Deep Ocean Outfalls Assessment

30 August 2025

In Compliance with Preliminary Investigation Notice Number SR-4851

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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1. Executive Summary

This report was prepared to satisfy the requirements of EPA preliminary Investigation Notice 1 c) 'Assess deep ocean outfall systems'. The report provides the results of Sydney Water's investigation into whether its three Deepwater Ocean Outfall (DOOF) systems indicate that there has been an accumulation of fats, oils and grease (FOG) being discharged from these systems causing debris balls to form. The report examines flow and pressure changes in the DOOFs around the time of debris ball landings (October 2024 through to January 2025) as well as inspections, operation and monitoring of the DOOFs. The commissioning of the DOOFs at North Head, Bondi and Malabar in the early 1990s brought about an immediate and substantial improvement in beach water quality. The DOOFs have been operating as designed for over 35 years and the presence of debris balls on beaches is a recent phenomenon.

The combined analysis and investigations indicate that the most likely origin of debris balls on Sydney's beaches from the period October 2024 through to January 2025 was the Malabar system - the Mill Stream Emergency Relief Structure (ERS) for the Botany Bay beaches and the Malabar DOOF for the Sydney coastal beaches.

A review of the Malabar Water Resource Recovery Facility (WRRF) and DOOF confirms that the plant and DOOF are compliant with the Environment Protection Licence (EPL) and are operating to their specifications.

Sydney Water's working hypothesis is that a significant amount of FOG has accumulated in the intersection chamber between the DOOF bulkhead stopboards and the ocean outfall tunnel over time. This chamber is an inaccessible dead zone and was not designed to be maintained without initiating an extended cliff face bypass. The hypothesis is that separate sloughing events have led to FOG exiting the DOOF diffusers and landing as debris balls on the beaches.

Further, the hypothesis is that the accumulation of this FOG correlates with a substantial increase in both FOG and volatile organic compounds (VOCs) in the influent coming into the plant. Increases are calculated as 39% for FOG as measured by the EPL parameter oil and grease (O&G) and 125% for VOCs over the past ten years.

A recent database analysis has identified that there could be up to 12,000 retail food businesses operating within the Malabar catchment without the necessary approvals from Sydney Water and that these could be significant contributors to FOG loads.

Investigations into the North Head and Bondi WRRFs and their DOOFs found no evidence of FOG accumulation in these systems.

Sydney Water's proposed next steps are:

- Continue targeted FOG removal in the Malabar DOOF bulkhead area. This will involve the scheduling of regular cleans every year (e.g. 24 cleans over 3 years) during low tide/flow conditions.
- Continue to investigate formation mechanisms for debris balls in the Malabar system.
- Initiate a proactive trade waste program for food businesses, review how aviation fuel is potentially entering the system, partner with Councils and the NSW EPA on FOGO mandates and waste oil collection programs and continue public education campaigns like "Save Our Sinks" to reduce household FOG contributions.
- Complete three in progress business critical projects for the Malabar PSTs to improve their reliability and availability by December 2028.
- Complete the Georges River plant upgrades under the Malabar System Investment Program (MSIP) by 2029 to take 10% load off the Malabar system.
- Review the long-term investment plan for the Malabar System to address debris ball risk and O&G compliance obligations. This would include assessing options such as removing additional flows

upstream of Malabar WRRF or removal of additional O&G at Malabar WRRF. Strategic options will be assessed considering other drivers, including growth, data centre water demands, the opportunity for PRW and future regulatory requirements.

2. Previous reports under SR 4851

This section of the report reviews the investigations covered by previous reports delivered to the NSW EPA under this Preliminary Investigation Notice and their outcomes.

Report 1 - Preliminary Investigation Notice SR-4851 Direction 1) a) '*Oceanographic modelling'*.

*"Sydney Water must provide a report from an appropriately qualified and experienced independent specialist in oceanographic modelling to use appropriate modelling techniques to model the physical movement and dispersion of the debris balls based upon wind driven ocean surface currents around the times that debris balls were detected on beaches (between October 2024 and January 2025) to determine potential origin (discharge) points. This assessment should consider Sydney Water's three deepwater ocean outfall sewer systems (North Head (Northern Suburbs), Bondi, and Malabar (South-Western Suburbs) as a likely source of the debris balls washed up on NSW beaches. Sydney Water must prepare a report detailing the conduct and results of this investigation and submit it to the EPA in writing by **30 May 2025**."*

The report provided to the NSW EPA was: The Origin of Debris Balls on Sydney and NSW South Coast Beaches Oceanographic Modelling (Tate & Li, Oceanographic Modelling: The Origin of Debris Balls on Sydney and NSW South Coast Beaches, 2025)

The oceanographic modelling investigated the potential origins of the debris balls which landed on Sydney's beaches and other beaches in NSW outside of Sydney between October 2024 and January 2025. At the time of this study, analytical testing had concluded that the debris balls were of wastewater origin and had established physico chemical characteristics of the debris balls (e.g. density) which contributed to the modelling.

The oceanographic modelling concluded that there was no single origin of the debris balls on all beaches between October 2024 and January 2025. The modelling suggested there were ten or perhaps more discharge events that resulted in the landings. Based on reported landing dates the oceanographic modelling report estimated both a potential origin and time of discharge for the landings. All three DOOFs were considered potential origin points for the October 2024 landings. Malabar DOOF was noted as the potential source for the January 2025 landings on Eastern suburbs beaches and North Head DOOF as the potential source for January 20025 landings on the Northern beaches. The modelling did not identify any of the three DOOF plants in landings outside of Sydney beaches or the landings in Botany Bay beaches.

The oceanographic modelling suggested one theory as to why this might be occurring – that the wastewater system had been "primed" by multiple wet weather events and then one of these triggered a discharge of higher loads of FOG. Investigations in the Assess Sewerage Networks report and this report indicate that wet weather clearly has a role in dislodging accumulated FOG from the sewers and releasing it via the Mill Stream ERS or onto the inlet screens at Malabar WRRF.

Report 2 - Preliminary Investigation Notice SR-4851 Direction 1) b) '*Results from laboratory analysis of WRRF, network and debris ball samples'*.

"Sydney Water must provide the results of a sampling and analysis program focussed on sampling accumulations of fats, oil and grease from wastewater streams of the three deepwater ocean outfall sewer systems (North Head (Northern Suburbs), Bondi and Malabar (South-Western Suburbs)) to enable comparison with solid matrix measurements from debris balls collected at Coogee Beach, Sydney's Northern Beaches and from beaches within Botany Bay. The following pollutants: total petroleum hydrocarbons (TPHs, fractionated), oil and grease, faecal bacterial indicators (e. coli, faecal coliforms), human faecal-associated microbial source tracking marker genes (Bacteroides HF183, CrAssphage CPQ_056, pepper mild mottle virus), nutrients and metals are to be assessed considering the potential age of material obtained. The reference parameter of

moisture content and melting point of solids (for solid samples) must also be noted in the analysis report. The sampling and analysis program must include these listed pollutants and reference parameter but need not necessarily be limited to them. The wastewater streams sampled must include but need not be limited to sedimentation tanks (bottom and top layers), fatty deposits on screens or pre-screens, and from the final discharge point immediately before discharge "behind the bulkhead sampling" at the deepwater ocean outfall plants (where safe and practicable).

Sydney Water must prepare a report detailing the conduct, sampling details and analysis of the results of this investigation, including copies of sampling documentation and laboratory analysis reports, and submit it to the EPA in writing by 13 June 2025."

The report provided to the NSW EPA was: Results from laboratory analysis of WRRF, network and debris ball samples (Besley C. , 2025)

While the oceanographic modelling was underway, Sydney Water was conducting its own physical, chemical and microbiological testing of debris balls that had been collected. Sydney Water prepared a report on its analysis and conclusions which it provided to the NSW EPA under Direction 1 b). Sydney Water's report on its laboratory analysis concluded that the debris balls were of a land-based sewerage system and not from marine sources. The report confirmed that the debris balls were positively buoyant and able to rise to surface waters if released from depth, such that a release from the DOOF diffusers is plausible.

Furthermore, the report identified the C10-C14 range of total petroleum hydrocarbons and naphthalene in debris balls. These hydrocarbons provided a "chemical signature" for the debris balls assisting in the source identification. This hydrocarbon range is typical of aviation jet fuels (e.g. kerosene) and was found in statistically similar elevated concentrations in debris ball samples from Mill Stream ERS in the Southwestern and Southern Ocean Outfall System (SWSOOS), Malabar WRRF and the landings on coastal beaches in 2024 and the northern beaches in 2025. Given that the SWSOOS transverses Sydney Airport, it is likely that stormwater runoff from the airport is infiltrating into the SWSOOS. This marker implicates the SWSOOS as the origin of debris balls, from the Mill Stream ERS for the Botany Bay landings or the Malabar DOOF for the landings on Sydney's eastern beaches in October 2024 and Sydney's eastern and northern beaches in January 2025.

