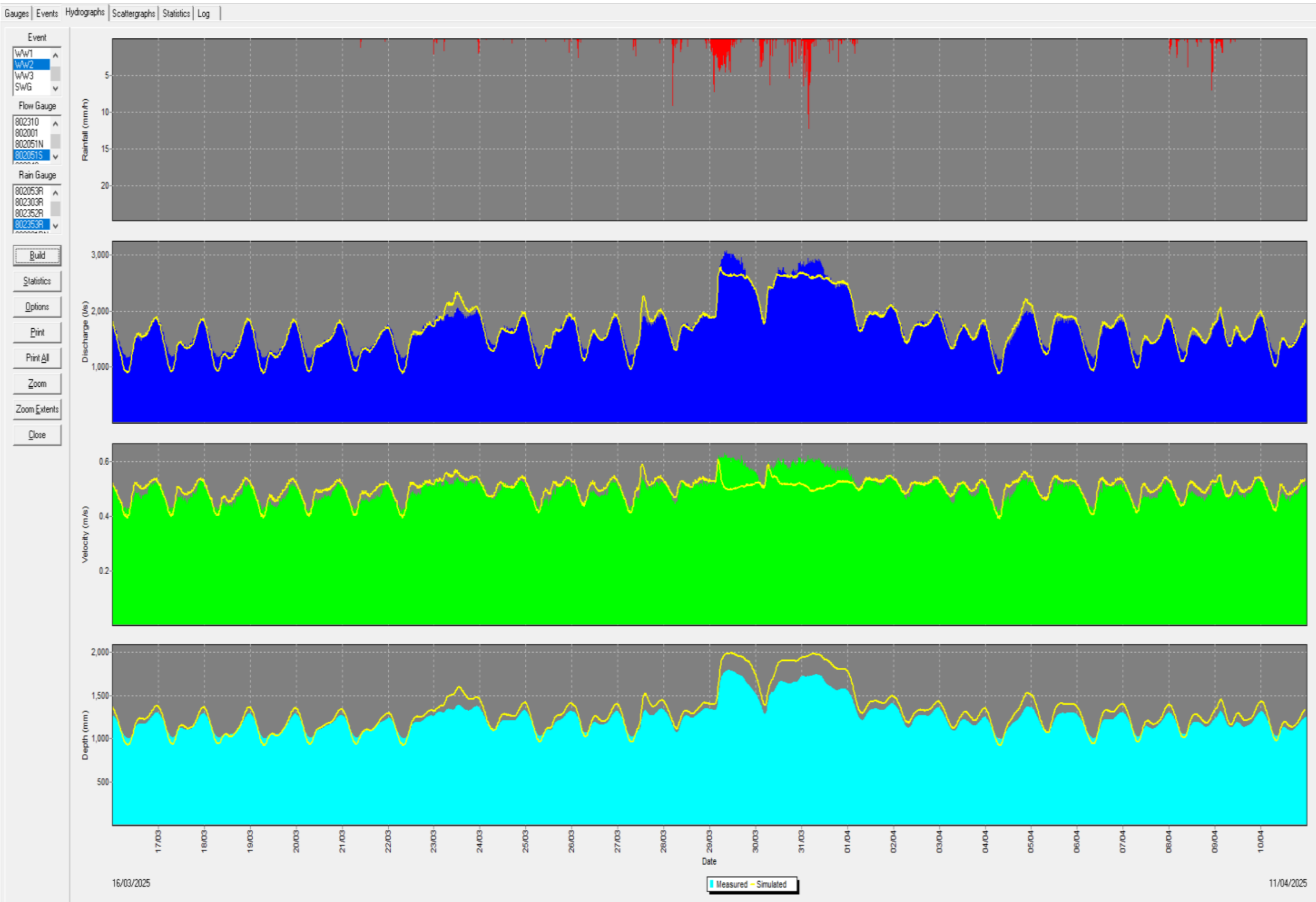
Depth

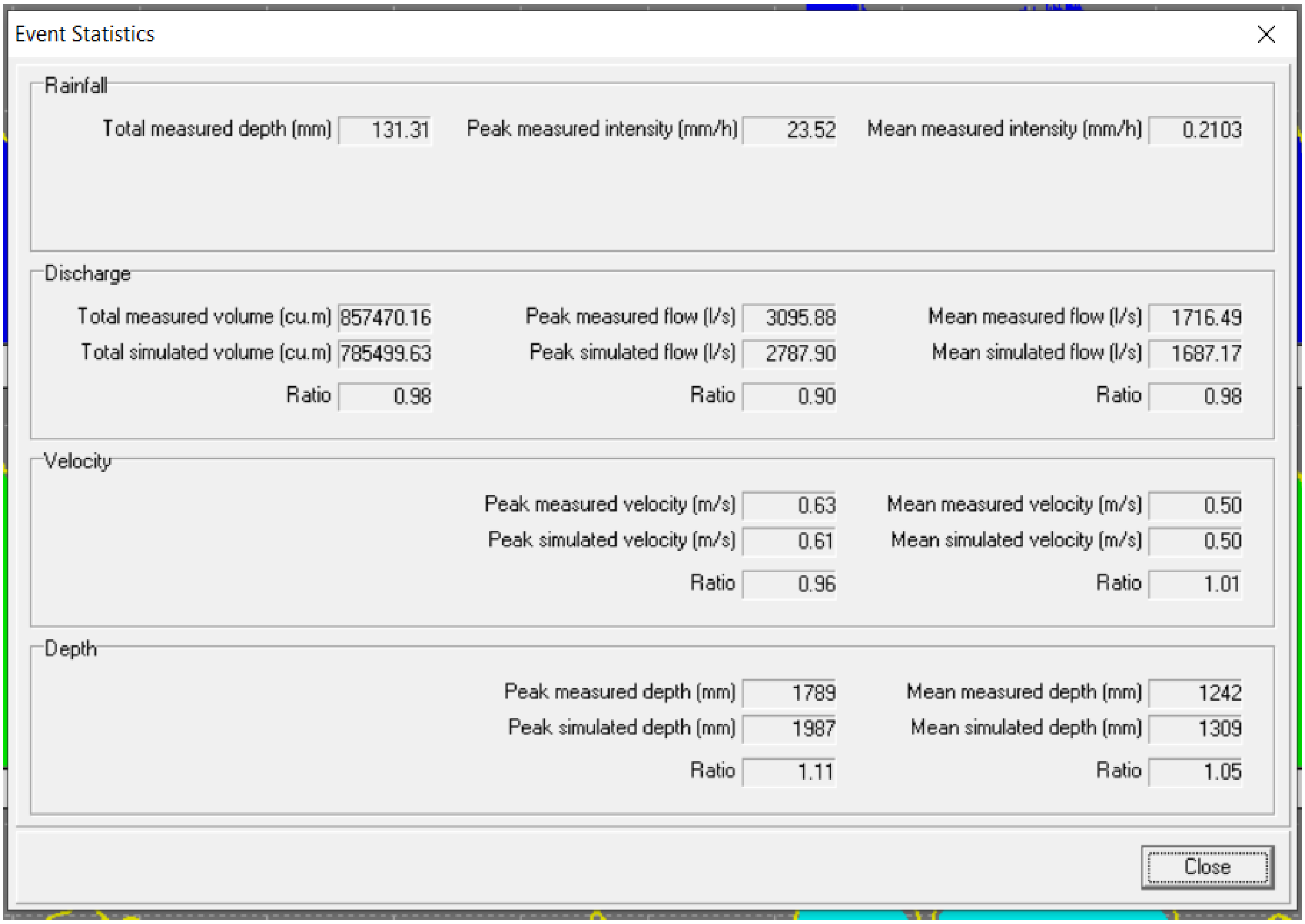
Peak measured depth (mm)	1548	Mean measured depth (mm)	665
Peak simulated depth (mm)	2100	Mean simulated depth (mm)	1418
Ratio	1.36	Ratio	2.13

Close

Due to Missing Gauge Data, the Statistics Average couldn’t be evaluated.

802051S WW2





Event Statistics

Rainfall

Total measured depth (mm)	131.31	Peak measured intensity (mm/h)	23.52	Mean measured intensity (mm/h)	0.2103

Discharge

Total measured volume (cu.m)	857470.16	Peak measured flow (l/s)	3095.88	Mean measured flow (l/s)	1716.49
Total simulated volume (cu.m)	785499.63	Peak simulated flow (l/s)	2787.90	Mean simulated flow (l/s)	1687.17
Ratio	0.98	Ratio	0.90	Ratio	0.98

Velocity

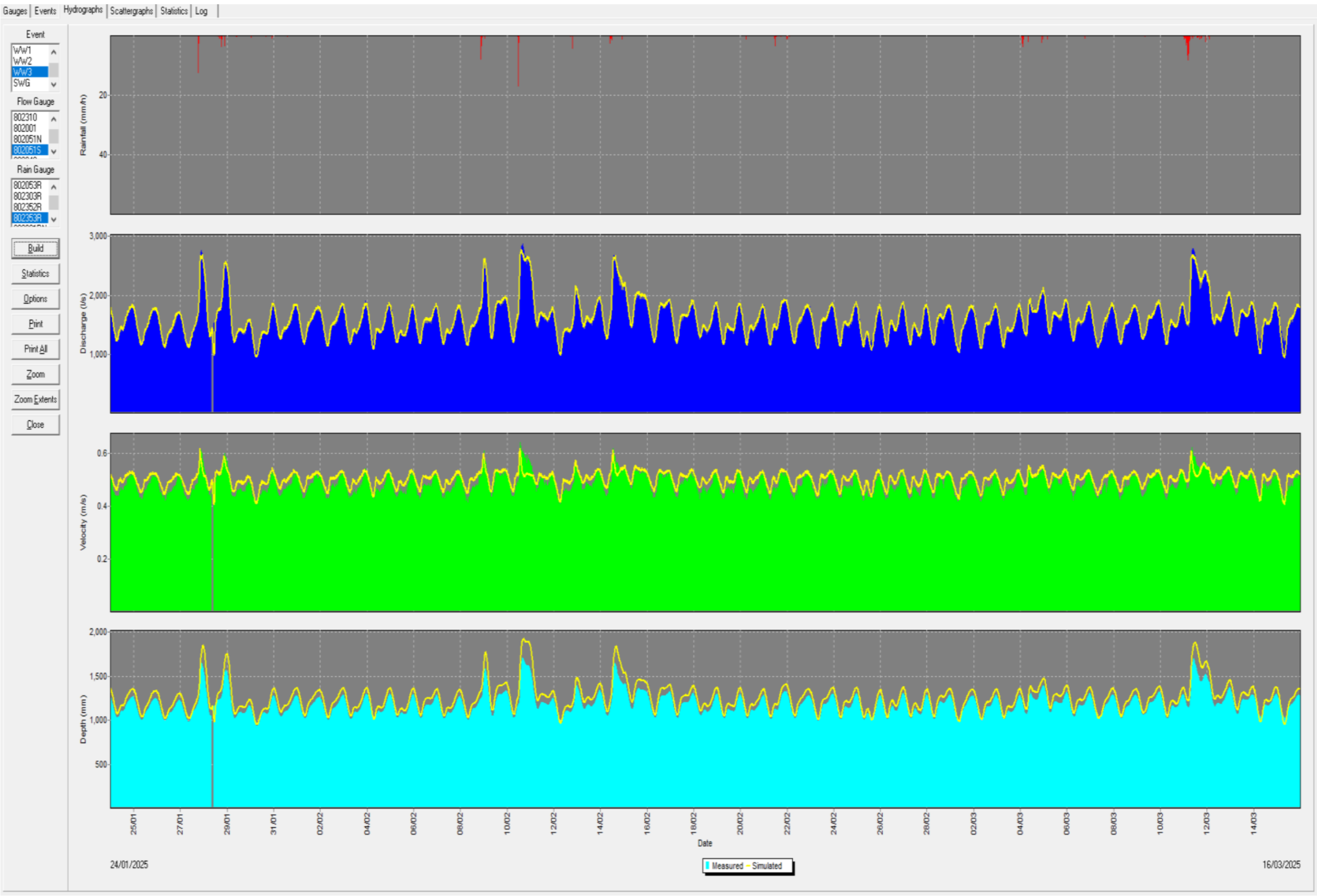
Peak measured velocity (m/s)	0.63	Mean measured velocity (l/s)	0.50
Peak simulated velocity (m/s)	0.61	Mean simulated velocity (m/s)	0.50
Ratio	0.96	Ratio	1.01

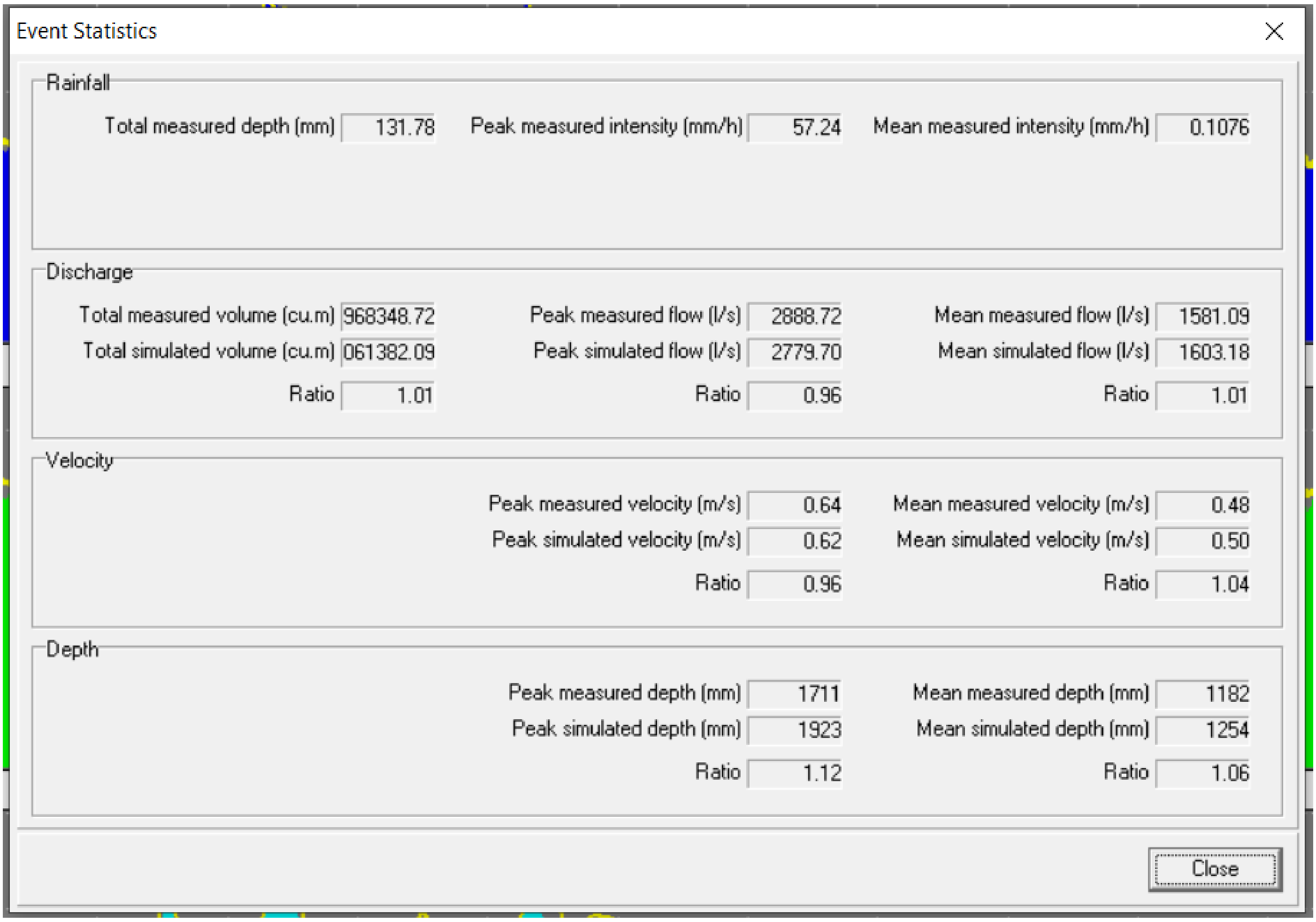
Depth

Peak measured depth (mm)	1789	Mean measured depth (mm)	1242
Peak simulated depth (mm)	1987	Mean simulated depth (mm)	1309
Ratio	1.11	Ratio	1.05

Close

802051S WW3





Event Statistics

Rainfall

Total measured depth (mm)	131.78	Peak measured intensity (mm/h)	57.24	Mean measured intensity (mm/h)	0.1076

Discharge

Total measured volume (cu.m)	968348.72	Peak measured flow (l/s)	2888.72	Mean measured flow (l/s)	1581.09
Total simulated volume (cu.m)	061382.09	Peak simulated flow (l/s)	2779.70	Mean simulated flow (l/s)	1603.18
Ratio	1.01	Ratio	0.96	Ratio	1.01

Velocity

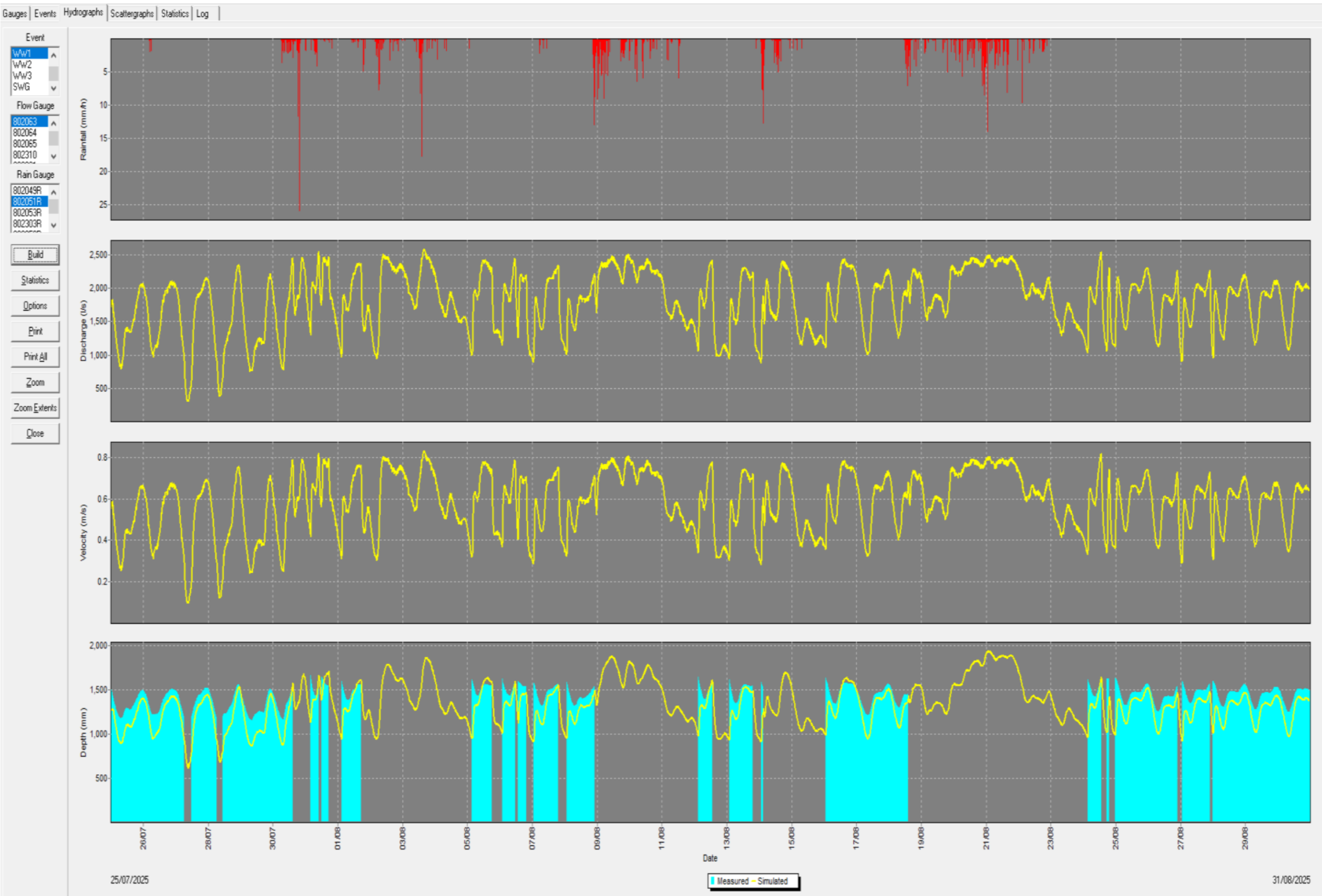
Peak measured velocity (m/s)	0.64	Mean measured velocity (m/s)	0.48
Peak simulated velocity (m/s)	0.62	Mean simulated velocity (m/s)	0.50
Ratio	0.96	Ratio	1.04

Depth

Peak measured depth (mm)	1711	Mean measured depth (mm)	1182
Peak simulated depth (mm)	1923	Mean simulated depth (mm)	1254
Ratio	1.12	Ratio	1.06

Close

802063 WW1



Event Statistics

Rainfall

Total measured depth (mm)	357.97	Peak measured intensity (mm/h)	26.04	Mean measured intensity (mm/h)	0.4030

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	788250.91	Peak simulated flow (l/s)	2589.30	Mean simulated flow (l/s)	1811.66
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

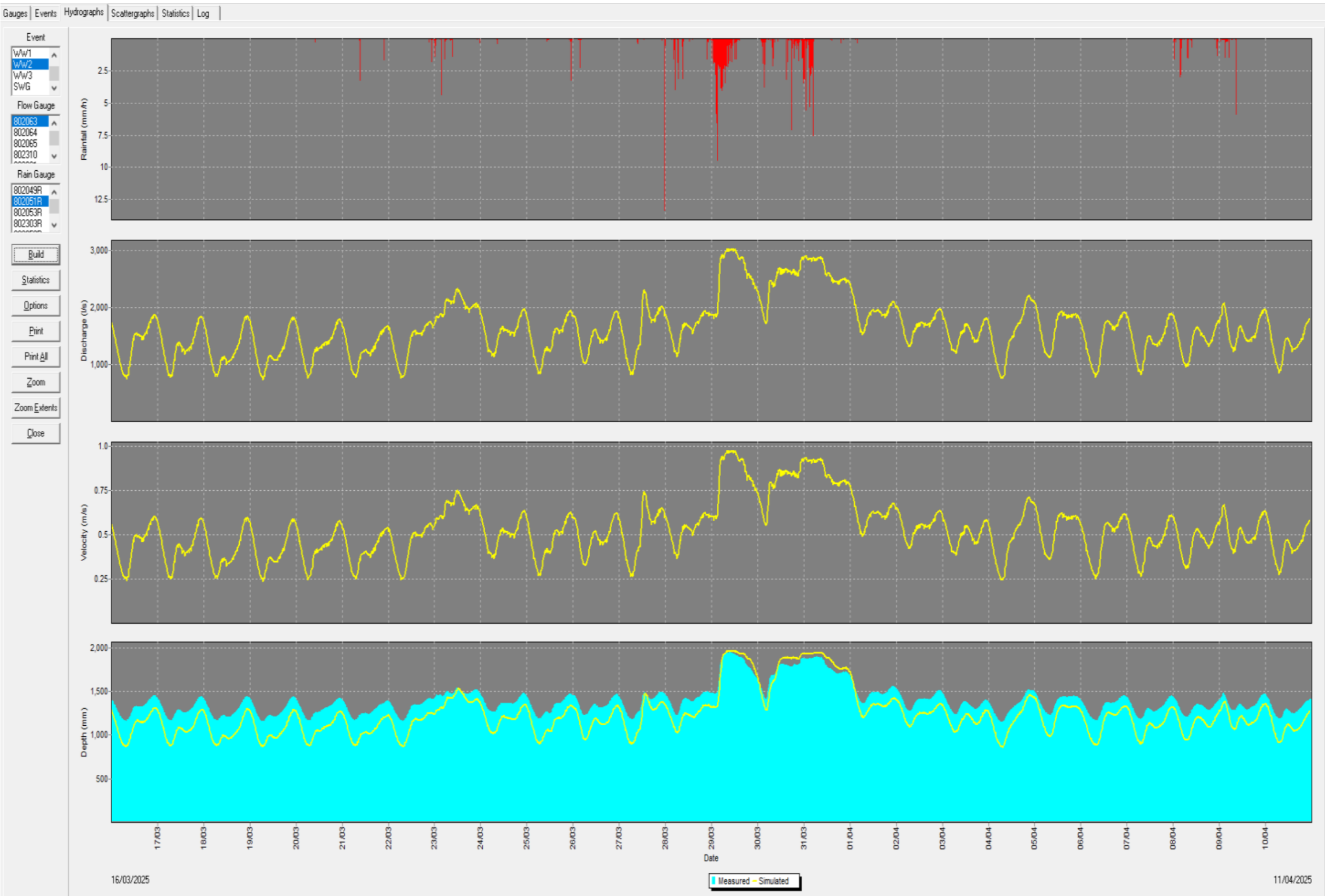
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.83	Mean simulated velocity (m/s)	0.58
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1669	Mean measured depth (mm)	747
Peak simulated depth (mm)	1941	Mean simulated depth (mm)	1336
Ratio	1.16	Ratio	1.79

Close

802063 WW2



Event Statistics

Rainfall

Total measured depth (mm)	89.02	Peak measured intensity (mm/h)	13.40	Mean measured intensity (mm/h)	0.1426

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	680562.42	Peak simulated flow (l/s)	3031.40	Mean simulated flow (l/s)	1640.40
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

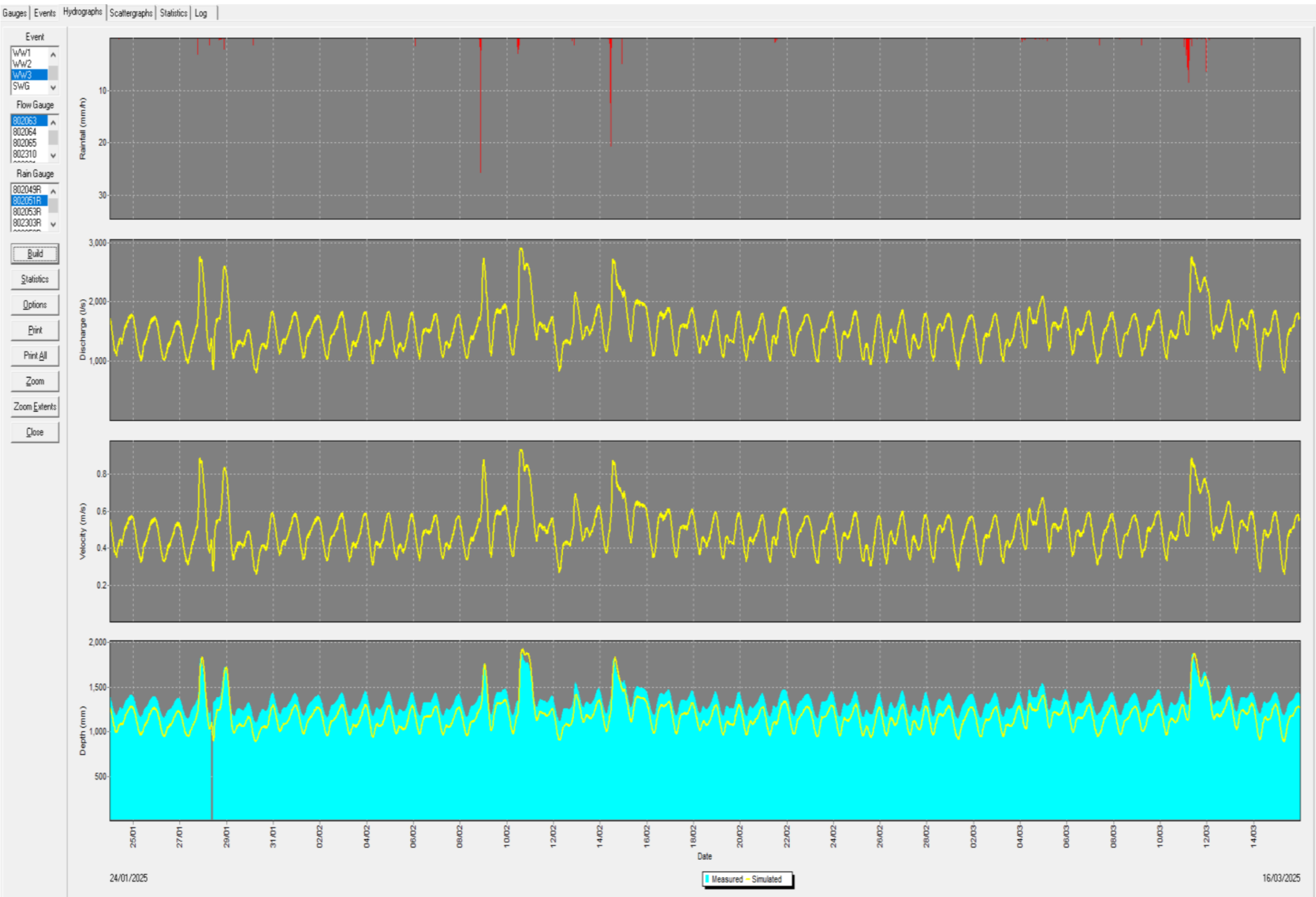
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.97	Mean simulated velocity (m/s)	0.53
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1952	Mean measured depth (mm)	1397
Peak simulated depth (mm)	1969	Mean simulated depth (mm)	1239
Ratio	1.01	Ratio	0.89

Close

802603 WW3



Event Statistics

Rainfall

Total measured depth (mm)		Peak measured intensity (mm/h)		Mean measured intensity (mm/h)	
	105.46		32.88		0.0861

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	786565.56	Peak simulated flow (l/s)	2907.40	Mean simulated flow (l/s)	1540.79
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

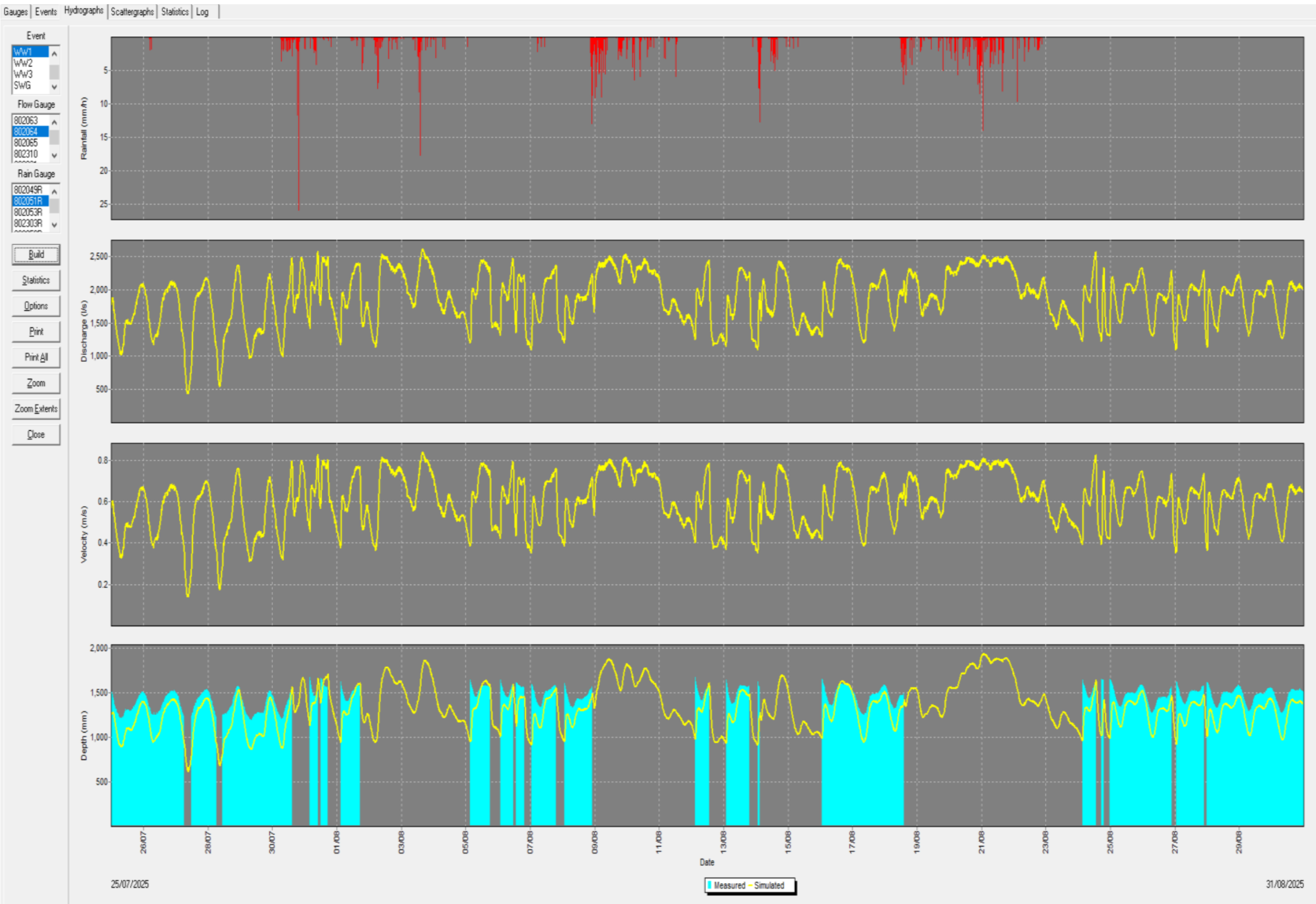
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.93	Mean simulated velocity (m/s)	0.50
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1879	Mean measured depth (mm)	1338
Peak simulated depth (mm)	1926	Mean simulated depth (mm)	1179
Ratio	1.03	Ratio	0.88

Close

802064 WW1



Event Statistics

Rainfall

Total measured depth (mm)	357.97	Peak measured intensity (mm/h)	26.04	Mean measured intensity (mm/h)	0.4030

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	001234.38	Peak simulated flow (l/s)	2616.30	Mean simulated flow (l/s)	1878.32
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

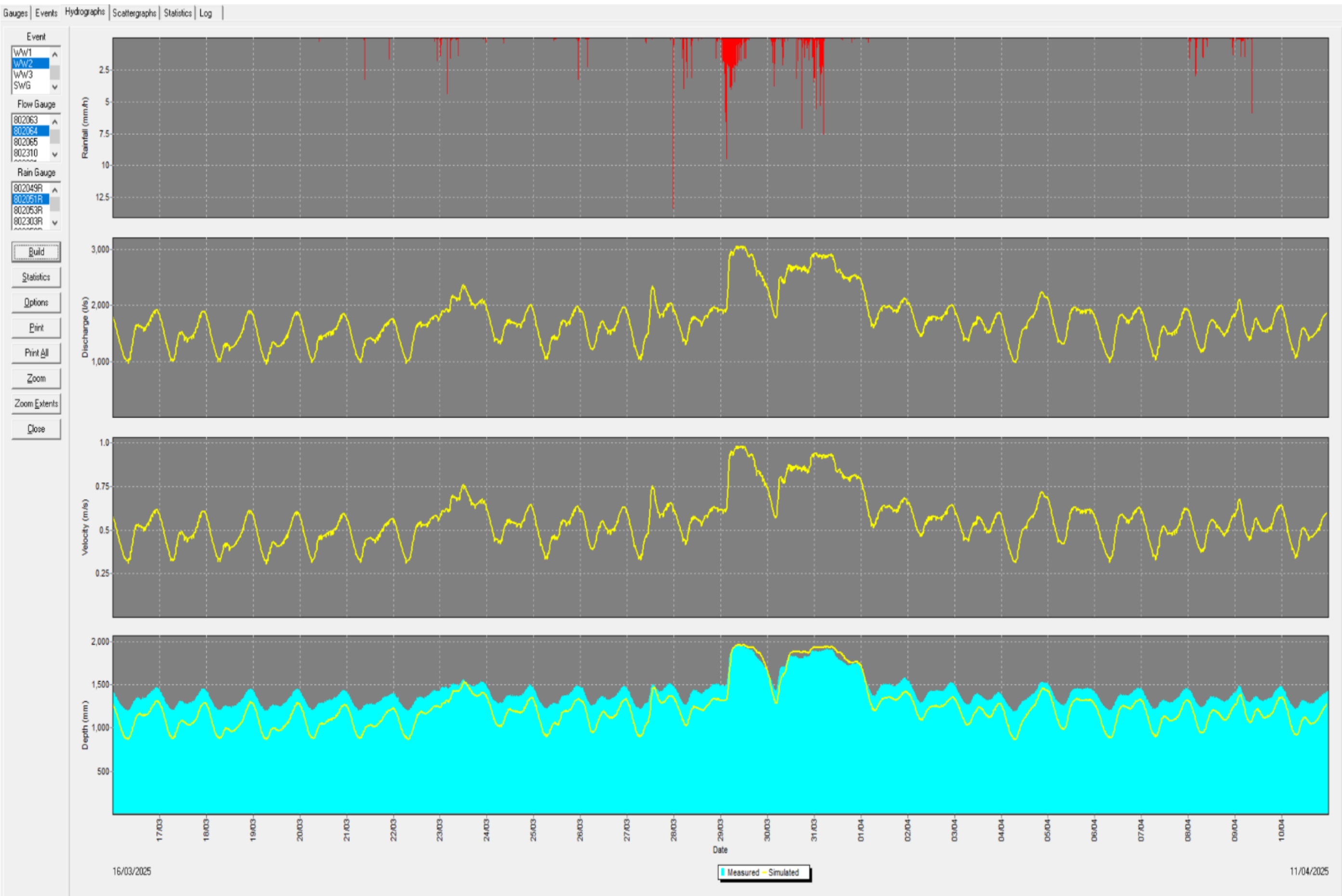
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.84	Mean simulated velocity (m/s)	0.60
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1683	Mean measured depth (mm)	757
Peak simulated depth (mm)	1938	Mean simulated depth (mm)	1333
Ratio	1.15	Ratio	1.76

Close

802064 WW2



Event Statistics

Rainfall

Total measured depth (mm)	89.02	Peak measured intensity (mm/h)	13.40	Mean measured intensity (mm/h)	0.1426

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	897460.98	Peak simulated flow (l/s)	3052.00	Mean simulated flow (l/s)	1737.07
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

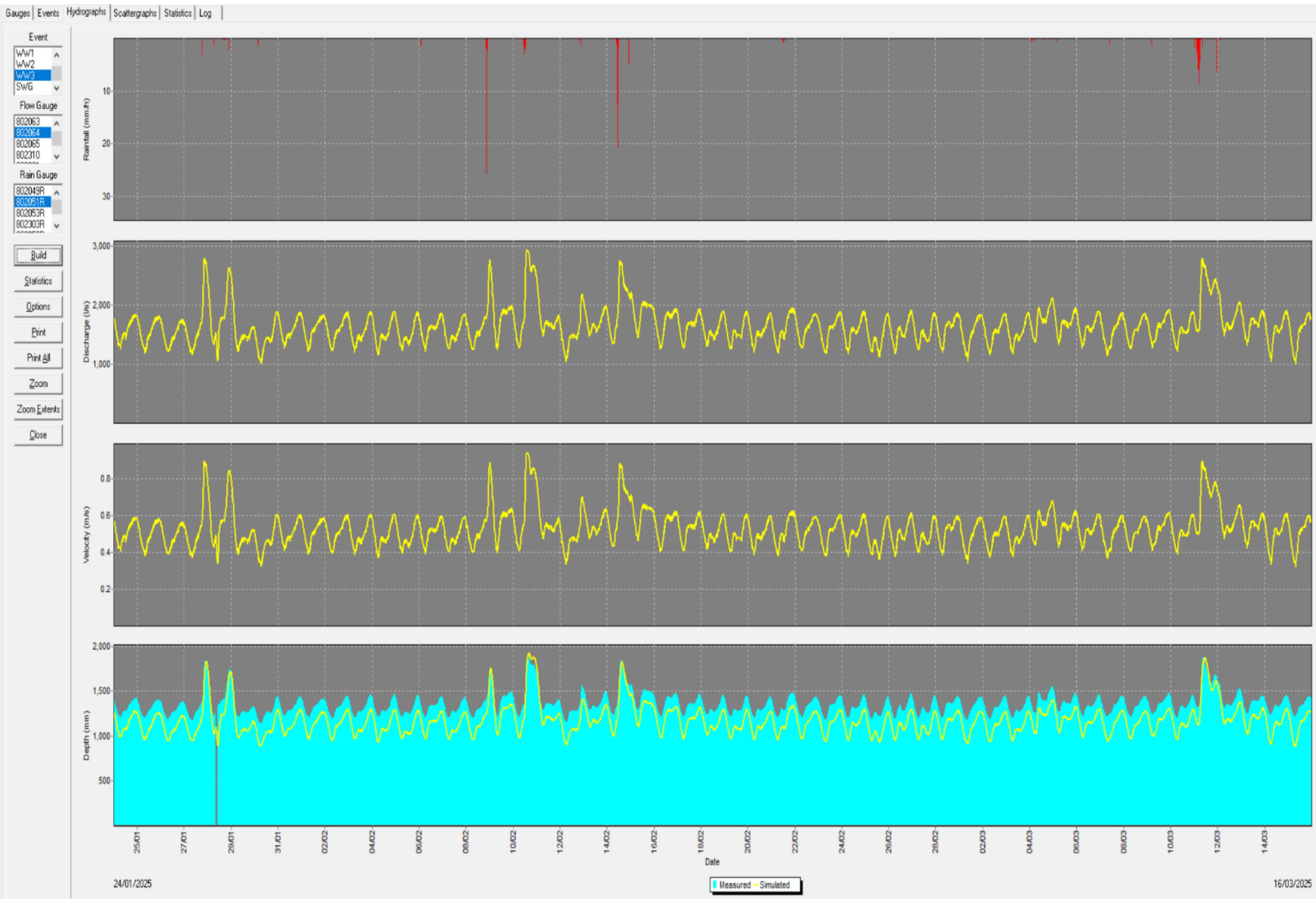
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.98	Mean simulated velocity (m/s)	0.56
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1966	Mean measured depth (mm)	1413
Peak simulated depth (mm)	1964	Mean simulated depth (mm)	1235
Ratio	1.00	Ratio	0.87

Close

802064 WW3



Event Statistics

Rainfall

Total measured depth (mm)	105.46	Peak measured intensity (mm/h)	32.88	Mean measured intensity (mm/h)	0.0861

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	253445.24	Peak simulated flow (l/s)	2938.20	Mean simulated flow (l/s)	1646.79
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