Report 3 - Preliminary Investigation Notice SR-4851 Direction 1) d) '*Assess Sewerage Networks*.

"Sydney Water must provide the results of an investigation into the potential for sewerage network assets such as pumping stations and Emergency Relief Structures (ERS) in Sydney Water's three ocean outfall sewer systems (North Head, Bondi, and Malabar), to potentially release fats, oils and grease into the aquatic environment.

Sydney Water must prepare a report on the extent, conduct and results of this assessment and submit it to the EPA in writing by 30 June 2025".

The report provided to the NSW EPA was: Sewerage Networks Assessment (Crawford, Gardner, & McCulloch, 2025).

The Sewerage Networks Assessment identified FOG accumulation and deposition in sewer mains. The report identified sources of FOG entering the network and how it is transported to the treatment plant. The report identified wet weather flows as a possible cause for scouring of FOG from above the free flow line in sewers and its subsequent dispersion through Emergency Relief Structures (ERSs) or transfer to the inlet works of WRRFs.

The Sewerage Networks Assessment showed FOG and debris reaching the inlet works of Malabar as well as on Botany Bay beaches following activation of the Mill Stream ERS in certain wet weather events. The report notes that the material found on Foreshore Beach following the Mill Stream ERS activation in wet weather was of a different morphology than the debris balls collected from the coastal beach landings. This notwithstanding, as noted in the Laboratory Analysis report and the oceanographic modelling report, there is a common chemical marker, and the different morphology is consistent with debris balls being more rounded and smoothed from wave action in the ocean.

In summary across the first three reports:

- The oceanographic investigation identified the possible sources of debris balls as the Mill Stream ERS for Botany Bay beaches and the DOOFs for the coastal beaches.
- The Laboratory Analysis of debris balls sampled from Networks, WRRFs and beach landings identified chemical markers particular to the Malabar system downstream of Sydney Airport, not to the North Head or Bondi DOOF systems.
- The Sewerage Networks Assessment identified that sewer debris is found on Foreshore Beach following the activation of the Mill Stream ERS and is also reaching the inlet of Malabar WRRF. The assessment also noted that dislodgement and discharge of FOG has only been noted for the Mill Stream ERS.

Considered together, these investigations are highlighting the Malabar system as the most probable cause of debris ball landings between October 2024 and January 2025. The Sewerage Networks Assessment strongly correlates sewer debris found on Foreshore Beach with activation of the Mill Stream ERS. The subsequent sections of this report will therefore drill down into the performance of the Malabar system including WRRF and DOOF performance.

Report 4 - Preliminary Investigation Notice SR-4851 and is provided to address the requirements of Direction 1) c) '*Assess deep ocean outfall systems*.

*"Sydney Water must provide the results of an investigation into whether its three deepwater ocean outfall sewage treatment systems (North Head (Northern Suburbs), Bondi and Malabar (South-Western Suburbs) indicate that accumulation of fats, oils and grease are being discharged from those systems into the ocean, causing debris balls to form. Sydney Water must undertake the following assessments, however the assessments undertaken need not be limited to these: i) examine pressure changes and abnormalities at the plants before, during and after the period where debris balls washed up on beaches (October 2024 to January 2025) and prepare a report documenting this process and the outcomes of the assessment , and ii) inspect the deep ocean outfall diffuser outlets for their operation and asset condition (using a remotely operated vehicle or similar). Prepare a report of the deepwater ocean outfall diffuser inspections for the EPA. This report must include any video or photographic footage taken during the inspections. The measure of fats, oils or grease that are exiting the diffusers will be the licensed discharge point of the plant at the entry to the deepwater ocean outfalls. Sydney Water must prepare a report detailing the conduct and results of these two investigations and submit it to the EPA in writing by **30 August 2025**."*

This report details the investigations conducted under Direction 1 c). The report firstly outlines key information about the Malabar system, the WRRF and the DOOF. The report presents the findings of the review of Malabar WRRF and DOOF performance then summarises the outcomes of the reports on the operation and condition assessment of the DOOF. The report goes on to assess flow and pressure changes or abnormalities around the time of the debris ball landings, guided by the oceanographic modelling. The report proposes a plausible hypothesis for the immediate causes of debris ball landings in October 2024 and January 2025 from the Malabar DOOF before presenting Sydney Water's findings on FOG in the Malabar system. The report ends with conclusions and next steps.

3. Context – Malabar Deepwater Ocean Outfall System

Malabar WRRF receives and treats flows from the SWSOOS. The SWSOOS starts in Campbelltown and Appin to the south and Smithfield to the west, coming down through Liverpool and Fairfield and across to Malabar north of the Georges River and Botany Bay. Two trunk carriers convey wastewater under the Sydney Airport across to Malabar. The Malabar catchment is the largest of the three DOOF catchments with approximately 787,000 customers and an equivalent population more than 1.8 million. Malabar currently treats about 36% of Sydney's wastewater.

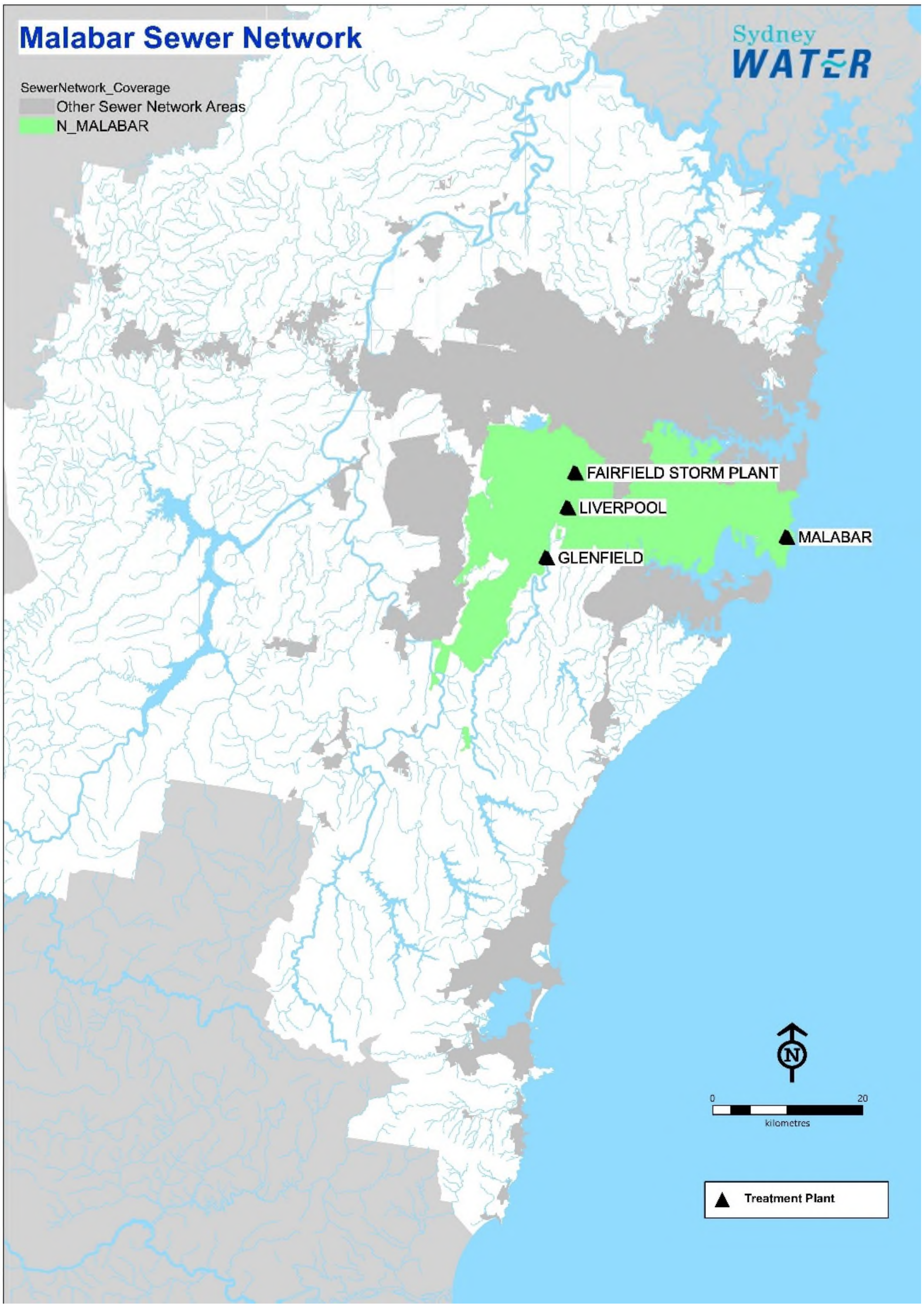

Figure 1: Sydney's wastewater system network showing the Malabar system in green

Malabar is a high-rate primary treatment plant. The treatment train is essentially coarse screenings, fine screenings and grit removal followed by primary sedimentation and discharge via the DOOF. Malabar requires pumping between the aerated grit tanks and PSTs to lift the flow and from there, effluent gravitates to the DOOF. The plant has solids treatment for the primary sludge including digestion, dewatering and cogeneration which produces electricity utilised in the plant with some export capacity. Malabar also exports gas to the grid as biomethane. Malabar treats air that has come from the process and ventilated areas of the plant through odour scrubbers as well as internal recycled water streams and other ancillary equipment. The plant produces biosolids which are 100% beneficially reused. Malabar operates under EPL 372. The Process Flow Diagram (PFD) for Malabar WRRF is shown in Figure 2 below.