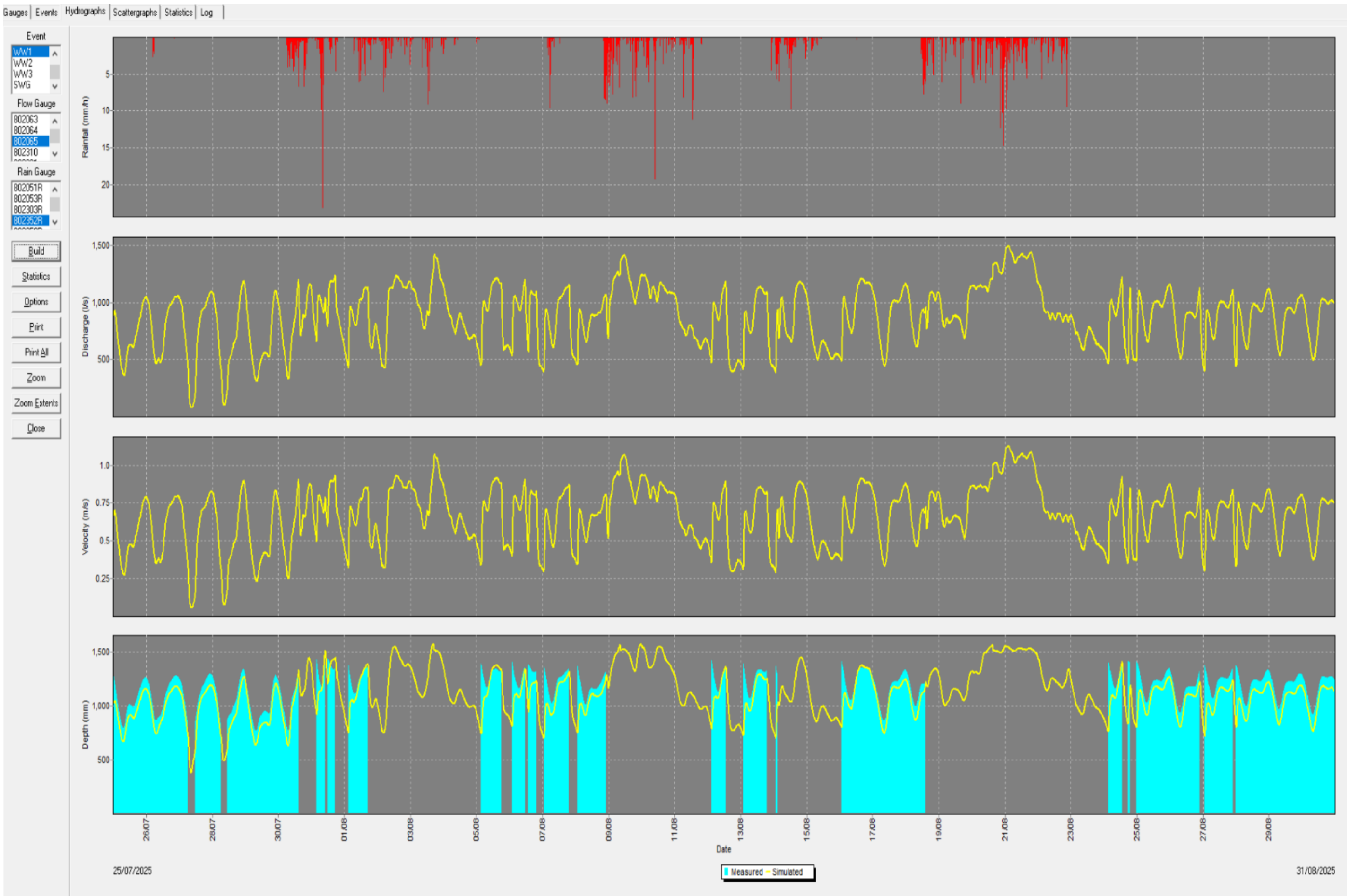
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.94	Mean simulated velocity (m/s)	0.53
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1889	Mean measured depth (mm)	1356
Peak simulated depth (mm)	1921	Mean simulated depth (mm)	1176
Ratio	1.02	Ratio	0.87

Close

802065 WW1



Event Statistics

Rainfall

Total measured depth (mm)	485.82	Peak measured intensity (mm/h)	23.20	Mean measured intensity (mm/h)	0.5469

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	824306.02	Peak simulated flow (l/s)	1501.80	Mean simulated flow (l/s)	883.98
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

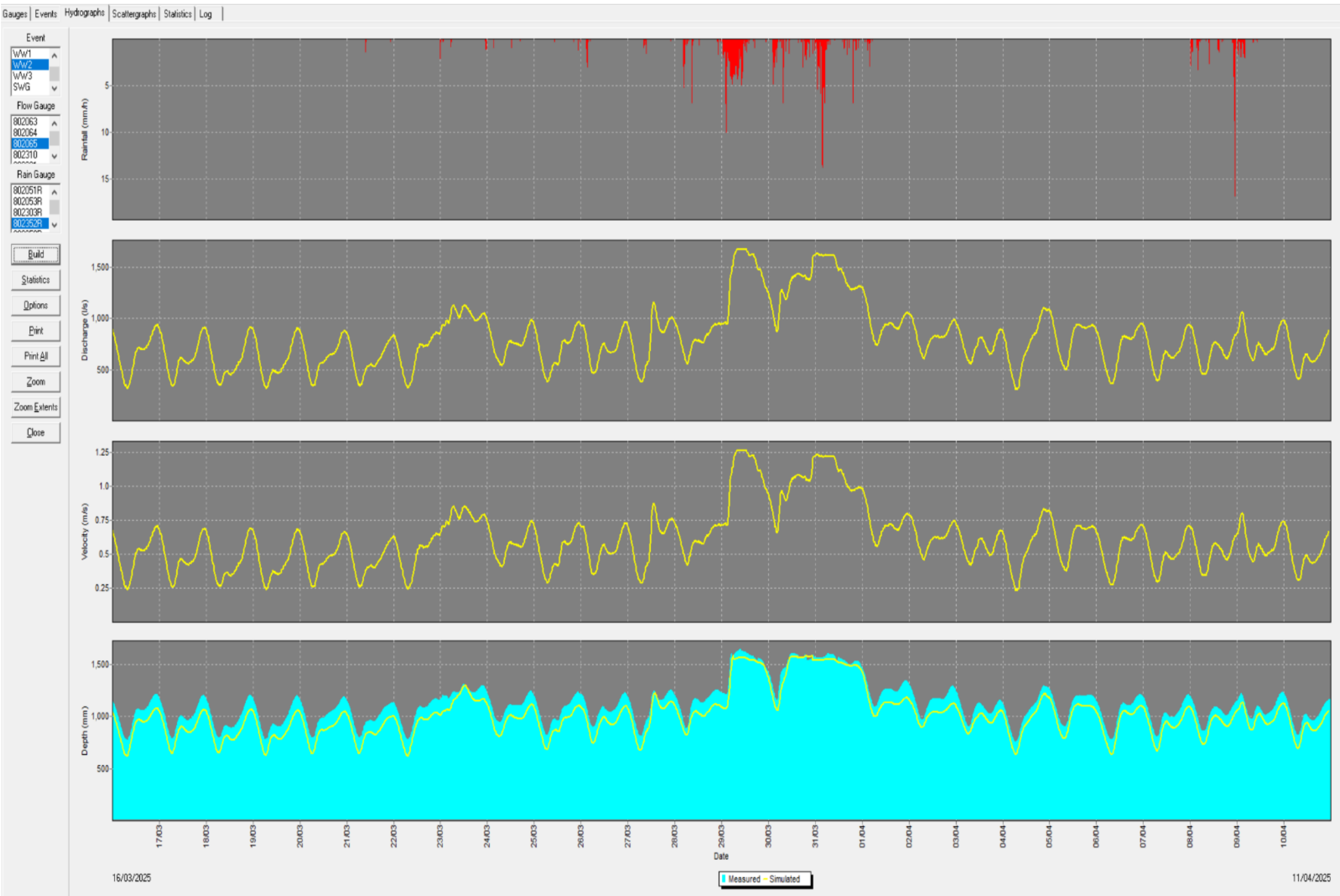
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	1.13	Mean simulated velocity (m/s)	0.67
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1446	Mean measured depth (mm)	613
Peak simulated depth (mm)	1573	Mean simulated depth (mm)	1114
Ratio	1.09	Ratio	1.82

Close

802065 WW2



Event Statistics

Rainfall

Total measured depth (mm)	133.87	Peak measured intensity (mm/h)	18.48	Mean measured intensity (mm/h)	0.2144

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	813994.46	Peak simulated flow (l/s)	1682.90	Mean simulated flow (l/s)	808.48
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

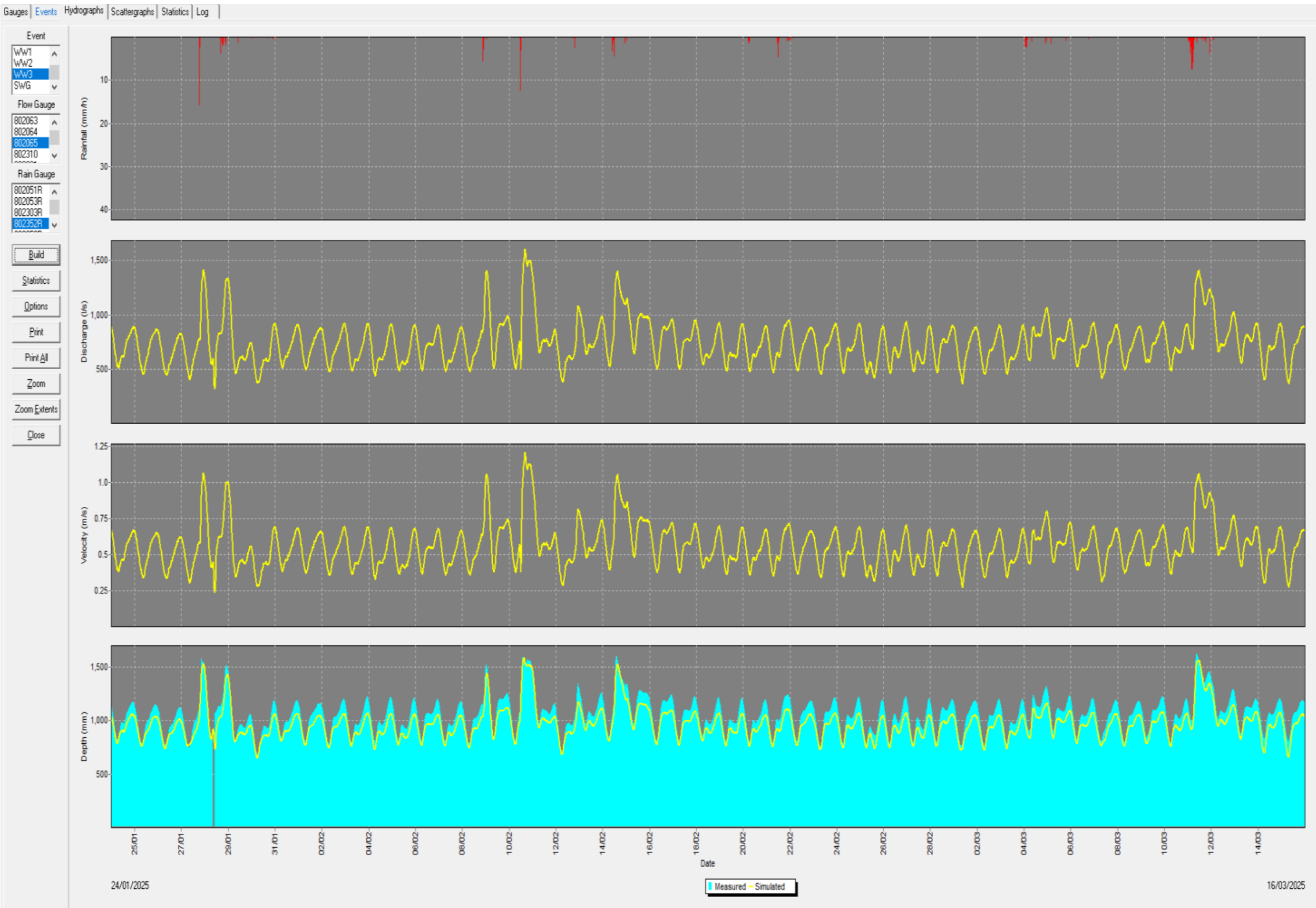
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	1.27	Mean simulated velocity (m/s)	0.61
Ratio	Undefined	Ratio	Undefined

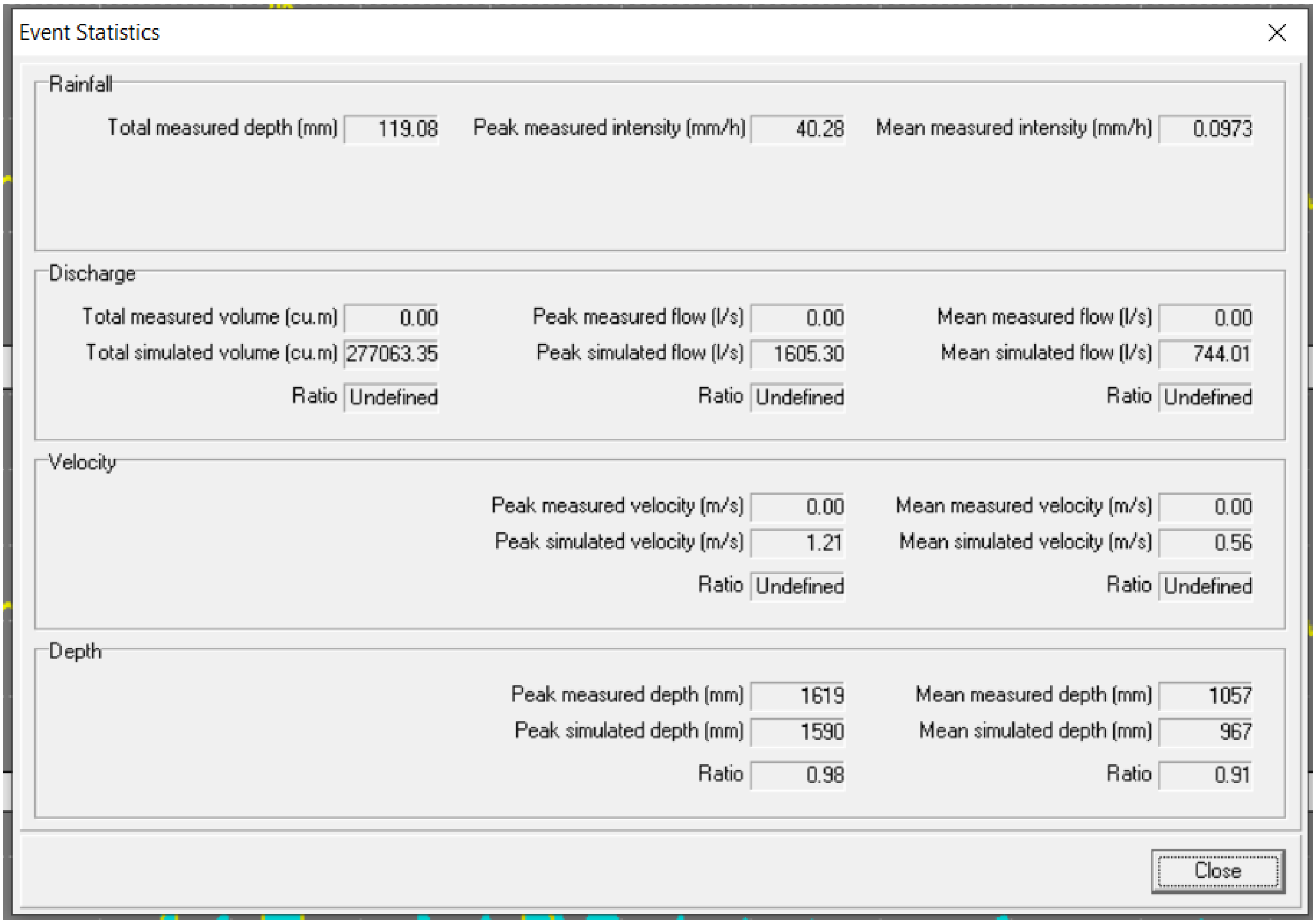
Depth

Peak measured depth (mm)	1642	Mean measured depth (mm)	1121
Peak simulated depth (mm)	1587	Mean simulated depth (mm)	1012
Ratio	0.97	Ratio	0.90

Close

802065 WW3





Event Statistics

Rainfall

Total measured depth (mm)	119.08	Peak measured intensity (mm/h)	40.28	Mean measured intensity (mm/h)	0.0973

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	277063.35	Peak simulated flow (l/s)	1605.30	Mean simulated flow (l/s)	744.01
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

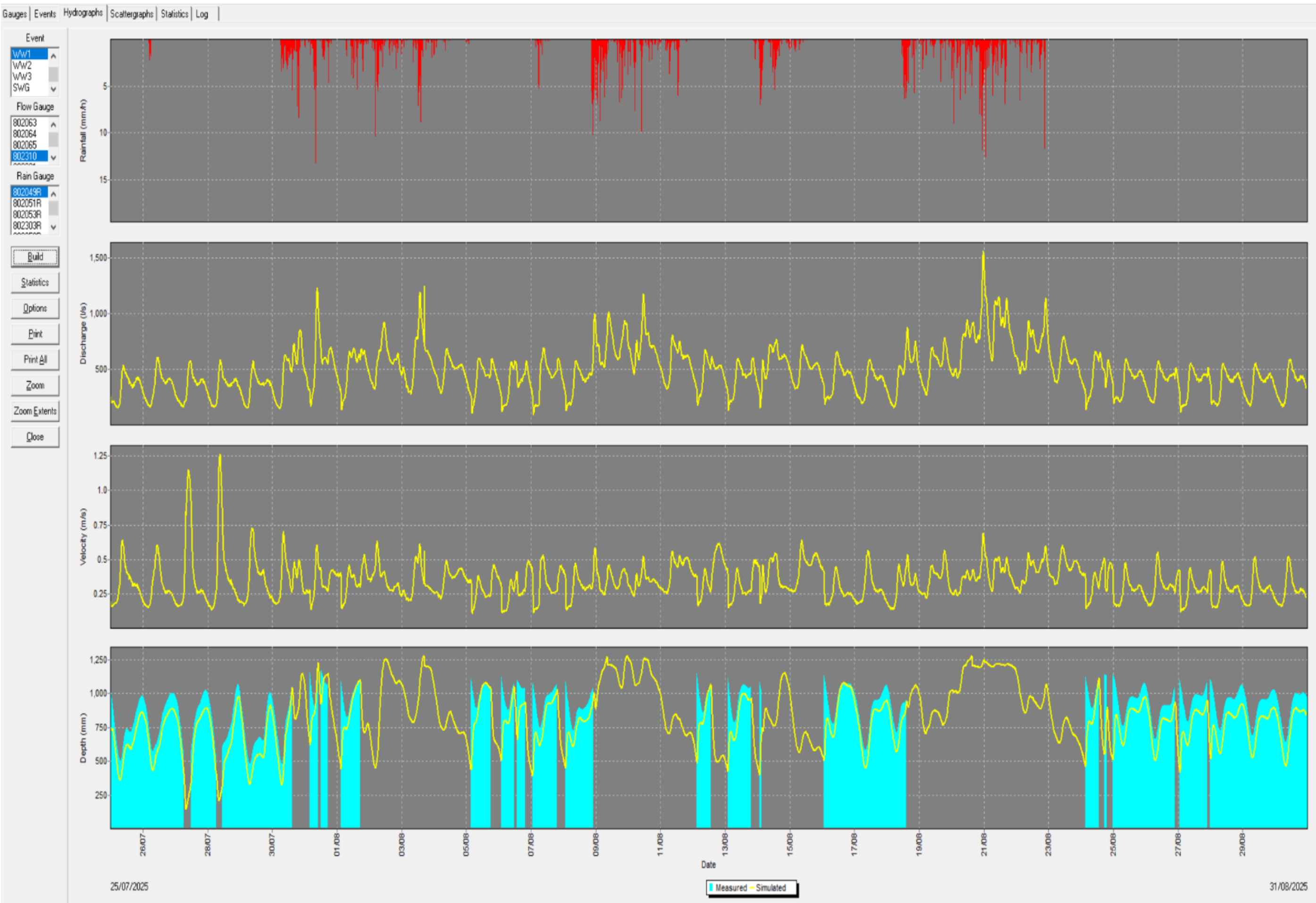
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	1.21	Mean simulated velocity (m/s)	0.56
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1619	Mean measured depth (mm)	1057
Peak simulated depth (mm)	1590	Mean simulated depth (mm)	967
Ratio	0.98	Ratio	0.91

Close

802310 WW1



Event Statistics

Rainfall

Total measured depth (mm)	443.13	Peak measured intensity (mm/h)	18.60	Mean measured intensity (mm/h)	0.4989

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	567630.08	Peak simulated flow (l/s)	1561.10	Mean simulated flow (l/s)	490.65
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

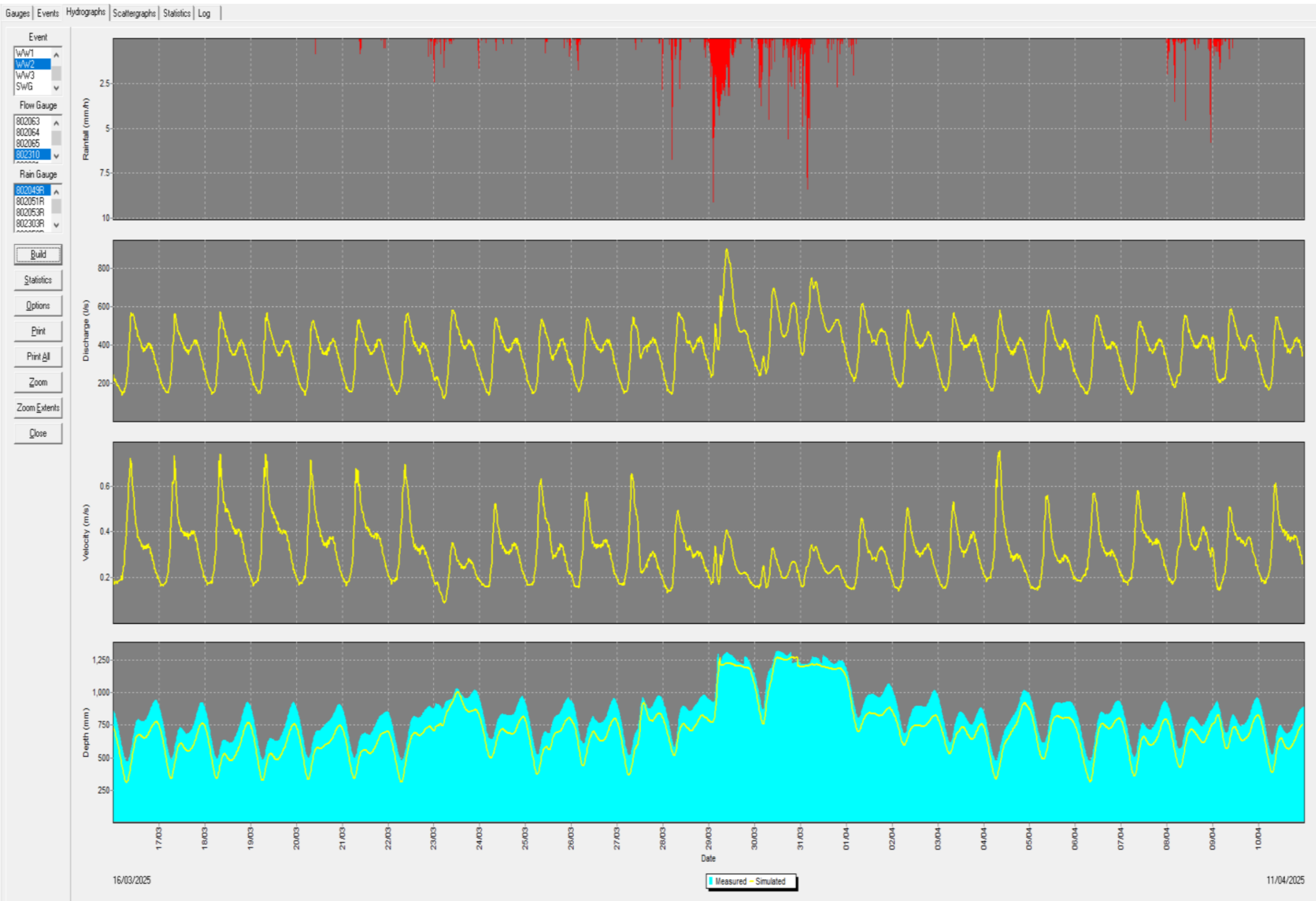
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	1.26	Mean simulated velocity (m/s)	0.34
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1180	Mean measured depth (mm)	470
Peak simulated depth (mm)	1278	Mean simulated depth (mm)	822
Ratio	1.08	Ratio	1.75

Close

802310 WW2



Event Statistics

Rainfall

Total measured depth (mm)	115.83	Peak measured intensity (mm/h)	9.60	Mean measured intensity (mm/h)	0.1856

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	837591.30	Peak simulated flow (l/s)	903.30	Mean simulated flow (l/s)	373.31
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

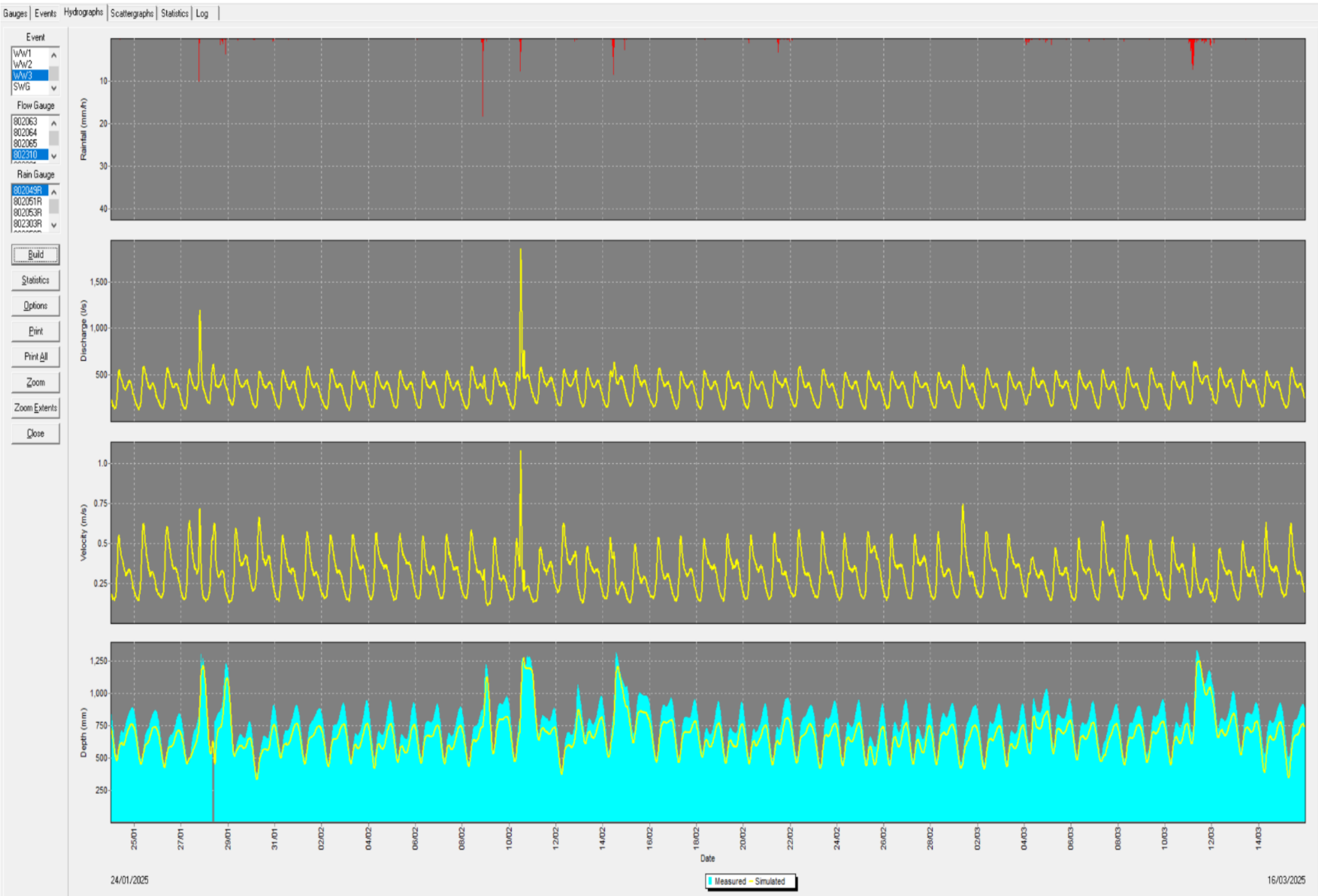
Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	0.75	Mean simulated velocity (m/s)	0.31
Ratio	Undefined	Ratio	Undefined

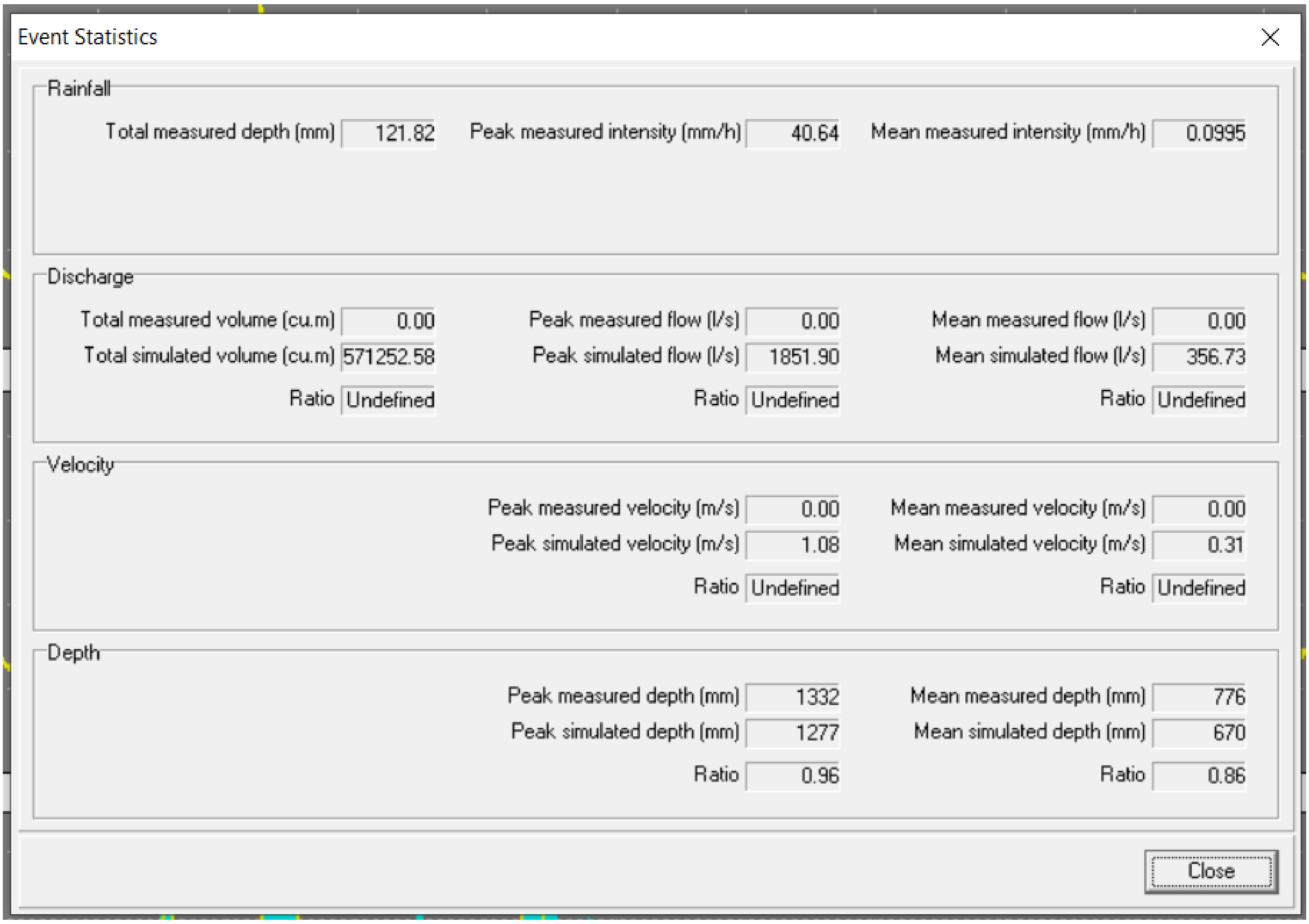
Depth

Peak measured depth (mm)	1322	Mean measured depth (mm)	839
Peak simulated depth (mm)	1278	Mean simulated depth (mm)	714
Ratio	0.97	Ratio	0.85

Close

802310 WW3





Event Statistics

Rainfall

Total measured depth (mm)	121.82
Peak measured intensity (mm/h)	40.64
Mean measured intensity (mm/h)	0.0995

Discharge

Total measured volume (cu.m)	0.00	Peak measured flow (l/s)	0.00	Mean measured flow (l/s)	0.00
Total simulated volume (cu.m)	571252.58	Peak simulated flow (l/s)	1851.90	Mean simulated flow (l/s)	356.73
Ratio	Undefined	Ratio	Undefined	Ratio	Undefined

Velocity

Peak measured velocity (m/s)	0.00	Mean measured velocity (m/s)	0.00
Peak simulated velocity (m/s)	1.08	Mean simulated velocity (m/s)	0.31
Ratio	Undefined	Ratio	Undefined

Depth

Peak measured depth (mm)	1332	Mean measured depth (mm)	776
Peak simulated depth (mm)	1277	Mean simulated depth (mm)	670
Ratio	0.96	Ratio	0.86

Close

Attachment 4 Bias Test (SWAGMAN) Analysis

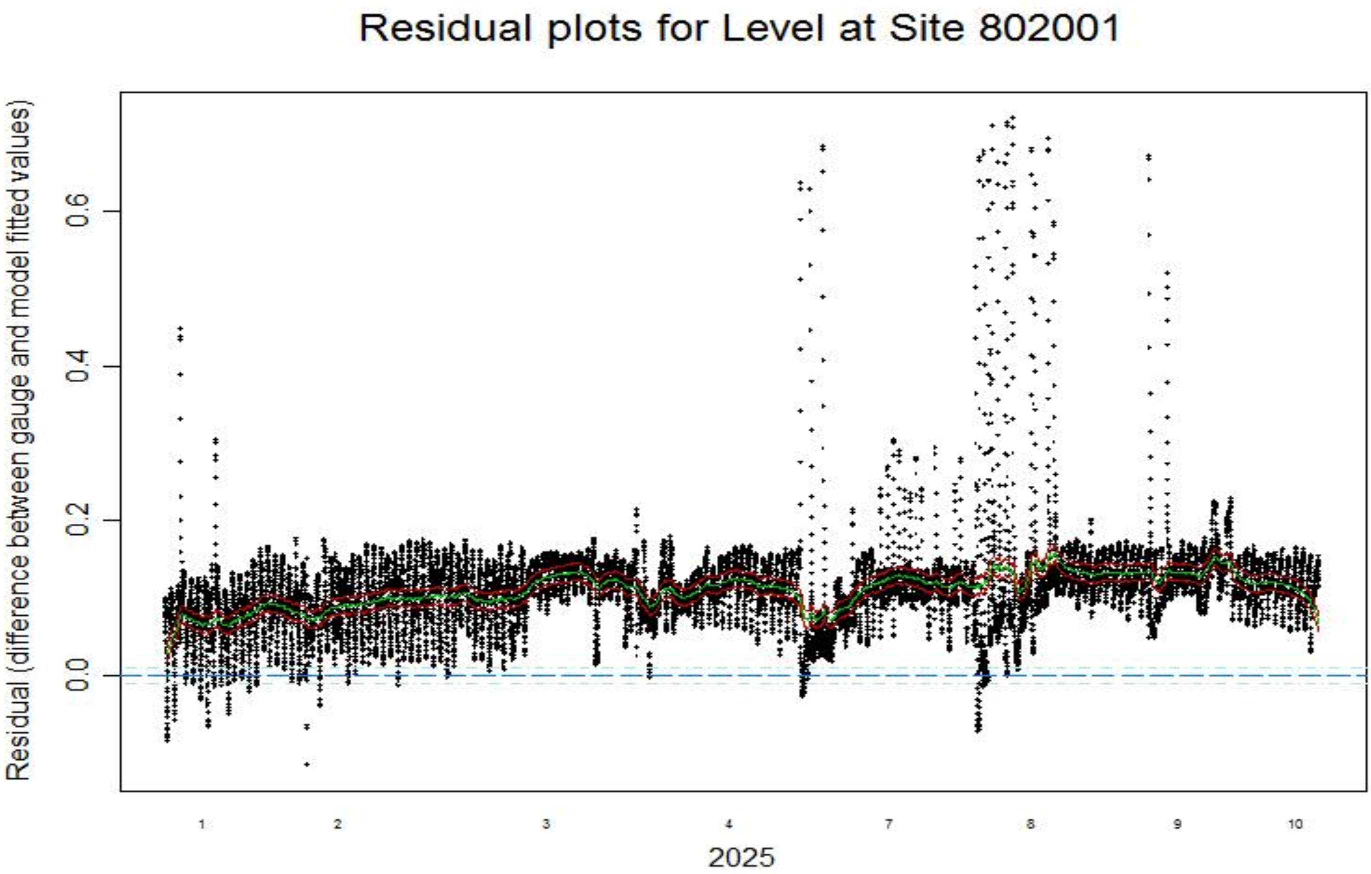
Level Report for Station 802001

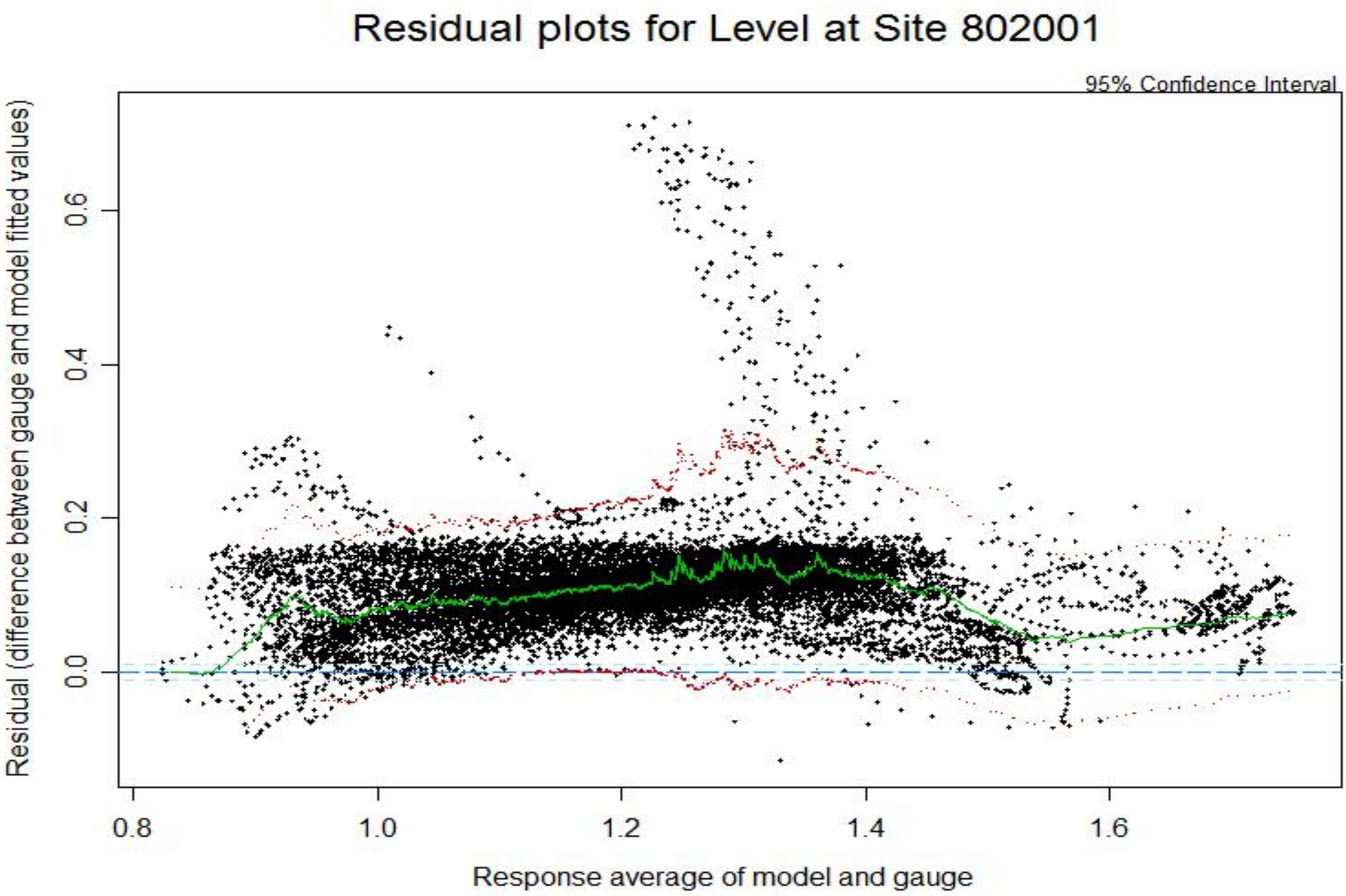
Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802001L.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802001L.txt (32925 observations)

15672 observations in matched dataset.

Criteria Values for assessing model performance
===

	all observations	specified region (1.1958 to 1.4093)
MSE	0.0158	0.0148
R abs	0.14	-1.26
R squared	0.87	0.76
R sq (lag gauge)	0.86	
R sq (lag model)	0.88	
adjusted R sq	0.40	-3.07
adjusted R sq (lag gauge)	0.39	
adjusted R sq (lag model)	0.41	


Residual plots for Level at Site 802001
Residual (difference between gauge and model fitted values)
0.0
0.2
0.4
0.6
1
2
3
4
7
8
9
10
2025


Residual plots for Level at Site 802001
95% Confidence Interval
Residual (difference between gauge and model fitted values)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Response average of model and gauge

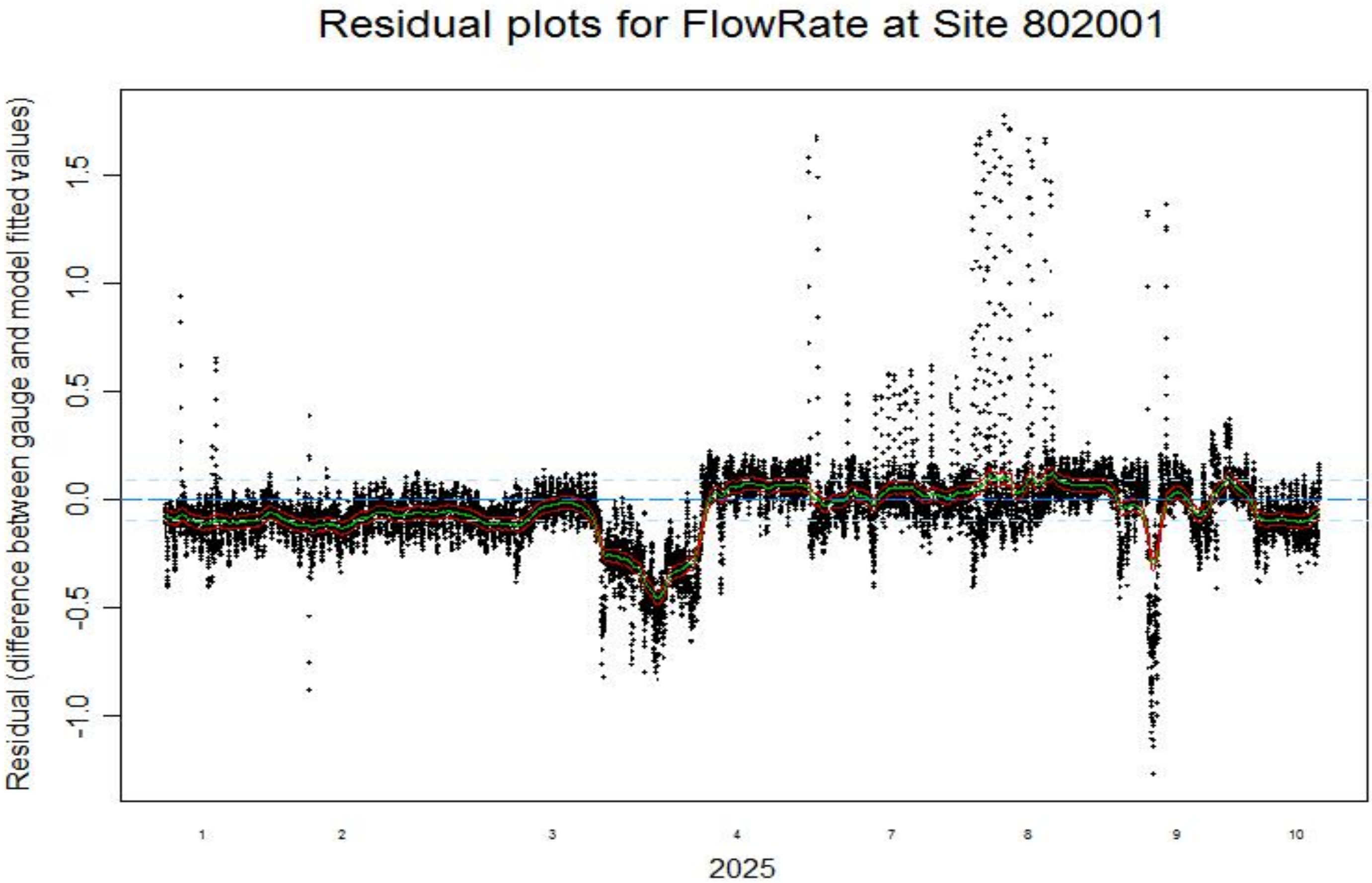
Flow Report for Station 802001

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802001Q.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802001Q.txt (32925 observations)

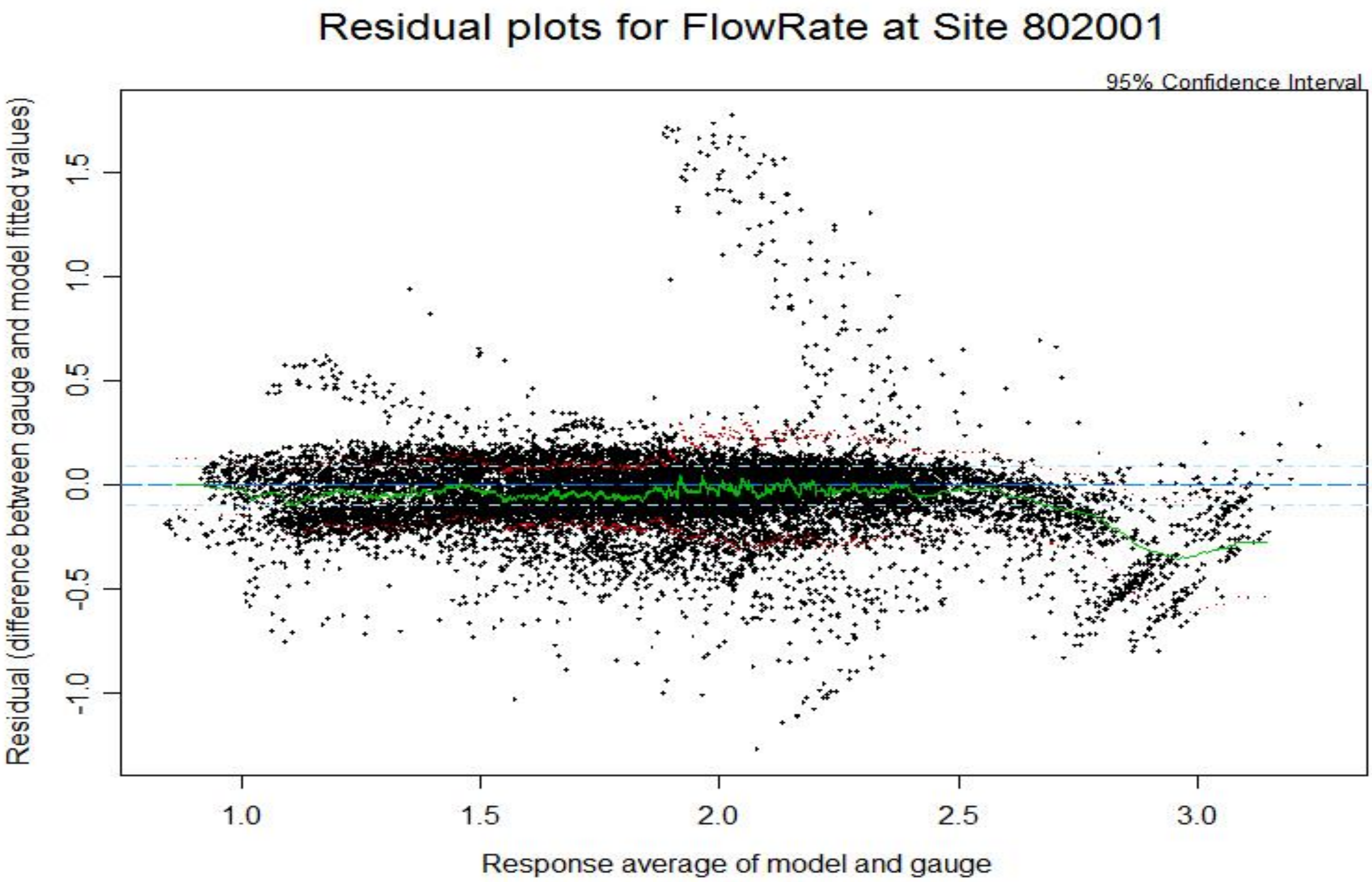
15457 observations in matched dataset.

Criteria Values for assessing model performance
===

	all observations	specified region (1.613704 to 2.198418)
MSE	0.0396	0.0242
R abs	0.63	0.23
R squared	0.82	0.5
R sq (lag gauge)	0.81	
R sq (lag model)	0.81	
adjusted R sq	0.78	0.06
adjusted R sq (lag gauge)	0.78	
adjusted R sq (lag model)	0.78	



Residual plots for FlowRate at Site 802001
Residual (difference between gauge and model fitted values)
1.5
1.0
0.5
0.0
-0.5
-1.0
1
2
3
4
7
8
9
10
2025



Residual plots for FlowRate at Site 802001
95% Confidence Interval
Residual (difference between gauge and model fitted values)
1.5
1.0
0.5
0.0
-0.5
-1.0
1.0
1.5
2.0
2.5
3.0
Response average of model and gauge

Level Report for Station 802051N

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802051NL.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802051NL.txt (32925 observations)

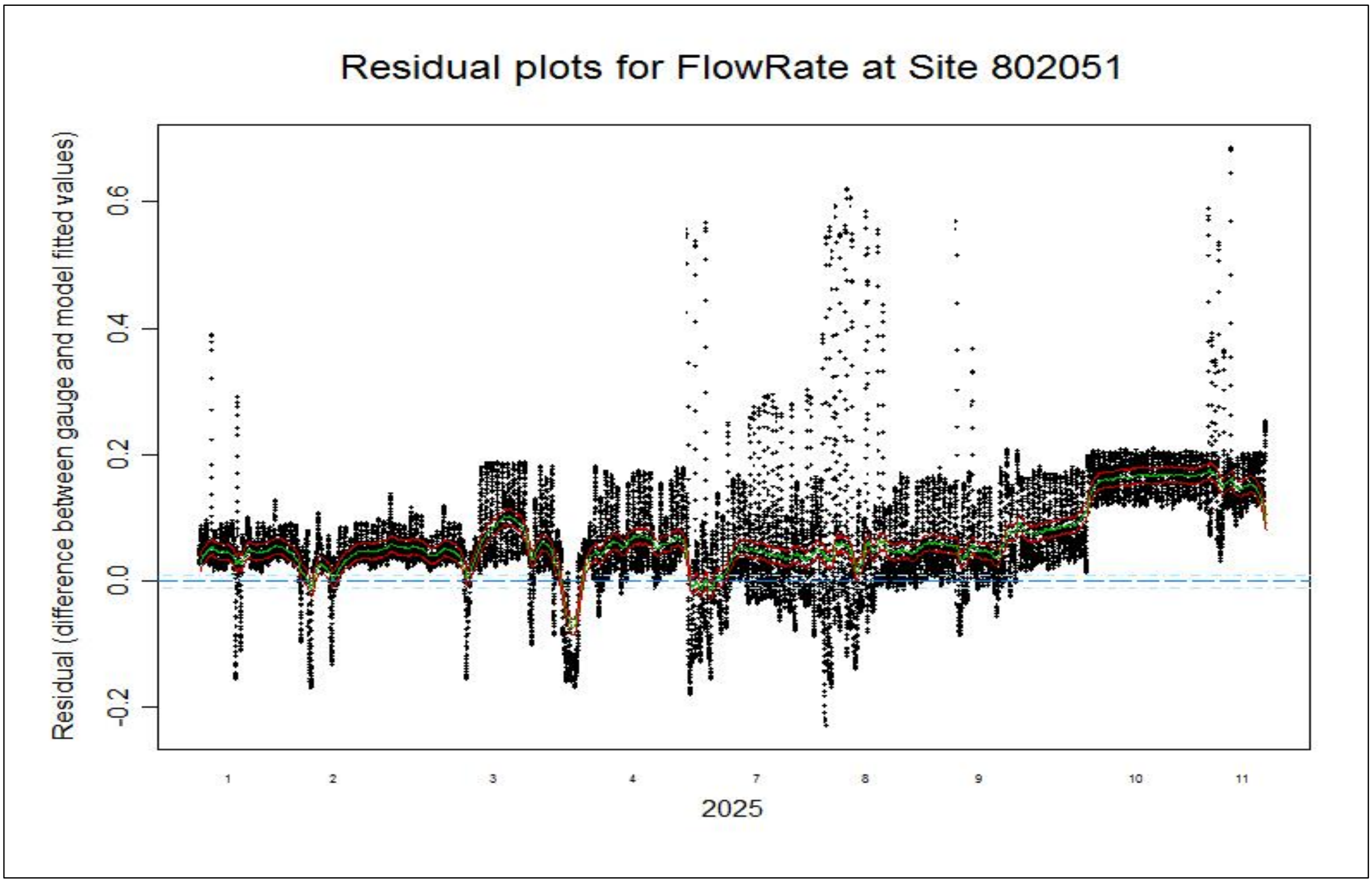
18837 observations in matched dataset.

Criteria Values for assessing model performance
===

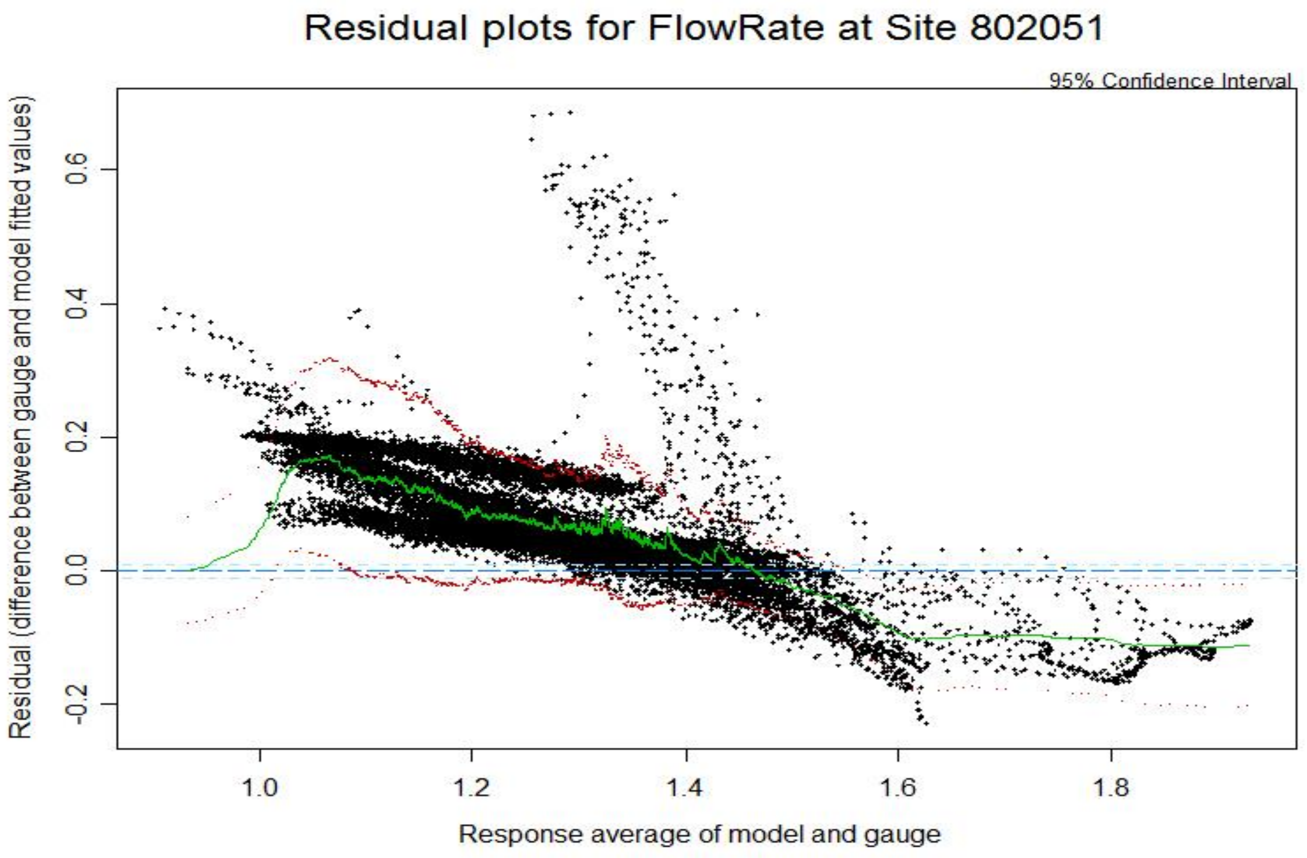
	all observations	specified region (1.2465 to 1.4107)
MSE	0.0112	0.006
R abs	0.16	-0.55
R squared	0.86	0.66
R sq (lag gauge)	0.85	
R sq (lag model)	0.85	
adjusted R sq	0.27	-1.82
adjusted R sq (lag gauge)	0.26	
adjusted R sq (lag model)	0.26	

Report date 08/01/2026 16:20

Resi dual Plots for Level at Site 802051N:



Resi dual Plots for Level at Site 802051N:



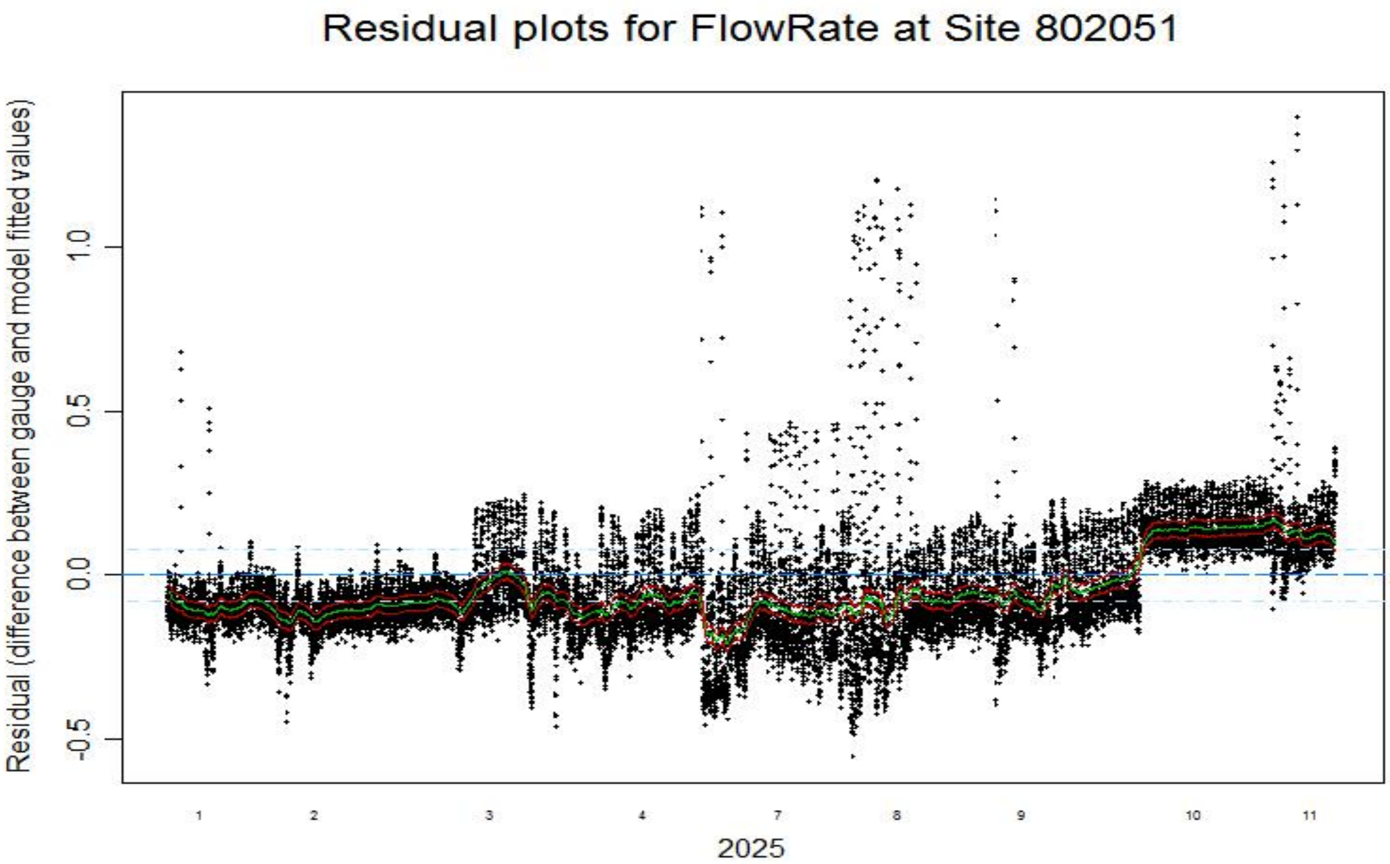
Flow Report for Station 802051N

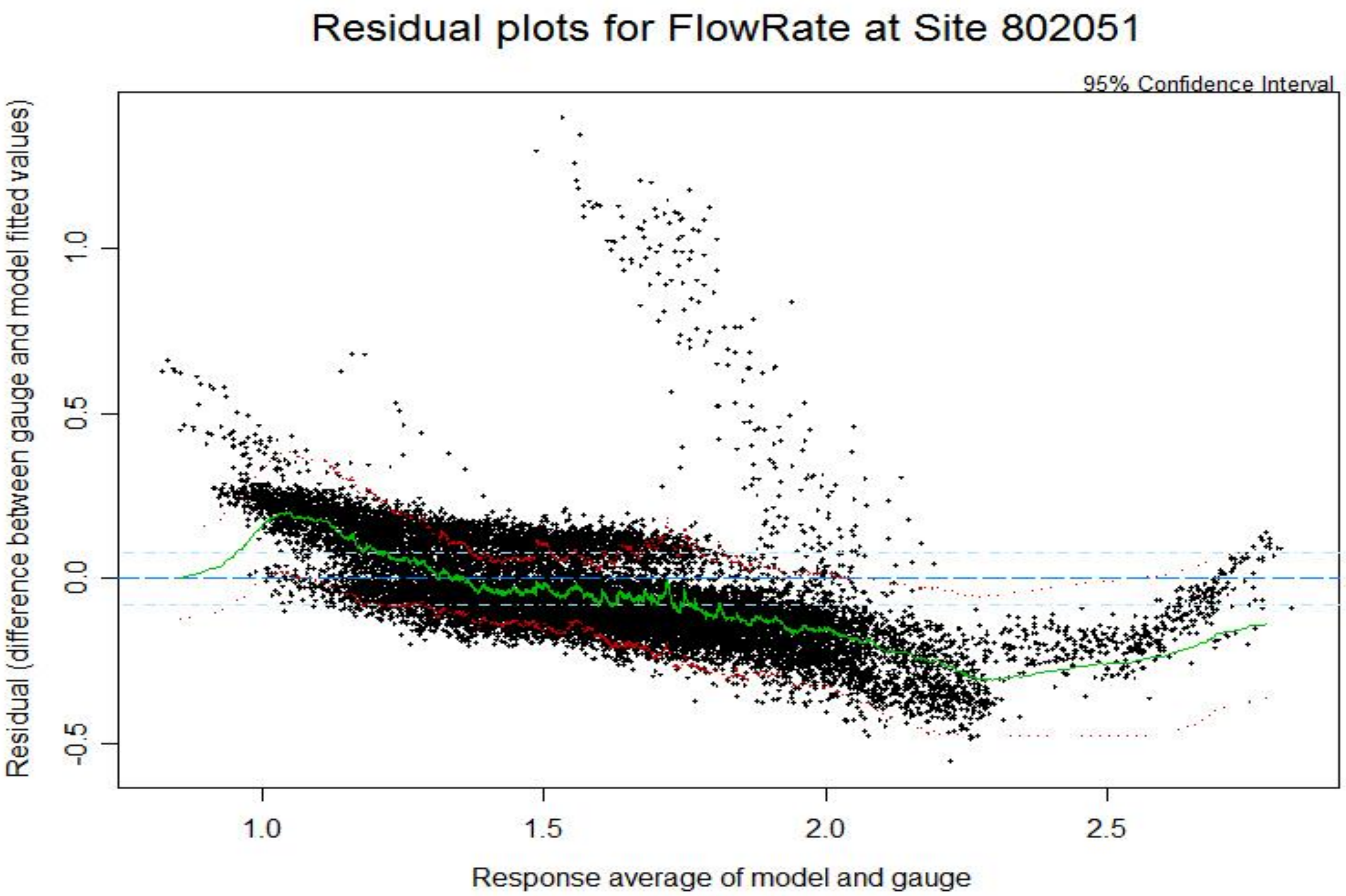
Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802051NQ.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802051NQ.txt (32925 observations)

18837 observations in matched dataset.

Criteria Values for assessing model performance
===

	all observations	specified region (1.406578 to 1.790018)
MSE	0.0263	0.0149
R abs	0.42	-0.15
R squared	0.85	0.64
R sq (lag gauge)	0.84	
R sq (lag model)	0.86	
adjusted R sq	0.67	-0.26
adjusted R sq (lag gauge)	0.65	
adjusted R sq (lag model)	0.67	





Report date 08/01/2026 16:20

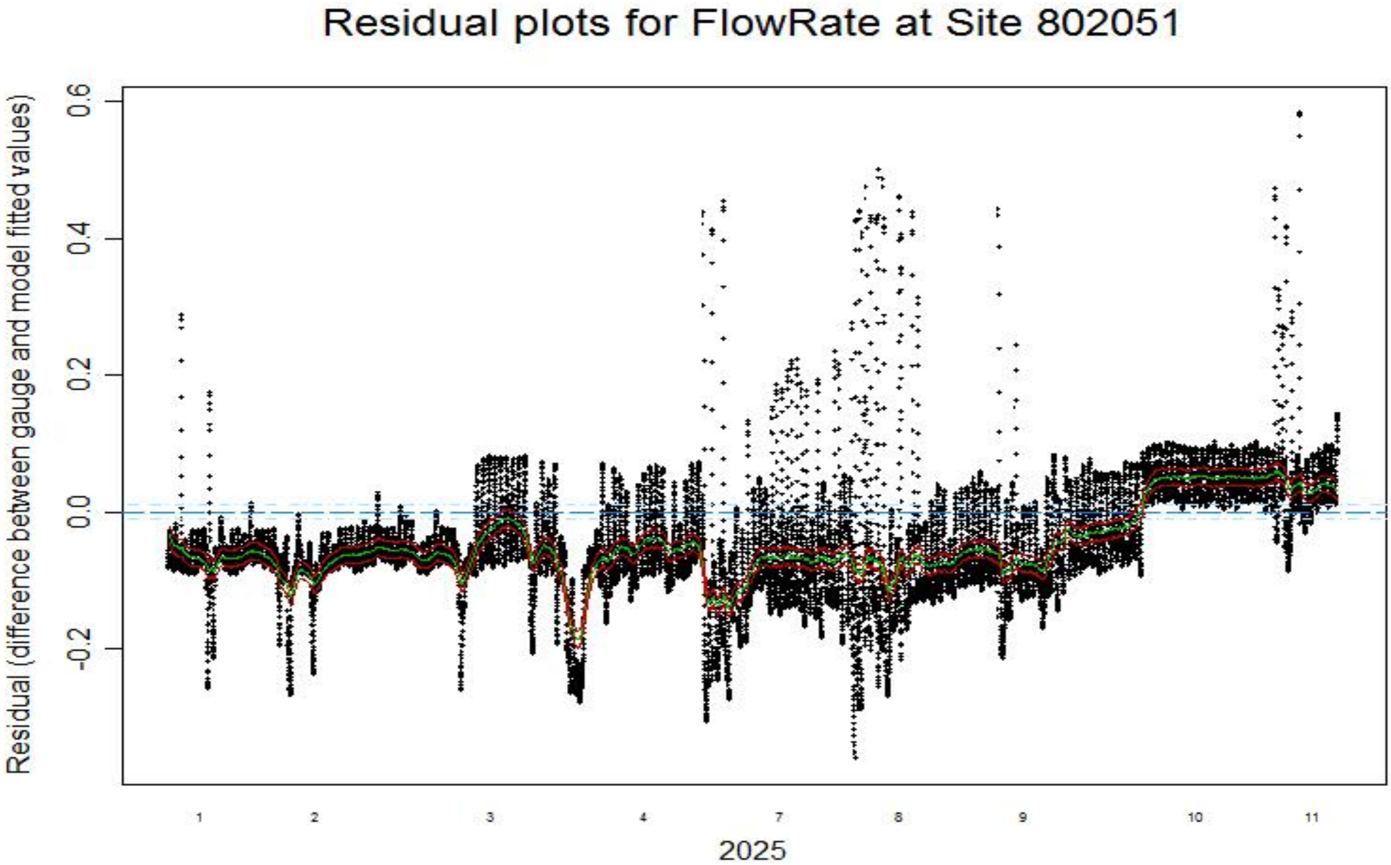
Level Report for Station 802051S

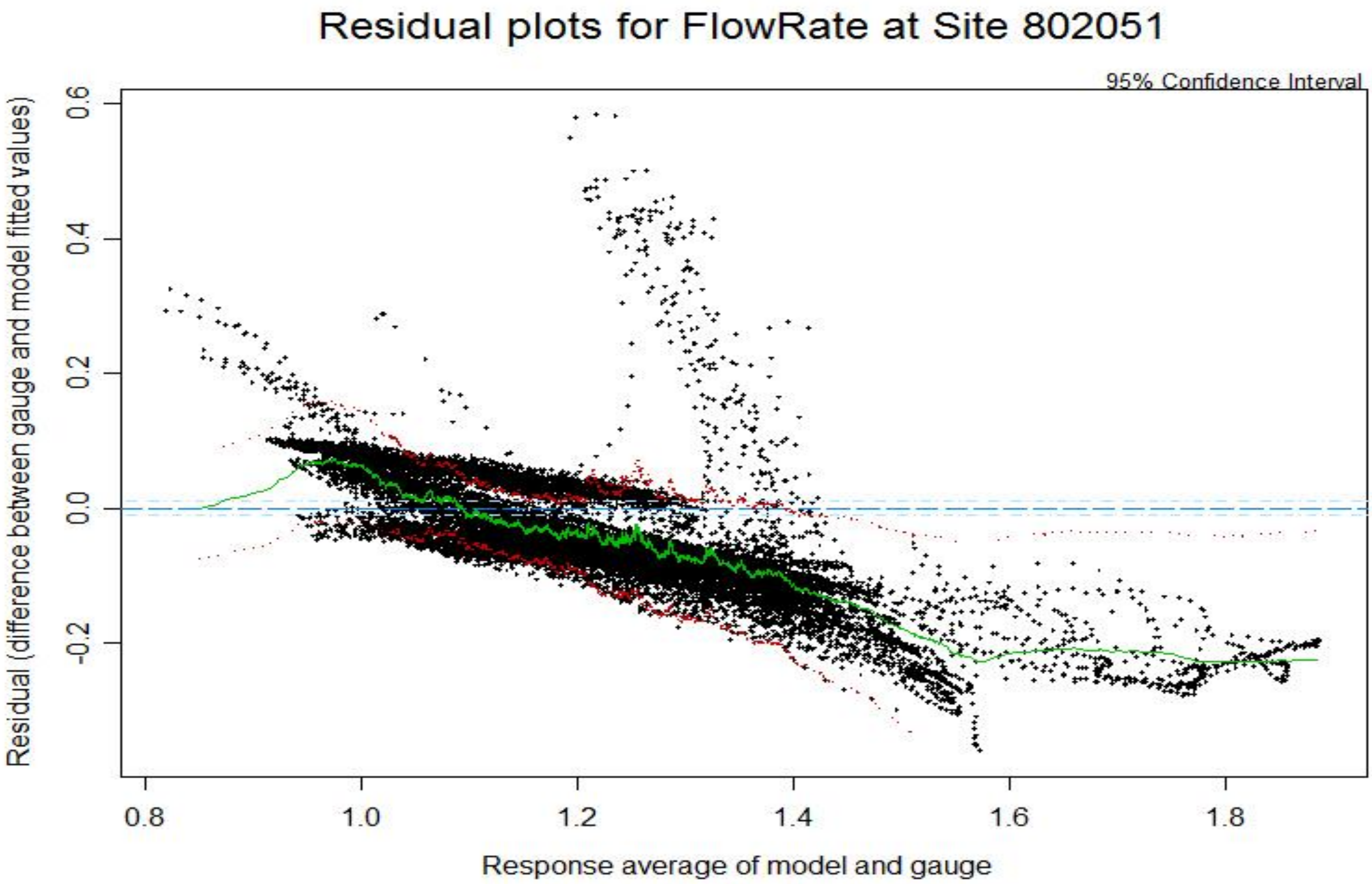
Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802051SL.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802051SL.txt (32925 observations)

18837 observations in matched dataset.

Criteria Values for assessing model performance
==

	all observations	specified region (1.1283 to 1.2952)
MSE	0.0092	0.0053
R abs	0.21	-0.61
R squared	0.86	0.67
R sq (lag gauge)	0.86	
R sq (lag model)	0.86	
adjusted R sq	0.42	-1.38
adjusted R sq (lag gauge)	0.41	
adjusted R sq (lag model)	0.41	





Report date 08/01/2026 16:20

Flow Report for Station 802051S

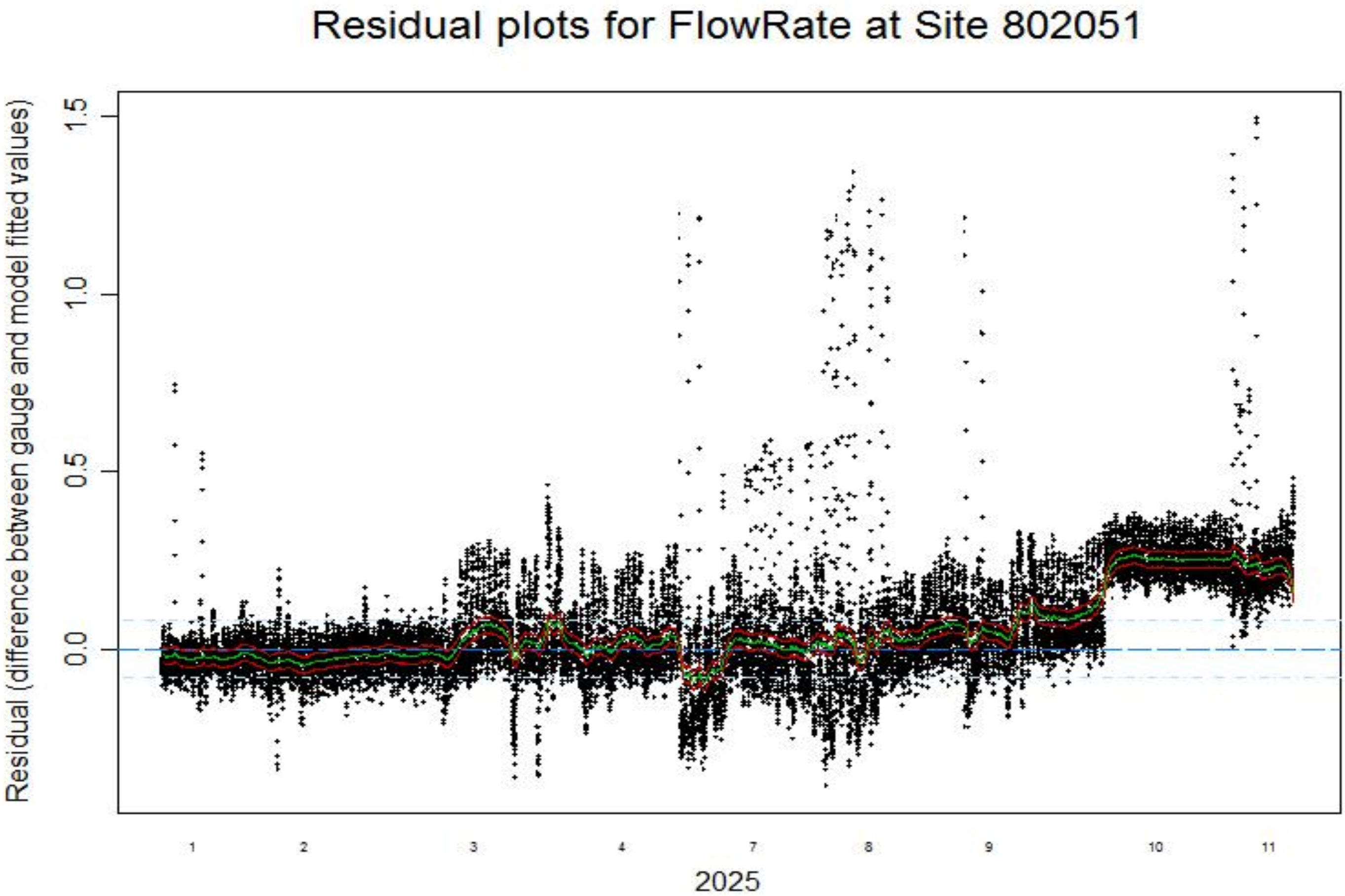
Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802051SQ.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802051SQ.txt (32925 observations)

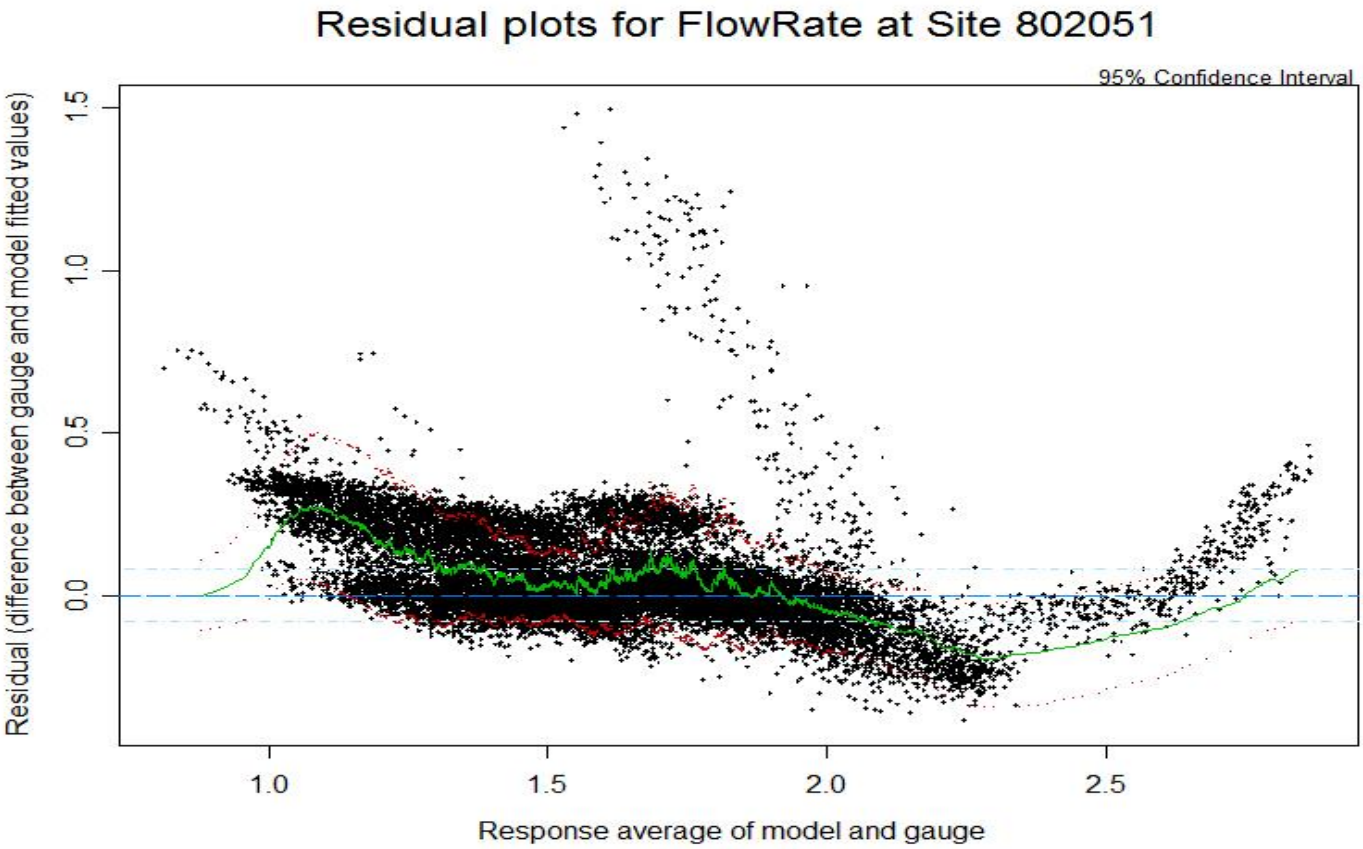
18837 observations in matched dataset.

Criteria Values for assessing model performance
===

	all observations	specified region (1.464534 to 1.881126)
MSE	0.0266	0.0143
R abs	0.54	0.22
R squared	0.83	0.57
R sq (lag gauge)	0.82	
R sq (lag model)	0.83	
adjusted R sq	0.7	0.11
adjusted R sq (lag gauge)	0.69	
adjusted R sq (lag model)	0.71	

Report date 08/01/2026 16:20





Report date 08/01/2026 16:20

Level Report for Station 802063

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802063L.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802063L.txt (32925 observations)

18837 observations in matched dataset.

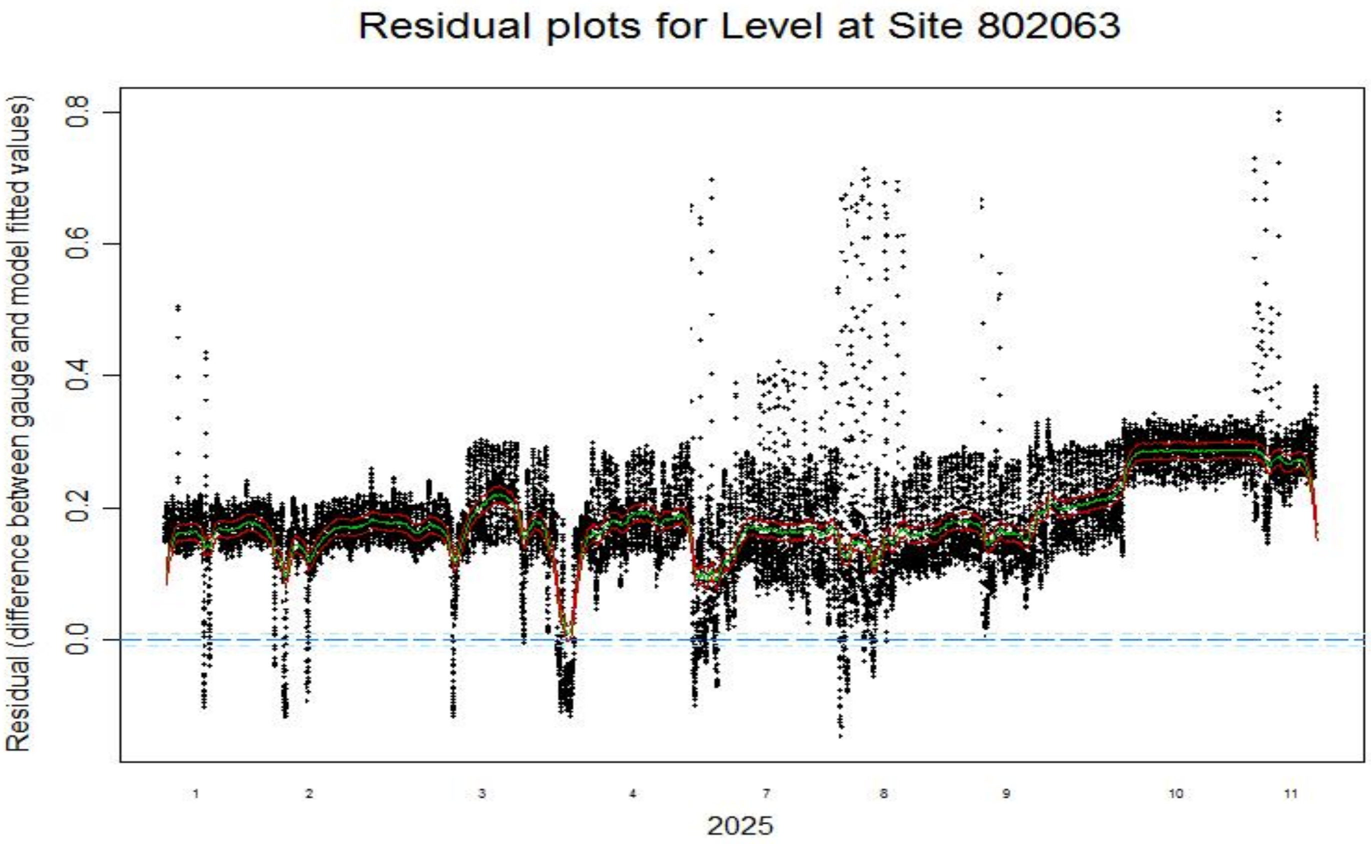
Criteria Values for assessing model performance
===

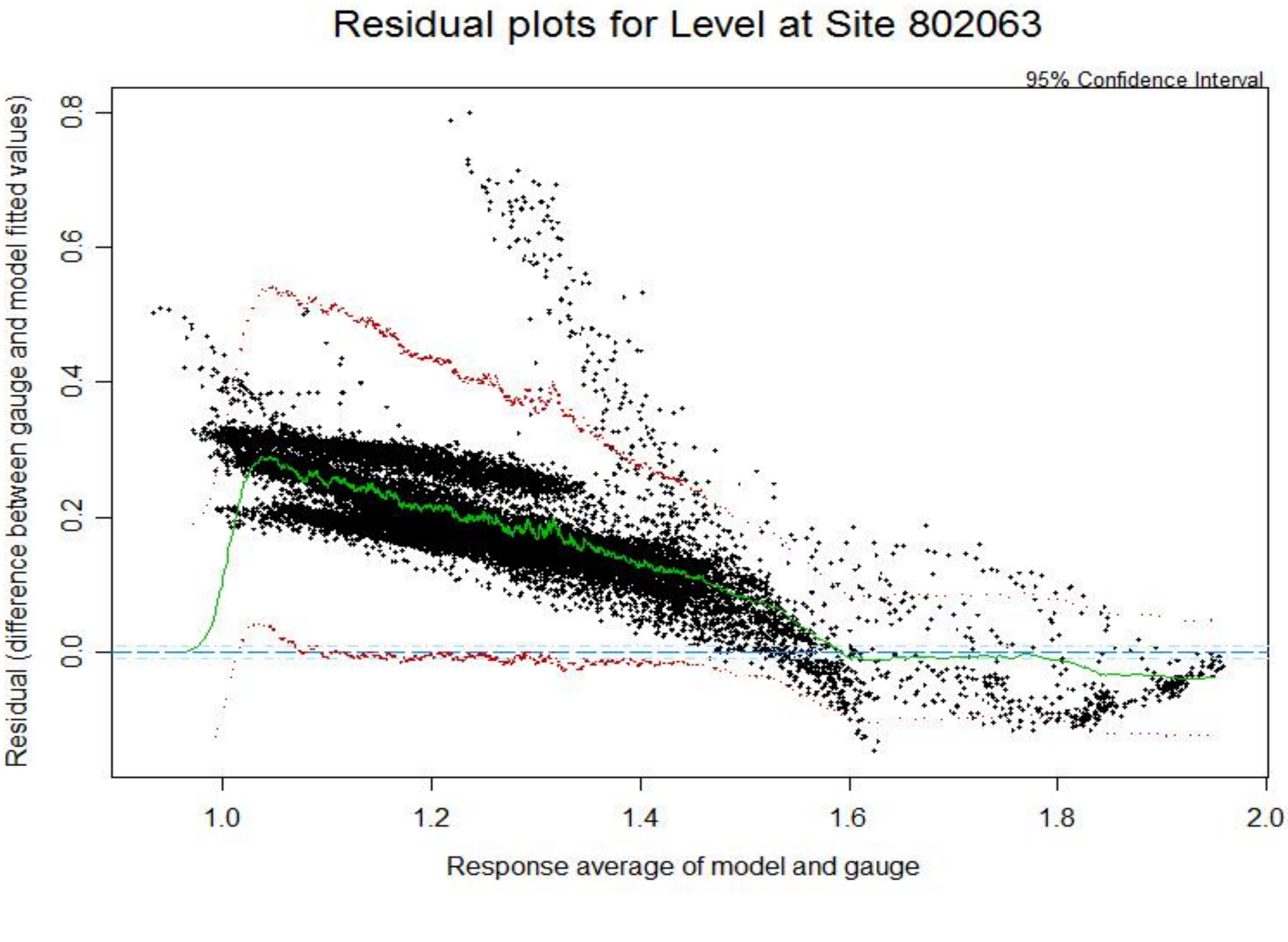
	all observations	specified region (1.2921 to 1.45)
MSE	0.0408	0.0357
R abs	-0.99	-3.68
R squared	0.88	0.64
R sq (lag gauge)	0.88	
R sq (lag model)	0.87	
adjusted R sq	-1.76	-16.74
adjusted R sq (lag gauge)	-1.75	
adjusted R sq (lag model)	-1.78	

Probability of weir overflow events
====================================

Event	Probability
Measured > 1.7	0.023
Fitted > 1.7	0.023
Both Measured & Fitted > 1.7	0.021
Measured > 1.7 given Fitted > 1.7	0.913

Report date 08/01/2026 16:20





Report date 08/01/2026 16:20

Level Report for Station 802064

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802064L.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802064L.txt (32925 observations)

18837 observations in matched dataset.