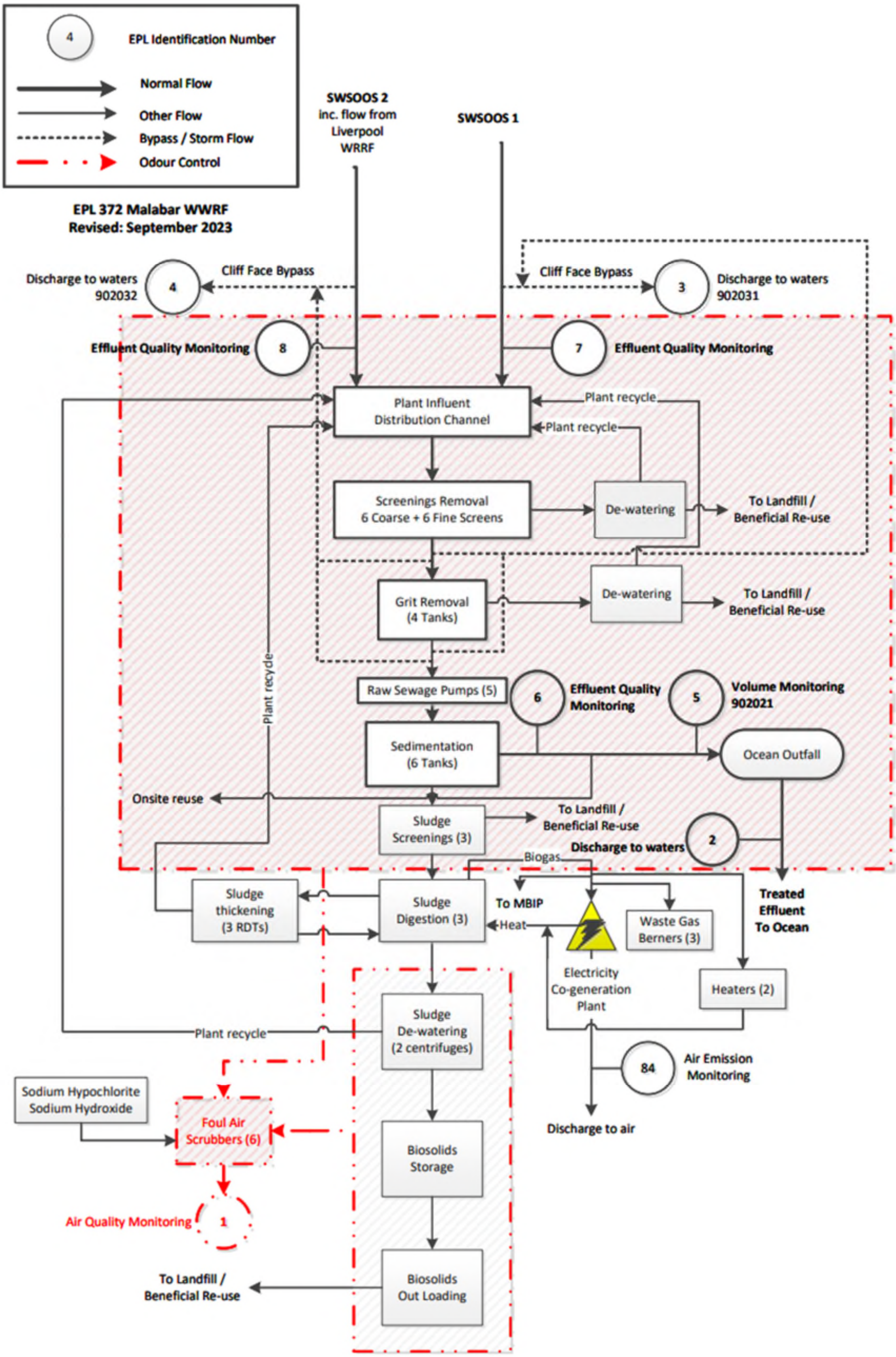

Figure 2: Malabar Process flow diagram

Extensive parts of the treatment plant are constructed underground. Prior to construction of the DOOF, Malabar discharged to its near shore, approximately 7 m below sea level.

The DOOFs were constructed and commissioned in the late 1980s and early 1990s and Malabar was the first DOOF to come online in September 1990. Upon commissioning, the beneficial improvement of the DOOFs on beach and ocean waters was immediate and substantial. The DOOFs have operated continuously with no major interruptions and no asset failures for 35 years.

The DOOF structures are of a similar design but with some differences for each plant based on hydraulics, existing plant structures and ultimate design capacity. All DOOFs have tapered tunnels to maintain self-cleansing velocities.

Some key information regarding the Malabar DOOF is presented below in Table 1.

Table 1: Malabar DOOF key data

Design	Malabar
Ultimate Hydraulic Capacity (ML/d) at pumped flow	2,250
Current Average Dry Weather Flow (ADWF) (ML/d)	501
Current Peak Wet Weather Flow (PWWF) (ML/d)	1,029
Minimum flow to prevent seawater ingress (ML/d)	200
Minimum flow to purge seawater ingress (for 45 min) (ML/d)	685
Tunnel internal diameter (m)	3.48
Riser zone distance to shore (approx.) (km)	2.28
Length of diffuser section (m)	720
Minimum cover to seabed (m)	45
Maximum water depth over diffusers (m)	80
Number of risers	28
Number of ports per riser (noting 1–4 ports capped for current flows depending on location)	8

The following figures provide schematic representations of the DOOF structures and along with Table 1 provide a sense of the size of the DOOF structures and the challenges for maintenance.

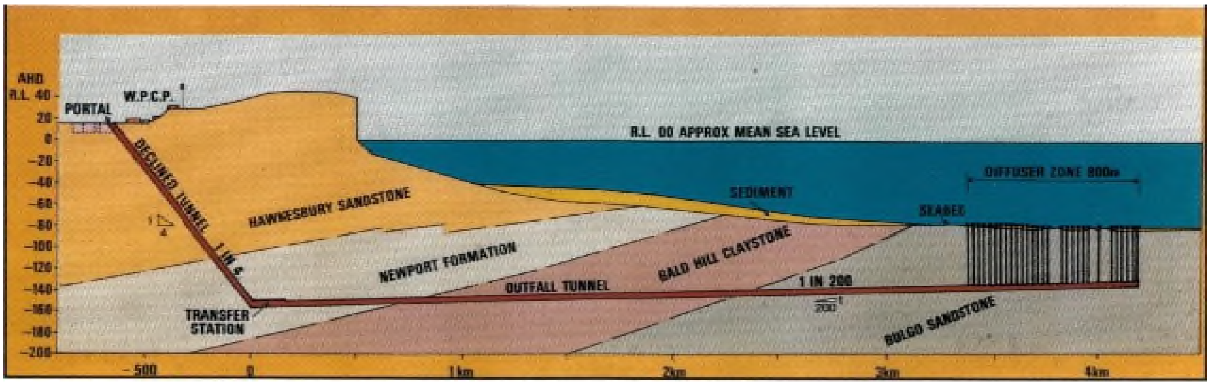

Figure 3: Schematic of DOOF structure

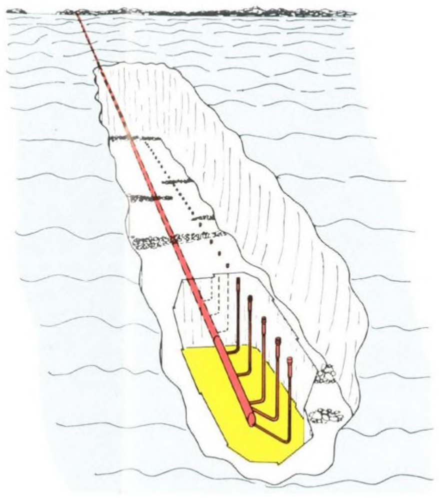

Figure 4: Schematic of the riser structure

The measures of DOOF condition and performance are:

- the hydraulic grade line (HGL)
- plume dilution
- plume surfacing
- diffuser nozzle (ports) availability
- asset condition assessment of civil structures, bulkhead, mechanical and electrical structures, sacrificial anodes and similar.

The HGL is measured in real time and the condition and availability of the risers and their open nozzles or ports has been assessed every by remotely operated vehicle (ROV) every 6 months across the life of the DOOF.