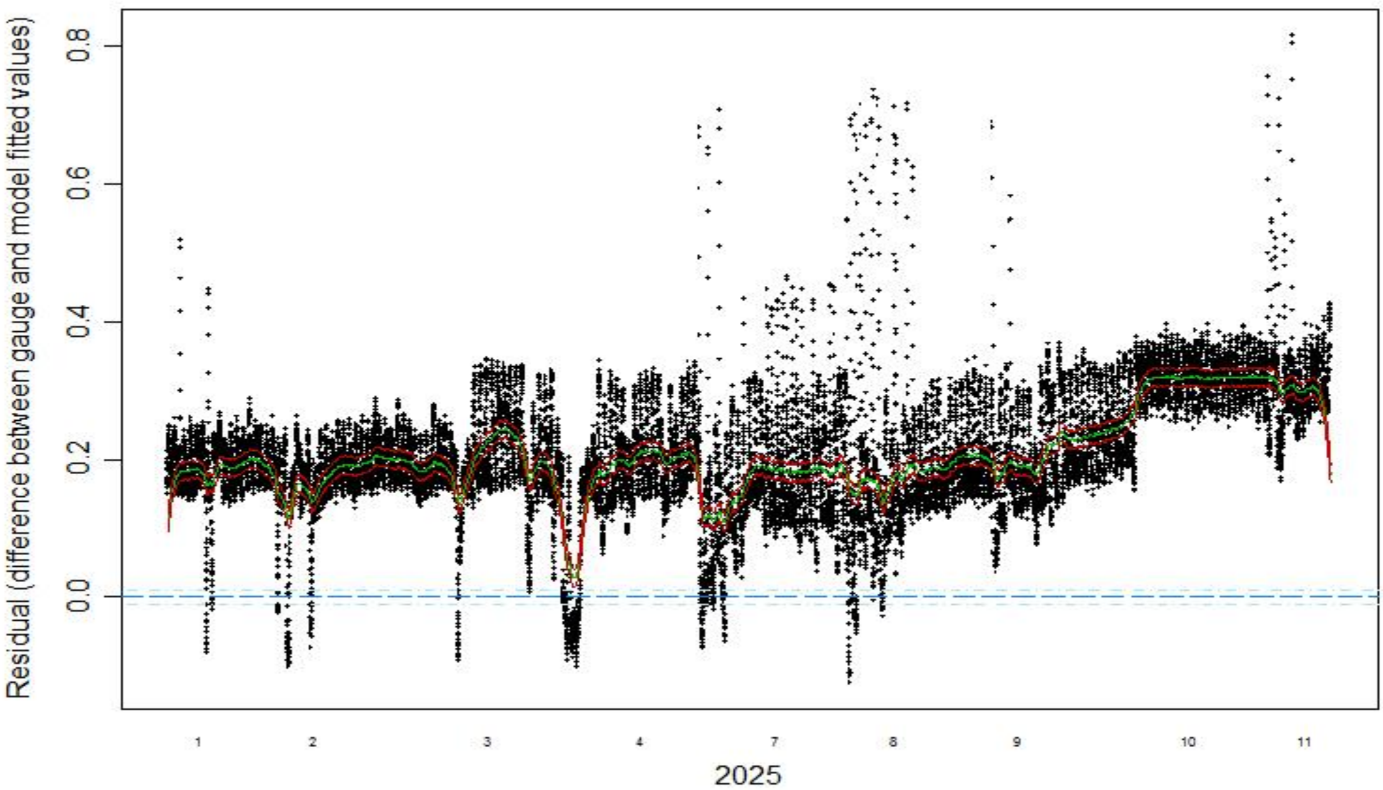
Criteria Values for assessing model performance
==

	all observations	specified region (1.3139 to 1.4671)
MSE	0.051	0.0451
R abs	-1.34	-4.36
R squared	0.85	0.56
R sq (lag gauge)	0.86	
R sq (lag model)	0.84	
adjusted R sq	-2.76	-22.54
adjusted R sq (lag gauge)	-2.74	
adjusted R sq (lag model)	-2.77	

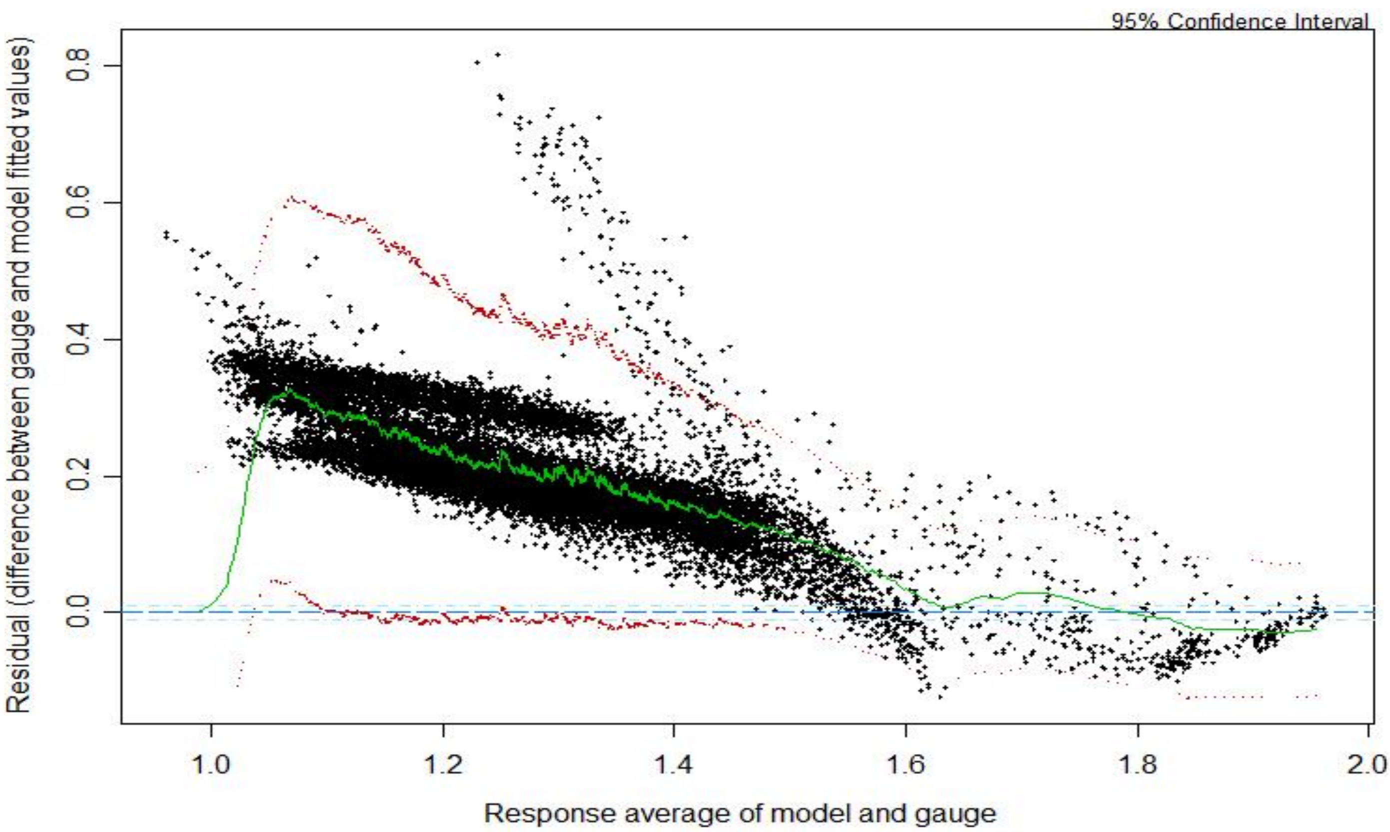
Probability of weir overflow events
======================================

Event	Probability
Measured > 1.7	0.024
Fitted > 1.7	0.023
Both Measured & Fitted > 1.7	0.022
Measured > 1.7 given Fitted > 1.7	0.957

Residual plots for Level at Site 802064



Residual plots for Level at Site 802064



Report date 08/01/2026 16:20

Level Report for Station 802065

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802065L.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802065L.txt (32925 observations)

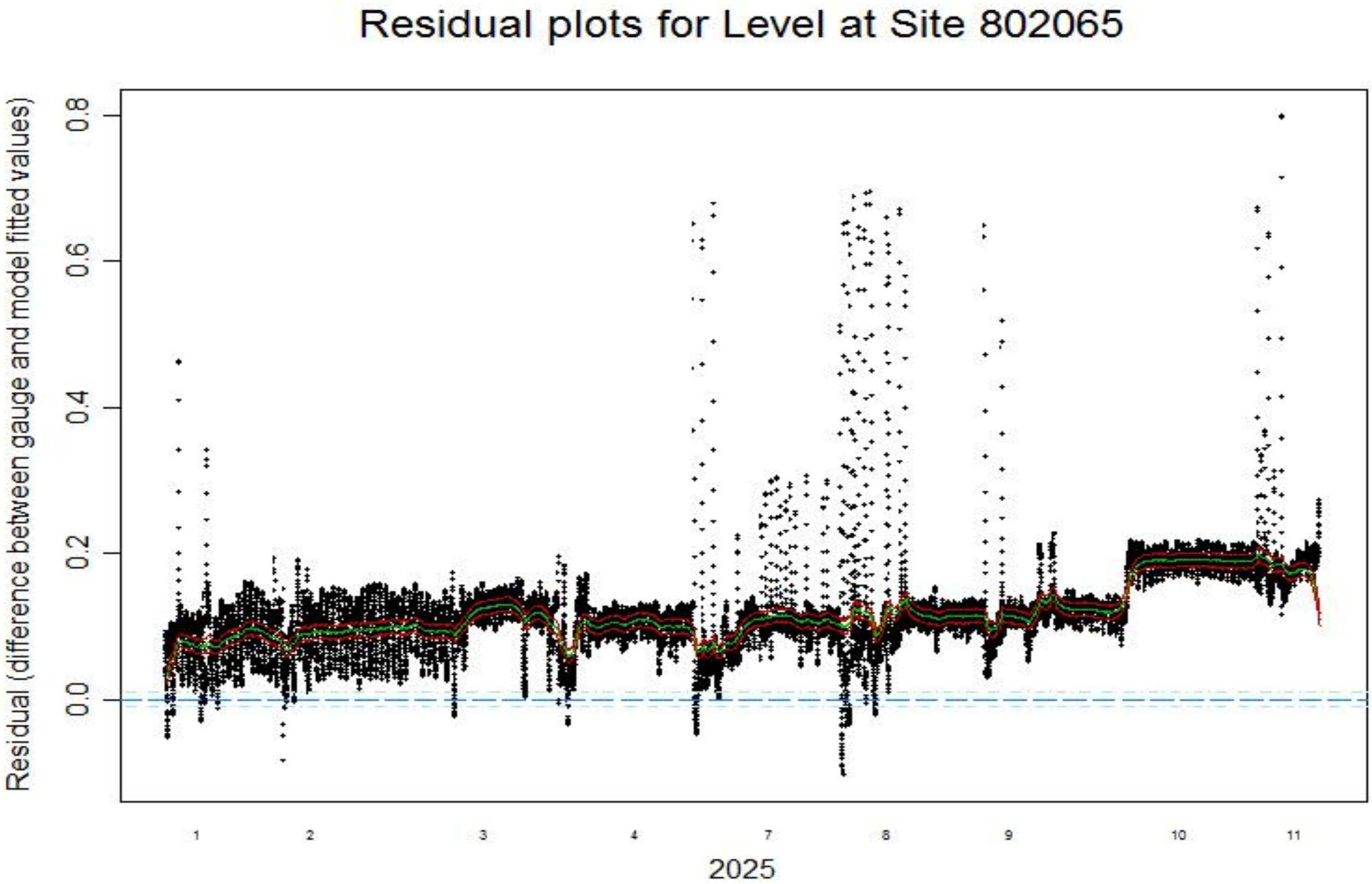
18837 observations in matched dataset.

Criteria Values for assessing model performance
===

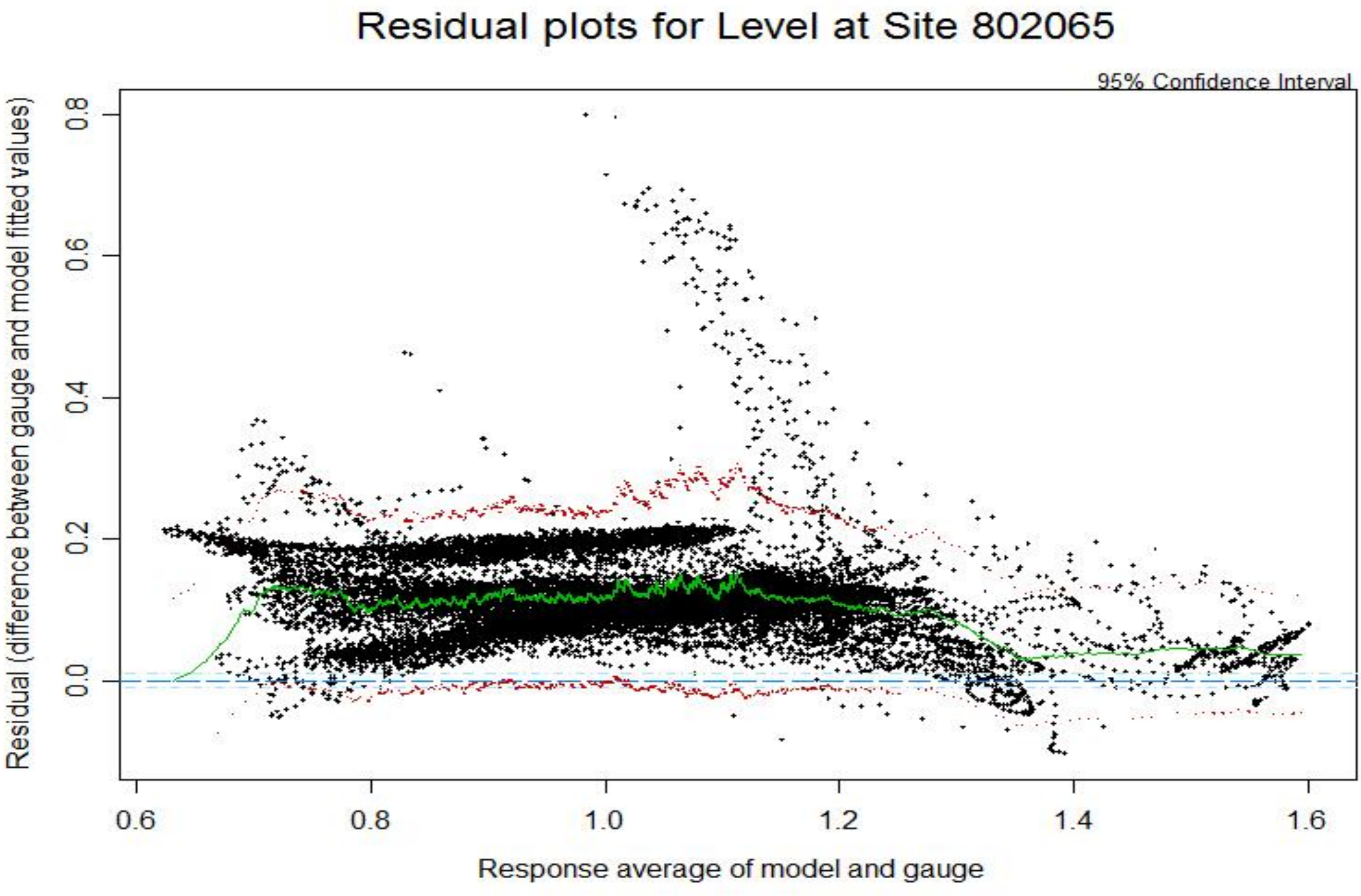
	all observations	specified region (0.9973 to 1.20318)
MSE	0.0173	0.0166
R abs	0.05	-1.45
R squared	0.87	0.67
R sq (lag gauge)	0.87	
R sq (lag model)	0.87	
adjusted R sq	0.30	-3.89
adjusted R sq (lag gauge)	0.30	
adjusted R sq (lag model)	0.30	

Probability of weir overflow events
====================================

Event	Probability
Measured > 1.3	0.928
Fitted > 1.3	0.264
Both Measured & Fitted > 1.3	0.264
Measured > 1.3 given Fitted > 1.3	1.000



Residual plots for Level at Site 802065
Residual (difference between gauge and model fitted values)
0.8
0.6
0.4
0.2
0.0
1
2
3
4
7
8
9
10
11
2025



Residual plots for Level at Site 802065
95% Confidence Interval
Residual (difference between gauge and model fitted values)
0.8
0.6
0.4
0.2
0.0
0.6
0.8
1.0
1.2
1.4
1.6
Response average of model and gauge

Level Report for Station 802310

Gauge filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/G802310L.txt (19030 observations)
Model filename: R:\Wwdih\Palms\Sts\Malabar\Swagman/M802310L.txt (32925 observations)

18837 observations in matched dataset.

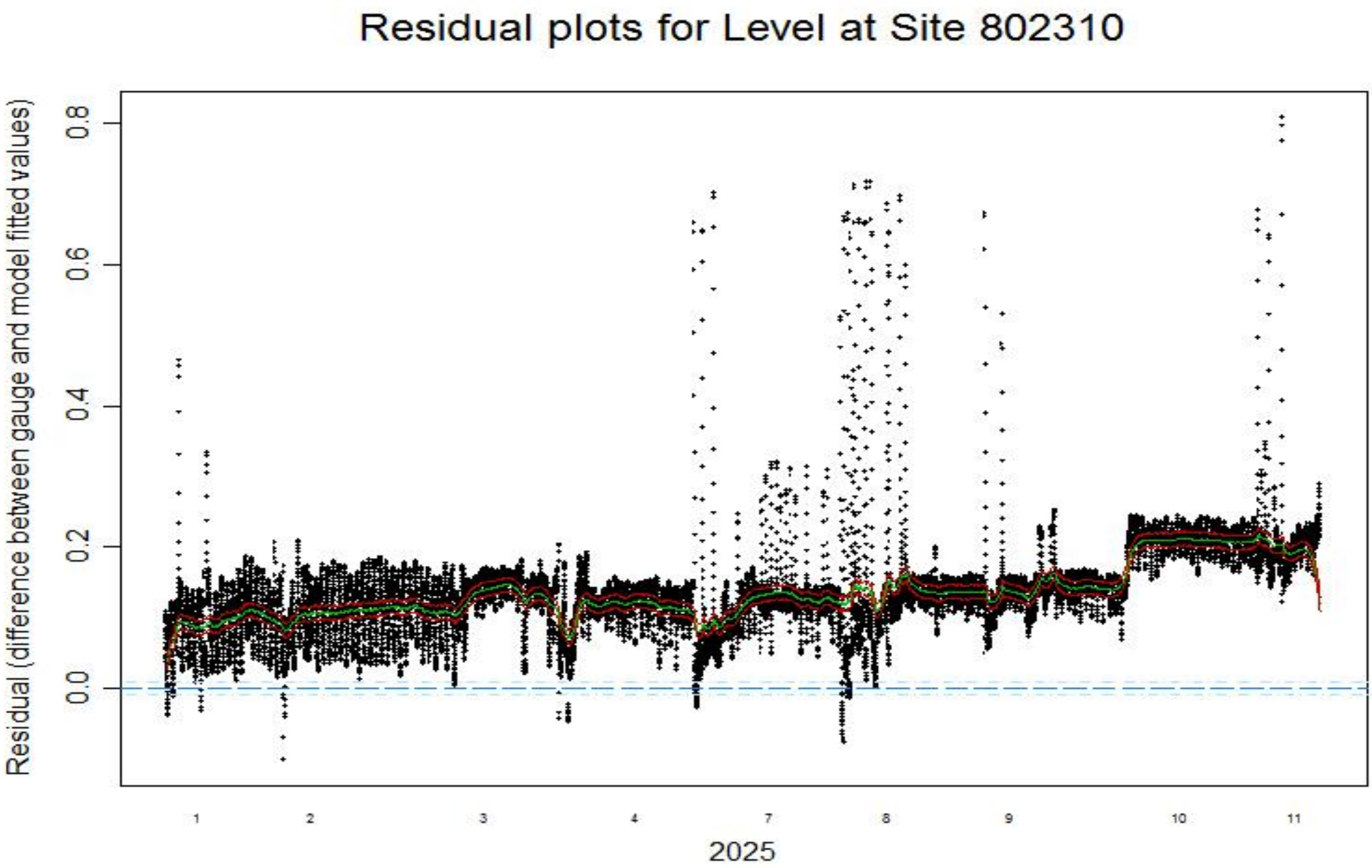
Criteria Values for assessing model performance
==

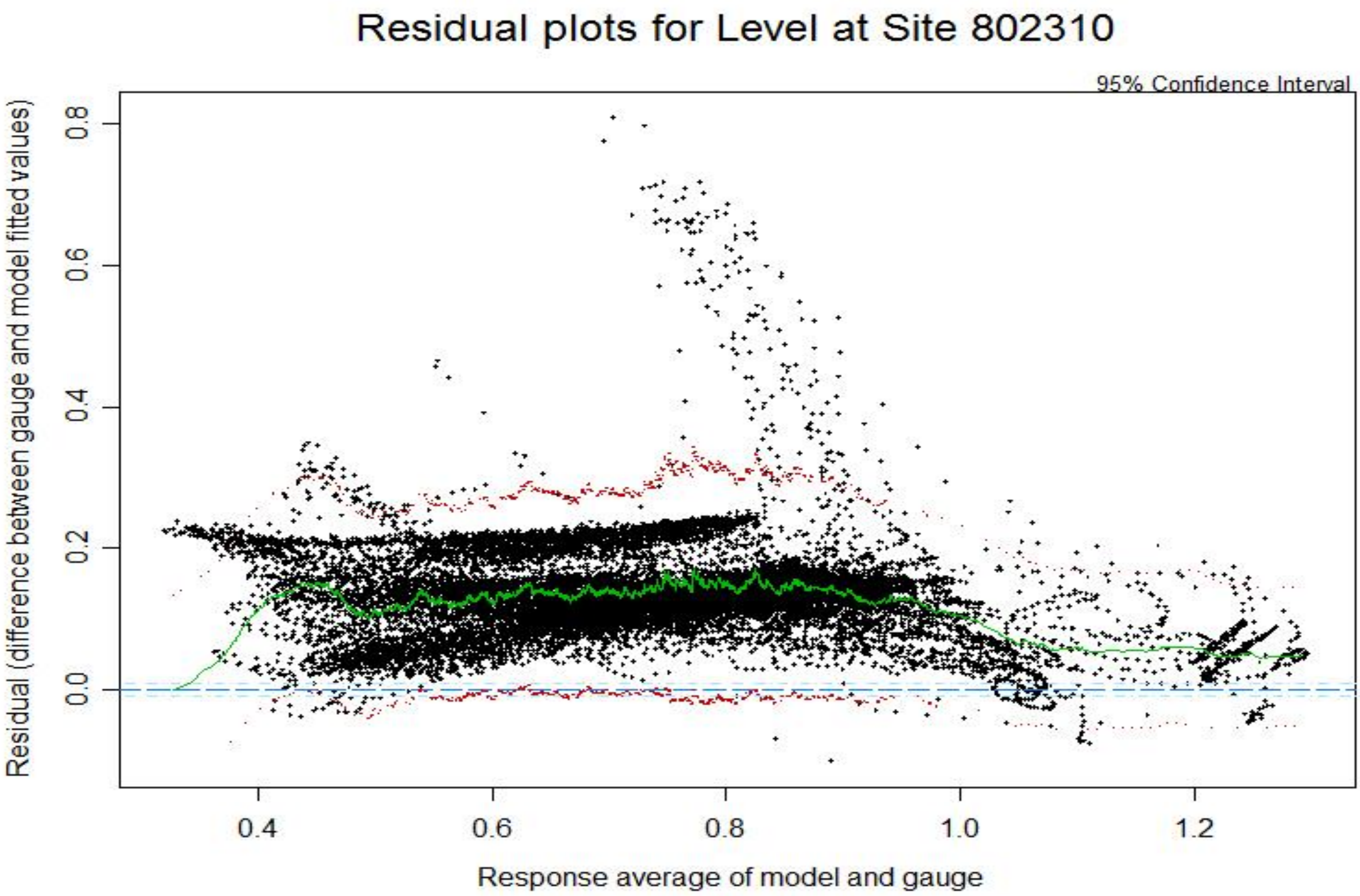
	all observations	specified region (0.7199 to 0.9302)
MSE	0.0221	0.0219
R abs	-0.06	-1.77
R squared	0.86	0.65
R sq (lag gauge)	0.85	
R sq (lag model)	0.86	
adjusted R sq	0.14	-5.14
adjusted R sq (lag gauge)	0.13	
adjusted R sq (lag model)	0.14	

Probability of weir overflow events
=====================================

Event	Probability
Measured > 1.2	0.023
Fitted > 1.2	0.013
Both Measured & Fitted > 1.2	0.013
Measured > 1.2 given Fitted > 1.2	1.000

Report date 08/01/2026 16:20


Residual plots for Level at Site 802310
Residual (difference between gauge and model fitted values)
0.0
0.2
0.4
0.6
0.8
1
2
3
4
7
8
9
10
11
2025


Residual plots for Level at Site 802310
95% Confidence Interval
Residual (difference between gauge and model fitted values)
0.0
0.2
0.4
0.6
0.8
0.4
0.6
0.8
1.0
1.2
Response average of model and gauge

Attachment 5 PRP 101.1 and 101.2

Sydney WATER

Pollution Reduction Program

PRP 101.1 System Model Performance Indicators

September 2000

DOCUMENT STATUS

This report was prepared in response to the Pollution Reduction Program No 101.1 attached to Sydney Water's 27 STS licences. During the preparation of this document, peer reviews were carried out at draft and final report stages. This is the final version of the report.

Any comments regarding this report should be directed to Mr Greg Barr on:

Phone 9350 5141
E-mail Greg.Barr@sydneywater.com.au

ENDORSED BY:

.... Date:

Warwick Eyles
Program Manager
Overflow Abatement Program.

CONTROL COPY SHEET

PRP 101.1

CONTROLLED COPY:				
Issue No.	Date	Description	Prepared By (Author)	Reviewed by:
1	29/9/00	Completed Document	Steven Linforth	Andrew Kasmarik

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Sydney Water is developing computer models of its sewerage networks in order to prepare plans for the improvement of the system. These models will be used to predict the performance of the network under both wet and dry conditions. The EPA wish to be assured that the predictions of these models compares favourably with measured data in the sewerage system .In this way the EPA can be confident that the model predictions are realistic and can be used for compliance monitoring.

The licence conditions for this pollution reduction program are as follows:

101.1.1

The licensee must develop a set of performance indicators for comparing the predictions of the hydraulic sewer system model with the data from the reticulation sewer gauge network operated by or on behalf of the licensee. The licensee must develop a set of performance acceptance criteria for the hydraulic sewer system model based on the indicators. The indicators and criteria must be applicable to all of the sewage treatment system specific models developed in 101.3 and the range of sewer flows in these systems.

101.1.2.

By 30 September the licensee must supply to the EPA a written report detailing:

(a) the proposed indicators and criteria developed under 101.1.1 for approval by the EPA

(b) the rationale explaining why these indicators or criteria are proposed.

101.1.3

Following approval by the EPA the licensee must apply the indicators and criteria to the models in accordance with 101.2 to 101.6

This report has been prepared to comply with the requirements of PRP101.1 System Model Performance Indicators for the 27 sewage treatment system (STS) licences indicated in **Table 1.1**.

Table 1.1: Sewage Treatment System Names and Licence Numbers

LICENCE NUMBER	LICENCE SYSTEM
1775	Bellambi
1712	Blackheath
1688	Bondi
1725	Castle Hill
1728	Cronulla
1407	Glenbrook
750	Hornsby Heights
2269	Kiama
1716	Mount Victoria
190	North Richmond
378	Northern Suburbs
1409	Penrith
1696	Port Kembla
1724	Quakers Hill
1726	Richmond
1796	Riverstone
2392	Round Corner
4965	Rouse Hill
211	Shellharbour
372	Malabar/Southern Suburbs
1729	St Marys
1778	Warragamba
1784	Warriewood
1675	West Camden
1695	West Hornsby
1963	Winmalee
218	Wollongong

1.2 Planning history and description of the system

Sydney Water is a major provider of water and wastewater services in Australia. It is a state-owned corporation belonging to the people of NSW. Sydney Water has three equally important principle objectives, which are to be a successful business and to protect the environment and public health. These objectives are expressed in terms of environmental, public health and commercial goals in response to customer commitments, which are defined in the Water Board Corporatisation Act (1994) and Operating Licence.

WaterPlan 21 is Sydney Water's vision for long term, ecologically sustainable wastewater management across the Sydney, Blue Mountains and Illawarra region. The plan resulted from a process of investigations commenced in the late 1980s devoted towards improving the sewerage systems performance. The plan includes $1.6 billion to overhaul Sydney Water's sewerage systems and ultimately eliminate an average of 80-90 per cent of wet weather overflow events across the area. In addition, Sydney Water proposes to spend $0.4 billion on linked dry weather overflow abatement programs. The total cost of the overflow abatement program (OAP) for wet and dry weather improvements is therefore $2 billion. These cost will be spread over the next twenty years. Any pricing impacts of this program will need an IPART determination.

Sydney Water provides sewerage services to almost three and three quarter million people and maintains 28 sewerage systems, consisting of some 22,000 kilometres of sewer. The current performance and Sydney Water long-term objectives for 2021 for the systems are shown in table 1.2.

Table 1.2: Current and Sydney Water 2021 objectives for sewerage system performance

Overflow type	Dry weather		Wet Weather	
	Current	**future**	**current**	**Future**
leakage (exfiltration)	suspected to cause failure of swimming / boating criteria in some receiving waters	will not cause dry weather failure of swimming / boating criteria	not applicable	not applicable
wet weather treatment	not applicable	not applicable	H/N STP's disinfection fails in small storms. Minor ocean plant *1 – beach fail faecal coliform criteria in storms	STP discharge will not cause failure of water quality criteria
directed overflows	50 individual discharges per year *2	less than 15 discharges per year	up to 200 events per 10 years 350,000 ML per 10 years	80-90 per cent average reduction in events per 10 years across Sydney
uncontrolled overflows	internal surcharge – 140 reported events per year 96 per cent of customers no external overflows	less than 10 internal surcharges per year due to sydney water capacity individual customers experiencing choke related overflows (2 per 6 months or 3 in 2 years) guarantee no repeat for two years	200 known areas *3	• no internal surcharges due to sydney water capacity • fix to known surcharge areas 96 per cent of customers no external overflows
odours	20 individual assets cause repeat odour complaints	less that 3 verified odour events per year for an individual asset (eg vent shaft, sps)	unknown	Frequency of odour events no greater that wet weather overflow frequency

*1 minor ocean plants include; Warriewood, Cronulla and Illawarra STP's
*2 predominantly SPS failures
*3 total unkown as not all wet weather events reported

The planning conducted to date has provided a firm base for implementation of the OAP. Whilst Sydney Water does not recommend any major changes to the proposal as defined in the overflows EISs, a number of other initiatives and events have occurred which could constrain or impact upon the delivery of the OAP. These include; the NSW Governments Waterways Package, amendments to the Clean Waters Regulation and Classification of Waterways, the enactment of the *Protection of the Environment Operations Act 1997* and the overflow abatement strategy proposed by the EPA.

It is recognised that additional detailed planning and environmental impact assessment will be undertaken as part of the OAP and through pollution reduction programs set by the EPA. Refinement of the detail of overflow abatement options will be via a continuous and adaptive process and will reflect current and future community concerns.

The EPA issued the Sewage Treatment System licences to Sydney Water on 26th May 2000. The STS licences set the EPA priorities and timetable for overflow abatement. The Pollution Reduction Programs (PRPs) set out the specific works and activities required to achieve that outcome. The documents produced here, form part of the suite of reports required to be prepared as part of the PRP's. Completion of the PRP's will not achieve the long-term objectives of Sydney Water.

1.3 Sydney Water monitoring framework

The monitoring undertaken by Sydney Water can be defined in two broad areas:

A. Monitoring programmes to measure system performance; and
B. Monitoring programmes to measure impacts of overflows on the environment.

These can further be subdivided into the following monitoring types:

1. **Routine** monitoring - undertaken as part of system performance monitoring;
2. **Project** monitoring – undertaken for specific works/ planning projects;
3. **R&D** monitoring – undertaken as specific research and development projects.

The existing routine monitoring that is undertaken as part of business performance reporting, can be broadly categorised into this framework as shown in Table 1.3.

Table 1.3 – Existing monitoring

Monitoring Type	Performance monitoring	Impact monitoring
Routine monitoring	• Chokes/100km Sydney-wide • No. customers affected by surcharges • Repeat chokes • Odour complaints • Representative overflow reporting • Incident monitoring –dry weather discharges to waterways	• Components of existing Environmental Impact Monitoring Program (under revision) • Incident management response monitoring
***Project monitoring**	• Interim I/E gauging programme • Sewer flow gauging	• Interim I/E water quality monitoring; • Ecological & human health risk assessment monitoring of overflows; • Northside storage tunnel pilot study monitoring; • Dry weather point source sewage detection
R&D monitoring		• Clean Waterways Program water quality stormwater and receiving water monitoring for model development

* = Some project monitoring occurs periodically over a cycle of several years.

It is proposed that the routine monitoring outlined above, would form the basis of the licence monitoring requirements. Project and R&D monitoring would continue to be applied on a needs basis.

1.4 Sydney Water modelling framework

The models used to develop the overflow abatement proposals in the Environmental Impact Statements (EISs), were deemed to be appropriate for strategic planning purposes, by two independent criteria review committees. Their continued use for the purposes of performance monitoring and licence compliance would however, require them to be further developed. The EPA has accordingly, developed a PRP to satisfy that outcome.

As part of the analysis conducted in the overflows EISs, it became apparent that system output performance measures were the most appropriate means of assessing the performance and indicating the impacts of the sewerage systems. It was clear, that modelling environmental condition, resulting from overflows was not appropriate, because of the confounding influence of external factors such as stormwater. Benefits delivered by overflow abatement would be masked by these external factors.

Sydney Water therefore proposes that output performance monitoring, measured by sewer system models and other non-modelled attributes, would form the basis of licence reporting. Environmental water quality models would continue to be used for setting strategic direction and assessing overall environmental condition but not for compliance monitoring. Whilst both suites of models would be improved over time, the majority of the effort would be devoted to improving the system models.

Performance monitoring will be measured by the sewerage system models, in terms of overflow frequency and/or volume. The system models will be upgraded by a process of developing a quality system, performance targets and re-calibration protocols. These processes will be reported as part of licence compliance reporting.

1.5 Achieving the long term objectives

The STS licences set the EPA priorities and timetable for overflow abatement. The PRPs reduction programs set out the specific works and activities required to achieve that outcome. Figure 1.1 indicates the interrelationships between the PRPs as a guide, to enable the process and interrelationships to be understood.

Figure 1.1: Pollution Reduction Program interrelationships

2. SELECTION OF PERFORMANCE INDICATORS

2.1 Introduction

The ideal performance indicator should be relevant to the problem at hand, easy to measure in the field and a direct output from the trunk sewerage system models. If a number of performance indicators are needed then they should be independent of each other. Comparison of the indicator between field measurement and model prediction will then provide a direct measure of the ability of the model to reproduce the behaviour measured in the field .It is the primary objective of these indicators that they be good measures of the ability of the model to reproduce field measurements.

The selected indicators must therefore be measurable in the field and a direct output of the model. As the system behaviour changes over time and with weather conditions the chosen indicators must be able to reflect this change.

As there are difficulties and costs associated in measuring system behaviour and in the modelling of this behaviour, the indicators must be chosen with an understanding of these difficulties. The following sections outline what is currently possible with respect to measurement of the behaviour of the system in the field and with respect to modelling this behaviour. The selection of appropriate indicators then follows.

2.2 Measurement Process

In order to establish performance indicators, it is first necessary to have an appreciation of the measurement process .The measurement process has a number of steps and at each step there will be some error added to the overall result. These errors provide a fundamental limit to the accuracy to which the subsequent computer models can be developed.

Sydney Water has installed monitoring devices to measure the depth and velocity of flow in sewers at critical points of interest. This data has been collected for a number of reasons including defining the hydraulic performance at a point in the network, for calibration of computer based hydraulic models, control of the system and for licensing purposes. As the need for sewer monitoring varies so does the need for a monitoring station at a given location. Over time this has meant that many points have been monitored over a particular period and then closed down.

When calibrating a model it is necessary to have contemporaneous data so that model parameters can be adjusted at the subcatchment level to account for variation in the local conditions. This requires a dedicated monitoring program in the local catchment for a period of at least three months in order to capture enough rainfall events to enable the computer model to be calibrated satisfactorily.

The primary data, which is collected, is sewage depth and velocity at predefined time intervals. The cross sectional properties of the pipe or channel are also needed to be measured in order to calculate sewage flow. The velocity of sewage in a pipe varies across the cross section from zero at the boundary to a maximum value somewhere near the top of the flowing surface. The location of this maxima change with increasing flow and in particular when the water surface hits the top of pipe and the pipe becomes pressurised.

Typically the device used to measure water level is an ultrasonic level sensor, located at the top of the pipe. The signal from the sensor is transmitted by a transducer, reflected off the surface of the flow and received by an adjacent transducer. Four ultrasonic transducers housed within the sensor are capable of both transmitting and receiving signals. The transducers operate in pairs, such that they have a maximum combination of twelve pairs. The depth of flow is calculated by subtracting the echoed range (of the sensors transmitted signal) from the pipe diameter.

The main variable, which must be compensated for, is the temperature of the air in which the signal travels. An internal temperature detection system is housed within the transmitter and is used to determine the temperature of the air in the sewer .The variations in temperature and resulting variation in travel time are then used in the computation of the final value.

When the height of the water exceeds the bottom surface of the transducer the ultrasonic device is out of range. In this circumstance another device is required to measure the water pressure. The pressure sensors measure the depth of sewage in the maintenance hole by comparing atmospheric pressure to the water height pressure at each sensor.

A digital doppler velocity sensor monitors velocity. The velocity sensor is mounted on the bottom of the pipe and emits an ultrasonic beam transmitted at a known frequency through the flow. Some of the transmitted energy is reflected by moving particles in the flow and received by the sensor at a different frequency .The Doppler principle states that the energy reflecting from a moving object will experience a shift in frequency proportional to the speed of the moving object. In the case of sewage flow, the object could be any suspended moving particle, air bubble or mass of organic matter.

A spectrum of reflected energy from all objects is gathered by the monitor and analysed to calculate the peak velocity of flow within the measured area. A relationship must then be made between the mean velocity and peak velocity. This requires techniques in the field to make this relationship. For the gauges installed on behalf of Sydney Water the methods used were velocity profile, peak velocity search and dye dilution techniques.

Monitoring was also undertaken on a number of pump stations. There were three common arrangements depending on the pump type and existing monitoring devices. For fixed speed stations the pump on /off status was recorded. For dual speed pumps, the high and low speeds were recorded and flow rates adjusted as for fixed speed pumps. Some pump stations have existing flow measurement devices and these were recorded.

Rainfall is the other major hydrological variable that is recorded. Sydney Water monitors rainfall at 140 locations. Tipping bucket pluviometers are used which log rainfall events of 0.5mm with a resolution of 2 minutes.

All data is stored electronically on the HYDSYS database.

2.3 Trunk sewerage system model

In order to establish performance indicators it is also necessary to have an appreciation of the hydraulic modelling process. The hydraulic modelling process has a number of steps and at each step there will be some error added to the overall result. These errors influence the accuracy of the computer models ultimately developed.

Sydney Water is developing computerised models of each of the sewerage networks and these are known as Trunk Sewerage System Models. The process of building a model requires extensive effort and resources. The key elements of the model building process are described in this section.

The catchment to which the sewerage system is connected must first be defined. Sydney Water has defined all boundaries to the sewer network and these are stored in a geographic information system (GIS). The physical characteristics of the pipe network must then be established. The primary source of this data is stored on the Hydra-Smallword GIS and needs to be simplified for the purposes of modelling. This simplification is necessary to allow the numerical computations of the system to be undertaken within practical timeframes.

The primary simplifications are to extend the model pipe network up to a point that has a permanent flow gauge. Within the defined pipe network the number of maintenance holes simulated is reduced to that necessary to define major junctions, flow measurement points, overflow points, changes in pipe diameter or pipe slope. The headloss from intermediate maintenance holes are lumped into the pipe friction. During this phase of the model building process it is often necessary to supplement the data from prime sources with other information such as cover levels, invert levels, pipe sizes, pipe shapes, missing overflow pipes and carefully check the connectivity of the system.

Where simplification has been undertaken it is necessary to ensure that surcharge volumes are maintained in the model and these will be allocated to the remaining maintenance holes. A pipe roughness must then be allocated to each pipe length and this is initially done on the basis of the pipe material. The type of maintenance hole cover must also be allocated.

The next major step is to assign dry weather flows to each maintenance hole. This is done by using census data to allocate populations to each maintenance hole. Commercial and Industrial users are allocated separately where appropriate. Sydney Water has developed routines, which allow water usage data to be used as a check against measured flow data. Sydney Water has also developed a range of flow profiles, which can be used to model diurnal flow patterns.

Following establishment of the dry weather behaviour the wet weather behaviour must be determined. A hydrological model known as MOUSENAM is used to predict inflows to the sewer system in response to rainfall in the catchment. It is a lumped rainfall runoff model, which classifies the wet weather flow hydrograph into a fast response component (FRC) and a slow response component (SRC). FRC is a direct consequence of rainfall and is not influenced by previous hydrologic conditions. SRC responds only slowly to rainfall and is highly dependent on previous hydrologic conditions. MOUSENAM is a combination of Surface Runoff Model, which generates FRC, and NAM model that generates SRC. Each model has a set of parameters that must be defined for each subcatchment.

Having defined the physical characteristics of the pipe network and the wet and dry weather inflows it is then possible to undertake a hydraulic simulation of the network. Sydney Water has chosen to use the MOUSE model for this purpose. The MOUSE model has been widely used around the world and has been endorsed by the Criteria Review Committee. It can simulate backwater effects, flow reversal, surcharging maintenance holes, free surface and pressurised flow, tidal outfalls and storage basins. The model computes discharge and water level at alternating points throughout the network at each time step. To ensure the equation produces stable, physically realistic results it is necessary to run the model at time steps typically less than 60 seconds.

The output from the model is water level and flow at each point in the network at each time step. As the model is run over long time periods it is therefore possible to generate a time series of water level and flow at each point in the network.

2.4 Recommended Performance Indicators

A key test of a performance indicator is the relevance of the indicator to the problem at hand. The problem in this case is to compare the predictions of the hydraulic model with data measured from the sewerage system network. From the discussion above it is apparent that the two variables that can be compared between measured and modelled data are water level above invert of pipe and flow in the sewer.

Of these two the primary indicator is water level above pipe invert as it has the advantage that it can be directly measured in the field and is explicitly computed in the trunk sewerage system model. Instruments are available which allow the recording and logging of this data over time. These data can be directly compared with the predictions of the trunk sewerage system models. This indicator meets the ideal criteria for a performance indicator as it is simple to measure and it is applicable for both low and high flows.

The second recommended performance indicator is flow in the sewer data. Flow in the sewer is a direct output of the model. It has a disadvantage in that it is not as easily measured as water level as it must be derived from water level, velocity and pipe cross sectional information. It is a fundamental indicator however as it is ultimately flow which influences the behaviour of the network. It also has the advantage that is a direct output from the trunk sewerage system model.