There is an oceanographic reference station (ORS) approximately 3km off Bondi which provides monthly data downloads for the assessment of plume dilution and surfacing.

The design intent of the ocean outfalls was to mitigate the impact of near shore discharge. They do this by achieving dilution of effluent into the dominant East Australian Current approximately 1.5 to 3 km off the coast from deep ocean diffusers. Effective dilution enables organic matter to be more easily broken down as the plumes from the diffusers are rapidly dispersed under most oceanographic conditions. The DOOFs have a 100-year design life for civil assets. They have been designed to maximise reliability by removing mechanical elements from the DOOF itself. The maintenance approach in the DOOF design is to:

- Monitor condition of the DOOF via performance through real time hydraulic monitoring, ongoing assessment of performance using the oceanographic reference station and through condition monitoring of the outlet structures by ROV.
- Monitor the DOOF assets around the bulkhead door by physical inspection and anode testing.
- For large maintenance activities and internal inspections of the DOOF assets, take the DOOF offline, divert flows to cliff face discharge, conduct inspections and maintenance activities as required and recommission the DOOF. This process has never been done as diversion to the cliff face is no longer considered an acceptable approach as it would lead to the likely closure of Sydney's beaches for months.

Since the DOOFs came online, Sydney Water has been assessing the long-term impact on the marine environment. These environmental assessments used oceanographic modelling to consider particle settling, dispersion and distribution of discharged wastewater as well as potential impact on bathing water quality. The assessments also considered impacts on sediment chemistry and benthic infauna. The initial assessments over the first three years of operation of the DOOFs found that the outfalls performed well, mitigating most of the impacts of shoreline discharge (Besley & Birch, 2019). The subsequent studies, reported in five yearly intervals have found no adverse impacts on the marine environment since operation of the DOOFs commenced in 1990 and 1991 (Besley & Birch, 2019), (Tate, Holden, & Tate, 2019), (Manning, Dixon, Birch, & Besley, 2019), (Besley & Birch, Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): Influence of deepwater ocean outfalls on shelf sediment chemistry, 2019), (Besley & Birch, Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): Influence of deepwater ocean outfalls on shelf benthic infauna, 2019), (Sydney Water, 2020). These conclusions are consistent with observations contained in various reports of the six-monthly ROV monitoring of the DOOF assets (Fitzhenry, Sydeny Water Deep Ocean Outfalls Inspections Diffusers and Pieplines Report, July 2025) (Fitzhenry, Sydney Water Deep Ocean Outfalls Inspections Diffusers and Pipelines Inspection, 2024).

The Malabar DOOF can be opened at the bulkhead door for inspection and assessment of the assets in this part of the DOOF. The bulkhead doors allow for access to the DOOFs. For Malabar, the bulkhead door can be under the water level depending on tide heights and flows.

Maintaining the structures behind the bulkhead door requires work on hydraulically live assets under confined space, hazardous gas conditions with limited time windows. Careful coordination with Network operations is required. The assets were not designed to enable maintenance and cleaning tasks of the DOOF without taking the DOOF offline. Opening and entering the bulkhead area of the DOOFs is a very high safety risk task requiring tight controls and detailed planning.

4. Malabar WRRF and DOOF Performance

This section of the report presents the outcomes of Sydney Water's review of the Malabar WRRF and DOOF performance. A review of WRRF EPA compliance confirms that the effluent Oil and Grease (O&G) and Total Suspended Solids (TSS) are fully compliant with 50%ile and 90%ile oil and grease and total suspended solids EPL Licence discharge limits over the last 4 years. Please see Figure 5 and Figure 6.

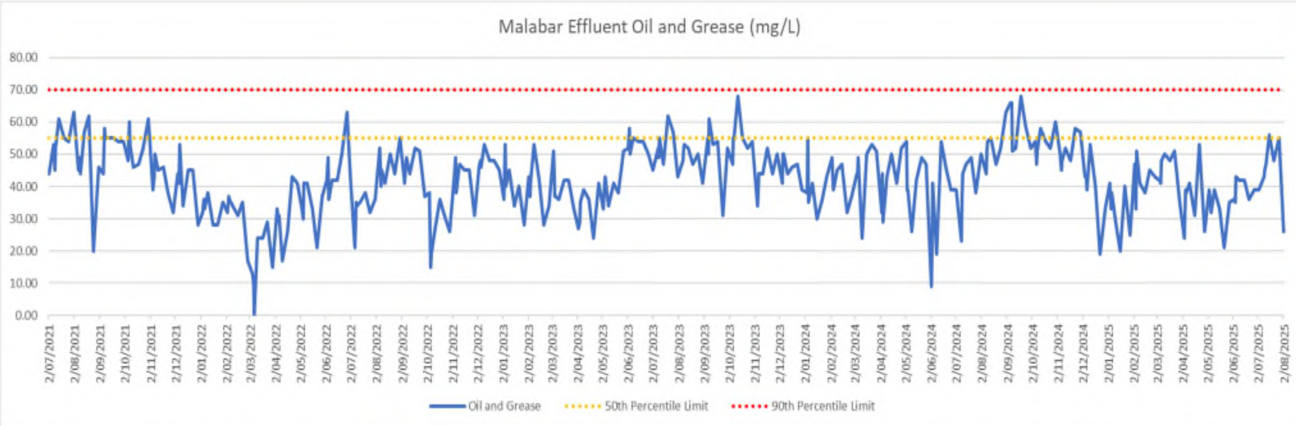

Figure 5: Malabar Effluent O&G compliance

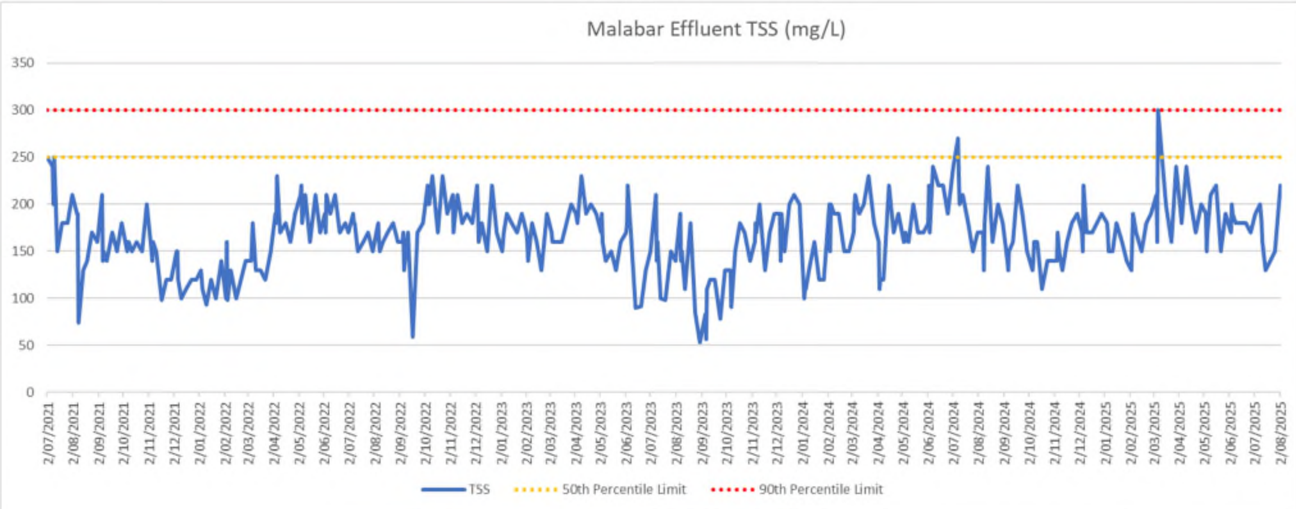

Figure 6: Malabar Effluent TSS compliance

The EPL for Malabar requires monitoring of oil and grease and the EPA direction SR-4851 is written in terms of the licence parameter; O&G. FOG collectively refers to all fats or oils or similar products disposed of in wastewater networks. The terms FOG and O&G are used interchangeably throughout this report, noting that the source of the O&G at the plant is the FOG from the source. The licence parameter used to quantify FOG at the influent and effluent discharge points of the Malabar WRRF is O&G.

A review of EPA monitoring requirements for the Deepwater Ocean Outfalls confirms that operating characteristics and underwater diffuser inspections are being monitored in line with EPL Licence requirements over the past 4 years.

Table 2: DOOF compliance with EPL

EPL Clause	Requirement	Compliance
M10.7	The licensee must collect the following information on the operating characteristics of the deepwater ocean	✓

EPL Clause	Requirement	Compliance
	outfall as necessary and in a manner approved by the EPA: a) tide height at the end of the outfall; b) head loss through the outfall; c) flow rate over time through the outfall.	
M10.8	The licensee must undertake an underwater inspection of the following components of the outfall as necessary: a) each individual diffuser nozzle, while discharge is occurring; b) external components of the riser and those parts of the diffuser not covered by (a) above; and c) the sacrificial anodes.	✓

All data required under M10.7 was collected and utilised to assess performance. Inspections as required under M10.8 have been completed by ROV every 6 months. Recent reports are provided in Appendix Two.