A model that can accurately predict flow and level can then be used for a wide range of purposes. Of specific interest to EPA and Sydney Water is the ability of the model to predict overflows. Overflows occur when the water level at the overflow structure exceeds the overflow level. The water level predicted at each timestep can be compared to the overflow level to see if an overflow is predicted. The probability of the model predicting an overflow incidence when the measurements indicate an overflow is the third recommended indicator and will be called the overflow incidence index.

The three recommended system performance indicators are therefore water level in the sewer, flow in the sewer and overflow incidence index. These three indicators will allow the performance of the trunk sewerage sewer system model to be assessed.

3. SELECTION OF ACCEPTANCE CRITERIA

3.1 Introduction

For each performance indicator there must be tests that can be applied to determine whether the predicted performance matches the measured performance. These tests need to be statistical in nature to ensure they are independent of the person undertaking the test. The criteria associated with these tests must be rigorous enough to ensure the model does reproduce measured behaviour. The criteria must also take into accounts the errors associated with measurement and modelling. These errors provide a fundamental limit to the degree models can reproduce measured behaviour.

These issues were raised by the Criteria Review Committee (CRC) meeting of October 1997. It was a finding of this Committee that Sydney Water should engage an independent consultant to develop statistical techniques to review model accuracy. Following this meeting Sydney Water engaged the CSIRO division of Mathematical and Information Sciences to undertake this work. The subsequent section detail the methodology recommended by CSIRO.

Following this review Sydney Water held another CRC in November 1999. This committee found that the,“adopted methodology appears to overcome inherent interpretation and understanding difficulties of more conventional statistical methods which rely on using standard deviations to determine whether differences between measured and model results are significant at adopted probability levels. The residual plots produced by the statistics package are simple to read and interpret although the underlying statistics may not be understood.”

The November 1999 CRC also considered that “the chosen statistics are statistically robust because they address both bias (temporal and magnitude) and variability due to the measurement and modelling processes“. This CRC recommended those additional non-statistical “common sense” criteria are also necessary to determine whether a model should be accepted or rejected. This is required because it is possible to have a statistically significant difference even though the difference is physically insignificant.

The November 1999 CRC also recommended that gauge contractors be encouraged to gauge over the full in-pipe flow range to improve gauge accuracy at higher flows. They also recommended that a protocol be developed to ensure gauge accuracy.

Another CRC was held in June 2000 and this found that the tool developed to assess model accuracy by CSIRO known as SWAGMAN “considers that all relevant sources of error are included in SWAGMAN. The package analyses bias (temporal and magnitude) and variability caused by measurement and modelling."

The following sections provide an outline of the principles of uncertainty in both measurement and modelling used to develop the methodology for determining appropriate acceptance criteria.

3.2 Uncertainty due to measurement error

Measurement uncertainty is caused by the process of measurement not replicating the true value the model is attempting to fit. Measurement uncertainty is the sum of the following uncertainties:

- Sampling errors: an example of this is sampling at a location in the sewer that does not give the maximum level of flow in the sewer. Alternatively, velocity meters could be positioned in the sewer in a manner where the true average velocity is not measured.
- Gauge errors: Gauge measurements are biased, for example, they give measured values consistently below the true value.
- Measurement errors of model input: Gauge rainfall not being measured accurately and the centroid rainfall is not the true centroid of the local catchment relating to a gauged value of level and flow rate

The errors generated in this process provide a fundamental limit to how well the model can explain the variability in the measured data. Monitoring for water level and velocity is now undertaken in accordance with specific limits for gauge bias and variability. The objective of these gauge accuracy tests is to ensure that these monitors have a within site error of less than 10%. These procedures together with those associated with measurement of rainfall are expected to limit the measurement error to less than 15%. This being the case it follows that the model can only explain the remaining 85% of the variation that is not due to measurement uncertainty

3.3 Uncertainty due to modeling

The process of building a model was described earlier and incorporates many steps. At each stage in this process errors are introduced. This is an unavoidable consequence of the modelling process. The skill of the modeller is in making the right simplifications and judgements to minimise the generation of errors.

Typically within the model building process considerable effort must go into defining the pipe network both in terms of its connectivity and its shape and level. As discussed in the earlier section on model building the network must be simplified in order to reduce the time for numerical computation. Significant effort is also required to adequately represent the dry and wet weather flow behaviour.

In making these decisions it is necessary to compare measured data to modelled output. As there is uncertainty on measured data the modeller must use judgement on how closely to match each measured point with the model output.

In addition to the errors associated with the input to the model there are many other forms that modelling uncertainty can take including:

- An important explanatory variable is not included in the model;
- The model has not made full use of the information in an explanatory variable ;
- Measurement uncertainty in the response variable makes it difficult to model measured responses;
- Measurement uncertainty in the explanatory variable makes parameter estimation less certain;
- Wrong parameterisation /functional form used to model the data;
- The process used to estimate the parameters of the model is sub-optimal and produces biased estimates;
- The calibration data generally does not cover the full range of response values the model is to predict and therefore model fit is poor in the range of values not represented in the calibration.

If we are able to define the contribution to prediction uncertainty caused by measurement error as say 15%, then we know that the best a modeller can do is fit the remaining 85% variation that is not due to measurement uncertainty. If for example the fitted model describes 80% of the variation in a validation sample, then the modelling uncertainty is defined in terms of its expected value if there were no measurement errors or sampling errors. That is in this example it would be estimated as

$$100\%-80\%/(100\%-15\%) \times 100\%= 5.8\%$$

Therefore we would say that measurement uncertainty is 15% and modelling uncertainty is 5.8%. With current technology and methods the aim is to ensure that model uncertainty is less than 15%.

3.4 Statistical techniques for comparing model predictions to data

There are two aspects that must be considered when comparing measured data to model output. The first is the bias the model exhibits in predicting the measured data. Biased values are encountered when the model on average over-predicts or under-predicts measured values. For example if the model predicts the level of sewage in the pipe to be on average 0.5m higher than it should be we would say there is a bias of 0.5m.

The second aspect, which relates to the lack of fit between the model and measured data, is the variation in prediction values from its on average prediction value. This is generally known as the prediction variance. If the same set of model inputs are repeated on several occasions then the measured value for the response is not usually reproduced on every one of these occasions. This happens because of both model and measured uncertainties. If for a large number of these repeated events the average response equals the model fitted value, then we say the model is unbiased for this set of inputs. The amount these response values vary from the model fitted value is an estimate of the predictive variance for this set of input values. The overall lack-of-fit of a model is the sum of the bias value squared and the predictive variance, and this is often called the mean squared error of prediction (MSEP).

The MSEP is a good measure for comparing models for the same response but as it is not scale invariant it is often difficult to judge whether a good fit has been achieved. Other criteria which are independent of scale include Pearson's Correlation Coefficient (r) and variations of this criteria known as adjusted R-squared and Rabs.

Pearson's correlation coefficient is widely used in practice and this coefficient measure the correlation between measured and model fitted data. A coefficient of one (1) would indicate a perfect association between the measured and modelled data. It is however possible to obtain a coefficient of one without the values of measured and modelled data being equal and this is due to bias.

A robust measure of the goodness of fit would therefore be scale invariant and consider bias and correlation. Two measures which do this are adjusted R-squared and Rabs. These measures test whether the model fitted values are better than fitting using only the mean response value .The first method known as adjusted R-squared uses squared deviations from measured values as a criterion of fit .The second measure uses absolute deviations from measured values as a criterion of fit and is known as Rabs. The second method is less sensitive to outliers than the first.

In both of these methods the maximum value which can be achieved is one (1) and that is when the model fitted data are identical to the measured values. If the criteria are negative it indicates that the model fitted values are worse than using the mean value to predict the response value. These indicators provide a valuable insight into the goodness of fit.

3.5 Recommended performance acceptance criteria

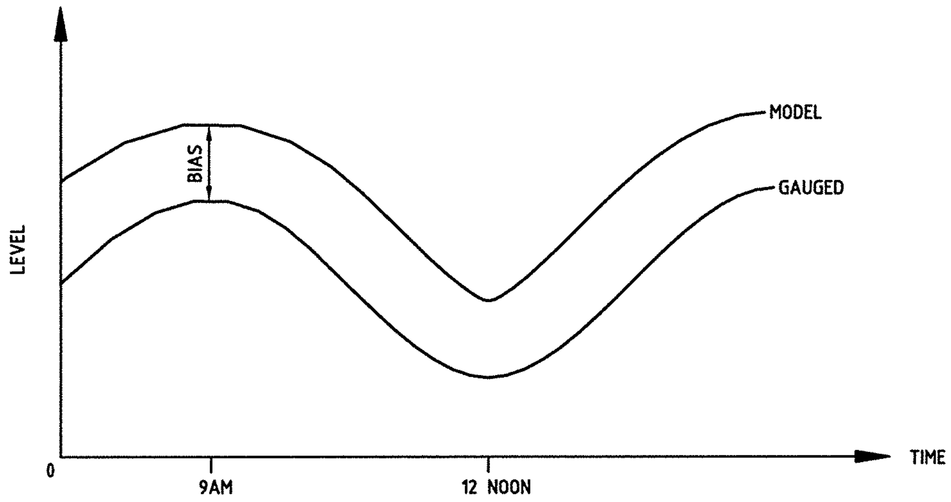
3.5.1 Introduction

From the work undertaken by CSIRO it is clear that a good model must be unbiased and must have an acceptable level of fit. Bias can take two forms and they are defined as temporal bias and magnitude bias. Temporal bias assesses how well the model reproduces the measured data in terms of closeness in time. Magnitude bias assesses how well the model reproduces the measured value as the magnitude of the performance indicator (level or flow) increases. The lack of fit can be measured by several statistics but as bias reduces to zero all of these values converge to Pearson's correlation coefficient.

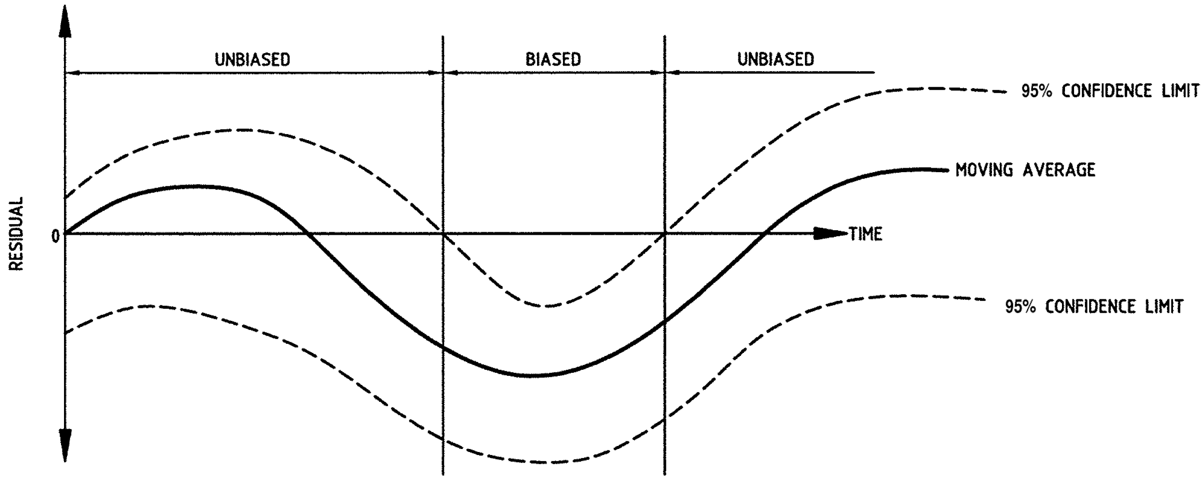
Acceptance criteria dealing with each of these aspects is discussed below. They have been developed based on the CSIRO methodology and enhanced with the contribution of the CRC and recent experience of Sydney Water in the application of these tests.

3.5.2 Temporal bias

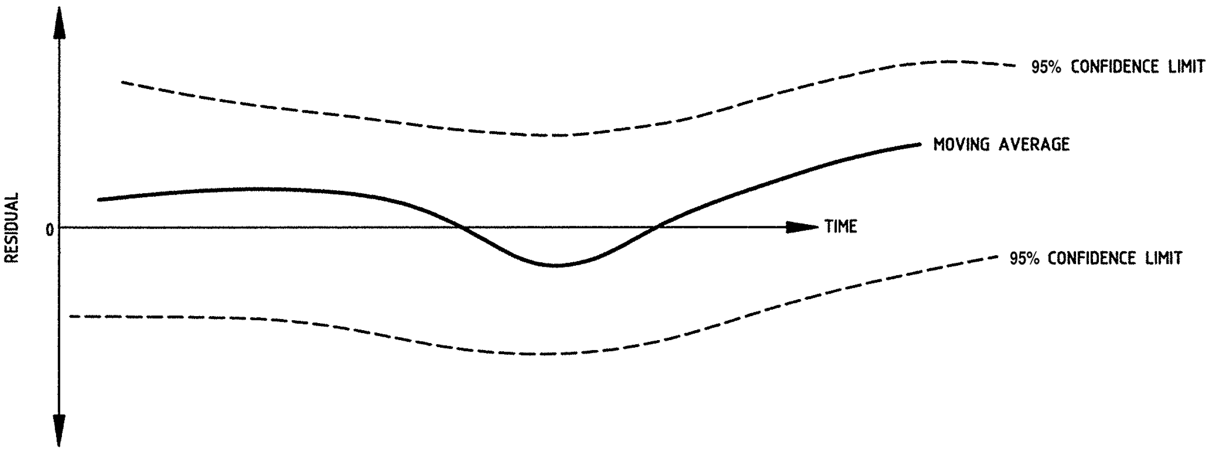
This is the bias that occurs at a particular time of the year, possibly because of seasonal variations, or biases in particular years because its weather differed from previous years. The figure below shows a plot of sewer level over time. There are two lines, one from a model output and the other from a sewer gauge. A similar distance separates them and this seems relatively constant with time. This difference is the local temporal bias.



This can be detected visually by subtracting the model values for the performance indicator from the measured value and plotting this against time. The difference between measured and modelled values is known as the residual. Over time the residual value should not differ significantly on average from zero. Any significant or consistent trend of the local mean away from the zero value will indicate a local bias in model predictions. The following figure shows an example where the model is unbiased initially and then becomes biased for a period of time. Following this period the model becomes unbiased again. This model would need re-calibration to correct for this bias.



For each gauge it will be required to compare measured data to model values in a pairwise comparison of the difference between gauge and model values. This residual should be plotted in a time series with a non-linear smoother passing through the local average residual value. Residuals should not differ significantly on average from zero, therefore the location mean of the residuals should be a random walk about the residual equal to zero line .The 95% confidence intervals of the local means should span the zero residual line. Where the 95% confidence intervals cross the zero residual line it should do this an equal amount of times above and below the line. The figure below shows the results from a model that is temporally unbiased.

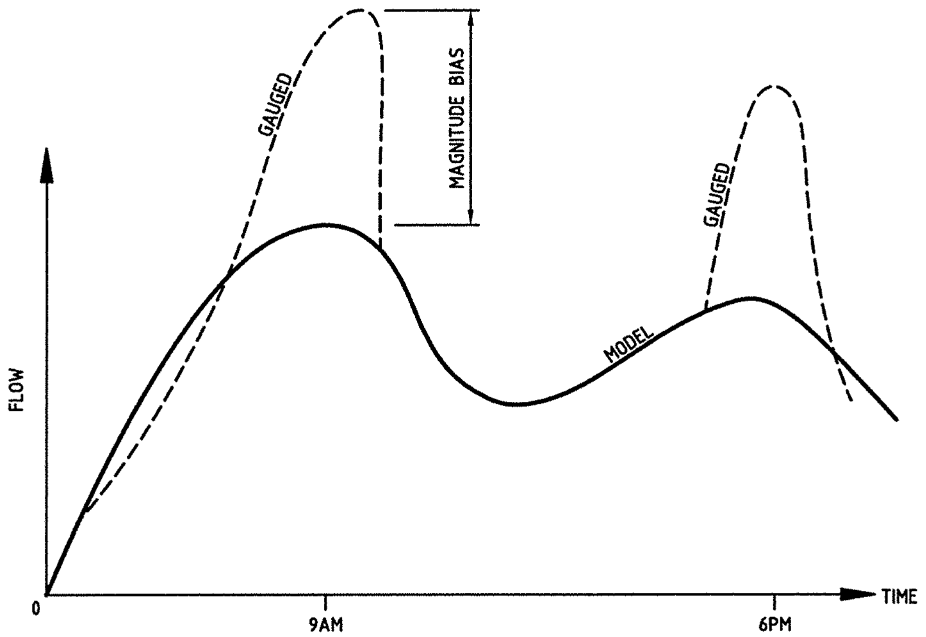


In rare circumstances the 95% confidence intervals may be very close as there is good agreement between the measured and modelled value but they do not span the zero line. In these cases if the arithmetic mean of the residual is less than 10mm for level or 5% of the average dry weather flow in the case of flow the model will have been considered to have passed the temporal bias test. This conditional criterion allows for the CRC comments of November 1999 where they noted that a statistically significant bias could occur which were physically insignificant.

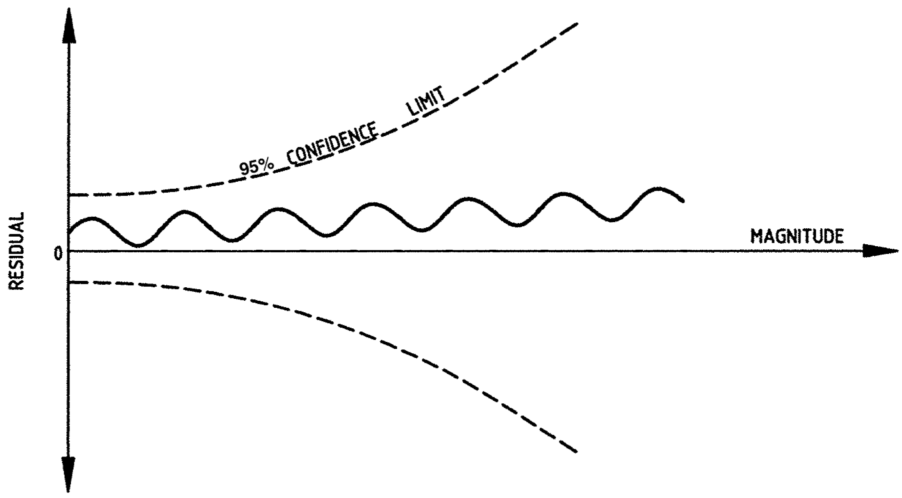
A recommended performance acceptance criterion therefore is that the model should have no significant temporal bias subject to a test for physical significance. This will provide assurance that the model ability to predict measured behaviour is unbiased over time.

3.5.3 Magnitude bias

This is the model bias that may have occurred because the model is calibrated for a specific range of magnitudes .For example, we may calibrate the model for dry weather periods that experience low flow and find that the model does not predict high flows well. This problem has been identified in earlier CRC meetings and the new gauging contracts encourage the contractors to take field measurements over the full range of flows. The figure below shows a plot of sewer flow over time. The results of a model output and a gauged flow are plotted on the figure. The plot indicates that the model under-predicts flow at high flow rates but is a good predictor at low flow rates. This model has a magnitude bias and this is indicated on the figure.



Magnitude bias is tested by plotting the difference between the gauge and model fitted value (residual) versus the average of these fitted and gauged values. In all cases the local mean of the residual should not trend significantly away from zero as model and gauge values increase. This is determined by plotting the 95 % confidence intervals of the local mean and ensuring that they span the zero residual line. Where the 95% confidence interval crosses the zero residual line it should do this an equal amount of times above and below the line. The output from a model that has no significant magnitude bias is shown in the following figure.



A recommended performance acceptance criterion therefore is that the model has no significant magnitude bias subject to a test for physical significance This will ensure that the model provides unbiased predictions over the range of flows and levels experienced.

3.5.4 Goodness of fit

Three Goodness of fit criteria has been described and they are Pearson's correlation coefficient r^2, **Adj.Rsq** and **Rabs**. These should be calculated over the period of record for both flow and level. These criteria assess the model ability to predict the variation observed in the measured data. As the models must be calibrated to ensure they have no significant temporal or magnitude bias it is proposed to use the conventional Pearsons correlation coefficient as the key measure .

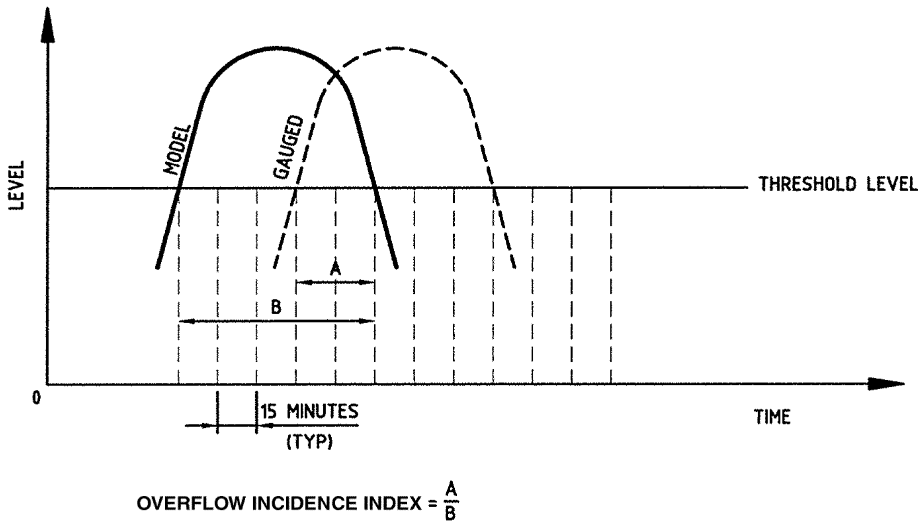
From earlier work it was indicated that measurement error could explain up to 15 % of the observed variation and modelling variation could also explain up to 15% of the variation. As these errors are independent it is not appropriate to simply add the errors but from work undertaken in the last year it is likely that they combine to explain on average 20 to 25% of the observed variation. The model should explain the remaining 75% to 80% of the observed variation.

The minimum acceptable Pearson's correlation coefficient is 0.75.

3.5.5 Overflow incidence index

Of broad interest to both the EPA and Sydney Water is the ability of the model to predict the incidence of overflow when an overflow has been measured. Overflows occur when the sewer level in the pipe exceeds the threshold level for overflows. This test is therefore a subset of the more general test for water level explained previously.

In this test a minimum of three months of data must be compared to model predictions on a 15-minute time increment. This time series should include at least three periods of time where significant overflows occurred (as a guide measured overflows should have occurred for at least 5 hours). The number of times the model predicts an overflow when the measurements have indicated an overflow should be noted. This number should be divided by the number of times the model predicted that the overflow level exceeded the threshold level over the entire time series. This comparison is shown for a single event on the figure below.



With current technology and the uncertainties associated with modelling and measurement, the model should be able to achieve an overflow incidence index exceeding 75%. The model shown above therefore would not be considered acceptable and would require re-calibration.

The minimum acceptable overflow incidence index is 75%.

3.5.6 Time for EPA approval of indicators and acceptance criteria

PRP101.3 requires that Sydney Water must complete re-calibration of all models by 31 October 2001. In order to achieve this tight time frame it will be necessary for EPA to approve the recommended indicators and their associated acceptance criterion by 31 October 2000.

4. REFERENCES

CSIRO Mathematical and Information Sciences, “Validation Process for fitted Models of LEVEL and FLOWRATE in Sewer Pipelines”, Report Number CMIS D16/112 June 1998

Sydney Water, System Services, Distribution “Statistical Validation of Sewerage Systems Northern Suburbs Ocean Outfall Sewage System”, October 1998

Sydney Water, Overflow Abatement Program, Criteria Review Committee (CRC) for Sydney Harbour Wastewater Planning Project (SHWPP) and OACIS for OAP, Nielsen Environmental Pty Ltd November 1999

Sydney Water, Overflow Abatement Program, Criteria Review Committee (CRC) No 2 for Sydney Harbour Wastewater Planning Project (SHWPP) and OACIS for OAP, Nielsen Environmental Pty Ltd June 2000

GLOSSARY

Response Variable	The measure we want the model to predict well. An example is level of the flow in sewer pipelines. This variable is denoted by y_t for the response measured at time t.
Explanatory Variable	These are the model-input variables. Their information is fed into the model to give the predicted response values. For example, rainfall at a catchment centroid is an explanatory variable used to predict level in sewer pipelines. The I'th measured input is denoted by x_{Iit} for measurements made at time t
Residual	The difference between measured values of a response variable and their corresponding model fitted value.

Sydney WATER

Pollution Reduction Program

PRP 101.2 Generic Model Re-calibration Protocol

September 2000

DOCUMENT STATUS

This report was prepared in response to the Pollution Reduction Program No 101.2 attached to Sydney Water's 27 STS licences. During the preparation of this document, peer reviews were carried out at draft and final report stages. This is the final version of the report.

Any comments regarding this report should be directed to Mr Greg Barr on:
Phone 9350 5141
E-mail Greg.Barr@sydneywater.com.au

ENDORSED BY:

.... Date:
Warwick Eyles
Program Manager
Overflow Abatement Program.

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PRP 101.2

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Issue No.	Date	Description	Prepared By (Author)	Reviewed by:
1	29/9/00	Completed Document	Steve Linforth	Andrew Kasmarik

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Sydney Water is developing computer models of its sewerage network in order to prepare plans for the improvement of the system. These models are used to predict the performance of the network under both wet and dry conditions. These models are calibrated to data collected over a specific period of time. These models will be used by Sydney Water to estimate overflows for licencing purposes into the future. It is therefore necessary to check the models from time to time to ensure they continue to produce reliable estimates. This PRP describes the process used to check the models and the process required to re-calibrate the models if these checks show that the model no longer meets acceptance criteria.

The specific licence conditions for this PRP are as follows

101.2.1

The licensee must develop a generic Model Re-Calibration Protocol for the ongoing re-calibration of the hydraulic sewer system models that, at a minimum, addresses the following issues:

(a) development of a set of re-calibration triggers based on factors such as time , completion of works or trends in model output:

(b) The nature and level of information required to carry out the re-calibration. The assessment of data requirements must address , at a minimum , the following concepts :

- (i) minimum acceptable time series rainfall data length;
- (ii) minimum number of rainfall events;
- (iii) minimum range of rainfall event size ;

that must be collected to enable the model to be re-calibrated.

(c) development of a generic re-calibration methodology that can be used to recalibrate the models and demonstrate that the subsequently re-calibrated models continue to meet the approved performance acceptance criteria;

(d) options and actions to be undertaken if the subsequently re-calibrated model is unable to achieve the approved performance acceptance criteria;

(e) the need to update monitoring requirements as a result of the re-calibration; and

(f) a process for convening an independent Criteria Review Committee for the purposes of PRP101.4.

101.2.2 The licensee must submit for approval to the EPA a copy of the written Model Re-Calibration Protocol by no later than 30 September 2000

This report has been prepared to comply with the requirements of PRP101.2 Generic Model Re-Calibration Protocol for the 27 STS licences indicated in **Table 1.1**.

Table 1.1: Sewage Treatment System Names and Licence Numbers

LICENCE NUMBER	LICENCE SYSTEM
1775	Bellambi
1712	Blackheath
1688	Bondi
1725	Castle Hill
1728	Cronulla
1407	Glenbrook
750	Hornsby Heights
2269	Kiama
1716	Mount Victoria
190	North Richmond
378	Northern Suburbs
1409	Penrith
1696	Port Kembla
1724	Quakers Hill
1726	Richmond
1796	Riverstone
2392	Round Corner
4965	Rouse Hill
211	Shellharbour
372	Malabar/Southern Suburbs
1729	St Marys
1778	Warragamba
1784	Warriewood
1675	West Camden
1695	West Hornsby
1963	Winmalee
218	Wollongong

1.2 Planning History and description of the system

Sydney Water is a major provider of water and wastewater services in Australia. It is a state-owned corporation belonging to the people of NSW. Sydney Water has three equally important principle objectives, which are to be successful business and to protect the environment and public health. These objectives are expressed in terms of environmental, public health and commercial goals in response to customer commitments, which are defined in the Water Board Corporatisation Act (1994) and Operating Licence.

WaterPlan 21 is Sydney Water's vision for long term, ecologically sustainable wastewater management across the Sydney, Blue Mountains and Illawarra region. The plan resulted from a process of investigations commenced in the late 1980's devoted towards improving the sewerage systems performance. The plan includes $1.6 billion to overhaul Sydney Water's sewerage systems and ultimately eliminate an average of 80-90 per cent of wet weather overflow events across the area. In addition, Sydney Water proposes to spend $0.4 billion on linked dry weather overflow abatement programmes. The total cost of the overflow abatement program (OAP) for wet and dry weather improvements is therefore $2 billion. These costs will be spread over the next twenty years. Any pricing impacts of this program will need an IPART determination.

Sydney Water provides sewerage services to almost three and three quarter million people and maintains 28 sewerage systems, consisting of some 22,000 kilometres of sewer. The current performance and Sydney Water long-term objectives for 2021 for the systems are shown in table 1.2.

Table 1.2: Current and Sydney Water 2021 objectives for sewerage system performance

	Dry weather		**Wet Weather**	
	Current	**future**	**current**	**Future**
leakage (exfiltration)	suspected to cause failure of swimming / boating criteria in some receiving waters	will not cause dry weather failure of swimming / boating criteria	not applicable	not applicable
wet weather treatment	not applicable	not applicable	H/N STP's disinfection fails in small storms. Minor ocean plant *1 – beaches fail faecal coliform criteria in storms	STP discharge will not cause failure of water quality criteria
directed overflows	50 individual discharges per year *2	less than 15 discharges per year	up to 200 events per 10 years 350,000 ML per 10 years	80-90 per cent average reduction in events per 10 years across Sydney
uncontrolled overflows	internal surcharge – 140 reported events per year 96 per cent of customers no external overflows	less than 10 internal surcharges per year due to sydney water capacity individual customers experiencing choke related overflows (2 per 6 months or 3 in 2 years) guarantee no repeat for two years	200 known areas *3	• no internal surcharges due to sydney water capacity • fix to known surcharge areas 96 per cent of customers no external overflows
odours	20 individual assets cause repeat odour complaints	less that 3 verified odour events per year for an individual asset (eg vent shaft, sps)	unknown	Frequency of odour events no greater that wet weather overflow frequency

*1 minor ocean plants include; Warriewood, Cronulla and Illawarra STP's
*2 predominantly SPS failures
*3 total unkown as not all wet weather events reported

The planning conducted to date has provided a firm base for implementation of the OAP. Whilst Sydney Water does not recommend any major changes to the proposal as defined in the Environmental Impact Statements (EISs) for Licencing Sewerage Overflows, a number of other initiatives and events have occurred which could constrain or impact upon the delivery of the OAP. These include; the NSW

Governments Waterways Package, amendments to the Clean Waters Regulation and Classification of Waterways, the enactment of the *Protection of the Environment Operations Act 1997* and the overflow abatement strategy proposed by the EPA.

It is recognised that additional detailed planning and environmental impact assessment will be undertaken as part of the OAP and through pollution reduction programs set by the EPA. Refinement of the detail of overflow abatement options will be via a continuous and adaptive process and will reflect current and future community concerns.

The EPA issued the Sewage Treatment System licences to Sydney Water on 26th May 2000. The STS licences set the EPA priorities and timetable for overflow abatement. The Pollution Reduction Programs (PRPs) set out the specific works and activities required to achieve that outcome. The documents produced here, form part of the suite of reports required to be prepared as part of the PRP's. Completion of the PRP's will not achieve the long term objectives of Sydney Water.

1.3 Sydney Water monitoring framework

The monitoring undertaken by Sydney Water can be defined in two broad areas:

A. Monitoring programmes to measure system performance; and
B. Monitoring programmes to measure impacts of overflows on the environment.

These can further be subdivided into the following monitoring types:

1. **Routine** monitoring - undertaken as part of system performance monitoring;
2. **Project** monitoring – undertaken for specific works/ planning projects;
3. **R&D** monitoring – undertaken as specific research and development projects.

The existing routine monitoring that is undertaken as part of business performance reporting, can be broadly categorised into this framework as shown in Table 1.3.

Table 1.3 – Existing monitoring

Monitoring Type	Performance monitoring	Impact monitoring
Routine monitoring	• Chokes/100km Sydney-wide • No. customers affected by surcharges • Repeat chokes • Odour complaints • Representative overflow reporting • Incident monitoring –dry weather discharges to waterways	• Components of existing Environmental Impact Monitoring Program (under revision) • Incident management response monitoring
***Project monitoring**	• Interim I/E gauging programme • Sewer flow gauging	• Interim I/E water quality monitoring; • Ecological & human health risk assessment monitoring of overflows; • Northside storage tunnel pilot study monitoring; • Dry weather point source sewage detection
R&D monitoring		• Clean Waterways Program stormwater and receiving water quality monitoring for model development

* = some project monitoring occurs periodically over a cycle of several years.

It is proposed that the routine monitoring outlined above, would form the basis of the licence monitoring requirements. Project and R&D monitoring would continue to be applied on a needs basis.

1.4 Sydney Water modelling framework

The models used to develop the overflow abatement proposals in the EISs, were deemed to be appropriate for strategic planning purposes, by two independent criteria review committees. Their continued use for the purposes of performance monitoring and licence compliance would however, require them to be further developed. The EPA has accordingly, developed a PRP to satisfy that outcome.

As part of the analysis conducted in the overflows EISs, it became apparent that system output performance measures were the most appropriate means of assessing the performance and indicating the impacts of the sewerage systems. It was clear, that modelling environmental condition, resulting from overflows was not appropriate, because of the confounding influence of external factors such as stormwater. Benefits delivered by overflow abatement would be masked by these external factors.

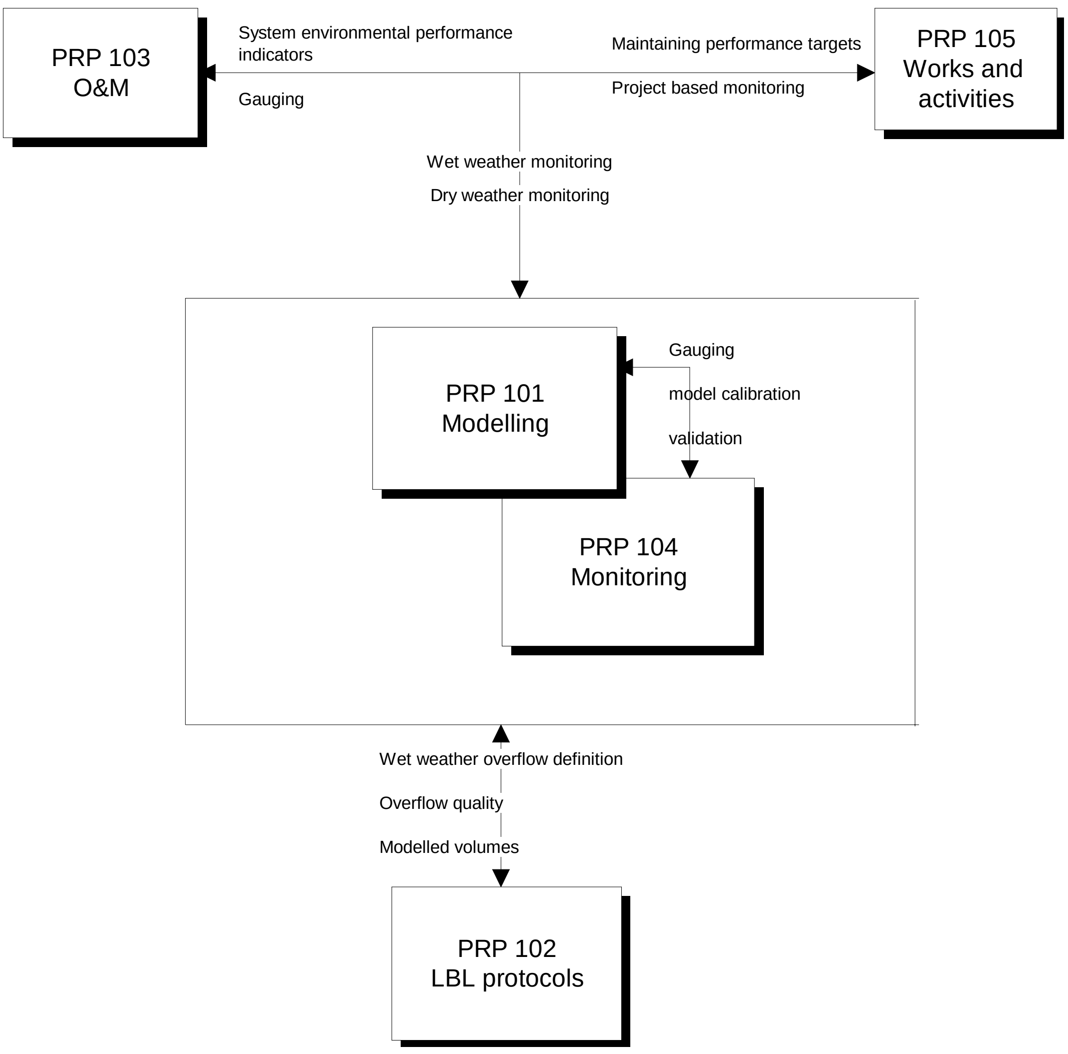
Sydney Water therefore proposes that output performance monitoring, measured by sewer system models and other non-modelled attributes, would form the basis of licence reporting. Environmental water quality models would continue to be used for setting strategic direction and assessing overall environmental condition but not for compliance monitoring. Whilst both suites of models would be improved over time, the majority of the effort would be devoted to improving the system models.

Performance monitoring will be measured by the sewerage system models, in terms of overflow frequency and/or volume. The system models will be upgraded by a process of developing a quality system, performance targets and re-calibration protocols. These processes will be reported as part of licence compliance reporting.

1.5 Achieving the long term objectives

The STS licences set the EPA priorities and timetable for overflow abatement. The PRPs set out the specific works and activities required to achieve that outcome. Figure 1.1 indicates the interrelationships between the PRPs as a guide, to enable the process and interrelationships to be understood.

Figure 1.1: PRP interrelationships



2. TRUNK SEWERAGE SYSTEM MODEL

2.1 Introduction

For each of the sewerage systems Sydney Water operates, a MOUSE model is being developed. These models are known as Trunk Sewerage System Models and they model the major pipes of the network down to a diameter of 300mm. Typically this results in the catchment being divided up into subareas in a range from 10 Ha to 800Ha. Within this network the major hydraulic features such as pump stations, overflow points and pipelines are incorporated.

This chapter discusses the processes that are being used to develop these models and the criteria that are being used to decide when a model is calibrated and verified. These models and the way they have been developed are introduced as background to this PRP. This PRP describes the triggers that will cause Sydney Water to re-calibrate the model, the data requirements for re-calibration and the protocols for recalibration in the following chapters.

2.2 Model building process

The catchment to which the sewerage system is connected must first be defined. Sydney Water has defined all boundaries to the sewer network and these are stored in a geographic information system (GIS). The physical characteristics of the pipe network must then be established. The primary source of this data is stored on the Hydra-Smallword GIS and needs to be simplified for the purposes of modelling. This simplification is necessary to allow the numerical computations of the system to be undertaken within practical timeframes.

The primary simplifications are to extend the model pipe network up to a point that has a permanent flow gauge. Within the defined pipe network the number of maintenance holes simulated is reduced to that necessary to define major junctions, flow measurement points, overflow points, changes in pipe diameter or pipe slope .The headloss from intermediate maintenance holes are lumped into the pipe friction. During this phase of the model building process it is often necessary to supplement the data from prime sources with other information such as cover levels, invert levels, pipe sizes, pipe shapes, missing overflow pipes and carefully check the connectivity of the system.

Where simplification has been undertaken it is necessary to ensure that surcharge volumes are maintained in the model and these will be allocated to the remaining maintenance holes .A pipe roughness must then be allocated to each pipe length and this is initially done on the basis of the pipe material. The type of maintenance hole cover must also be allocated.

The next major step is to assign dry weather flows to each maintenance hole. This is done by using census data to allocate populations to each maintenance hole. Commercial and Industrial users are allocated separately where appropriate. Sydney Water has developed routines that allow water usage data to be used as a check against measured flow data. Sydney Water has also developed a range of flow profiles that can be used to model diurnal flow patterns.

Following establishment of the dry weather behaviour the wet weather behaviour must be determined. A hydrological model known as MOUSENAM is used to predict inflows to the sewer system in response to rainfall in the catchment. It is a lumped rainfall runoff model that classifies the wet weather flow hydrograph into a fast response component (FRC) and a slow response component (SRC). FRC is a direct consequence of rainfall and is not influenced by previous hydrologic conditions. SRC responds only slowly to rainfall and is highly dependent on previous hydrologic conditions. MOUSENAM is a combination of Surface Runoff Model that generates FRC and NAM model that generates SRC. Each model has a set of parameters that must be defined for each sub-catchment.

Having defined the physical characteristics of the pipe network and the wet and dry weather inflows it is then possible to undertake a hydraulic simulation of the network. Sydney Water has chosen to use the MOUSE model for this purpose. The MOUSE model can incorporate backwater effects, flow reversal, surcharging manholes, free surface and pressurised flow, tidal outfalls and storage basins. The model computes discharge and water level at alternating points throughout the network at each time step. To ensure the equation produces stable, physically realistic results it is necessary to run the model at time steps typically less than 60 seconds.

Output from the MOUSE model is in terms of flow and level at each point in the network. The model is calibrated by selecting a known period of time and adjusting the input variables described above until a match is made between measured flow and level and computed flow and level. The model is then verified by choosing another period of time and without modifying any of the calibration parameters observing the fit between measured and modelled flow and level.

2.3 Performance Indicators

The proposed performance indicators and acceptance criteria for calibration have been discussed in PRP101.1. Prior to testing for the performance indicators it will be necessary to test for gauge accuracy to ensure the gauge meets its acceptance criteria. Having ensured the gauge data complies with its acceptance criteria it is then permissible to test for the performance indicators. There are three performance indicators and these are water level in the sewer, flow in the sewer at each gauge location and sewer overflow index.

2.4 Summary of acceptance criteria for calibration

There are three criteria to be applied to the comparison of measured water level and flow with modelled estimates in order that the model overall be accepted;

- No significant temporal bias
- No significant magnitude bias
- The minimum acceptable Pearson's Correlation Coefficient is 0.75

In addition the minimum acceptable overflow incidence index is 75%. The development of these criteria is detailed in PRP101.1.

3. TRIGGERS FOR RE-CALIBRATION

3.1 Introduction

Each of the models being developed for the trunk sewerage system will undergo a comprehensive process of model development, calibration and verification. These models remain in calibration until physical changes occur in the system. This assumption can be tested by annual comparisons of the model to data collected at licence gauge locations. The decision to re-calibrate a model should be based on the results of comparing measurements at the licence gauge with predictions from the model. These comparisons become the primary trigger for re-calibration.

There are also other reasons why the model may need to be updated and this may not require re-calibration of the model. The main reasons are listed below.

- System geometry and components changes
- New pipes or modifications to existing pipes
- Overflow weir level changes
- Pump station upgrades
- Changes to operating rules
- Wet weather flow behaviour
- Effect of leakage reduction works

3.2 Primary trigger

It is proposed that load be calculated annually using the trunk sewerage system models. This will require that the models need to be run using the last year's rainfall data to calculate flows and levels throughout the system. In each sewer system there will be at least one gauge measuring flow and level. It is appropriate at that time to compare the model prediction with the measured water level and flow at the licence gauge locations. The performance acceptance criteria discussed in section 2.4 can then be applied to see if the model has remained in calibration for the past year.

As described in PRP101.1 the acceptance criteria for a calibrated model are close to what is physically possible given errors in measurement and modelling. It is statistically likely that small excursions from the acceptance criteria will occur for a selected subset of the data. (such as using only one year of data rather than the whole record). Large excursions such as a change of 0.1 in the Pearsons Correlation Coefficient is unlikely to occur unless a significant physical change in the catchment has occurred.

It is proposed that this annual test of model accuracy be applied to each system as the primary trigger for assessing the need to recalibrate. This test would require that the immediate past year would be run through the model and the results compared to the original calibration acceptance criteria.

If the Pearsons Correlation Coefficient were less than 0.65 in the year this would trigger the need to begin the re-calibration process immediately. This process would be completed by the following year. If the Pearson's Correlation Coefficient is between 0.65 and 0.75 in each of two consecutive years then this would also be a trigger for re-calibration .If the Pearson's Correlation Coefficient is greater than 0.75 there is no need for re-calibration.