A review of Deepwater Ocean Outfall diffuser availability confirms an average 93% availability against an EPL licence target of >76% over the past 4 years.

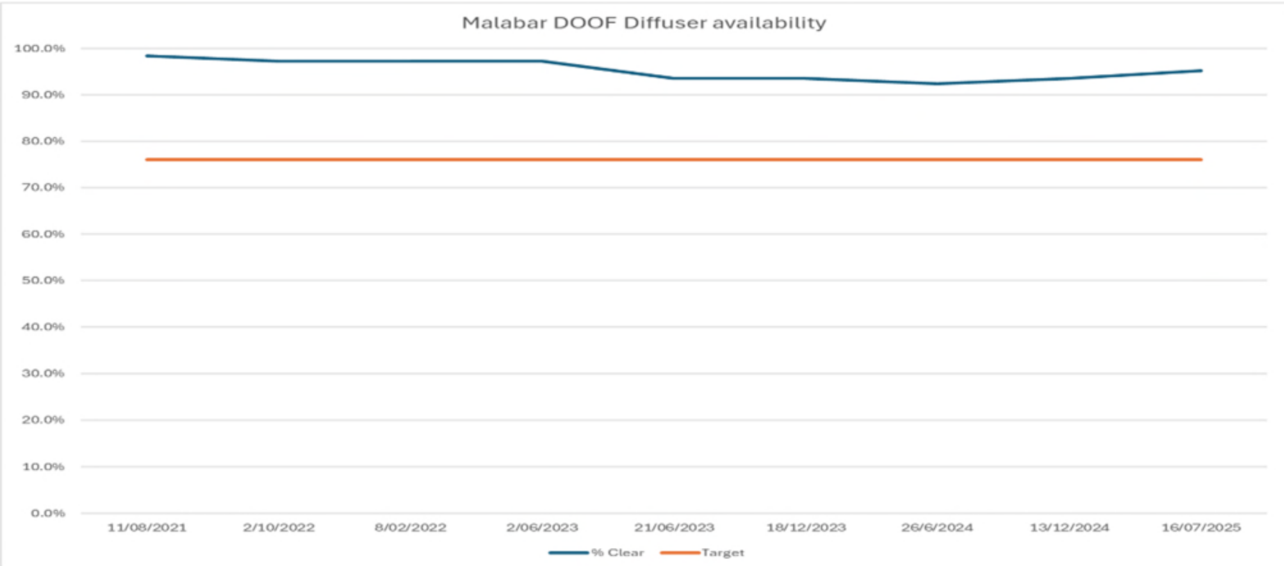

Figure 7: DOOF compliance with diffuser availability

O5.3 of the North Head EPL requires 76% of diffusers to be ‘on-line’. Sydney Water has assumed that this requirement applies to all three DOOF plants. Data here is taken from the 6 monthly ROV surveys.

A review of Deepwater Ocean Outfall performance versus design criteria since 2006, confirms that plume dilution has outperformed design criteria every year. The plume dilution should exceed the minimum design criterion of 40:1 98% of the time. The following graph, Figure 8, shows the 98%ile plume dilution ratio for the Malabar DOOF.

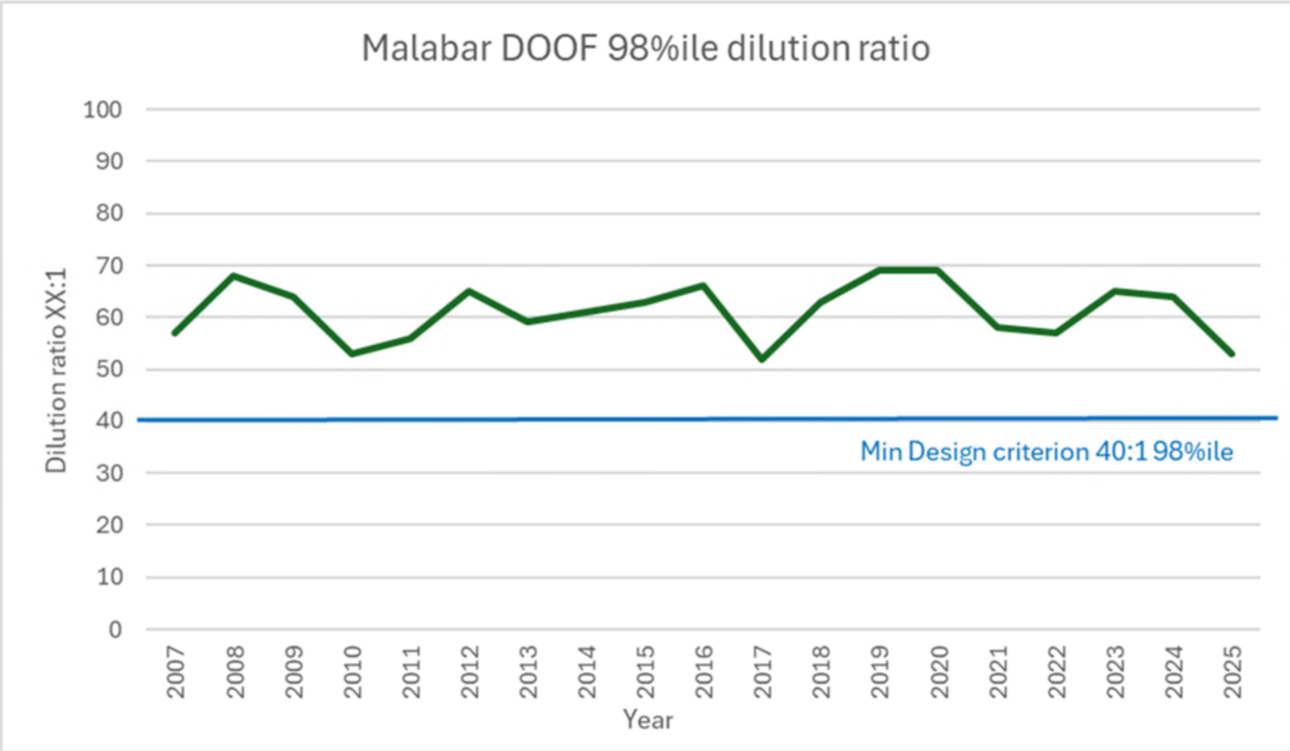

Figure 8: Malabar Plume dilution ratio98%ile

The way to read Figure 8 is, for example, in 2008 the Malabar DOOF achieved a plume dilution ratio of 68:1 98 % of the time, exceeding the minimum design criterion.

A review of Deepwater Ocean Outfall performance versus design criteria since 2006, confirms that submergence, displayed has outperformed design criteria every year. This is the percentage of time in summer that the plume remains submerged (does not surface).

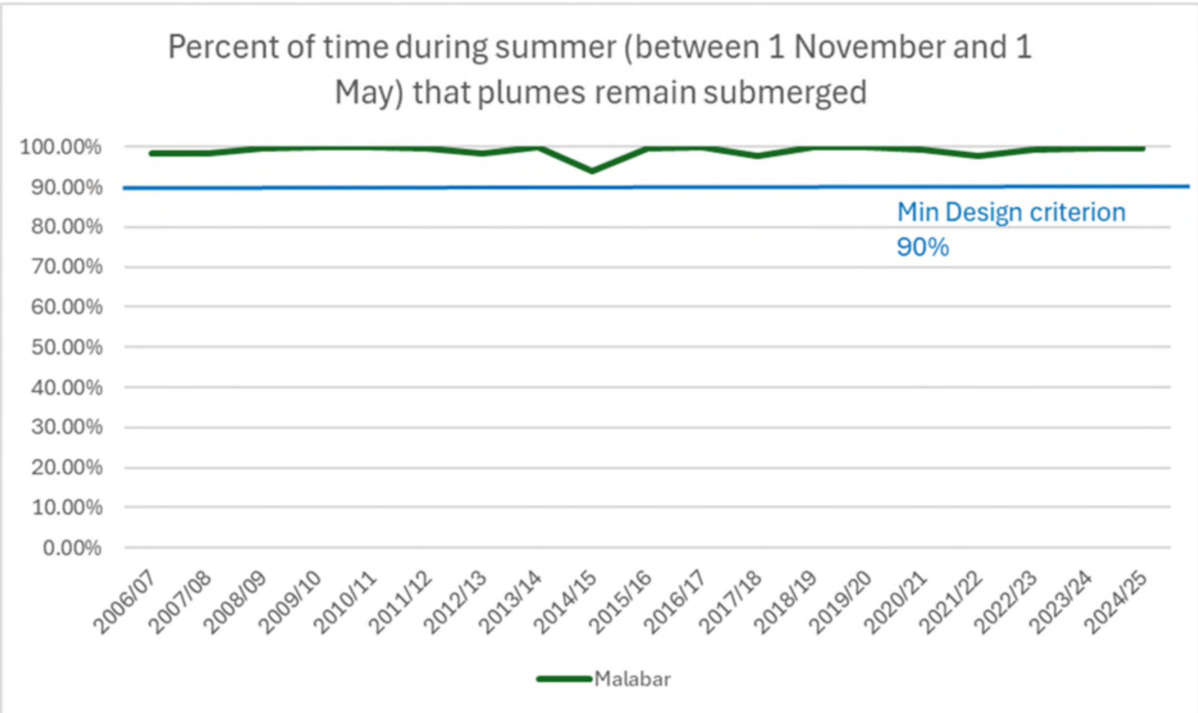

Figure 9: Percentage of time the DOOF plume is submerged in summer

A review of Deepwater Ocean Outfall Operating and Maintenance Guidelines confirms 100% of guideline requirements are being met.