3.3 Other reasons to update the model

There are two main reasons for modifying the model. They are changes to system geometry and the effect of leakage reduction works. These will require a local modification to the model and not a system wide re-calibration. These changes are required to ensure that the basic assumptions of the model remain valid. These factors should be monitored on an annual basis.

3.3.1 System geometry and components

The MOUSE model is comprised of a network of pipes, maintenance holes, and pump stations, rising mains and overflow structures. Clearly if there are significant changes to this network they will need to be incorporated into an updated model .An obvious example is the construction of the Northside Storage Tunnel which comprises of a long tunnel, penstocks, inlet/overflow structures and pump stations. This major change in the trunk network would drive an update of the model.

As the MOUSE model only incorporates the major trunk mains it will not be necessary to modify the model if only changes to pipes outside the current model extent has occurred. Amplification of trunk mains within the model extent will need to be incorporated into the model as they occur but it will be sufficient to accumulate these and incorporate them in an annual update. Physical changes of this type will not necessitate a re-calibration of the model but rather a simple modification of pipe data in the MOUSE model.

Pump stations can have a significant influence on flow and level behaviour. Sydney Water has a program to reduce the risk of overflow at many of the pump stations and this will potentially effect system behaviour. Modifications to pump stations should be incorporated into the annual model update.

Changes to overflow weir levels can also have a significant effect on flow and level behaviour in the system. These will need to be incorporated into the annual update of the model.

3.3.2 Leakage reduction works

Wet weather flow behaviour will be influenced over time by leakage reduction works undertaken in the catchment. Typically a sub area of a catchment will have a program of works undertaken to reduce the amount of leakage which occurs in the sub area. As the trunk sewerage system models extent typically terminates at a sub area this improvement to behaviour will be reflected in changes to the inflow hydrograph and reticulation overflow behaviour. The trunk sewerage system models should be updated for this effect once the post-gauging program for the particular subarea is complete.

4. DATA REQUIREMENTS FOR RE-CALIBRATION

4.1 Model Build

As the models exist for each sewerage system the existing parameters become the basis for re-calibrating the model. The model build process covers the following steps

- model network definition
- data clean up
- processing and application of network asset data
- processing and application of catchment asset data
- modelling ancillary structures
- model simplification
- model export and stability check

A review of these steps is required to ensure that the current system reflects the existing model structure.

4.2 Rainfall

Rainfall data will be required covering a period of at least one month prior to the commencement of flow gauging for calibration purposes. Rainfall data has been shown to be critical in obtaining good correlation between measured and predicted flows. Where possible access should be made to all of the rainfall data Sydney Water collected in the catchment area of interest .The location of rainfall gauges needs to be plotted with reference to the location of sub-catchments and there topographic contours to 10m accuracy. From this plot it will be possible to assign rain gauges to each sub-catchment

A review of rainfall data is required to understand the quality of the data and to investigate the spatial variability of the recorded data. The data for each rain gauge should be compared to identify

- Rain gauges with missing or lost data
- Spurious or inconsistent data
- Spatial trends

Where data from a rain gauge is inconsistent or there is doubt over its validity, it should ideally be rejected. Where data from a rain gauge is considered suspect for only part of its record, the data should be rejected.

4.3 Flow Gauges

The extent of flow gauging required to be re-calibrated will depend on the size of the network and the number of licence monitoring gauges that failed the primary trigger. If a new set of gauging data is required the protocol for selecting the number of gauges shall be as described in PRP104.2.

The flow data to be used for calibration should be inspected to establish its suitability for its use in the calibration task .The flow and level data collected at each gauge are routinely audited to ensure they are unbiased and meet accuracy specifications. The results of these audits need to be reviewed prior to their use in calibration.

The CSIRO Division of Mathematical and Information Sciences has developed the gauge accuracy tests. They are conducted on velocity and level measurements. The tests are designed to check for gauge bias and variation .The gauge is required to be unbiased and variances must not exceed $10mm^2$ for level or $0.009m^2/s^2$ for velocity.

Other aspects of the flow data, which should be considered, are;

- The completeness of record
- Consistency of dry weather over the survey period
- Availability of both flow and depth data during storm events
- Synchronisation between rainfall and storm flows

Where data from a flow monitor does not meet the accuracy tests, it should be rejected.

4.4 Selection of a Dry Weather Period

During the review of flow data the modeller should identify the optimum week of data to calibrate the model for dry weather flow. The selected week will ideally have the following characteristics:

- All monitors have returned a full record of suitable data
- There has been no significant rainfall in the preceding week
- There has been no public holidays or other “extraordinary “events
- Not during school holidays

It is often difficult to achieve all of the above criteria and so a compromise will generally be necessary. The objective of the exercise is to establish the normal “representative” pattern of weekly diurnal flow at each monitoring site.

4.5 Selection of a Wet Weather Period

The selection of appropriate wet weather events is critical to successful model calibration. Criteria for events selected for calibration include:

- The set should include a range of rainfall events from relatively short intense storms to longer, soaking rains to best enable both the fast and slow response components to be identified.
- Minimal spatial variation in recorded rainfall across the rain gauge network.
- Some of the events should result in system surcharge to assess the suitability of un-modelled storage estimates and the interface between the hydraulic and hydrologic models.

The minimum number of events that will be needed are two to define fast and slow response parameters and a third to define system surcharge behaviour. It will normally require at least three months of monitoring to find three storms that meet these criteria.

5. RE-CALIBRATION METHODOLOGY

5.1 Introduction

Once the primary trigger has been exceeded it will be necessary to modify the model. There are two basic areas that may require modification and these are in the model building process or in the model calibration process. The model building process refers to the physical features of the network such as catchment area, model network definition, ancillary structures, asset data, catchment hydrologic data and model simplification process.

The re-calibration process is that associated with adjusting the hydrologic parameters within the model so that the dry weather and wet weather behaviour represents measured flow behaviour. This chapter discusses the re-calibration methodology, the procedures for this method are included in the quality management system for models.

5.2 Model Building

Trunk sewerage system models have been built up using standard procedures. Changes to the physical system are incorporated in the model building phase. These have been discussed previously and relate to major physical changes to the system such as

- New pipes
- Overflow weir level change
- Pump station upgrades
- Changes to operating rules

Changes to these parameters should be recorded and the model updated annually. Changes in the model build process do not require re-calibration of hydrological parameters as discussed below.

5.3 Model Re-calibration

5.3.1 Introduction

Model re-calibration will require examination and modification of both dry and wet weather parameters. This requires the collection of flow and rainfall data as described in section 4. Calibration of both dry and wet weather flows requires the catchment to be divided into monitored catchments. A monitored catchment is described as the sub-catchments upstream of each individual flow monitor. The characteristics of each monitor catchment are adapted to produce the best fit between observed and predicted data. At all times it is important to ensure that the parameters remain within sensible limits and do not vary dramatically within a small area without justification.

5.3.2 Dry Weather

The sources of inflow to a sewerage network during dry weather are as follows:

- Residential Population derived flows
- Commercial /Industrial flows
- Ground Water Infiltration (GWI)

During the model building phase a table for each sub-catchment is developed and this contains the following details:

- Residential population
- Residential water consumption
- Commercial /Industrial water consumption
- The down stream flow monitor

A site specific per capita flow rate for residential flows is then calculated by taking the flow from the selected period and subtracting the commercial /industrial sewage flows (assuming 90% of water consumption) from the average daily flows for each monitor. This will provide an estimate of the residential flow for the catchment. These values will be used in the sub-catchments applicable.

The MOUSE model allows a number of dimensionless weekly profiles to be applied to the residential and commercial/industrial flows to simulate the diurnal patterns of dry weather inflows .The residential patterns will be affected primarily by socio-economic factors while the commercial /industrial flows will be a function of the specific activity undertaken.

Once all estimated inflows have been input into the model an eight day dry weather simulation starting 24 hours before the selected dry weather period should be commenced. The initial 24 hours will ensure that the flows are fully initialised for the start of the calibration period.

The results of this simulation should be compared visually in the first instance against measured data. Adjustments to diurnal flow profiles, per capita flow rates for residential flows are made until a good fit between observed and predicted is achieved.

5.3.3 Wet Weather

The wet weather behaviour of the model should be established by reference to at least three storms. The first two storms should be small enough to cause a response within the sewer but not large enough to cause an overflow. The third storm should be representative of a storm which causes wide spread overflow. When the model can reproduce the behaviour of the system for a small, medium and large storm it is considered to be calibrated. The model must then be verified on an extended time series.

5.3.4 Model Verification

Model verification is the process of subjecting the model to testing over a minimum of a 3 month time series to see if it can achieve the performance acceptance criteria described in PRP101.1 and reproduced in Chapter 2. It should also have a range of events from small events that do not surcharge the system to large events that result in significant overflows. To achieve this a longer verification period than 3 months may be required.

6. CONVENING A CRITERIA REVIEW COMMITTEE

PRP101.4 requires an independent Criteria Review Committee (CRC) to confirm that the trunk sewerage system models meet the approved performance acceptance criteria following the completion of calibration, which is required by 31 October 2001. This PRP also requires that the re-calibration protocol must also be reviewed by the CRC. It is proposed that the CRC meet by 31 April 2001. At this time the majority of models will be calibrated and the tests will be available for the CRC to determine whether the stated acceptance criteria have been met. By holding the CRC at this time it will be possible to accommodate the CRC recommendations prior to the final completion date of 31 October 2001.

Attachment 6 Sydney Water QMS Certification

bsi.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2015

This is to certify that: Sydney Water Corporation
1 Smith Street
Parramatta NSW 2150

Holds Certificate Number: **FS 683290**

and operates a Quality Management System which complies with the requirements of ISO 9001:2015 for the following scope:

Please see scope page.

For and on behalf of BSI:

Charlene Loo, Managing Director, BSI Group Australia & New Zealand

Original Registration Date: 2018-05-10
Latest Revision Date: 2024-05-15

Effective Date: 2024-05-15
Expiry Date: 2027-05-09

...making excellence a habit™

Certificate No: **FS 683290**

Registered Scope:

To plan, deliver, operate, manage, maintain, and improve the systems, services and products for water, wastewater, recycled water, stormwater, and other recovered resources for Sydney Water Customers throughout its area of operations.

This is a Multi-site certification and details of the site addresses and respective activities are retained with BSI System Certification. Due to privacy and confidentiality regulations, site information including name, relevant normative document, scope and geographical location (e.g. city and country) for each certified client (or the geographic location of the headquarters and any sites within the scope of a multi-site certification) shall be requested directly from the certified client.

Previous Certificate expires on 2024-05-09
Recertification audit ended 2024-03-20

Original Registration Date: 2018-05-10
Latest Revision Date: 2024-05-15

Effective Date: 2024-05-15
Expiry Date: 2027-05-09

This certificate was issued electronically and remains the property of BSI Group ANZ Pty Limited, ACN 078 659 211 and is bound by the conditions of contract. This certificate can be verified at www.bsi-global.com/clientdirectory. Printed copies can be validated at www.bsi-global.com/ClientDirectory, or www.jas-anz.org/register or telephone + 61 2 9420 2700. Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2015 requirements may be obtained by consulting the organization. This certificate is valid only if provided original copies are in complete set.

Information and Contact: BSI Group ANZ Pty Limited, ACN 078 659 211: Suite 1, Level 1, 54 Waterloo Road, Macquarie Park, NSW 2113
A Member of the BSI Group of Companies.

Attachment 7 Criteria Review Committee (CRC) on Trunk Modelling

Prepared for

Australian Water Technologies

CRC on Trunk Modelling

Professional Services Contract No ENC 339

Draft Report for SWC Review

Reference: 110328

May 2001

CH2M HILL AUSTRALIA Pty Ltd
Level 16, AGL Building
111 Pacific Highway
NORTH SYDNEY NSW 2060
Phone 02 9966 1166
Fax 02 9966 1453

Executive Summary

Objectives of CRC

PRP 101.4 in the Environmental Protection Licences requires that Sydney Water should convene an independent Critical Review Committee (CRC) to confirm that the trunk sewerage system models meet the technical specification as proposed in PRP 101.1 and 101.2. The specific objectives of the CRC, as provided by Sydney Water, are shown in **Table 1.1**.

CRC Members

The members of the CRC are as follows:

- Dr Jeppe Nielsen. Manager Catchment Planning, CH2M HILL Australia (Chairperson).
- Mr Sam Austin. General Manager, Asset Services, Yarra Valley Water.
- Mr Daniel Large. Manager Environmental Information and Statistics, NSW EPA.
- Mr Glenn McDiarmid. Senior Consultant, Gutteridge Haskins & Davey.
- Mr Neil Moody. Principal, Moods Consulting.

Meeting Procedure

The CRC met on 16 and 17 May, 2001, in the Nepean Room, Sydney Water Business Office, Interchange Building, 432 Victoria Avenue, Chatswood. The agenda and presenters are shown in **Table 1.2**.

Presentation of CRC Findings

This report describes the findings of the CRC under the following main headings:

- Overall findings; and
- Specific findings with respect to each of the objectives listed in **Section 1.2**.

Overall Findings of the CRC

The CRC was appreciative of Sydney Water's candour. It is acknowledged that building, calibrating and applying sewer models for simulating sewer overflows for licensing purposes is a learning exercise for all concerned. However, it is evident that Sydney Water and the EPA have a common will to ensure that the modelling process is successful.

The CRC also recognises the large extent of work that has been undertaken by Sydney Water since the last CRC.

However, the CRC has identified a number of issues that may impact on model recalibration and benchmarking, including the ability to meet performance acceptance criteria, high flow gauge calibration, the appropriate level of model detail and the adequacy of the data for benchmark model recalibration.

Specific Findings of the CRC

The following specific findings are presented under each of the CRC objectives (refer Section 1.2).

Review Actions Completed by Sydney Water Regarding Recommendations of the previous CRC

Significant progress has been made for all the recommendations that are relevant to this CRC (refer **Table 3.1)**.

Quality Plans

The content and implementation of the Quality Plans were generally considered to be satisfactory. The CRC supports the continued use of internal auditing and recommends that the auditors take account of the recommendations made in this report.

*However, the CRC recommends the inclusion of a number of additional procedures in SSEPQP003_001, SSEPQP003_002 and SSEPQP003_003. The recommended additional procedures are summarised in the "Conclusions and Recommendations" (**Section 4.2.2**).*

Appropriateness of the Proposed Performance Acceptance Criteria Used for Re-Calibration of Trunk Models

Performance Indicators

The CRC considers that pipe level and flow are appropriate performance indicators for the trunk sewer models because corresponding measured and model results can be obtained and compared. Although in principal the Overflow Incidence Index is a sound performance indicator because it provides a measure of a model's ability to simulate the occurrence of overflows, the CRC considers there are problems with its use as a calibration parameter in view of data limitations and the calculation method. Furthermore, it should only be used if the models have been demonstrated to be unbiased in terms of magnitude and time.

Sydney Water should continue to use the following two performance indicators for calibrating the trunk sewer models: level above pipe invert and sewer flow. The Overflow Incidence Index should not be used in its present form as a primary recalibration parameter. Its method of calculation should be revised. It should then be used to confirm a models capability for predicting the occurrence and duration of overflows.

Performance Acceptance Criteria

Sydney Water has nominated four performance acceptance criteria - magnitude and temporal bias tests, the Pearson Correlation Coefficient (reported as r^2) and the Overflow Incidence Index. It is not clear why Sydney Water has concluded that a model needs to pass all of the acceptance criteria in order to be recalibrated.

The two bias tests are non-parametric tests whereas the r^2 test assumes that the data are normally distributed. The CRC has identified issues with the use of the Overflow Incidence Index. It can be concluded that a model reproduces the occurrence of overflows in terms of magnitude and time if it if passes the two bias tests (assuming that the flow gauges have been calibrated for all flows).

The two bias tests should be the primary performance acceptance criteria.

The r^2 test should only be used if it can be demonstrated that the data are normally or approximately normally distributed.

The calibration protocol should be revised to separately use dry and wet weather data for statistical verification of recalibration results instead of the use of data for all flow conditions, as is current practice (to avoid the possibility of wet weather data being "swamped" by more numerous dry weather data).

Non-statistical "common-sense" criteria should be used in addition to statistical criteria for calibrating the models. The relevant non-statistical performance acceptance criteria are that the model results are unbiased if differences between measured and modelled levels and flows are less than 10 mm or 5% of average dry weather flow (ADWF), respectively.

Measured, operating and model data should be plotted or otherwise reviewed before statistical analyses are undertaken. In other words, the acceptance criteria should be viewed as a supplement to good modelling practice, not a substitute.

The sampling frequency of SWAGMAN should be reviewed and adjusted as necessary for each trunk sewer model so that the full range of data are used.

Calibration Process for a Selection of Completed 1994 Trunk System Benchmark Models and Results for Available Completed Models

Review Appropriateness of Steps Undertaken to Transfer Models to OACIS Platform, Undertake Statistical Tests and Verification of the 1994 Benchmark Models.

It is understood that all of the 27 STS trunk sewer benchmark models have been transferred to the OACIS platform. The recalibration process provides confidence that the transfer of the trunk sewer model to the OACIS platform has been undertaken satisfactorily.

The CRC is satisfied that the statistical requirements specified in SSEPQP003_002 are being followed by the trunk sewer modellers. However, the CRC has concerns about the way in which the acceptance criteria are calculated and used, as summarised above.

Eight STS benchmark models are being recalibrated for dry and wet weather flows and statistically verified. Recalibration/verification of these models is not completed. The CRC considers that the models will have been recalibrated and verified as far as possible using the available data when the issues identified in the Sydney Water presentations and in this report have been addressed.

Several of the model presentations indicated that data used for recalibration and statistical verification are considered to be of inadequate quality and/or quantity.

The CRC recommends that where inadequate data prevent successful benchmark model recalibration, Sydney Water should identify a more recent and improved period of calibration data and update the benchmark trunk sewer models with the newer and improved data.

However, Sydney Water would need to demonstrate that the sewerage system has not deteriorated during the time from the current benchmark model (1991) to the recalibrated model using the newer data in order for the EPA to accept the calibrated model using the newer data as the new benchmark model.

Do the Re-Calibrated 1994 Benchmark Models Now Meet the Specified Acceptance Criteria?

Twenty six of the 64 flow gauges in these eight STS models pass all of the performance acceptance tests. However, none of the recalibrated 1994 benchmark models meet all of the specified acceptance criteria.

The reasons for incomplete model calibration include inadequate rainfall, sewage pump station (SPS) operations and sewer gauge data across catchments for the 10 year (1985 to 1994) time series, and insufficient model detail.

CRC recommendations concerning these issues are summarised in the "Conclusions and Recommendations" (**Section 4.2.4**). Major issues concern the lack of high flow calibration of gauges and the need to augment the STS models with SCAMP data.

There are also concerns that physical changes in catchments over time, eg population increases, SPS upgrades and changes to sewers, are not being adequately included in the models. The CRC is also concerned about the extensive use of virtual nodes in models and some model build parameters, eg the spacing of grid points used.

The CRC considers that modellers should routinely communicate with sewerage system operators in order to obtain improved understanding of the sewer systems being modelled.

If not, have all steps been taken to calibrate the model given input data availability and accuracy?

The CRC considers that when the issues identified in the presentations and in this report have been addressed the models will have been recalibrated and verified as far as possible using the available data.

Are the actions identified by Sydney Water to improve these models appropriate?

Several actions have been identified by Sydney Water to improve model calibration. Most of these actions are under way and should result in improved model calibration. The CRC also considers that recommendations presented in this report will need to be implemented for satisfactory model calibration and benchmarking.

Comments are made in this report concerning the need for modellers to review raw data, ie levels, flows and other operating data, prior to statistical analyses and to communicate with sewerage system operators to obtain better understanding of STS operations.

It is also recommended that modellers review SCAMP data, including maintenance records, customer complaints and choke data, to obtain additional verification data.

Furthermore, it is strongly recommended that modellers regularly discuss problems, issues and successes with each other to obtain mutual support and maximise operational knowledge of the models.

The CRC also strongly recommends that Sydney Water should develop a protocol for system models that appear not able to be recalibrated to the adopted performance acceptance criteria, as required in PRP 101.2.

The Proposed Model Re-Calibration Protocol Specified in Report PRP 101.2

The protocol appears logical and practical, although it is a generic protocol and little detail is presented. However as noted above, the issue of models that are unable to meet the adopted performance acceptance criteria has not been adequately addressed.

The CRC recommends that the adequacy of three months/three storm events for recalibration purposes needs to be demonstrated. The adequacy of the primary trigger (r^2) *should also be demonstrated and revised as necessary.*

Associated Model Re-Calibration Processes that are being Implemented by Sydney Water

The necessary processes for maintaining and updating model calibration were not covered in detail in the Sydney Water presentations to the CRC. The CRC suggests that this topic should be addressed at a later date when the issues and recommendations by this CRC, as presented in this report, have been addressed.

In principal the CRC agrees that the trunk sewer models should be maintained as calibrated models for sewer overflow licensing purposes. The CRC makes the following preliminary comments at this stage:

- Significant system changes should be identified for use as triggers to determine which models should be updated and recalibrated. Suitable triggers could include ADWF, customer complaints and incidences of overflows. It is suggested that models would not be considered for recalibration unless trigger values had changed significantly since the model was last revised.

- Suitably skilled resources will need to be made available to meet the modelling requirements as specified in the STS licences. It is noted that Sydney Water may find it difficult to meet licence delivery dates for all STSs with existing resources.

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Abbreviations

ADWF	Average Dry Weather Flow
CRC	Critical Review Committee
EPA	NSW Environmental Protection Authority
NSW	New South Wales
POEO	Protection of the Environment Operations
PRP	Pollution Reduction Program
r^2	Square of the Pearson Correlation Coefficient value
SCAMP	Sydney Catchment Area Management Plan
SOLP	Sewerage Overflow Licensing Programme
SPS	Sewage Pump Station
STP	Sewage Treatment Plant
STS	Sewage Treatment System

1 Introduction

1.1 Background

Following an intensive community and stakeholder consultation process involving submission of Environmental Impact Statements, Sydney Water has been issued Environmental Protection Licences from the NSW Environmental Protection Authority (EPA) under the Protection of the Environment Operations (POEO) Act for each of its 27 sewage treatment systems (STSs). The licences are issued for the scheduled activity of operating a sewerage treatment system. They are combined licences in that they include both the sewage treatment plant (STP) and sewage transport /reticulation system. Discharges from all components of the sewage transport /reticulation system owned and operated by Sydney Water are included in the licence and include sewage pump stations (SPSs), sewer lines, vents, siphons, overflow points and access chambers.

The STS licences include several requirements, including:

- Administrative conditions;
- Defining discharge, monitoring and reporting points in the STSs;
- Setting limit conditions for loads, volumes, masses, concentrations and frequencies of sewage overflow discharges;
- Operating conditions;
- Monitoring and recording conditions;
- Reporting conditions;
- Pollution reduction programs; and
- General conditions.

Sydney Water has developed computer system models for its sewerage network to predict the performance of the STSs under wet weather conditions. The models are used to predict frequency, volume and duration of overflows for specified rainfall events.

There are a number of Pollution Reduction Programs (PRPs) in the environmental protection licences that require either the provision of technical reports to the EPA or specific works and activities to be undertaken to deliver improvements to STS performance. The PRPs that are relevant to this CRC address the performance of the system models developed by Sydney Water and can be summarised as follows:

- PRP 101.1: Development of Approved Performance Indicators and Performance Acceptance Criteria;

- PRP 101.2: Generic Model Recalibration Protocols; and
- PRP 101.3: Recalibration of Models.

1.2 Objectives of CRC

PRP 101.4 in the Environmental Protection Licences requires that Sydney Water should convene an independent CRC to confirm that the trunk sewerage system models meet the technical specification as proposed in PRP 101.1 and 101.2. The specific objectives of the CRC, as provided by Sydney Water, are shown in **Table 1.1**.

Table 1.1 Objectives of the CRC	
1	Review the appropriateness of the proposed performance acceptance criteria used for re-calibration of the trunk models and specified in report PRP 101.1. against the use of the models for licence reporting and compliance. • The criteria have been reviewed in a previous CRC, however, there have been some minor changes to selection of indicators and targets that require review.
2	Review the calibration process for a selection of completed 1994 trunk system benchmark models and results for available completed models at the time of the CRC. • Review appropriateness of steps undertaken to transfer models to OACIS platform, undertake statistical tests and verification of the 1994 benchmark models. • Do the re-calibrated 1994 benchmark models now meet the specified acceptance criteria? • If not, have all steps been taken to calibrate the model given input data availability and accuracy? • Are the actions identified by Sydney Water to improve these models appropriate ?
3	Review the proposed model re-calibration protocol specified in report PRP 101.2 • Is the re-calibration protocol appropriate to meet ongoing licence compliance and reporting requirements; • Does the re-calibration protocol ensure that the models will continue to meet the proposed performance acceptance criteria.
4	Review of associated model re-calibration processes that are being implemented by Sydney Water to ensure that the models will continue to meet the performance acceptance criteria. Include: • Review of the appropriateness of the trunk model quality system, in particular review of the annual return reporting procedure; • Review of the appropriateness of Sydney Water's proposed scheduling of CRCs against current STS licence requirements.

The following two additional objectives were also identified:

- Review the CRC recommendations of the previous CRC of May 2000 and actions completed by Sydney Water; and,
- Review the Quality Plans developed by Sydney Water since the previous CRC.

1.3 CRC Members

The members of the CRC are as follows:

- Dr Jeppe Nielsen. Manager Catchment Planning, CH2M HILL Australia (Chairperson).
- Mr Sam Austin. General Manager, Asset Services, Yarra Valley Water.
- Mr Daniel Large. Manager Environmental Information and Statistics, NSW EPA.
- Mr Glenn McDiarmid. Senior Consultant, Gutteridge Haskins & Davey.
- Mr Neil Moody. Principal, Moods Consulting.

1.4 Meeting Procedure

The CRC met on 16 and 17 May, 2001, in the Nepean Room, Sydney Water Business Office, Interchange Building, 432 Victoria Avenue, Chatswood. The agenda and presenters are shown in **Table 1.2**.

All of the Sydney Water presentations took place, although the times of some presentations differed from those in **Table 1.1**.

Table 1.2 Agenda and Presenters for CRC

Time	Topic	Presenter
Wednesday, 16 May 2001		
8:30	Introductions / Agenda / CRC Conduct	R Keessen/J Nielsen
8:45	CRC Objectives	P Fisher
9:00	Background – STS licences, key licence requirements related to models	W Eyles
9:30	SSEP QMS Trunk Models Overview	S Frtunik
9:45	Question and Answer Session	
10:00	Morning Tea	
10:15	Review of recommendations from previous CRC related to trunk models	A Kasmarik
10:30	PRP 101.1 – Proposed Acceptance Criteria	A Kasmarik
11:00	Trunk Sewerage System Model Methodology and Re-calibration Process	M Mohanathasan
11:40	Question and Answer Session	
12:00	Lunch	
12:30	West Hornsby System Calibration and Results	W Cox
13:30	Question and Answer Session	
14:00	Afternoon tea	
14:20	CRC panel closed session	
17:00	Close	
18:00	Dinner	
Thursday, 17 May 2001		
8:30	West Camden System Calibration and Results	N Brown
9:30	Summary / Progress / Key Issues for other systems	K Goodhew T Loxton, B Griffiths, M Mohanathasan
10:10	Question and Answer Session	
10:30	Morning Tea	
10:45	PRP 101.2 re-calibration protocol	M Mohanathasan
11:00	STS Licence - Annual return requirements	S O'Donoghue

Table 1.2 Agenda and Presenters for CRC		
Time	**Topic**	**Presenter**
11:15	Summary issues for Trunk Model / Closing comments	R Keessen
11:30	Final Question and Answer Session	
12:00	CRC Panel closed session	
13:00	Lunch	
15:00	CRC Panel closed session	
16:30	CRC Panel Discussion / Review of major findings	
	Close	

1.5 Presentation of CRC Findings

This report describes the findings of the CRC under the following headings:

- Overall findings; and
- Specific findings with respect to the objectives listed in **Section 1.2**.

2 Overall Findings of the CRC

The CRC makes the following general comments:

- The CRC was appreciative of Sydney Water's candour in discussing work carried out to date and problems that have been overcome and still remain to be solved.

- It is acknowledged that building, calibrating and applying sewer models for simulating sewer overflows for licensing purposes is a learning exercise for all concerned, particularly Sydney Water and the EPA.

- It is evident that Sydney Water and the EPA have a common will to ensure that the modelling process is successful.

- The previous CRC recommended that "Sydney Water and the EPA continue negotiations to resolve current differences in investigating and licensing sewerage overflows". Sydney Water personnel indicated that positive negotiations between the two organisations had largely resolved earlier differences.

The CRC also recognises the large extent of work that has been undertaken by Sydney Water since the last CRC. Considerable progress has been made in the following specific areas:

- Improved project planning and management;

- Implementation of quality systems;

- Application of model performance criteria;

- Draft protocols for PRPs;

- Improvements in in-sewer flow gauging during higher flow conditions;

- Internal auditing;

- Improved understanding of the sewerage system; and

- Use of OACIS has improved transparency and coordination.

However, the CRC identified the following issues, which are discussed more fully in this report:

- Ability to meet performance acceptance criteria;

- The lack of protocols for statistically non-complying STS models;

- Impacts of future improvements to the high flow calibration of gauges and models need to be investigated;

- Sufficient detail in the trunk models is required to minimise the proportion of system overflows and hydraulic details that are represented by virtual nodes;
- Systematic augmentation of the trunk models with data that has been collated and verified as part of the Sydney Catchment Area Management Plans (SCAMPs);
- Better spatial resolution of rainfall data;
- Ongoing need for improved operational knowledge (eg pump settings etc);
- The extensive amount of work to meet EPA licence deadlines; and
- Availability of suitably skilled resources for model recalibration, benchmarking and SCAMP programs.

3 Specific Findings of the CRC

3.1 Review Actions Completed by Sydney Water Regarding Recommendations of the previous CRC

The recommendations made by the previous CRC are presented in **Table 3.1**.

It should be noted that several recommendations of the previous CRC (held in May 2000) were not included in the objectives for the current CRC, as noted in **Table 3.1**. The focus of the present CRC was on the procedures for model calibration and verification that Sydney Water has developed and implemented since the previous CRC.

Comments of the present CRC are included for previous recommendations that are relevant to the objectives of the present CRC. Significant progress has been made for all the recommendations that are relevant to this CRC.

Table 3.1 Findings of Previous CRC (May 2000) and Actions Completed

CRC May 2000 recommendations	Current status	Comments by this CRC
Several recommendations from the previous CRC have not been completed or commenced by Sydney Water. These relate mainly to the preparation of Management Plans and various protocols associated with SCAMP development.	Management plans have been prepared for all SCAMP work. A management plan has also been prepared for the recalibration of the Strategic models.	The SCAMP management plan is not a topic for this CRC.
An overall Management Plan for the entire 20 year $2 billion Overflow Abatement Program is completed as soon as possible. It should be used as the basis for more detailed shorter term Management Plans. The Management Plan should be updated as overflow planning priorities and investigation methods are revised or changed. Additional SCAMPs should not be commenced before the Management Plan is available.	A Management Plan has been prepared.	The Management Plan was discussed with the CRC. The detail of the Plan is not a topic for this CRC.
The investigation and QA/AC protocols that are to be followed for all phases of SCAMP investigations are completed as soon as possible.	Quality Plans have been completed.	The following Quality Plans were presented to the CRC: • SSEPQP003_001 (Trunk Model Build) • SSEPQP003_002 (Model Calibration & Verification) • SSEPQP003_003 (Model Modification & Recalibration) Comments regarding these plans are presented in **Section 3.2**.
Sydney Water has commenced too many SCAMPs without implementing documented management procedures. The CRC considers that only sufficient SCAMPs should be completed to refine skills development of staff and to validate the methodologies to completion so that completed investigation protocols and QA/QC procedures can be prepared.	Document management procedures now exist. These include QA/QC procedures for modelling and planning. They apply to the strategic models as well as the SCAMP models. 25 SCAMPs are currently in progress. The Chatswood and Concord West SCAMPs have reached the options stage.	Trunk modelling management plans were presented to the CRC. They are considered to be appropriate.

Table 3.1 Findings of Previous CRC (May 2000) and Actions Completed

CRC May 2000 recommendations	Current status	Comments by this CRC
All SCAMP models, whether undertaken by Sydney Water or by others, should be independently audited.		Not a topic for this CRC.
The CRC is concerned by the lack of integration and communication between the OACIS modelling, Environmental Assessment and Community Communication programs. Timing, level of detail and dialogue between the three programs needs to be addressed. The existing OACIS Scope of Work should be modified to incorporate formal feedback from the Environmental Assessment and Community communication programs and that appropriately integrated Scopes of Work be prepared for the Environmental Assessment and Community Communication programs.	Procedures for integrating the three environmental planning components have been built into SCAMP planning procedures. The environmental planning module of OACIS has been incorporated into the software and the work instructions.	Not a topic for this CRC.
Is the SCAMP prioritisation process appropriate? A more quantitative ranking methodology should be developed. Sydney Water should consider using risk assessment methodology for this purpose.	SCAMP planning has been fast tracked to be completed by July 2003. Prioritisation is based on EPA requirements, growth and known operational problems. The speed of the planning process will ensure all problems are addressed in a short time.	Not a topic for this CRC.
Sydney Water should establish an overarching consultative group that comprises peak environmental bodies to provide input and to validate the SCAMP prioritisation process	This recommendation has not currently been adopted. All consultation is being carried out with local interest groups using the local Council as a focus point.	Not a topic for this CRC.
Sydney Water should clarify the extent of community communication that is proposed.	The community consultation plan is still being developed although the principles have been trialed in the Chatswood SCAMP.	Not a topic for this CRC.
The Community Communication Plan should be developed and more closely integrated with the other SCAMP investigation and planning methodologies.	This has occurred in the Chatswood SCAMPs and is currently occurring in the Blue Mountains SCAMPs.	Not a topic for this CRC.

Table 3.1 Findings of Previous CRC (May 2000) and Actions Completed

CRC May 2000 recommendations	Current status	Comments by this CRC
Sydney Water should undertake a database search to determine whether other relevant sources of data should be used.	The consultation phase and information gathering phase with local councils checks for all relevant data available in the local communities. The consultation with the operators of the sewerage systems similarly searches for any local additional system information. To date the information gathered has been adequate for decision making associated with SCAMP planning.	Not a topic for this CRC.
Flow gauges should be calibrated at medium and high in-pipe flows which are likely to cause overflows as well as at low flows.	This recommendation has been adopted in the new gauging contracts that commenced in November 2000.	Calibration has been undertaken for flows up to 70% full pipe flow. The CRC remains concerned that gauges have not been calibrated for full pipe flows.
Sydney Water develops a protocol for applying the statistical and non-statistical tests in a consistent manner. Furthermore, the protocol should include requirements for checking and decision-making points which are to be signed off by the Manager or other qualified personnel.	Protocols were developed as part of PRPs 101.4.1 and 101.4.2.	Quality Plan SSEPQP003_002 (Model Calibration & Verification) was reviewed. Comments are provided below.
Sydney Water should address staffing issues relating to the possible need for more experienced SCAMP personnel and for the preparation of Management Plans and protocols.		Not a topic for this CRC.
Sydney Water and the EPA should continue negotiations to resolve current differences in investigating and licensing sewerage overflows.	STS Licences issued	Sydney Water is implementing licence PRPs. The CRC notes the higher level of cooperation between Sydney Water and the EPA.
A documented strategy be developed and implemented by Sydney Water so that appropriate accountabilities are defined for ownership and maintenance of the SCAMP tools and data for the life of the Overflow Abatement Program.	To be addressed.	Not a topic for this CRC

3.2 Quality Plans

The following Quality Plans were reviewed by the CRC:

- SSEPQMS001. Quality Management System Manual;
- SSEPQMS003. Trunk Sewerage System Modelling Operations Manual;
- SSEPQP003_001. Trunk Sewerage System Model Build Procedure;
- SSEPQP003_002. Trunk Sewerage System Model Calibration & Verification Procedure;
- SSEPQP003_003. Model Modification and Recalibration Procedure; and
- SSEPQP003_004. Model Annual Reporting Procedure.

These Quality Plans were generally considered to be satisfactory. However, the CRC has the following comments regarding the SSEPQP Quality Plans.

Review of SSEPQP003_001 (Model Build Procedure)

Defining Model Extent

A procedure should be included to incorporate sufficient hydraulic detail and constructed overflows so that the use of virtual reticulation nodes is minimised.

Pipe Conveyance (Model Link) Elements

The procedure should specify how pipe lengths have been aggregated in the simplified models.

Access Chambers

The only access chambers that discharge and are not formal overflow structures included in the trunk models are those determined by consultation with the regional operations personnel. It is possible that other chambers overflow and should be included. A suggested means of determining these chambers would be by simulating the most significant rain event through a fully detailed model and finding all points of discharge or where the hydraulic grade line rises above the surface level in a chamber. It could be argued that these points represent minor overflow locations, however, they are overflow points that may not otherwise be captured. Furthermore, the lids could be so tight at some or all of the access chambers that discharges do not occur. This can be determined by inspection, bearing in mind that if the chamber is accessed for maintenance the lid is no longer tight and discharge may occur after such access.

Reducing Model Size Using Equivalent Circular Sections

Where simplification of non-standard pipe shapes is undertaken by representing them as circular cross sections, the procedure should require verification that this simplification is appropriate for the full range of flows.

Reticulation Overflows Representation

The CRC has concerns about the use of virtual nodes and reticulation overflows. As demonstrated by the recalibrated model presentations, the major changes in overflow frequency occurred at these locations. It is considered that the use of virtual nodes should be minimised by representing currently unmodelled parts of the system as subcatchment models or the geometry of each model should be extended as appropriate.

Anecdotal Information

No procedure has been included for the collection of anecdotal information about the operation of the system. Prior to building the model all relevant personnel should be interviewed to determine their knowledge of the configuration of the system and the performance of the system. Furthermore, all reported system problems such as customer complaints, CCTV inspections and maintenance records should be obtained. These items are key elements of the SCAMP procedure. It is considered that the MOUSE modelling and SCAMP program need to be fully integrated.

This information may lead to additional components being included and/or less simplification of the network.

Unavailable Data

No procedures are included for dealing with unavailable data, eg missing pump station configuration data.

Logic Checks

No procedures are defined for undertaking model logic checks, eg are all pipes going downhill, are pipe sizes decreasing downhill, are pipe slopes excessive, is the downstream pipe lower than the upstream pipe at all chambers.

Check Off/Audit Procedure

There are no apparent check-off or audit procedures. Various details are required to be included in the project file to demonstrate they have been done or considered. However there is no check off procedure or form to verify that all relevant factors have been checked.

The CRC recommends the inclusion of the following procedures in SSEPQP003_001:

- *Inclusion of sufficient detail to ensure that the system is adequately represented and to minimise the use of virtual nodes and overflows;*
- *Specification of pipe lengths in simplified models;*
- *Inclusion of all relevant access chambers;*
- *Verification of simplification procedure of non-standard pipe shapes;*
- *Verification that all overflow points have been included in the trunk model;*

- *All anecdotal information has been obtained;*
- *For dealing with missing data;*
- *Logic checks; and,*
- *Check or audit procedures that all relevant factors have been considered.*

Review of SSEPQP003_002 (Model Calibration and Verification)

Hydraulic Parameters (Manning n) Calibration

The procedure allows for the Manning n value to be modified in the downstream links such that a good match of depth is obtained. The procedure does not specifically state that all links from one gauge point to the next should have the same Manning n value, unless there is evidence that this should not be the case. Furthermore, it does not specify the procedure to deal with the situation of two gauged links converging prior to a third gauge point, ie how to handle the common section if the Manning n value is apparently different for the two independent links.

It is noted that the flow pattern calibrations are undertaken simultaneously with the calibration of the hydraulic characteristics of the pipes, as represented by the Manning n values. These are different processes and should be calibrated independently.

Wet Weather Flow Calibration

The procedure indicates that the methodology described in Robert Carr's MOUSE RDII calibration guidelines should be used. This reference was not provided and cannot be commented on. The CRC considers that a generic wet weather flow calibration procedure should be included in the Quality Plan.

Furthermore, the use of virtual reticulation nodes is included. It is considered that the model build procedure should include sufficient detail to minimise the use of virtual nodes.

Verification of Model Suitability

The verification process comprises a statistical analysis of the gauged versus modelled level and flow results for the adopted calibration data. It is considered that this process should be extended. The hydrological process modelled includes three separate water storages – upper level (surface storage), lower level (root zone storage) and groundwater (water table level) – all of which impact on the amount of inflow/infiltration to the model. These storages should be in long term equilibrium.

All storages will exhibit increases and decreases over shorter time periods but not over longer time periods. Trends may be evident over a two to three year period due to el-nino/la-nina, but over the longer ten year period there should be no trends. In general the upper storage should show variations over its full capacity over short time periods (days) and the lower storage should have a "base level" around which it will vary over a period of days to weeks. The groundwater level should also vary around an equilibrium level with variations upwards and sometimes downwards which can be over many months and sometimes years.

Attachment A: Audit Validation Check Points

This is considered to be a good audit procedure. However, it should include checks of all adopted hydrological process parameters and statistical bias tests of storages, as discussed above. It should also include a check that consultation with operators and field inspections has been undertaken.

The CRC recommends the inclusion of the following procedures in SSEPQP003_002:

- *To ensure that the same Manning n value is used between adjacent gauge points;*
- *To deal with different Manning n values for two independent gauged links with a common section;*
- *Separate calibration of flow and Manning n value;*
- *Bias tests should be applied to the three water storages (surface zone, root zone and ground water) using the ten year rainfall time series. This analysis should be included as part of PRP 101.1 System Model Performance Indicators.*
- *An explicit procedure for wet weather flow calibration;*
- *The audit validation should include checks of all adopted hydrological process parameters, statistical bias tests of storages and a check that consultation with operators and field inspections has been undertaken.*

Review of SSEPQP003_003 (Model Modification and Recalibration)

The details contained in this procedure are generic only.

The CRC recommends that the procedures in this Quality Plan should either be detailed as in the other Quality Plans or should refer to the other Quality Plans.

3.2.1 Implementation of Quality Plans

Sydney Water described the following procedures for implementing the quality plans:

- All modelling staff, including consultants, are trained to use the quality plans;
- Internal technical audits are undertaken at ten week intervals to ensure that modelling staff are complying with the quality plans;
- Relevant staff are trained whenever quality procedures or the models are changed.

The CRC considers that implementation of the quality plans has been satisfactory.

3.2.2 Audits

Sydney Water undertakes internal audits of recalibration and verification results for trunk sewer models. The following audit reports were provided to the CRC:

- Technical Audit Report for West Hornsby STS Trunk Model; and
- Technical Audit Report for West Camden STS Trunk Model.

The audits are intended to be non-adversarial and are joint efforts between the modeller and auditor to identify practical improvements. Issues covered in the audits vary for the two reports, but include:

- Import/create trunk model;
- Dry weather flow calibration, eg use of all available gauges, flows, development during calibration period, changes in pump operation;
- Wet weather flow calibration, eg use of all available gauges, rainfall data, leakage, SPS operations, friction factors, overflow points;
- Model verification;
- Anomaly resolution;
- Benchmark model comparison;
- Report preparation; and
- Comments on gauge anomaly resolution and modeller responsibility.

The audit reports have addressed the main issues described in Quality Reports SSEPQP003_001 and SSEPQP003_002. It is recommended that the comments and recommendations made by the CRC in this report should also be considered for inclusion in the auditing procedure.

The CRC encourages the continued use of internal auditing and recommends that the auditors take account of the recommendations made in this report.

3.3 Appropriateness of the Proposed Performance Acceptance Criteria Used for Re-Calibration of Trunk Models

PRP 101.1 requires that "the Licensee must develop a set of performance indicators for comparing the predictions of the hydraulic sewer system model with the data from the reticulation sewer gauge network operated by or on behalf of the licensee. The licensee must develop a set of performance acceptance criteria for the hydraulic sewer system model based on the indicators. The indicators and criteria must be applicable to all of the sewage treatment system specific models developed in 101.3 and the range of sewer flows in these systems".

The dry and wet weather calibration methodology for hydraulic sewer models and the statistical assessment of calibration results are respectively provided in:

- Report SSEPQP003_002 "Trunk Sewerage System Model Calibrations and Verification Procedure"; and
- SWAGMAN manual.