Sydney Water reviews DOOF performance against its Unit Process Guideline (UPG). Table 3 below confirms that the DOOF has been operated and maintained in accordance with the design requirements and guidelines.

Table 3: Operation of the Malabar DOOF against UPG guidelines

UPG requirement	Frequency	Requirement met
Borehole flushing should be carried out by jetter	Not specified	✓
The outfalls were originally designed to be taken offline for inspection at a frequency similar to that of major sewer carriers, with flows discharging through the original cliff-face outfalls while the DOOF was offline. However, … this is now deemed to only be acceptable if no other course of action is available…	Not specified	✓
6-monthly inspections of the diffusers and nozzles are undertaken by a contracted ROV. Still and video pictures are taken of all nozzles and observations made about their condition / performance, with a corresponding report. Also, the report indicates the condition of sacrificial anodes placed around the circumference of each of the risers, the condition of the manhole at the top and makes comment about visible sea life. …	6 monthly	✓
Each riser is fitted with numerous sacrificial anodes and ROV inspection will indicate the need or otherwise for replacement.	6 monthly	✓
Inspection and maintenance of the bulkhead doors and the anodic protection system, as well as cleaning and removal of scum and screenings from behind the bulkhead door.	Intermittent/ Periodic	✓
It is an EPL requirement to monitor the DOOF performance. All three DOOF EPLs have the following monitoring clauses. M10.7 Monitoring of Deepwater Ocean Outfall The licensee must collect the following information on the operating characteristics of the deepwater ocean outfall as necessary and in a manner approved by the EPA: a) tide height at the end of the outfall; b) head loss through the outfall; and c) flow rate over time through the outfall. Note: Deepwater Ocean Outfall monitoring data is analysed in accordance with Condition M5.1 of the licence in the Sewage Treatment System Impact Monitoring Program: Interpretative Report.	Online monitoring and annual reporting	✓
M10.8 The licensee must undertake an underwater inspection of the following components of the outfall as necessary: a) each individual diffuser nozzle, while discharge is occurring; b) external components of the riser and those parts of the diffuser not covered by (a) above; and c) the sacrificial anodes.	6 monthly	✓
O7.1 Appropriate flushing procedures must be used if saltwater intrusion into the deepwater outfall occurs or considered to have occurred	As required	✓
O7.2 The licensee must have at least 76 percent of the diffusers installed on the deepwater ocean outfall online unless the prior written approval of the EPA has been received [Note, while this only appears in the North Head EPL, Sydney Water assumes this applies to all DOOFs.	At all times (inferred)	✓
Flushing or cleaning of borehole sensors (not possible at Bondi) will clear the sensor of any build up and ensure they are reading accurately. … At Malabar the Maintenance can be performed on the sensors as they are accessible without needing to enter the DOOF.	Not specified	✓
The HGL should be within a target range of ± 20% of the design HGL and If this flow isn't achieved during the daily diurnal flow pattern, ponding of the influent sewage may be required to build up enough volume to force purging flowrates	Continuously then as required	✓

Figure 10 shows plant flow overlaid with the minimum flow required to prevent saltwater intrusion (200 ML/d for Malabar) and the flow required for purging saltwater intrusions (685ML/d for Malabar). Note that these are instantaneous flowrates for short durations and are different from the totalised flow for a given 24-hour period. Should the DOOF flow drop below 200 ML/d saltwater ingress is possible and a purging flow is recommended for at least 45 minutes. The Malabar DOOF has not dropped below the minimum flow of 200 ML/d for possible saltwater intrusion and regularly achieves the purging flow of 685 ML/d.

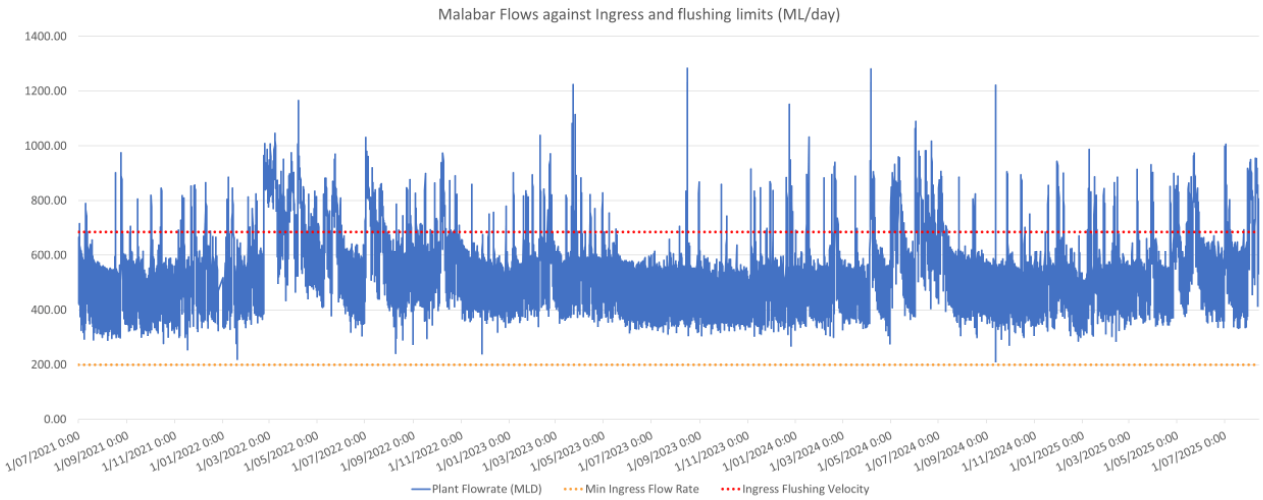

Figure 10: Malabar flows and hydraulic limits

Figure 11 presents Malabar's actual HGL against the upper and lower bounds of the HGL. The HGL curve is the real time hydraulic monitoring of the DOOF. It is calculated using the tide height and DOOF flow and for this reason is a dynamic curve. A high HGL can indicate a restriction in flow and thus blocked diffusers. A low HGL can indicate that there is no back pressure on flow and hence excess flow from damaged risers/ diffusers. HGL trends are viewed in concert with the physical ROV inspections of diffuser condition and other flow and performance data. Malabar's HGL trend is within its limits and, considered with the ROV inspections and other data, shows performance as per design.

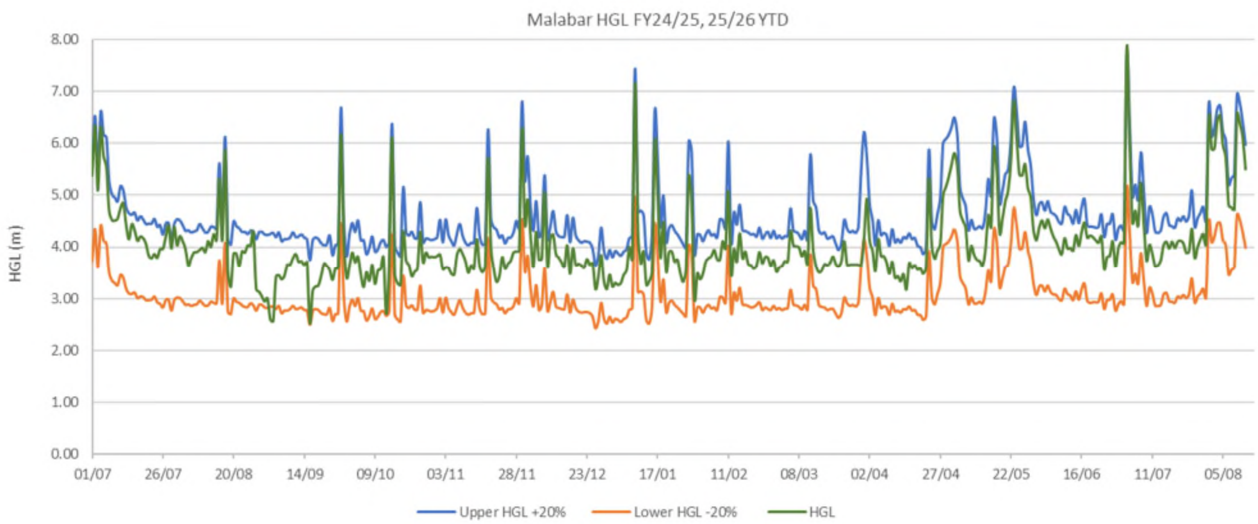

Figure 11: DOOF performance against the HGL criteria

A review of the effectiveness of preventative maintenance (PM) in preventing asset failure across the key liquid stream unit processes at Malabar: Raw Sewage Pumping (RSPs), Screens, Screening Handling, PSTs and grit capture systems, confirms that PM effectiveness exceeded the target of >80% for every stream. Taking a Reliability Centred Maintenance approach and using tools such as Failure Mode Effects and Criticality Analysis a recent maintenance optimisation review led to the updating of job plans, asset data and identification of additional spares to further improve maintenance delivery.