3.3.1 Performance Indicators

Sydney Water is using the following three performance indicators for recalibrating the trunk sewer models:

- Level above pipe invert;
- Sewer flow; and
- Overflow Incidence Index.

Outputs of the MOUSE trunk sewer models are water levels and flows at each point in the network at each time step. Field monitoring of sewage flows measures level and velocity. Flows are calculated from these two measurements. The measurement of level and velocity is well understood and relatively simple and accurate, assuming that flow gauges are adequately calibrated for all flows.

The CRC considers that pipe level and flow are appropriate performance indicators for the trunk sewer models because corresponding measured and model results can be obtained and compared. Furthermore, these indicators influence the behaviour of sewer networks and are fundamental to quantifying the occurrence, duration and volumes of sewer overflows.

The Overflow Incidence Index is defined as "the probability of the model predicting an overflow incidence when the measurements indicate an overflow incident" (refer to Sydney Water report PRP 101.1. System Model Performance Indicators).

In other words, this indicator compares the measured and model pipe level results as a function of time. If there is perfect agreement between the measured and model results for the time when the threshold level in the pipe (ie the level above which overflows occur) is exceeded, the Overflow Incidence Index would equal "1". Conversely, no agreement between the measured and modelled results would provide an Overflow Incidence Index of "0".

The Overflow Incidence Index is calculated according to the following equation:

Overflow Incidence Index = A/B

where: A= duration of overflow period when measured and model results overlap; and

B = duration of overflow as predicted by the model.

The CRC considers that in principal the Overflow Incidence Index is a sound performance indicator because it provides a measure of a model's ability to simulate the occurrence of overflows. The ability to simulate overflows is considered to be a major requirement for the trunk sewer models. However, it should only be used if the models have been demonstrated to be unbiased in terms of magnitude and time.

The CRC also has a concern about the method used by Sydney Water to calculate the Overflow Incidence Index. It is considered that the above equation is inconsistent with the previous definition of Overflow Incidence Index.

The definition describes overflows in terms of measurements that indicate an overflow incident. This has been interpreted as referring to field measurements and not model measurements. The equation calculates overflows in terms of duration of overflow as predicted by the model. Irrespective of the CRC's interpretation of "measurements" in the above definition of the Overflow Incidence Index, it is considered that this index should be calculated in terms of field measurements and not modelling results. Field measurements reflect actual occurrences and are not subject to modelling errors.

Several of the presentations indicated that there were inadequate data to calculate Overflow Incidence Index values. Therefore, in view of data limitations and the calculation method, the Overflow Incidence Index in its present form should not be used as a primary recalibration parameter. It is considered that models have good predictive capability for overflows if they pass the bias tests.

It is recommended that Sydney Water should continue to use the following two performance indicators for calibrating the trunk sewer models: level above pipe invert and sewer flow.

The Overflow Incidence Index should not be used in its present form as a primary recalibration parameter. Its method of calculation should be revised. It should then be used to confirm a models capability for predicting the occurrence and duration of overflows.

3.3.2 Performance Acceptance Criteria

Sydney Water has adopted the following performance acceptance criteria for calibrating the trunk sewer models. Models are required to pass all of these criteria in order to be considered to be calibrated.

- Pipe levels and flows should have no significant (95% confidence interval) temporal bias. Temporal bias is estimated by plotting residual (ie the difference between corresponding measured and model results) versus time.

- Pipe levels and flows should have no significant (95% confidence interval) magnitude bias. Magnitude bias is estimated by plotting residual (ie the difference between corresponding measured and model results) versus the average of model and gauge results.

- There is considered to be no bias if differences between measured and modelled levels and flows are less than 10 mm or 5% of Average Dry Weather Flow (ADWF), respectively, irrespective of the statistical results.

- The minimum value of the Pearson Correlation Coefficient (reported as the r^2 value) for corresponding measured and model level and flow data is 0.75. This value was chosen because measurement and modelling errors could collectively explain 20% to 25% of the total random variation. Therefore, the model should explain the remaining 75% to 80% random error.

- The minimum acceptable value for the Overflow Incidence Index is 0.75 using data periods of at least three months that include at least three significant overflows.

The two previous CRCs concluded that the statistical acceptance criteria are statistically robust because they measure both bias and random variability and include all relevant sources of error. Pearson Correlation Coefficient is useful as a measure of a model's predictive capability if it has no bias.

This CRC confirms these conclusions and the use of SWAGMAN to undertake the statistical acceptance tests.

However, this CRC has the following comments concerning the way in which the acceptance criteria are calculated and used:

- It is not clear why Sydney Water has concluded that a model needs to pass all of the acceptance criteria in order to be considered to be calibrated. The CRC considers that the models should be unbiased and should have the capability to correctly predict the occurrences, durations and volumes of overflows. Therefore calibrated models should ideally pass the two bias tests and the r^2 test.

It was noted that some of the trunk sewer models, for example the West Hornsby model, passed the two bias tests but not the r^2 test. It was concluded that the model had not been recalibrated satisfactorily.

However, it can be concluded that a model reproduces the occurrence of overflows in terms of magnitude and time if it passes the two bias tests (assuming that the flow gauges have been calibrated for all flows), irrespective of the r^2 value. It should be noted that the two bias tests are non-parametric tests, ie they do not assume a particular distribution of data, whereas the r^2 test assumes that the data are normally distributed. A lower r^2 value may therefore be the result of data distribution and may not be a true reflection of a model's predictive capability.

It is considered that the r^2 test should not be used as a primary performance indicator unless it can be demonstrated that the data are normally or approximately normally distributed.

The Overflow Incidence Index should not be used as a calibration variable, as discussed above.

The CRC recommends that the two bias tests should be the primary performance acceptance criteria.

The r^2 test should only be used if it can be demonstrated that the data are normally or approximately normally distributed.

- The primary purpose of the trunk sewer models is to simulate wet weather overflows. Therefore, the main objective of the calibration procedure should be to ensure that the models simulate wet weather flows satisfactorily. Although it is acknowledged that the models should be properly set up for dry weather conditions, their purpose is not to simulate dry weather conditions.

  The CRC is concerned that all modelling results, ie dry and wet weather results, are used for statistical verification of wet weather model recalibration. There are considerably more dry weather data than wet weather data. Therefore the dry weather data could "swamp" the wet weather data and have a major influence on the statistical calibration results. One solution would be to only use wet weather data for calibration purposes, although it is recognised that the pass criteria may need to be revised because of the inherently greater scatter of wet weather data compared to dry weather data. It is understood that SWAGMAN has the capability to only analyse parts of pipe flow, such as high flow data.

  The use of wet weather data for model calibration would require that sewer flow and level gauges are calibrated for high flows so that good calibration data are obtained. The issue of gauge calibration at high flows is discussed below.

The CRC recommends that the calibration protocol should be revised to separately use dry and wet weather data for statistical verification of recalibration instead of data for all flow conditions, as is current practice.

- The two previous CRCs suggested that non-statistical "common-sense" criteria should be used in addition to statistical criteria for calibrating the models. This CRC notes that statistical performance criteria should be regarded as a supplement to good modelling practice and not be regarded as an end result in themselves. Good modelling practice requires modellers to adequately understand the configuration and performance of the systems being modelled.

  One of the performance acceptance criteria is that the model results are unbiased if differences between measured and modelled levels and flows are less than 10 mm or 5% of ADWF, respectively. This is a non-statistical criterion that requires modellers to review the data being statistically analysed.

  Some of the presentations gave the impression that modellers were applying the statistical tests and accepting the results without adequately understanding the causes and significances of inconsistencies between model and measured data. SWAGMAN provides the capability of plotting measured and model data as well as undertaking statistical analyses. The use of this capability should be encouraged to enable modellers to obtain improved understanding of the data and the causes of disagreements between measured and modelled data before applying the statistical tests.

  The CRC reiterates the suggestion of previous CRCs that non-statistical "common-sense" criteria should be used in addition to statistical criteria for calibrating the models. Furthermore, measured, operating and modelled data should be plotted or otherwise reviewed before statistical analyses are undertaken. In other words, the acceptance criteria should be viewed as a supplement to good modelling practice, not a substitute.

- The possibility of biases being introduced because of the frequency of data sampling by SWAGMAN was described in the West Camden model recalibration report. SWAGMAN samples data every 15 minutes whereas the sewage pump station (SPS) turns on and off at intervals of seven minutes or less. Therefore, the SWAGMAN sampling frequency is not sufficient to reflect the range of flows at the SPS. The West Camden model report recommended that SWAGMAN should sample data at one minute intervals.

The CRC recommends that the sampling frequency of SWAGMAN be reviewed and adjusted as necessary for each trunk sewer model so that the full range of data are used.

3.4 Calibration Process for a Selection of Completed 1994 Trunk System Benchmark Models and Results for Available Completed Models

The driver for model recalibration is PRP 101.3 (Model Recalibration). The relevant clauses in this PRP for the purposes of this CRC are as follows:

"Following approval by the EPA of the model Re-calibration Protocol, the licensee must re-calibrate the hydraulic sewer model(s) for the premises to a standard of accuracy that, at a minimum, meets the approved performance acceptance criteria."

"Prior to convening the Criteria Review Committee under 101.4, the licensee must run the approved re-calibrated hydraulic model sewer system model(s) for the premises with the 10-year rainfall time series data used in the EISs to refine the existing system performance used in the EISs."

Specific questions for the CRC are as follows (refer **Table 1.1**).

3.4.1 Review Appropriateness of Steps Undertaken to Transfer Models to OACIS Platform, Undertake Statistical Tests and Verification of the 1994 Benchmark Models.

Transfer of Models to OACIS Platform

The OACIS platform includes routines for importing models and data and links together the following five software packages in order to integrate the usage and exchange of data required for sewerage planning:

- HYDSYS;
- MOUSE;
- ModAsset;
- Hydra; and
- SWAGMAN.

The data integration provided by OACIS facilitates the model build and calibration process.

It is understood that all of the 27 STS trunk sewer benchmark models have been transferred to the OACIS platform prior to recalibration. A satisfactorily calibrated model provides confidence that the transfer to the OACIS platform has been undertaken satisfactorily. An uncalibrated model requires that model parameters should be reviewed and revised as necessary so that model results agree satisfactorily with corresponding measured results. Therefore, the recalibration process ensures that the transfer of the trunk sewer models to the OACIS platform has been undertaken satisfactorily.

Statistical Testing

The quality system described in SSEPQP003_002 "Trunk Sewerage System Model Calibrations and Verification Procedure" specifies the use of statistical tests for calibrating the truck sewer models. The SWAGMAN package is used to calculate the statistical indices specified in SSEPQP003_002.

The CRC is satisfied that the statistical requirements as specified in SSEPQP003_002 are being followed by the trunk sewer modellers. However, the CRC has concerns about the way in which the acceptance criteria are calculated and used, as discussed in **Section 3.3.2**.

Verification of 1994 Benchmark Models

The model recalibration/verification procedures are described in:

- SSEPQP003_001: Trunk Sewerage System Model Build Procedure; and
- SSEPQP003_002: Trunk Sewerage System Model Calibration and Verification Procedure.

Comments are made on these procedures in **Section 3.2**. The CRC recommendation that a bias test should be applied to the three water storages (surface zone, root zone and ground water) using the ten year rainfall time series should be noted.

The following eight STS benchmark models are being recalibrated for dry and wet weather flows and statistically verified:

- Mount Victoria;
- Bellambi;
- West Hornsby;
- St Marys;
- West Camden;
- Blackheath;
- Northern Suburbs; and
- Malabar/Southern Suburbs.

Detailed presentations were provided to the CRC for the West Hornsby and West Camden systems and overview presentations were provided for the other systems.

Recalibration/verification of these models is not completed. The process to date has identified issues that need to be addressed before the models can be considered to be satisfactorily recalibrated. However, the CRC considers that when the issues identified in the presentations and in this report have been addressed the models will have been recalibrated and verified as far as possible using the available data.

Several of the presenters commented on a variety of data issues. Much of the data used for recalibration and statistical verification are considered to be of inadequate quality and/or quantity. It is a widely held truism that calibration of any model is only as good as the calibration data that are available. The poor quality of much of the data collected during the 1980s and early 1990s suggests that the benchmark trunk sewer models should be revised with newer and improved data.

The CRC recommends that where inadequate data prevent successful benchmark model recalibration, Sydney Water should identify a more recent and improved period of calibration data and update the benchmark trunk sewer models with the newer and improved data.

However, Sydney Water would need to demonstrate that the sewerage system has not deteriorated during the time from the current benchmark model (1991) to the recalibrated model using the newer data in order for the EPA to accept the calibrated model using the newer data as the new benchmark model.

3.4.2 Do the Re-Calibrated 1994 Benchmark Models Now Meet the Specified Acceptance Criteria?

Twenty six of the 64 flow gauges in these eight STS models pass all of the performance acceptance tests. However, none of the recalibrated 1994 benchmark models meet all of the specified acceptance criteria.

It is noted that the above eight STS models are generally satisfactorily calibrated for dry weather flows. However, they are not fully calibrated for wet weather flows, particularly large storm events. The reasons for incomplete model calibration include the following:

Inadequate Rainfall Data across Catchments for the 10 Year (1985 to 1994) Time Series

Virtual rainfall gauges were created to better represent spatial variations across catchments. However, most of the sewer catchments do not have rain gauges located within their boundaries. Furthermore, only a few of the actual rainfall gauges have data for all of the 10 year (1985 to 1994) time series. Therefore, the virtual rainfall gauges in some of the models use identical data for long periods of the 10 year time series because they include the few rain gauges with data for all or most of the 10 year period. This is considered to be a major issue because rainfall is the primary type of data required for wet weather modelling and is the major source of error in hydrological models.

The CRC recommends that more rain gauges should be installed. It considers that, as a minimum, each of the licence gauge locations should have a rain gauge.

Inadequate SPS Operating Data

It is important for modellers to have satisfactory SPS data so that they can build satisfactory models and interpret model results. This requires an understanding of system operations, as discussed previously.

There are several reasons for poor SPS data, including:

- gaps in the wet weather flow data due to the methodology for determining flows at pump stations based only on pump operations. To obtain improved assessment of wet weather flows, monitoring at SPSs could be supplemented, for example, by monitoring the well level at appropriate time increments or by including in-sewer flow gauges upstream of SPS wells;

- undocumented upgrades during the calibration period; and

- localised flooding.

The CRC considers that it is important for modellers to routinely communicate with sewerage system operators in order to obtain improved understanding of the sewerage systems being modelled.

The CRC considers that it is important to revise the monitoring undertaken at SPSs to ensure that all wet weather flow data are captured.

The CRC recommends that a procedure should be developed to record all SPS configuration and operational changes and to maintain a historical record of all such changes.

Inadequate Data from Sewer Gauges

The results from several sewer gauges were affected by nearby SPSs. For example, the West Camden Model Recalibration report discusses the difficulty of the model matching the hydrograph shape at Gauge 828002 because the nearby SPS 614 switches on and off very frequently. This problem was difficult to resolve because of lack of operating data for SPS 614.

The CRC recommends that sewer gauge locations should be reviewed and changed, if necessary, to avoid future influences of SPS on gauge and model results.

Another problem relates to the lack of gauge calibration for high flows. It is understood that the highest flow that has been calibrated at some gauges is at 70% of full pipe flow. However, some gauges have only been calibrated for low flows. The assumption that 70% full flow is representative of full pipe flow needs to be tested. It is highly unlikely that low flow calibrations are applicable to high flows. This would mean that the trunk models may not accurately predict wet weather overflows because they are not calibrated for the high flows at which these overflows occur. This was also a major concern of the previous CRC.

This CRC reiterates the concerns of the previous CRC regarding the lack of gauge calibration at high flows and recommends that future improvements to the high flow calibration of gauges and models should be investigated.

Insufficient Model Detail

Several of the models have upstream "virtual" nodes to replicate the combined storage, surcharge and overflow characteristics of upstream subcatchments. The West Camden model also had a virtual catchment upstream of gauge 806000 to simulate large storm events. The use of virtual nodes indicates the possibility of inadequate model detail and/or understanding of the systems being modelled.

The CRC considers that virtual nodes should be systematically minimised with subcatchment models or the geometry of each model should be extended as appropriate so that the proportion of the system represented by virtual nodes is minimised.

Another problem relates to phase differences between corresponding measured and modelled data. These differences could be caused by changes in population, and hence dry and wet weather flows, during the recalibration period for several of the models. However, for the Malabar/Southern Suburbs model, phase differences are believed to be mainly caused by the influence of the North Georges River system. There is generally inadequate data available to conclusively resolve the phase difference issues. There are no suitable gauge data available to resolve the phase difference in the Malabar/Southern Suburbs model and SPS on/off data are being used.

It is recommended that Sydney Water should ensure that the trunk sewer models are systematically augmented with SCAMP data to ensure that changes in population and operating changes are included in the models.

Another reason for phase differences between the model and measured results could be the number of grid points used in the models. All models are currently being run with three grid points between each chamber. It is understood that depths are calculated at the upstream and downstream grid points, and flows and velocities are calculated at the middle grid point. The flow gauges are generally located at the downstream grid points. If the upstream pipe is very long this could potentially introduce a significant variation in the flow modelled at the middle grid point and the actual flow at the downstream grid point, in particular when the hydraulic grade line slope is different from the pipe slope.

The use of three grid points in long pipes leading to a steep slope (including a drop) could also artificially increase the "draw down" of the hydraulic grade line leading to a steeper slope or drop. This effectively increases the apparent pipe capacity of this section and could lead to an overall lowering of the hydraulic grade line for a significant section upstream, particularly at flow rates in excess of the real pipe capacity.

It is recommended that the spacing of the grid points, at least at the licence gauges, should be reviewed to minimise errors in modelled flows.

3.4.3 If not, have all steps been taken to calibrate the model given input data availability and accuracy?

This question has been answered above. In summary, recalibration/verification of these models is not completed. The process to date has identified issues that need to be addressed before the models can be considered to be satisfactorily recalibrated. However, the CRC considers that when the issues identified in the presentations and in this report have been addressed the models will have been recalibrated and verified as far as possible using the available data.

3.4.4 Are the actions identified by Sydney Water to improve these models appropriate?

Several actions have been identified by Sydney Water to improve model calibration, including:

- More detailed models;
- Confirmation of populations and population growth;
- Improved understanding of system, including hydraulics and flows;
- Improved SPS operating information, including wet well level data to be used for verifying modelled SPS performance;
- Flow gauge calibration at high flows;
- Ensure that flow gauges record high flow events accurately;
- Smaller time steps for data sampling by SWAGMAN;
- Installation of surcharge sensors at licence gauge sites;

Most of these actions are under way and should result in improved model calibration. The CRC also considers that the recommendations discussed above (refer **Sections 3.3** and **3.4**) will also need to be implemented for satisfactory model calibration and benchmarking.

Comments have been previously made in this report concerning the need for modellers to review raw data, ie levels, flows and other operating data, prior to statistical analyses and to communicate with sewerage system operators to obtain better understanding of STS operations.

It is also recommended that modellers review SCAMP data, including maintenance records, customer complaints and choke data, to obtain additional verification data.

Furthermore, it is strongly recommended that modellers regularly discuss problems, issues and successes with each other to obtain mutual support and maximise operational knowledge of the models.

It is possible that some models may not be able to be satisfactorily calibrated. Sydney Water did not present procedures that are used to deal with systems that appear not able to be calibrated. It is considered that such procedures are required.

The CRC strongly recommends that Sydney Water should develop a protocol for system models that appear not able to be recalibrated to the adopted performance acceptance criteria, as required in PRP 101.2.

3.5 The Proposed Model Re-Calibration Protocol Specified in Report PRP 101.2

The continued use of the trunk sewer system models will require them to be further developed to include physical changes in the sewerage system. PRP 101.2 requires Sydney Water to develop a generic Model Recalibration Protocol for the ongoing recalibration of the hydraulic sewer system models. Sydney Water has prepared the report PRP 101.2 "Generic Model Re-Calibration Protocol" in response to PRP 101.2. This report describes the generic recalibration under the following main headings:

1 Introduction

2 Trunk Sewerage System Model

3 Triggers for Re-calibration

4 Data Requirements for Re-calibration

5 Re-calibration Methodology

The models remain in calibration until physical changes occur in the system. Sydney Water proposes to test this assumption annually by comparing model results for level and flow with comparable data collected at licence gauges. Data from the immediate past year would be run through the model and the results compared to the original calibration acceptance criteria. It is proposed that the minimum wet weather calibration period would be three months and that this period should contain at least three rainfall events (two to define fast and slow response parameters and a third to define system surcharge behaviour).

The report proposes that the primary trigger for recalibration would be a value of less than 0.65 for the r^2 value. Other reasons to update the model include changes to system geometry and the effect of leakage reduction works.

The protocol appears logical and practical, although it is a generic protocol and little specific detail is presented. The CRC has the following comments:

- As noted above, the issue of models that are unable to meet the adopted performance acceptance criteria has not been adequately addressed.

- It is not certain whether three months/three storm events will provide sufficient data for recalibration purposes.

- The adequacy of the primary trigger (a value of less than 0.65 for r^2) needs to be demonstrated. It is not clear why the trigger value for r^2 should be 0.65 instead of 0.75. The performance acceptance criteria specify that the r^2 value should be at least 0.75 for a model to be considered to be calibrated, as discussed in **Section 3.3.2**. Therefore, a value of less than 0.75 would indicate that the model is not calibrated and should be the trigger for recalibration.

  Furthermore, it is considered that the r^2 test should not be used as a primary performance indicator unless it can be demonstrated that the data are normally or approximately normally distributed. This is because the Pearson Correlation Coefficient is a parametric test and lower values of r^2 may therefore be the result of data distribution and may not be a true reflection of a model's predictive capability.

- Sydney Water should consider using the magnitude and temporal bias tests as the primary trigger for recalibration. These are non-parametric tests and are therefore not affected by data distribution. It can be concluded that a model reproduces the occurrence of overflows in terms of magnitude and time if it if passes the two bias tests (assuming that the flow gauges have been calibrated for all flows).

The CRC recommends that the adequacy of three months/three storm events for recalibration purposes needs to be demonstrated. The adequacy of the primary trigger (r^2) should also be demonstrated and revised as necessary.

3.6 Associated Model Re-Calibration Processes that are Being Implemented by Sydney Water

Sydney Water proposes to check the calibration of each of the 27 system trunk models annually and update as necessary. Annual cycles for undertaking the model recalibration process were described to the CRC. It is proposed to undertake the following activities each year:

- Obtain system data including new pipes, modifications to existing pipes, overflow weir level changes, SPS upgrades, SPS operating changes, population and sewage flow changes;

- Upgrade models to include the above system changes;

- Run the updated models to check calibration at licence gauge stations. Model results would be compared with the previous calender year gauge data using performance assessment criteria in PRP 101.1; and

- Re-benchmark models to check that STSs have not deteriorated.

The necessary processes for maintaining and updating model calibration were not covered in detail in the Sydney Water presentations to the CRC. The CRC suggests that this topic should be addressed at a later date when the issues and recommendations by this CRC, as presented in this report, have been addressed.

In principal the CRC agrees that the trunk sewer models should be maintained as calibrated models for sewer overflow licensing purposes. The CRC makes the following preliminary comments at this stage:

- Significant system changes should be identified for use as triggers to determine which models should be updated and recalibrated. Suitable triggers could include ADWF, customer complaints and incidences of overflows. It is suggested that models would not be considered for recalibration unless trigger values had changed significantly since the model was last revised.

- Licence annual returns are required for all 27 STSs each year within 60 days from 30 June for the prior year. Suitably skilled resources will need to be made available to meet the modelling requirements as specified in the STS licences. It is noted that Sydney Water may find it difficult to meet licence delivery dates for all STSs with existing resources.

4 Conclusions and Recommendations

4.1 Overall Findings of the CRC

The CRC was appreciative of Sydney Water's candour. It is acknowledged that building, calibrating and applying sewer models for simulating sewer overflows for licensing purposes is a learning exercise for all concerned. However, it is evident that Sydney Water and the EPA have a common will to ensure that the modelling process is successful.

The CRC also recognises the large extent of work that has been undertaken by Sydney Water since the last CRC.

However, the CRC has identified a number of issues that may impact on model recalibration and benchmarking, including the ability to meet performance acceptance criteria, high flow gauge calibration, the appropriate level of model detail and the adequacy of the data for benchmark model recalibration.

4.2 Specific Findings of the CRC

4.2.1 Review Actions Completed by Sydney Water Regarding Recommendations of the previous CRC

Significant progress has been made for all the recommendations that are relevant to this CRC (refer **Table 3.1)**.

4.2.2 Quality Plans

The content and implementation of the Quality Plans were generally considered to be satisfactory. The CRC supports the continued use of internal auditing and recommends that the auditors take account of the recommendations made in this report.

However, the CRC recommends the inclusion of the following procedures:

SSEPQP003_001

- *Inclusion of sufficient detail to ensure that the system is adequately represented and to minimise the use of virtual nodes and overflows;*
- *Specification of pipe lengths in simplified models;*
- *Inclusion of all relevant access chambers;*
- *Verification of simplification procedure of non-standard pipe shapes;*
- *Verification that all overflow points have been included in the trunk model;*
- *All anecdotal information has been obtained;*
- *For dealing with missing data;*

- *Logic checks; and*
- *Check or audit procedures that all relevant factors have been considered.*

SSEPQP003_002:

- *To ensure that the same Manning n value is used between adjacent gauge points;*
- *To deal with different Manning n values for two independent gauged links;*
- *Separate calibration of flow and Manning n values;*
- *Bias tests should be applied to the three water storages (surface zone, root zone and ground water) using the ten year rainfall time series. This analysis should be included as part of PRP 101.1 System Model Performance Indicators.*
- *An explicit procedure for wet weather flow calibration;*
- *The audit validation should include checks of all adopted hydrological process parameters, statistical bias tests of storages and a check that consultation with operators and field inspections has been undertaken.*

SSEPQP003_003:

Procedures in this Quality Plan should either be detailed as in the other Quality Plans or should refer to the other Quality Plans.

4.2.3 Appropriateness of the Proposed Performance Acceptance Criteria Used for Re-Calibration of Trunk Models

Performance Indicators

The CRC considers that pipe level and flow are appropriate performance indicators for the trunk sewer models because corresponding measured and model results can be obtained and compared. Although in principal the Overflow Incidence Index is a sound performance indicator because it provides a measure of a model's ability to simulate the occurrence of overflows, the CRC considers there are problems with its use as a calibration parameter in view of data limitations and the calculation method. Furthermore, it should only be used if the models have been demonstrated to be unbiased in terms of magnitude and time.

The CRC recommends that:

Sydney Water should continue to use the following two performance indicators for calibrating the trunk sewer models: level above pipe invert and sewer flow.

The Overflow Incidence Index should not be used in its present form as a primary calibration parameter. Its method of calculation should be revised. It should then be used to confirm a models capability for predicting the occurrence and duration of overflows.

Performance Acceptance Criteria

Sydney Water has nominated four performance acceptance criteria- magnitude and temporal bias tests, the Pearson Correlation Coefficient (reported as r^2) and the Overflow Incidence Index. It is not clear why Sydney Water has concluded that a model needs to pass all of the acceptance criteria in order to be recalibrated.

The two bias tests are non-parametric tests whereas the r^2 test assumes that the data are normally distributed. The CRC has identified issues with the use of the Overflow Incidence Index. It can be concluded that a model reproduces the occurrence of overflows in terms of magnitude and time if it passes the two bias tests (assuming that the flow gauges have been calibrated for all flows), irrespective of the r^2 value.

The CRC recommends that:

The two bias tests should be the primary performance acceptance criteria.

The r^2 test should only be used if it can be demonstrated that the data are normally or approximately normally distributed.

The calibration protocol should be revised to separately use dry and wet weather data for statistical verification of recalibration instead of the use of data for all flow conditions, as is current practice (to avoid the possibility of wet weather data being "swamped" by more numerous dry weather data).

*Non-statistical "common-sense" criteria should be used in addition to statistical criteria for calibrating the models (*The relevant non-statistical performance acceptance criteria are that the model results are unbiased if differences between measured and modelled levels and flows are less than 10 mm or 5% of ADWF, respectively).

Measured, operating and model data should be plotted or otherwise reviewed before statistical analyses are undertaken. In other words, the acceptance criteria should be viewed as a supplement to good modelling practice, not a substitute.

The sampling frequency of SWAGMAN be reviewed and adjusted as necessary for each trunk sewer model so that the full range of data are used.

4.2.4 Calibration Process for a Selection of Completed 1994 Trunk System Benchmark Models and Results for Available Completed Models

Review Appropriateness of Steps Undertaken to Transfer Models to OACIS Platform, Undertake Statistical Tests and Verification of the 1994 Benchmark Models.

All of the 27 STS trunk sewer benchmark models have been transferred to the OACIS platform. The recalibration process provides confidence that the transfer of the trunk sewer model to the OACIS platform has been undertaken satisfactorily.

The CRC is satisfied that the statistical requirements as specified in SSEPQP003_002 are being followed by the trunk sewer modellers. However, the CRC has concerns about the way in which the acceptance criteria are calculated and used, as summarised above.

Eight STS benchmark models are being recalibrated for dry and wet weather flows and statistically verified. Recalibration/verification of these models is not completed. The CRC considers that when the issues identified in the presentations and in this report have been addressed the models will have been recalibrated and verified as far as possible using the available data.

Several of the model presentations indicated that data used for recalibration and statistical verification are considered to be of inadequate quality and/or quantity.

The CRC recommends that where inadequate data prevent successful benchmark model recalibration, Sydney Water should identify a more recent and improved period of calibration data and update the benchmark trunk sewer models with the newer and improved data.

However, Sydney Water would need to demonstrate that the sewerage system has not deteriorated during the time from the current benchmark model (1991) to the recalibrated model using the newer data in order for the EPA to accept the calibrated model using the newer data as the new benchmark model.

Do the Re-Calibrated 1994 Benchmark Models Now Meet the Specified Acceptance Criteria?

Twenty six of the 64 flow gauges in these eight STS models pass all of the performance acceptance tests. However, none of the recalibrated 1994 benchmark models meet all of the specified acceptance criteria.

The reasons for incomplete model calibration include inadequate rainfall, SPS operating and sewer gauge data across catchments for the 10 year (1985 to 1994) time series, and insufficient model detail.

The CRC makes the following recommendations:

More rain gauges should be installed. It considers that, as a minimum, each of the licence gauge locations should have a rain gauge.

Future improvements to monitoring undertaken at SPSs to ensure that all wet weather flow data are captured.

SPS configuration and operational changes should be recorded and maintained as a historical record.

Sewer gauge locations should be reviewed and changed, if necessary, to avoid future influences of SPS on gauge and model results.

Future improvements to the high flow calibration of gauges and models should be investigated.

Virtual nodes should be systematically minimised with subcatchment models or the geometry of each model should be extended as appropriate.

Sydney Water should ensure that the trunk sewer models are systematically augmented with SCAMP data to ensure that changes in population and operating changes are included in the models.

The spacing of the grid points, at least at the licence gauges, should be reviewed to minimise the real time lag between the modelled flow and gauged flow.

Modellers should routinely communicate with sewerage system operators in order to obtain improved understanding of the sewer systems being modelled.

If not, have all steps been taken to calibrate the model given input data availability and accuracy?

The CRC considers that when the issues identified in the presentations and in this report have been addressed the models will have been recalibrated and verified as far as possible using the available data.

4.2.5 Are the actions identified by Sydney Water to improve these models appropriate?

Several actions have been identified by Sydney Water to improve model calibration. Most of these actions are under way and should result in improved model calibration. However, the CRC considers that the recommendations presented in this report should also be applied to obtain satisfactory model calibration.

Comments are made in this report concerning the need for modellers to review raw data, ie levels, flows and other operating data, prior to statistical analyses and to communicate with sewerage system operators to obtain better understanding of STS operations.

It is also recommended that modellers review SCAMP data, including maintenance records, customer complaints and choke data, to obtain additional verification data.

Furthermore, it is strongly recommended that modellers regularly discuss problems, issues and successes with each other to obtain mutual support and maximise operational knowledge of the models.

The CRC also strongly recommends that Sydney Water should develop a protocol for system models that appear not able to be recalibrated to the adopted performance acceptance criteria, as required in PRP 101.2.

4.2.6 The Proposed Model Re-Calibration Protocol Specified in Report PRP 101.2

The protocol appears logical and practical, although it is a generic protocol and little detail is presented. However as noted above, the issue of models that are unable to meet the adopted performance acceptance criteria has not been adequately addressed.

The CRC recommends that the adequacy of three months/three storm events for recalibration purposes needs to be demonstrated. The adequacy of the primary trigger (r^2) *should also be demonstrated and revised as necessary.*

4.2.7 Associated Model Re-Calibration Processes that are Being Implemented by Sydney Water

The necessary processes for maintaining and updating model calibration were not covered in detail in the Sydney Water presentations to the CRC. The CRC suggests that this topic should be addressed at a later date when the issues and recommendations by this CRC, as presented in this report, have been addressed.

In principal the CRC agrees that the trunk sewer models should be maintained as calibrated models for sewer overflow licensing purposes.

The CRC makes the following preliminary comments at this stage:

- Significant system changes should be identified for use as triggers to determine which models should be updated and recalibrated. Suitable triggers could include ADWF, customer complaints and incidences of overflows. It is suggested that models would not be considered for recalibration unless trigger values had changed significantly since the model was last revised.

- Suitably skilled resources will need to be made available to meet the modelling requirements as specified in the STS licences. It is noted that Sydney Water may find it difficult to meet licence delivery dates for all STSs with existing resources.

Attachment 8 Criteria Review Committee Report

SYDNEY WATER CORPORATION

INDEPENDENT CRITERIA REVIEW COMMITTEE
TO REVIEW
STS LICENCE MODELLING AND REPORTING
NOVEMBER 2025

Prepared by:

CRC Chairman - Neil Moody

Principal Wastewater Engineer

Urban Water Solutions Pty. Ltd.

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Table of Contents

Abbreviations

ADWF	Average Dry Weather Flow
AM	Asset Management
CRC	Criteria Review Committee
DWF	Dry Weather Flow
EPA	NSW Environment Protection Authority
LTS	Longterm Time Series
FRC	Fast Response Component, used in MOUSENAM
PR	Peer Review
PRP	Pollution Reduction Program
PWWF	Peak Wet Weather Flow
r^2	Square of the Pearson Correlation Coefficient value
RDII	Rainfall Dependent Inflow/Infiltration
SCAMP	Sewerage Catchment Area Management Plan
SME	Subject Matter Expert
SPS	Sewage Pumping Station
SRC	Slow Response Component, used in MOUSENAM
STP	Sewage Treatment Plant
STS	Sewage Treatment System
SW	Sydney Water
TMR	Technical Management Review
WRRF	Water Resource Recovery Facility
WWF	Wet Weather Flow
WWOA	Wet Weather Overflow Abatement

1 Introduction

1.1 Background

Since 2000, Sydney Water has developed and been using computer models of the sewerage networks for each of its Sewage Treatment Systems (STSs), to assess the hydraulic and environmental performance of each system and report the findings to the EPA as part of the Annual Return Reporting process.

The sewerage system models are updated annually to reflect any physical or operational changes that have occurred over the reporting period. The updated models are then simulated with the rainfall record from the previous 12 months with the model results then compared with the recorded flow and depth data. If the model results fall within the required tolerances, the model is then used to assess the system with the benchmark 10-year rainfall time series. If the updated model falls outside of the required tolerances, the model is recalibrated prior to being simulated with the 10-year rainfall time series. All models are recalibrated and audited at least once every five years.

As part of the Annual Return Reporting, the environmental performance of each system is compared against the results from the benchmark year system performance, or the target system performance, to assess whether the system performance has deteriorated or improved over time.

The model simulated 'wet weather overflow performance' is compared to the limit condition or target system performance specified in the STS licence, to determine the compliant or non-compliant status of the system.

The current STS licences issued to Sydney Water, effective from 1 July 2024, for the period of 2025 to 2030, contain several requirements related to hydraulic sewer system models and their applications and reports. These are:

- Limit Condition, L7.1 – Hydraulic Sewer System Model
- Limit Condition, L.7.2 – Wet weather overflow limits
- Limit Condition, L.7.3 – Wet weather overflow improvement requirements that development of a wet weather overflow prioritisation methodology for the purpose of producing a baseline prioritisation profile
- Operating Condition, O4.8 (c) – No Deterioration clause for Networks
- Operating Condition, O4.9 – No Deterioration clause for WRRFs (Water Resources Recovery Facilities)
- Reporting Condition, R5.6 – Wet weather overflow abatement

A further requirement of the STS licences is that Sydney Water convenes an independent Criteria Review Committee (CRC) at least once every three Reporting Periods to review the methodology and findings of the Quality Systems audits and report the outcome of the review to the EPA.

Previous CRCs and one round of Independent Model audits on the STS models were conducted in May 2001, September 2001, May 2002, November 2002, May 2008, June 2013, May 2018 &

April 2022. An Independent Model Audit was conducted over 15th-16th October 2025 as a prelude to this year's CRC in November

1.2 STS Licence Requirements

The specific clauses of focus within the STS Licences for the period 1 July 2020 to 2025 pertaining to the CRC are:

L7.1 - Hydraulic Sewer System Model

a) The licensee must maintain a hydraulic sewer system model which has no temporal or magnitude bias in either flow volume or water levels at the licence gauges as referenced in the document titled "PRP101.1 System Model Performance Indicators, September 2000" and subsequent modifications made by the CRC.

b) The licensee must undertake an annual Quality System audit of the hydraulic sewer system model to determine if the model used during that reporting period meets the standards set out in condition L7.1 a).

c) The licensee must prepare a written report on each Quality System audit of any model used to assess sewage system wet weather overflow performance for the purpose of determining compliance with this licence. The report must also include the Pearson's correlation coefficient for the model used during the reporting period.

d) The licensee must provide a written report with each Annual Return on any Quality System audit of the hydraulic sewer system model stating the methodology and results of the audit.

e) The licensee must convene an independent Criteria Review Committee at least once every three Reporting Periods to review the methodology and findings of each of the Quality System audits.

f) The licensee must ensure that the independent Criteria Review Committee prepares a written report on the review required by condition L7.1 e).

g) The licensee must submit to the EPA a copy of each independent Criteria Review Committee report received by the licensee in a particular Reporting Period with the following Annual Sewage Treatment System Performance Report required by condition(s) at R5.6 of this licence.

This report fulfils the requirements of L7.1 e) to L7.1 g).

1.3 Objectives of Criteria Review Committee

The specific objectives of the 2025 CRC as identified by Sydney Water at the start of the CRC meeting were:

1. Compliance with L7.1 e)

Review Sydney Water's model rebuild and calibration processes to ensure continued compliance with performance acceptance criteria. This includes:

- Assessing the adequacy of the wastewater system model quality system.
- Reviewing the methodology and findings of recent Quality System audits.

2. Review of Integrated Catchment Modelling (ICM) approaches and evaluate Sydney Water's ICM framework, which aims to:

- Develop and improve base flow and quality models for wastewater, stormwater, and receiving waters.
- Integrate these models to simulate interactions through flow and level boundary conditions.

1.4 Scope

The scope provided by Sydney Water for the CRC was:

The CRC will assess the modelling and review processes by examining technical review reports and associated corrective or improvement actions. Detailed model evaluations are not required, as these have already been completed by Sydney Water's internal technical reviewers.

Through pre-reading and formal presentations, the CRC will evaluate and report on:

1. The alignment of the following documents with ISO 9000 requirements:
   - WWNP0007 – Model update, re-calibration and annual reporting procedure
   - WWNP0009 – Technical Management Review
   - NPSP0004 – Good modelling guidelines
2. Compliance with previous QMS Audit Findings
3. Progress and Outcomes of Model Rebuilds and Their Use in License Reporting.
4. Proposed changes to the base wastewater models and advice on any potential license implications that should be considered.

1.5 Key Stakeholder Expectations

In reviewing the modelling processes and performance assessments, it is essential to meet the expectations of both internal and external stakeholders.

The **internal stakeholders** include:

- Infrastructure Investment and Asset Performance (IIAP),
  - Environmental Regulatory
  - Waterway Health
  - Wastewater System Performance
- System Plans and Land Acquisition (SP&LA)
- Operational Technology – Hydrometric Services
- Customer Experience – Network Operations
- Engineering & Technical Support (ETS).

The **external stakeholders** identified include:

- NSW Environment Protection Authority (EPA)
- Department of Climate Change, Energy, the Environment and Water (DCCEEW)
- Local Councils

These stakeholders rely on the wastewater models and their outputs for a range of purposes, including:

- Ensuring regulatory compliance and environmental protection
- Supporting infrastructure planning and investment decisions
- Informing operational strategies and performance monitoring
- Engaging with the community and responding to development needs

1.6 Members of the Panel

The CRC Panel consisted of three independent experts with a broad mix of sewerage network system modelling, monitoring, planning, environmental modelling, system operations and Corporate Governance.

Mr Neil Moody (CRC Chairman)	Managing Director, Urban Water Solutions (Vic)
Ms Angela Dwyer	Principal, Beca HunterH2O
Mr Clint Cantrell	Managing Director, SCO Consulting, New Zealand.

The CRC Chairman, Mr Neil Moody, has been a CRC participant since 2001.

Ms Angela Dwyer, participated in the 2022 CRC and again provided many insightful observations during both the Audit and CRC.

Mr. Clint Cantrell has extensive international experience in wet weather programs throughout the USA, NZ and Australia and provided many nuanced observations and commentary in his first CRC. The CRC has benefited greatly from the perspectives of "fresh sets of eyes".

1.7 Agenda and Meeting Procedure

The CRC met on Monday 3rd and Tuesday 4th November 2025, in Room 4.01 and 4.02 at Sydney Water's Head Office, 1 Smith St, Parramatta. The agenda and presenters are shown below.

Monday 3rd November 2025

Time	Sessions	Topics	Presenters
9:30	1	Introductions	Wasif Elahi
9:45	2	Agenda / CRC conduct	Graham Orgill
10:00	3	CRC Objectives - License requirements	Graham Orgill
10:15	4	Previous CRC outcomes and Actions	Graham Orgill
10:30		**Morning Tea**	
11:00	5	Sydney Water's management systems frameworks	Iain McCrae
11:15	6	CAMMs - how compliances are tracked and reported	Ellie Robbie / Courtney Keep
11:30	7	Sewer and rain gauging & Data quality auditing processes	Chris Harris
11:45	8	Summary and progress of 2024/2025 modelling	Anwar Hoosain
12:00	9	Peer review and technical management review processes	Noor Hossain
12:15	10	Open forum – Discussions	All
12:30		**Lunch**	

13:15	11	Re-building Wastewater Network Models - Narrabeen	Aman Kidanemariam
13:30	12	Re-building Wastewater Network Models - West Middle Harbour	Hossein Samadi
13:45	13	Re-building Wastewater Network Models - Mid Parramatta	Farhana Noor
14:00	14	Re-building Wastewater Network Models - NSOOS_NST	Siming Gong
14:15	15	Open forum – Discussions	All
15:00		**Afternoon Tea**	
15:30	16	Panel Closed Session	
16:30	17	Day 1 Finishes	

Day 2 - Tuesday 4th November 2025

Time	Sessions	Topics	Presenters
9:00	18	CRC Panel closed session	
10:00		**Morning Tea**	
10:30	19	Integrated Catchment Modelling	Kaushal Kumandur
10:45	20	OACIS 3 -Widgets for Mike+	Aman Kidanemariam
11:00	21	Stormwater 1D/2D Model Development – Sydney CBD	Sadeq Zaman, Dong Le, Khang Nguyen
11:15	22	Receiving Water Models outputs for Risk Assessment	Pei Tillman
11:30	23	Modelling Road Map	Graham Orgill
11:45	24	Open forum - Discussions	All
12:30		**Lunch**	
13:00	25	CRC Panel closed session	
14:30	26	CRC de-briefing	CRC Members
15:30		**Afternoon Tea**	
16:00	27	CRC meeting Closed	Graham Orgill

1.8 Pre CRC Audit

In accord with Recommendation 05 from the 2022 CRC report an independent audit of 3 selected STS models and the application of the quality system was undertaken over the 15th and 16th October 2025. The Audit team was comprised of:

- Mr. Neil Moody, CRC Chairman and UWS Managing Director & Principal Wastewater Engineer
- Ms. Angela Dwyer, Beca HunterH2O, Principal Water Engineer
- Ms Maggie Goldie, Beca HunterH2O, HSEQ Manager/Facilitator

Engineering Modelling (EM) Manager Graham Orgill commenced proceedings with an overview of the major changes in team structure and composition that had been implemented since 2022. In particular, the clarification of the roles and responsibilities for the EM team with regards to Base and Growth Model custodianship.