Table 4: Malabar Maintenance Effectiveness

FY 2024		Target > 80%
Site	**System**	**PM Effectiveness**
Malabar	RSPs	100%
	Screens	92%
	Screening Handling	93%
	PSTs	85%
	Grit	92%

In summary, the investigations into plant and DOOF performance show that:

- WRRF EPA compliance confirms that the effluent Oil and Grease and Total Suspended Solids are fully compliant with 50%ile and 90%ile EPL Licence discharge limits.
- EPA monitoring requirements for the DOOF confirms that operating characteristics and underwater diffuser inspections are being monitored in line with EPL Licence requirements.
- Deepwater Ocean Outfall diffuser availability confirms average 93% availability against an EPL licence target of >76%.
- DOOF performance versus design criteria since 2006, confirms that plume dilution and submergence have outperformed design criteria every year.
- Deepwater Ocean Outfall Operating and Maintenance Guidelines confirms 100% of guideline requirements are being met.
- The effectiveness of the preventative maintenance program in preventing asset failure across the key liquid stream unit processes at Malabar, confirms that PM effectiveness exceeded the target of >80%, with an average PM effectiveness of 92% across the streams.

5. DOOF inspections

The EPA requested Sydney Water to "…inspect the deep ocean outfall diffuser outlets for their operation and asset condition (using a remotely operated vehicle or similar) …." Sydney Water has conducted 6 monthly inspections of the DOOF structures since their commissioning in 1990/91. The assets covered in these inspections are the risers, the diffusers and nozzles on the risers. This section of the repot summarises the outcomes of those inspections and reports. The full reports for inspections over the period June 2024 to July 2025 are in Appendix Two and include photographic images. Recent videos have been transmitted separately to this report.

The 6 monthly ROV monitoring over the period from June 2024 to July 2025 indicated that the DOOF assets were in generally good condition and that the DOOFs were all working with some minor works required to clear some diffuser blockages. Figure 7 trends the data from these reports showing the number of available diffusers well exceeds the design minimum required. A small number of blockages in the DOOF diffuser nozzles is common and these are generally cleared using a jetter attached to the ROV. HGL monitoring (Figure 11) shows that the small number of blockages does not affect the performance of the DOOF and as noted earlier in the report, the average diffuser availability over the past 4 years is 93% against the target of >76%.

Occasionally, follow up jetting activities are required to remove a blockage. Over the 35 years of operation very few separate maintenance projects have been required. It should also be noted that there is insufficient volume in a single riser to generate a mass of debris balls consistent with that collected in October 2024 and January 2025 beach landings. Accordingly, even a full blockage of a single riser is highly unlikely to be the cause of a debris ball event in October 2024, nor would any of the maintenance activities.

The reports document asset condition and operation of the diffusers and nozzles. Many of the blockages of the Malabar nozzles are noted as having rags and detritus or plastic "flitches." Current assessment of the two stage screens at Malabar indicates that they are working effectively.

The reports also note surrounding aquatic conditions with minimal deposition of materials and a general healthy population of sea life. Video footage at times reveals fish swimming around the risers and diffusers. The contractor who has performed the ROV monitoring since the commissioning of the DOOFs confirmed that they have never seen evidence of debris balls or other buoyant objects rising in the plumes from the DOOFs over the last 35 years ((Fitzhenry, Pers Comm, 2025).

6. Examining pressure changes and abnormalities at Malabar WRRF

The EPA requested Sydney Water to "…examine pressure changes and abnormalities at the plants before, during and after the period where debris balls washed up on beaches (October 2024 to January 2025)". This section of the report details those investigations at Malabar WRRF.

6.1 Flow and pressure changes

Based on the oceanographic modelling, and assuming that the Malabar DOOF was the origin of the October 15, 2024, landings at Coogee Beach, the release time from the Malabar DOOF would have been ~0800 on 13 October. Around 0130 on the morning of 13 October, Malabar WRRF experienced a very short duration power supply fault, and this caused RSP 1 to stop pumping for approximately 4 minutes from 0128 – 0132 causing flow to drop by 210 ML/d, from 523 ML/d to 313 ML/d. RSP5 then ramped up to 97% speed at the same time to compensate for RSP 1, and the plant experienced a flow increase over 5 minutes back up to 474ML/d which can be seen in Figure 12. In this case a very rapid flow variation from high, down to low with a corresponding drop in outlet channel level, followed by a rapid increase to high flow again.

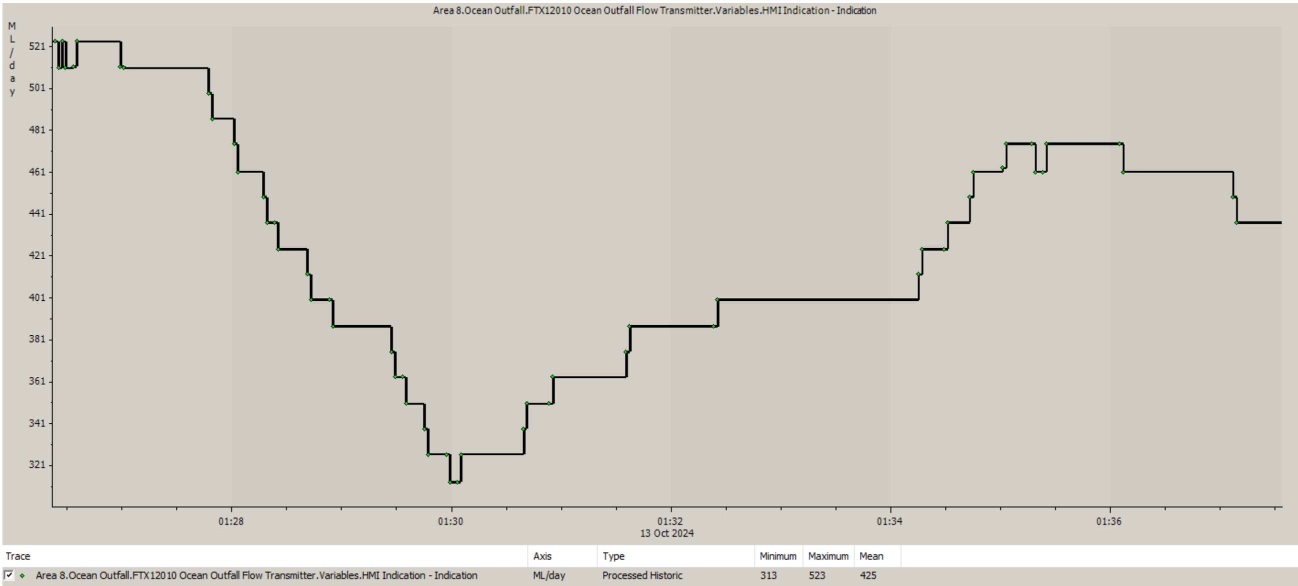

Figure 12: Flow changes in the morning of October 13, 2024, resulting from the power supply fault

HGL is the measure of pressure on the DOOF. It is calculated based on plant flows and tide heights and is constantly varying. The following graph, in Figure 13, shows the HGL of the DOOF at the time of the power supply fault and pumping changes along with plant flow. The HGL represents the pressure change in the DOOF, and it tracks with the plant flow. The HGL is as expected and results from the variation in flow.