A further major positive improvement since the 2022 CRC has been the expansion of detail in the larger STS systems that has resulted in the 23 STS models being expanded into 41 detailed WWCM models, all at SCAMP level of details.

The three models selected for review were agreed upon by the CRC Chairman and SW and covered the following small, mid-size and large STS systems:

- Narrabeen (part of the North Head system)
- Shellharbour
- Rouse Hill

The model Audits were well attended by the SW Engineering Modelling team, many of whom only had around 12 months' experience with SW's processes and systems.

Details of the outcomes from these "deep dive" audits will be addressed later in the report but overall, the audit team was impressed with the level of understanding displayed by the presenters and team members in attendance of the SW modelling systems and processes from the largely new team.

1.9 Presentation of CRC Findings

The following sections in this report have been broken into three categories:

- General findings and observations noted during the presentations.
- Specific findings with respect to the stated CRC objectives; and
- Consolidated findings with recommendations for improvements.

2 Comments On Presentations

2.1 Introduction

The presentations to the CRC were all made in PowerPoint format and digital copies were made available to the CRC Panel. The presentations were of a good quality; the presenters spoke knowledgeably and displayed interest and enthusiasm when discussing their areas of focus.

As has been the custom on previous CRCs, questions were raised by the CRC Panel during presentations that resulted in robust discussions between panel members, presenters and the members of Sydney Water's project team in the audience. The following sections detail the topic from each session with significant comments and questions raised during the presentations, together with a summary of discussions made in the CRC Panel closed sessions.

2.2 Session 1: Introductions

The opening presentation provided a general overview of the conduct of the CRC, Acknowledgement of Country, general housekeeping issues, the proposed agenda for the CRC, introductions of CRC participants, their roles and responsibilities.

CRC Panel Discussion and Comments

On review of the Agenda, the CRC Panel identified that some sessions may need additional time and advised that they were satisfied that there was sufficient time at the days end to allow additional session time if required.

2.3 Session 2-3: CRC Objectives, License Requirements and Strategy Overview

Summary

A comprehensive presentation was delivered by Engineering Modelling (EM) Senior Manager Mr Graham Orgill:

- Graham outlined the purpose and principles of the CRC and composition of the key panel members
- Graham demonstrated the key features of SW strategy for 2025-2035 and the complexities and challenges entailed to integrate and align many SW processes to achieve the end goal.

- To deliver the needs of the Strategy, a comprehensive resourcing plan was presented identifying the annual resourcing needs for the Engineering Modelling group from 2025 to 2030.
- Reframing the function of the EM group as the creators and custodians of all Base Engineering Models which then become a single source of truth for distribution to other users of models across the business has clarified the primary roles for the group.
- EM group also responsible for the development of Growth Area Models and STS license modelling and reporting.
- Clear distinction made between the function and responsibility for Base models and Scenario modelling.
- A key aspect of interest with the resourcing plan was the distinction between what modelling activities are designated as a Capital Expense and what activities are considered an Operational Expense.
- Michelle Cassidy presented an informative video demonstrating the overflow abatement progress over the past 9 years

CRC Panel Discussion and Comments

Panel overall very impressed with the breadth and depth of progress over the past 3 years since the last CRC in 2022, particularly with regards to the framing and clarification of the roles of the EM group and where it sits within the delivery of the broader Strategy.

Clear distinction between accountability and Authority.

Satisfied that the STS modelling aspect, which is the main driver for the CRC, is well addressed within the broader Strategy, particularly as the Base models will be the STS models used for reporting.

The panel was also very impressed by the efforts to capitalise certain aspects of model development and treating models as assets, which is industry leading and, in our opinion, is an example for other utilities to follow.

2.4 Session 4: Previous CRC Outcomes and Actions

Summary

SW reported on the actions undertaken in response to the recommendations from the 2022 CRC. The majority of recommendations have been addressed, or activities are in progress to address the identified issues.

Rec No.	2022 CRC Panel Comments/ Recommendations	
Rec01	Sydney Water to undertake an assessment of alternate hydraulic modelling software available in the market to replace MOUSE which is currently unsupported. Given the major modelling program transformation that is currently taking place in SW, adoption of the new software platform prior to finalisation of revised system performance benchmarks would be highly desirable. In addition to having similar hydraulic/hydrologic capability to Mouse, additional features to be considered in assessing alternate software platforms include: • Ability to explicitly incorporate pump curves and pressurised rising mains into the model. • Potential to incorporate and simulate sewage water quality parameters for the purpose of prioritising overflow abatement works based upon pollutant load in addition to volume and frequency considerations. Add on capability to import forecast rainfall data and undertake forecast simulations.	**In Progress** SW assessing alternative hydraulic modelling software. • Mike conversion widget for ICM • OACIS and ModAsset replacement • Modelling roadmap
Rec02	The CRC Panel fully support the transition of all models to the SCAMP level of detail acknowledging that this will result in the need to redefine and renegotiate system benchmark baselines.	**Completed** All models have been developed to SCAMP level of detail
Rec03	The CRC Panel supports the proposal to break up the larger STS systems into smaller subsystems for management and license reporting purposes, delineated where possible based upon the overflow receiving waters.	**Completed** Larger STS systems have been broken up into smaller subsystems
Rec04	The CRC Panel support the 3-stage targeted approach to address wet weather overflow abatement compliance and expect that following post rehabilitation monitoring that the program and approach will be refined over coming years	In progress
Rec05	The 2008, 2013 and 2018 CRCs identified the need	**Completed**

Rec No.	2022 CRC Panel Comments/ Recommendations	
	to engage suitably qualified experts that have been external to the license modelling process to undertake detailed audits/reviews of the STS models. This recommendation is reiterated from this CRC.	Independent audit of wastewater models undertaken in October 2025 Plan to undertake audit every 3 years
Rec06	Resourcing: The CRC Panel recommends that SW evaluates future staffing levels required to support the increased requirements for model update and calibration as all models transition to SCAMP level models.	**Completed** Team size has increased from 7 to over 25 with 4 defined streams. Roles and responsibilities clearly defined The expanded team has allowed SW to deliver the STS modelling internally
Rec07	The CRC Panel fully encourages SW to continue the development of stormwater models to provide ERS boundary conditions to support the wastewater modelling program.	**In Progress** ICM project is progressing
Rec08	The CRC Panel supports Sydney Water in the need to review system performance benchmarks, particularly once all licensing models are created to the SCAMP level of detail. In addition to redefining the baseline system performance based upon the frequency and volume of overflows predicted by the detailed models, establishment and definition of benchmark overflow “event periods” to resolve the current anomaly whereby a significant reduction in overflow volume could result in one long “overflow incident” being redefined as two or more overflow events.	**In Progress** Discussions have been held with EPA with regards to revised baseline STS model performance
Rec09	The CRC Panel encourages further refinement of the processes involved in creating SPS inflow/outflow data at each SPS, thus providing additional potential model calibration points.	**Not yet started**
Rec10	The CRC Panel supports the strategic sewer gauging review and recommends a staged implementation over several years.	**In Progress/ BAU** More gauging has been implemented as part of ICM project.

CRC Panel Discussion and Comments

Of the 10 recommendations from 2022, the only items not covered clearly over the course of the CRC were items 8 and 9. SW advised that discussions had been held with EPA with regards to the revised baseline STS model performance associated with bringing all STS models up to SCAMP level of detail.

2.5 Session 5: Sydney Waters Management System Framework

Summary

- Mr Iain McCrae provided an overview SWs quality management system
- External 2025 audit of SW quality systems resulted in zero non-conformances and 5 opportunities for improvement.
- Overview provided of internal processes to provide management system governance.
- Information mapping shed a lot of light on where duplication was occurring, and where improvements could be made.
- SW moving toward an Integrated Management System (IMS) which will reduce duplication of controls/processes and provide a single source of truth and improve risk and compliance outcomes.

CRC Panel Discussion and Comments

Panel satisfied with the corporate system in place and concur with the transition to an IMS to simplify and reduce duplication of systems and processes and to further mitigate risk around development, refinement and use of models to inform compliance reporting and capital investment planning.

2.6 Session 6: CAMMs

Summary

- Ms Ellie Robbie and Courtney Keep provided an overview of the CAMMs system and how it is used to record and report on EPL compliance.
- CAMMs used to assist with review and sign off for the 2024-25 EPL Annual Returns.
- Demonstration of the process flow from incident initiation through compliance status, review and obligation acceptance to lodgement with EPA

CRC Panel Discussion and Comments

Panel satisfied with the overview provided that the CAMMs system seems to adequately track the progress of reported incidents from initiation through to EPA submittal

2.7 Session 7: Sewer and Rain Gauging & Data Quality Auditing Processes

Summary

Mr Chris Harris, SW Hydrometric Services (HS) Manager, presented on the range of services provided by the SW Hydrometric services group including gauge deployment, calibration, data collection, data processing and delivery with the overarching quality controls embedded within their processes.

These systems and processes are well established and have been reviewed in detail in previous CRC's and are considered to be of a high standard.

- The HS group currently maintains over 1,100 gauges at present as well as 19,000 IoT gauges.
- Existing IoT devices are relatively simple under/over trigger level however new generation devices will which provide real time level data. It is planned to install the new devices in MHs with ERSs.
- There are 150 level gauges sited in ERS's that have associated ratings tables to compute flows assuming free discharge into the receiving water.
- HS group looking at Power BI dashboards and incorporating machine learning to improve detection of anomalies.
- Modeller issued queries treated as an anomaly
- EM team have been involved in monitoring site visits with HS team to gain broader understanding of challenges associated with collecting data from sewers in urbanised areas.
- Since last CRC a new role has been created within HS for dedicated hydrometric data specialist.
- ERS investigations ongoing as part of ongoing source control program

CRC Panel Discussion and Comments

The processes in place to collect, review and quality control data are of a high standard and the culture to continuously improve the processes and delivery of data is commendable.

Potential issue for overestimation of flows calculated from ERSs to receiving waterway identified with the working assumption of a free outfall from the ERS. Combined system modelling will assist in identifying ERS that have high potential for being submerged from the storm water system. Inclusion of additional depth sensors in storm water system may be warranted.

IoT data not currently readily accessible to EM team. Consider mechanisms for making this data more broadly available.

Panel commend the increased interaction between EM and HS staff particularly with regard to site visits to assess suitability of gauging locations.

The panel also recommends careful consideration of a future scenario where all ERSs are monitored and reported on in real time, including community access to this data. This is largely based on the recent experience in the UK, which has resulted in some unintended consequences in terms of managing perceptions and expectations on how benefits are assessed beyond simple spill frequency and spill duration metrics. Also, will IoT devices located at all ERSs result in some deeper assessments of model accuracy in terms of overflow frequency and duration predictions?

2.8 Session 8: Summary and Progress of 2024/25 Modelling

Summary

Mr Anwar Hoosain delivered an informative presentation on the significant changes that have been made to the License modelling program since the last CRC in 2022.

SW have transitioned from managing 224 SCAMP models, which fundamentally included all pipes 225 mm and above, and 23 STS trunk models to now managing and maintaining 41 Wastewater Catchment Models (WWCMS) which are all constructed to SCAMP level of detail. The WWCMS will now provide a single point of truth and will be used for license reporting, planning and system analysis.

To achieve this level of detail, and maintain reasonable model simulation times, it has been necessary to break down the larger STS systems, in particular Malabar and North Head, into a number of catchment models generally using long term gauges as boundary conditions.

Statistics provided in the presentation illustrated that the 9 WWCMs that now comprise the Malabar system have resulted in a major increase in the length of sewer explicitly modelled from 586 Km up to 2348 Km, with modelled ERSs increased from 467 to 1,112 and SPs from 50 to 163.

One concern discussed at the last CRC, that may have arisen from this process, was the potential need to redefine the base overflow targets when the more detailed models were simulated with the LTS. The presented system performance data comparing the former 2022 trunk model of the North Head system with the 7 WWCMs that now comprise the North Head system showed a very similar overflow frequency from the 10-year LTS.

CRC Panel Discussion and Comments

Transitioning to the SCAMP level of detail for all WWCM’s and maintaining these models as the single point of truth for STS reporting, system analysis and planning is a very welcome step change.

With all WWCMs now at the same level of SCAMP will provide a greater level of confidence of the modelled system performance higher up in the catchments and provides a consistency of model across the whole service area.

In addition to the efficiencies gained with this process, the inclusion of all constructed ERS into the models, together with all significant pumping stations, has resolved a number of long-term queries associated with the larger, heavily simplified STS trunk models and the use of virtual overflows to represent unmodelled ERSs.

2.9 Session 9: Peer Review and Technical Management Review Processes

Summary

Mr Noor Hossain presented on the systems in place to fulfill the section L7.1b requirements from the EPL to undertake an annual Quality System audit of each hydraulic sewer model to determine whether the model fulfils the requirements of L7.1a in the EPL.

These processes have continuously evolved over the 25-year life of the program and are well known to the CRC panel and considered to be robust and mature.

The review is a two-part process:

1. Peer review – undertaken within the modelling team
2. Technical Management Review (TMR) – external to the modelling team but within SW.

The QA process for Peer Review was demonstrated with a flow chart based on the verification plan WWNP00007.01.

The TMR QA process was also described in detail and an example of a complete review for the Mid Parramatta WWMC was provided. The 3 stages of the TMR process were described in detail and the completed TMR for the West Camden model was demonstrated.

There are currently 4 experienced TMR reviewers on the panel, 2 from the EM team and 2 from Planning.

CRC Panel Discussion and Comments

- The Peer Review and TMR processes are generally robust, have matured over the past 25 years and are well understood by SW team members and the CRC.
- Based upon the information presented, the CRC is generally satisfied with the application of these reviews and processes.

- The CRC panel has noted a subtle change in the verification process since the last CRC. Previously it was understood that all STS models, following the annual update, were simulated with the previous year's rainfall and a verification comparison made with data from the License gauges. In recent years it appears that STS models that haven't triggered a need for recalibration due to population growth, network changes etc have not undergone verification simulations.
- While it is understood by the Panel that not every model can be recalibrated each year, the Panel considers it necessary to undertake the verification simulations annually and to make the verification results available to downstream users of the model, even if out of calibration.
- Going forward the Panel recommends that additional resources be recruited / trained up to expand the pool of qualified reviewers to enable a smooth transition.

2.10 Sessions 11-14: Rebuilding Wastewater Catchment Models North Head System

Summary

The following sessions comprised presentations on the building and calibration of four of the WWCMs that are part of the North Head system. Due to the commonality between these presentations, the following section provides a few key details for each specific WWCM and a range of common observations.

The modellers who have developed these WWCMs and presented on their work are all new to the CRC panel each with approximately 12 months experience with SW and were all involved in the October 2025 detailed Audit sessions. During the CRC and detailed Audit sessions it was apparent that the new resources have assimilated well and have a good understanding of the OACIS system and underlying processes. Some of detailed commentary in the following is drawn from the findings from the October 2025 Audit but is consistent with what was observed at the CRC.

Narrabeen System

- The Narrabeen system WWCM explicitly contains more than double the length of pipe contained in the former STS model for this area.
- A good level of calibration was generally achieved for flows however there were a few examples presented at gauge 820113 where it appears that either the depth sensor data was truncated during two of the larger events or that there may be a manhole overflowing upstream.
- A challenging aspect to model this system is the operation of the 18 ML storage tank at SU0163. Real Time Control (RTC) rules have been developed based upon the "normal" operation of this facility; however, it is apparent that on some occasions there has been operator intervention to modify the actual operation during wet weather events. The

MOUSE modelling software is unable to readily accommodate these "ad hoc" changes to system operation.

- During the Audit review it was identified that the calibration was undertaken using the "virtual" rain gauge assignation used for the previous STS model and in particular the LTS simulations used to establish system performance. In the period between the Audit and the CRC this anomaly was rectified with subcatchments reassigned to the available calibration rain gauges using the Thiessen polygon method.
- Overall, a satisfactory level of calibration was achieved.

West Middle Harbour System

- The West Middle Harbour WWCM has had a dramatic increase in the extent of assets explicitly modelled. The WWCM includes 297 km of sewer, up from 34 km in the STS trunk model with the number of ERS increased to 150 from 35 in the STS model.
- While a satisfactory calibration was achieved some anomalies were identified when comparing the model results with the observed data between small, median and large events with "flat topping" occurring at some monitor sites. This generally indicates an overflowing upstream manhole or unidentified ERS and needs to be explicitly modelled to ensure hydraulic robustness during these large events.
- The need for additional gauging identified at 3 locations.

Mid Parramatta System

- The Mid Parramatta WWCM has had a relatively minor increase in the extent of assets explicitly modelled. The WWCM includes 113 km of sewer, up from 96 km in the STS trunk model with the number of ERS increased to 93 from 79 in the STS model.
- Given its position in the North Head network, the Mid Parramatta system has 3 major upstream inflows, 3 minor inflows and a downstream boundary condition at 820011.
- Additional gauging required to better quantify all the upstream inflows, particularly in West Ryde area.
- Modelling the complex siphonic overflows challenging for any modeller and a good effort from a relatively new modeller.

NSOOS NST System

- The NSOOS NST WWCM has had a significant increase in the extent of assets explicitly modelled. The WWCM includes 488 km of sewer, up from 211 km in the STS trunk model with the number of ERS increased to 248 from 144 in the STS model as well as the number of pumping stations increased to 51 from 30.

- The NSOOS NST is the most downstream of the WWCMs and receives inflows from the Mid Parramatta, Lane Cove, West Middle Harbour and Narrabeen WWCMs with 8 boundary inflow locations and the outfall at Manly.
- The land use in this WWCM contains major commercial centres in North Sydney, Artarmon and Chatswood as well as popular tourist destinations including Manly and South Curl Curl and hence there is noticeable seasonal fluctuations in flows at some gauges.
- A suggestion was made from the modeller to create diurnal flow patterns for mixed land use areas to improve the DWF representation. From extensive past experience with these issues the Panel suggested that more detailed subcatchments be delineated in these mixed areas to differentiate between the different land use types when significant.
- Approximately 75% of the flows in this catchment are inflows from upstream WWCMs and hence variations in flow patterns, minor inaccuracies in flow data (even within specified accuracy limits) and dropouts from the observed inflows will all impact the performance of this WWCM.
- Given the challenges with this WWCM with inflow sources a satisfactory level of calibration was achieved.
- As identified by the modeller, due to the complexities and dependency on high quality inflow data at the boundaries there is an ongoing need to refine the cross-team investigation of the boundary inflows and further collaboration with the Hydrometrics data management team.

Shellharbour System – (Reviewed during October 2025 Audit)

The Shellharbour WWCM is comprised of 3 former SCAMPS and was interrogated during the October 2025 Audit. This WWCM was selected for detailed review as there have been issues identified in this system during previous CRC reviews, in particular involving the operation of the major SPSs which control the flows in the network. Key findings:

- SW team members demonstrated a high level of understanding of the OACIS system and how to access supplemental data on historical pumping station performance data from IICATS.
- The historical SPS data from IICATS clearly demonstrated that the wet weather operation of the major SPSs have frequent operator intervention with regards to pump speeds and operation. This type of ad hoc operational change is unable to be modelled with limitations of the MOUSE RTC facility.
- Given the significant growth occurring upstream in this system, there appears to be opportunities to improve wet weather system performance through optimised use of available storages in the network and modifying pump operations to best manage wet weather flows.

CRC Panel Discussion and Comments

Overall, the Panel was impressed with the quality of the presentations and the understanding of the systems performance demonstrated by the presenters. The following comments cover a few systemic matters with have come to light with the transition to the WWCM models and other matters that will need to be addressed with the selection of the future modelling platform.

- A common theme across all of these WWCMs was the need for additional gauges, particularly at boundaries, and/or the need to refine WWCM catchment extents, understanding the challenges with the existing OACIS processes with geographically non-contiguous catchment areas.
- The future modelling platform needs to have capability of modelling ad hoc changes to RTC rules at pumping stations, storages and other facilities that are operator regulated.
- The "flat topping" observed in some of the flow and depth data comparisons tend to indicate that upstream or downstream manholes, or unidentified ERS, are activating during some of the larger events. The new modelling platform needs to have the capability for all manholes to overflow when the water level reaches the cover level by default with the ability to seal those manholes in the model that are known to have been bolted down.
- Further interrogation of data in consultation with the Hydrometrics group required to distinguish between gauge sites that have "capped out" versus upstream or downstream manholes that are overflowing and not represented in the model.
- As demonstrated with the version of the Narrabeen model presented at the Audit compared with the version at the CRC, there is the need to distinguish between rain gauge assignation for each subcatchment during calibration / verification and the virtual rain gauge assignment associated with the LTS simulations.

2.11 Session18: Engineering Modelling Road Map

Summary

Mr Kaushal Kumandur delivered a presentation on the comprehensive body of work undertaken by SW to define "where are we" and "where do we need to head" and what processes and systems get carried forward and what needs to be refined, updated or replaced, looking at the entire modelling processes undertaken by SW.

Following canvassing of reflections and opportunities within the EM team, key takeaways were:

- Resourcing constraints
- Progression within team/ career and skills
- Digital experience

The recent realignment of the group has largely addressed the first two areas of concern. The group has grown from 7 to 20+ over the past 2 years and with the new structure there are multiple layers of seniority and opportunities for new team members to learn from Senior/Principals, clear lines of responsibility with managers leading different streams as well as pathways for professional progression.

Progress with Digital is underway and the team have engaged with Digital to see what can be done to uplift the modelling processes.

Key modelling requirements have been streamed into 4 primary channels:

- Data management
- Technology Development
- Modelling Process Improvements and
- Model outputs

The presentation went into detail covering the Enterprise Capabilities and Functional Requirements for the Engineering Modelling cycle with defined needs, assessment of current status and desired Future State.

SW has identified the importance to develop a comprehensive plan that will work from end to end rather than looking at functional requirements in a piecemeal fashion.

From the perspective of a business feasibility lens, it is apparent that SW can't deliver all the functional requirements at once. The priority and risk of the range of fundamental modelling requirements was assessed, and the highest risk items were generally data related.

The known challenges of upgrading existing systems include but are not limited to:

- ModAsset – written in Delphi, 32 bit with unsupported underlying database
- MOUSE – DHI simulation engine has been unsupported for a number of years
- OACIS – Bespoke technology, SW unable to support due to inadequate Code documentation and incompatibility with 64-bit architecture.

SW not just looking at software capability to do the modelling they need but also through a digital and commercial lens.

A draft high level roadmap was presented identifying the priorities for the Modelling Strategy over the next 5 years, however due to the criticality of OACIS it may need to be dealt with in advance of its Needs Assessment Business Case (NABC).

The team is currently working with vendors to discuss the functional requirements with the intention of going to the market by mid-2027. SW is adopting a holistic approach, moving away from user preference and instead focusing on functional requirements.

CRC Panel Discussion and Comments

The Panel was pleased to see that there are solid plans in place to upgrade and replace existing systems, as this was viewed as one of the critical items to address from the previous CRC. The early engagement with the market demonstrates the commitment to replacing the aging systems with products that meet all the functional requirements of the 200+ users of the models.

2.12 Session 19: Integrated Catchment Modelling

Summary

Mr Kaushal Kumandur presented on the progress of SWs Integrated Catchment Modelling program.

A key driver for the ICM is to be able to better quantify and compare the impact of the overflows from the sewerage system into the receiving waters, and the subsequent prioritisation of engineered solutions.

The process is currently a “soft integration”, with stormwater and receiving water models run independently from the sewerage system models. Time series outputs from the stormwater models provide tail water boundary conditions that are applied to the downstream outlets for each ERS.

As part of this process, ERSs that are identified as being prone to elevated water levels in the receiving waterway, particularly those exceeding ERS levels, are being investigated and faulty flap valves etc being remediated.

Details were provided of the flow monitoring and water quality sampling programs proposed for the sewerage system, stormwater network and receiving waterways.

The program of works required to effect delivery of the prioritised IPART submission by 2029 was demonstrated to enable source control works to be completed over the 2030-35 period.

GHD, DWS and UNSW have been contracted to develop the new models for this program and works have commenced on the hydraulic model component.

CRC Panel Discussion and Comments

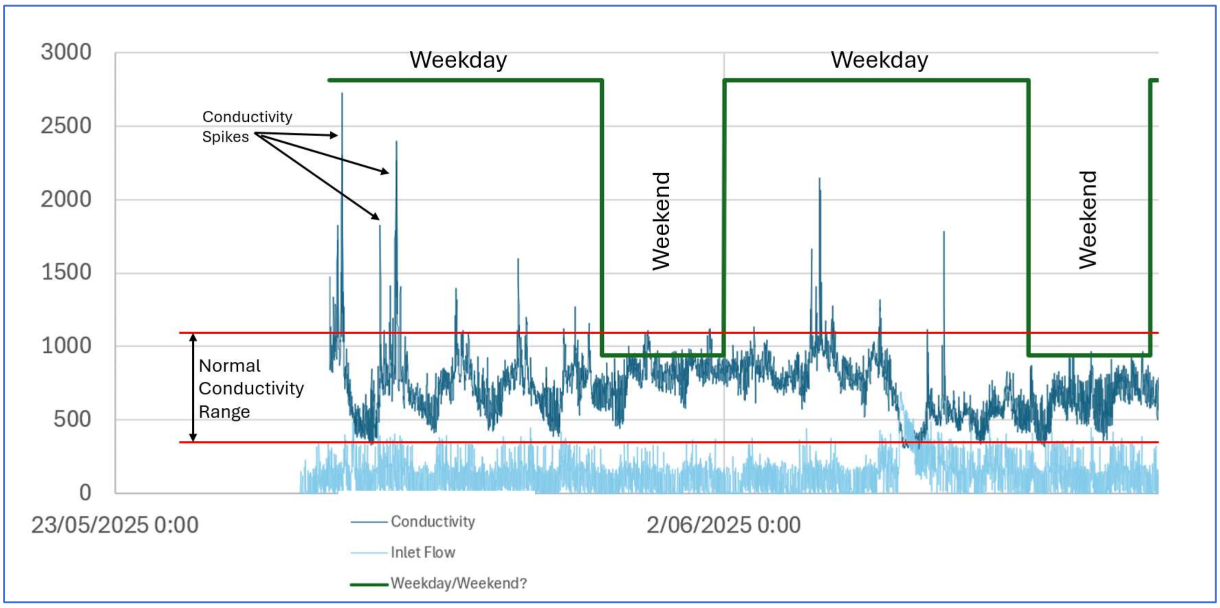
The program appears to be well thought out with challenging but achievable timelines.

The panel endorses the ICM approach to better refine the understanding of interactions (and effects) between ERSs and the associated discharge environments both in terms of hydraulics and water quality.

It is recommended that SW consider targeted use of IoT level sensors at ERSs and the discharge waterways (operating in tandem) to confirm the model’s accuracy of hydraulic interactions including backwater effects. Without sufficient monitoring data covering a range of weather and waterway conditions (including tidal impacts), it is very difficult to model these variable conditions with any certainty. Given the potential for waterway conditions to have a substantial impact on the hydraulics of ERSs, the panel recommend development of a specific plan to monitor conditions sufficiently to ensure the ICM models are fit for purpose.

The water quality sampling program proposed for the sewerage system should provide suitable data for DWF calibration of WQ parameters. Globally, the process of modelling water quality in sewerage systems has evolved – with a focus on monitoring key parameters which can act as surrogates and/or tracers for simulating other parameters which are part of an overall ERS effects assessment approach. Given that the "strength" of wastewater can vary substantially as a function of inputs sources (residential, commercial, industrial, others) and inflow/infiltration rates (including groundwater infiltration), monitoring parameters which can be measured in real time with continuous probes can provide a much greater insight as to how best to represent water quality in sewers. For example, ammonia, pH, temperature and conductivity are examples of direct and surrogate parameters which can be measured in real time using continuous probes. This approach does require active maintenance to ensure the probes operate as intended in these harsh environments, but this has been successfully implemented on many studies around the world.

Following is an example plot of real time conductivity, measured in the raw sewage influent to a treatment plant, to track down likely trade waste sources causing plant performance issues. This data shows clear "spiking" patterns which correlated directly with changes in the sewage strength associated with input sources. In this case this led to the identification of the problematic trade waste entities operating outside of their license agreements.



To complement the periodic and intensive sampling program the Panel recommends further consideration of installing continuous quality probes at key sites in the vicinity of proposed intensive sampling locations. The data from such probes will provide seasonal context to the data collected during the intensive sampling periods as well as identification of periods anomalous data. This data will further enable model calibration to sewer water quality parameters including how they fluctuate in wet weather conditions when ESRs are likely triggered – enhancing the representation of overflow discharges beyond simplistic event mean concentrations which tend to normalise relative pollutant load contributions and effects.

2.13 Session 20: OACIS 3 – Widgets for Mike+

Summary

Mr Aman Kidanemariam provided an informative presentation on the works undertaken to adapt the legacy OACIS software, originally developed in 2000, to be able to:

- export modelling data in a format suitable for the Mike+ software.
- initiate simulations using the Mike1D hydraulic engine.
- extract results from Mike simulations and import into the Graph Manager and associated components.

The presentation provided a clear definition of the issues and challenges together with the logical workflows adopted to adapt the OACIS platform to interface with the Mike 1D simulation engine while only requiring relatively minor changes for the end users experience.

While it was acknowledged that these updates are an interim solution pending delivery of the future modelling platform the areas for potential future technical and operation risks are well defined.

Key themes are the need for process documentation to be thorough and regularly maintained over the transition period.

CRC Panel Discussion and Comments

Panel highly impressed with the clarity of the presentation, the definition and distinction of the workflows, the underlying software “widgets” developed and the ability to integrate the changes within the existing OACIS user interface to minimise adaption challenges for existing OACIS users.

The defined potential technical and operational risks associated with this transition software have been well defined together with considered mitigation strategies going forward.

The defined need to continually update documentation and development of a knowledge transfer strategy in relation to the OACIS software is commended.

While the example shown from the Narrabeen catchment, comparing modelled flows from the original MOUSE with the results from the Mike+ model for the same network appear similar there may be need to expand the range of comparison tests. Comparison of the modelled outputs from large wet weather events in the vicinity of areas of complex hydraulics or known problem locations and ERSs should also be considered as part of the transition process to ensure that the Mike+ models demonstrate parallel performance.

2.14 Session 21: Stormwater 1D/2D Model Development

Summary

This presentation detailed the progress made in developing a model of the Sydney CBD catchment stormwater system.

A clear workflow was demonstrated that provided a logical sequence of activities.

The presenters discussed the work that has been completed to date (1D stormwater model build, 2D overland flow model build and rainfall-runoff model build) and identified future tasks includes coupling of 1D and 2D models, water quality modelling and LTS simulations.

The team highlighted the challenges with missing data in one of Sydney's oldest stormwater systems and reliance on the City of Sydney's asset database for information and discussed assumptions that were made to fill missing data.

The approach for developing the 2D model was discussed including the use of Mike Zero Mesh Generator to create high resolution elements.

CRC Panel Discussion and Comments

While still in its early stages the staged workflow presented demonstrated clearly how the outputs from this model will ultimately feed into the broader ICM work being undertaken

2.15 Session 22: Receiving Water Models

Summary

This presentation from Dr Pei Tillman demonstrated the receiving water modelling that has been undertaken by SW and some of the key outputs from these models and how they will feed into the broader ICM initiatives.

Modelling work to date has been swayed towards tidal and estuarine areas and the future focus is geared toward fresh water.

The proposed water quality sampling program, described in the Session 19 Integrated Catchment Modelling, will provide additional data to refine the calibration of the receiving water model and better quantify the impact of sewerage system overflows on the receiving waters.

CRC Panel Discussion and Comments

The incorporation of water quality parameters into the wastewater modelling aspect of the ICM program will provide useful inputs to better understand the contribution and impact of sewage overflows into the receiving water bodies. Based upon Panel members experience with sewerage system water quality modelling and sampling; the default use of event mean concentration for pollutants associated with overflows may be overly conservative at many locations.

The proposed monitoring program will enable the baseline models to be refined and coupled with the outputs from wastewater model overflows provide greater visibility of the actual contribution and impact of these overflows and in turn the benefits from source control programs.

2.16 Session 23: CRC Chairman's Wrap Up

Summary

The CRC concluded with a brief presentation from the Chairman summarising the key takeaways from the review. The Panel were overall very impressed with the advances that have been made over the past 3 years.

3 Findings with Regard to Objectives and General Discussion

The CRC Panel reports the following findings in response to the specific objectives outlined for the CRC:

- **PRP L7.1**

  Since the last CRC in 2022, the systems, methodologies and processes associated with the Licence Model update, verification and recalibration have been further refined from what was an already mature well understood system.

  The recent creation of the WWCMs, which has broken the larger systems into smaller receiving water based sub-systems for licensing purposes and rebuild of all models to a SCAMP level of detail is highly commended. This has enabled SW to maintain a single model that can be used across all areas of the business and provide a single source of “truth”. This reduces the number of models to be maintained and avoids duplation of model build, model maintenance and model calibration efforts. The reestablishment of the current baseline (with the vast majority of ERSs now explicitly modelled) has been discussed with the EPA and we understand that no major concerns have been raised.

  With all WWCMs constructed to the same SCAMP level of detail, and particularly the explicit inclusion of the majority of ERSs in the model networks, has provided a firm foundation for the ICM modelling program.

  The ongoing system of Peer Reviews and Technical Management Reviews is well established and should ensure that the models are of a high quality and the results representative of the system performance. The Annual Reporting procedure is a well-developed process and seems to be implemented consistently.

  The Panel have noted that there has been a subtle change to the workflow over the past 3 years whereby models that have only had minor changes in the model update process have not been simulated with the previous year’s rainfall for verification assessment.

  The succession planning issue identified at the previous has been largely addressed with the expansion of the team and broader resource base however an ongoing recruitment process will be required to ensure that resource levels are maintained. It is recommended that the team continue to build skills internally, particularly with regards to ensuring that there are sufficient people with the necessary skills to undertake peer reviews and technical reviews.

  The transition to a new modelling software platform is underway although it is recognised that this is a work in progress and is not expected to be fully implemented for another two years.

- **PRP Integrated Catchment Model**

  The Integrated Catchment Modelling program is a major undertaking, and the Panel are generally satisfied that the program has been well thought through as was demonstrated by the interconnecting workflows shown in a number of presentations.

  While the wastewater modelling aspects of the program should be achievable, the challenges encountered with the CBD stormwater modelling example will likely be encountered across much of the stormwater system. Engaging Consultants as additional resources to undertake much of this work will hopefully ensure that the proposed timelines will be achieved.

  The ongoing program of ERS inspections and additional gauging at ERS sites is encouraged. Those ERS locations that are predicted or known to discharge into submerged outlets due to the level in the stormwater system exceeding the ERS level are of primary importance for additional gauging.

  The addition of continuous monitoring to enhance the accuracy of ICM models, in our opinion, would add significant value to the use of these tools. This includes use of IoT level sensors and real time water quality probes as previously discussed.

  There are a few areas that the CRC Panel feels that SW need to address in the near term:

  - All models need to undergo annual verification following update. If a model has fallen out of verification tolerances, to not investigate the “why” is a lost opportunity for improvement. Given the WWCM models are now the single point of truth for Licensing, Planning and system analysis, it is important for downstream users to have an appreciation of the aspect of the models that need to be considered with a level of caution. Even if it is not possible to recalibrate every model that falls out of verification tolerances, providing an explanatory Tech Memo detailing the how and why of any discrepancy will inform and empower the downstream users to apply engineering judgement in those areas.
  - Calibration / verification issues were encountered in the Narrabeen and Shellharbour WWCMs when operational settings for pumping stations and storage facilities have on occasion been modified by the operators during wet weather events. These types of irregular operational changes will occur across the system and will impact the model performance during the annual verification simulations. The MOUSE RTC protocols are unable to adapt to these temporary changes in operational rules when running a longer time series simulation (i.e. one set of rules only for the whole simulation). In addition to compromising the results comparisons, between observed and modelled performance, it appears that a lot of modeller time is being expended to resolve or work around these types of issues. There is also the

possibility that other hydraulic issues are being masked by these workarounds. With the interim migration toward MIKE+ for all WWCMs, we note that there may be opportunity to leverage the "Time Series" sensor functionality, documented in the MIKE+ user guide, to reflect actual historical operation at these operators' regulated facilities.

General Discussion Points and Considerations

As an overarching comment the Panel is extremely impressed with the remarkable transition that has occurred over the past 3.5 years within what is now the Engineering Modelling group.

The clear definition of the EM group's roles and responsibilities, primarily Base Model construction and maintenance together with Growth model development, and the 6-year resourcing plan (2024-2030) to fulfill those roles has made clear the resourcing needs for the EM group. The distinction between what activities undertaken by the EM group are a Capital Expenditure by nature (e.g. the re-building of the tools and models primarily, model updates) and those that are Operational Expenditures by nature (e.g.recalibration, annual verification, STS reporting).

The Panel is impressed with the calibre and number of new recruits to the EM group. During the detailed Model Audits, and the CRC, the Panel were pleased to see firsthand their adeptness at working through the OACIS framework, understanding of the modelling processes and ability to readily access ad hoc information requests from the Audit panel. We also note that we were pleased with the openness shown by the team during Audits and the CRC and the overall positive collegiate and collaborative attitude displayed in both sessions.

Given the majority of the new team members have had limited previous exposure to the operation of a water and sewerage business, activities such as undertaking gauging site visits with the Hydrometric teams are strongly encouraged. The Panel would also recommend that site visits are arranged with operators when modelling large pumping stations and other complex facilities such as storage tanks.

In most water authorities, model development and concept level planning are generally undertaken within the same group. While the Panel concurs with the role distinctions of these groups within the current SW framework there are many potential benefits that could be derived from creating staff rotation programs between these groups. The less experienced Planners would gain a solid appreciation of what is involved the model development process and its nuances while the less experienced model developers would gain an appreciation of how the tools that they are developing are applied. In addition to expanding the knowledge of both groups it may also provide the opportunity for temporarily reallocating staff during crunch periods and potentially enable quick expansion of the resource pool to undertake peer and technical management reviews.

The transition to SCAMP level of detail in all WWCMs, and the resultant consistency of analysis across the network, has been a progressive improvement for the SW modelling program over a number of years that has now reached fruition. Breaking down the large North Head and Malabar system into a number of interdependent WWCM models has not been without challenges, particularly at the boundary interfaces. While this aspect of the program wasn't able to be fully reviewed over the time available during the Audit and the CRC, there may be opportunities to realign WWCM boundaries and/or relocate gauging to streamline this process going forward and additional permanent gauging sites need to be considered.

A quirk that came to light during the Audit of the WWCM calibration for Narrabeen was the use of LTS virtual rain gauges for calibration when higher resolution data was available from the temporary and permanent rain gauge network. We note that this was rectified in the Narrabeen presentation made at the CRC. While the application of the established virtual rain gauges needs to be maintained when undertaking the 10-year LTS simulations, during calibration the use of Theissen polygons developed with all permanent and temporary rain gauges is recommended.

During the Audit it was noted that the majority of the modelling associated guides and documents had not been reviewed for many years. With the major process changes, modelling platform etc that have occurred over recent years it is considered vital that these documents are reviewed, updated or replaced to ensure that these guides reflect the current best practice.

The work that was shown on the development of the "Widget" to enable OACIS to export model files in a MIKE+ format, launch model simulations and process and view results is to be commended as near-term fix until the future modelling platform is operational. While not thoroughly discussed during the CRC we recommend that a detailed comparison be undertaken between the MOUSE and MIKE+ model results, particularly at hydraulically complex areas of the model and at ERSs, to ensure that any differences are well understood with reference to LTS system performance.

4 Consolidated Recommendations

Based upon the range of matters and issues identified and discussed over the two days, the CRC Panel has consolidated the following recommendations for review by SW.

Rec No.	CRC Panel Comments/ Recommendations	Sydney Water's Accepted Improvement Initiatives/ Actions/ Commentary words	
Rec01	All WWCMs need to go through the annual verification process, regardless of how minor the updates and changes have been since the previous year.	Agreed in principle	Sydney Water will assess the resource and time requirements for verifying all WWCMS and determine whether these verifications should be conducted annually or biennially (once every two years).
Rec02	The stormwater component of the ICM program, given these will largely be completely new models, and knowing that stormwater asset data is often limited, will potentially be the critical path and recommend that progress be reviewed regularly. Provisional allowance for additional resourcing for this aspect of the program may be prudent.	Agreed	Sydney Water is building internal capabilities to automate GIS data processes, streamline stormwater catchment modelling procedures, and strengthen modelling resources to tackle complex tasks. In addition, implementing regular peer review processes will help ensure stormwater modelling stays on track and is delivered within the agreed timeframes.
Rec03	The issues identified with the inability of the MOUSE RTC functionality to replicate short term Operator interventions within a longer time series needs to be addressed in the future modelling platform. The MIKE+ platform, which all WWCMs are being migrated to in the near term as a temporary measure, may have the capability to replicate these types of irregular operations. Exploration of the capabilities of MIKE+ RTC is strongly recommended in the near term.	Agreed	The MIKE+ platform supports using external time series data (such as IICATS actual operations) to control MIKE+ RTC. Sydney Water will explore these capabilities and develop a procedure for incorporating them into model calibration and validation processes.
Rec04	Recommend that further consideration be given to the inclusion of continuous water quality monitoring to better understand sewage water quality and associated variability for ICM modelling.	Agreed in principle	Sydney Water plans to conduct a post-implementation review (PIR) of the ICM project once all deliverables are completed in late 2027. The review will assess the benefits achieved, capture lessons learned and identify opportunities for future improvements. The PIR will also include water quality monitoring within wastewater networks and evaluate water quality outputs from the ICM modelling.

Rec No.	CRC Panel Comments/ Recommendations	Sydney Water's Accepted Improvement Initiatives/ Actions/ Commentary words	
Rec05	SW to consider a rotation program for less experienced modellers between the EM group and Planning to increase skills and awareness in both groups and potentially increase the resource pool for TMR Reviewers.	Agreed	A working group has been established between Planning (the primary user of models) and Engineering Modelling to foster collaboration, improve processes, set priorities, and share knowledge to strengthen communication between the teams. This forum will also provide opportunities to explore job rotation and/or sharing programs, helping to build skill sets in modelling, planning, and model applications within Planning.
Rec06	For the larger systems such as North Head and Malabar, further refinement of the WWCM catchment boundaries and/or additional or relocation of permanent gauges needs to be considered in the near term to minimise inaccuracies and streamline calibration and verification modelling.	Agreed	The Engineering Modelling team will collaborate with Hydrometric Services to review the required boundary gauges and explore options such as adding or relocating gauges or merging catchment models to eliminate the need for boundary gauges.
Rec07	The majority of the modelling related guides and documents associated with the STS modelling need to be reviewed, updated and/or replaced with documentation that better reflects the current WWCM modelling processes in the near term.	Agreed	The Engineering Modelling team is currently developing new modelling procedures as part of the Integrated Catchment Modelling approach. In addition, Sydney Water will be transitioning to a new modelling platform, which will enable more advanced capabilities and improved efficiency. As part of these changes, the STS modelling-related documents will be reviewed and updated to align with future requirements and best practices.
Rec08	New or updated documentation to include distinction between calibration rain gauges and LTS virtual gauges.	Agreed	See responses to Rec 03 and Rec 07. The updated documentation will clearly distinguish between calibration and LTS run inputs, such as rain gauge data and actual operational data for RTC.
Rec09	Recommend that a rigorous and systematic procedure is developed and documented during model transitions to confirm that the MIKE+ model results compare well with the former MOUSE results, particularly at areas with complex hydraulics or at ERSs.	Agreed	The Engineering Modelling team, in collaboration with ICM project delivery partners, has developed detailed workflow instructions and a peer review checklist for converting models from the MOUSE platform to the MIKE+ platform, as well as for validation processes. Moving forward, the outputs from model conversion and validation will be documented in a comprehensive model build report for each system, ensuring consistency and supporting future enhancements.

Rec No.	CRC Panel Comments/ Recommendations	Sydney Water's Accepted Improvement Initiatives/ Actions/ Commentary words	
			These improvements will help streamline modelling practices, enhance quality assurance, and provide a solid foundation for future projects.