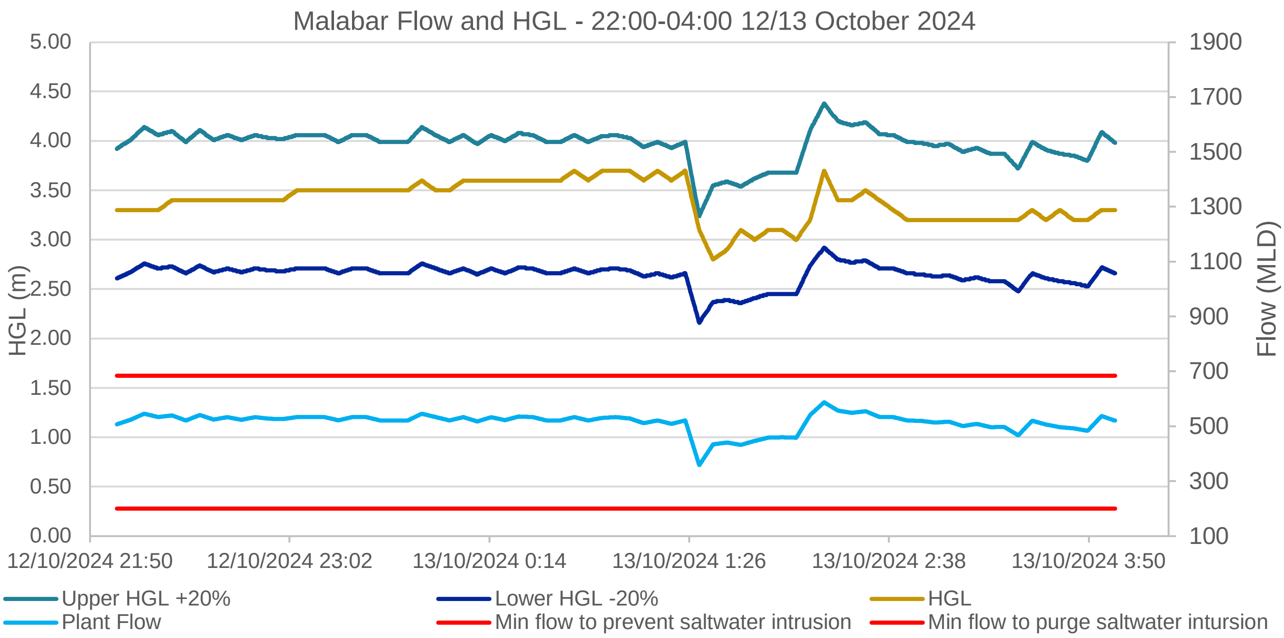

Figure 13: Malabar HGL trend 13/10/2024

On 11 January at 0123 the flow was 659 ML/d and in 4 minutes it had dropped to 498 ML/d. By 0132 the flow had increased up to 720 ML/d. These flow changes were a result of RSP changes. This flow and pressure variation did not align as closely with the modelled release dates and locations from the oceanographic modelling as for the October 2024 landings. Sydney Water discussed these findings with the independent oceanographer and requested remodelling to assess if this was a feasible solution. The findings from the remodelling were that a release from the Malabar DOOF in the morning of 11 January is the likely cause of the landings on the South Malabar and city beaches (Tate P. , Supplementary Information on Debris Balls Observed on Sydney Beaches in January 2025 Oceanographic Modelling, 2025). The report also determined that a release from the Malabar DOOF on this day was a possible source of the debris balls that landed on the northern beaches, although the modelling indicated that an origin from the North Head DOOF was more likely. While acknowledging this conclusion from the modelling:

- Sydney Water's analytical evidence identified the same chemical marker in the debris balls from the northern beaches landings as was found in the Coogee beach landings and Malabar system, matching the signature from the Malabar system, and
- the inspection and cleanout of the North Head bulkhead chamber identified screenings but not accumulated FOG and debris balls (Figure 46).

Assuming that the mechanism for entrainment of FOG and debris balls is the same as hypothesised for the October 13 event, this rapid change in instantaneous flow could also have given rise to the debris ball landings in January 2025.

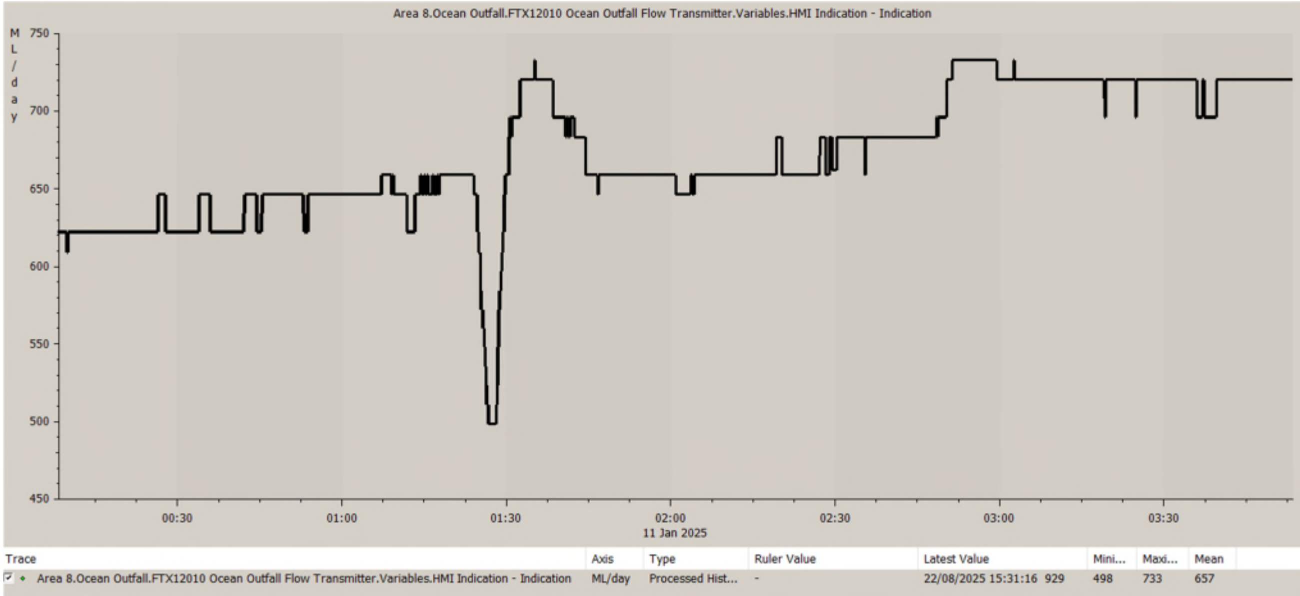

Figure 14: Flow changes on 11th January 2025

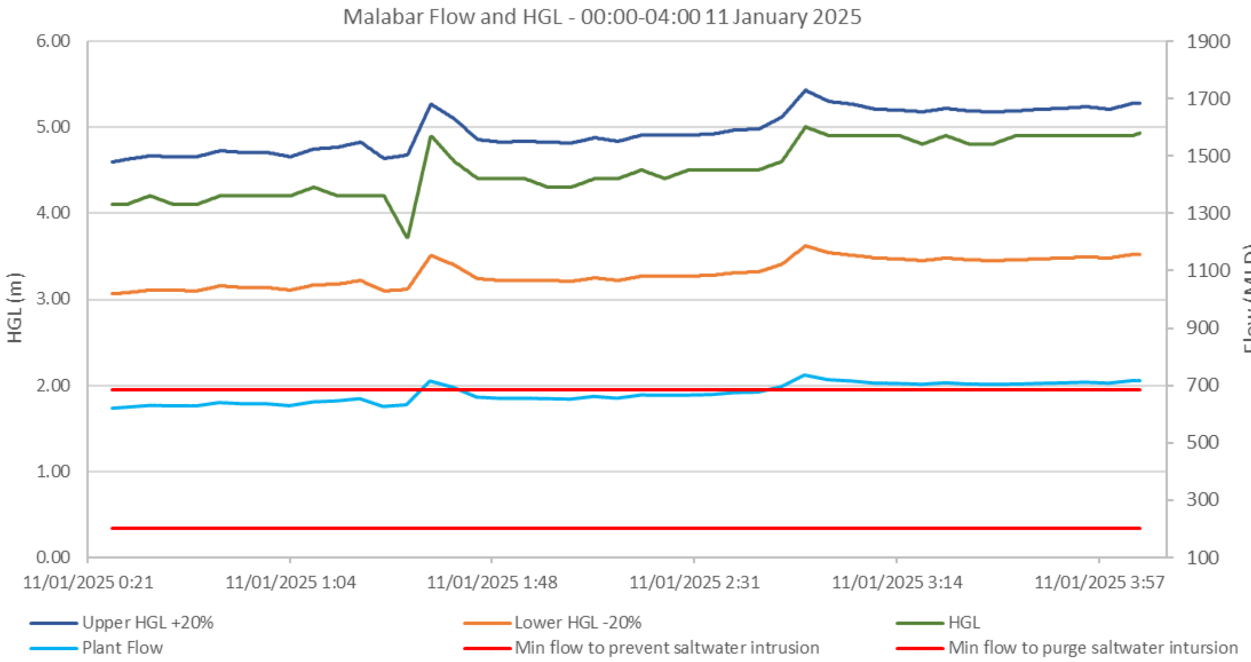

Figure 15: HGL trend 11 January 2025

Figure 15 demonstrates, as for Figure 13, the HGL trend follows the flow trend for the plant. Note that the higher flows on this occasion are due to wet weather.

6.2 DOOF bulkhead inspections

One requirement of managing the DOOF is the maintenance of the DOOF bulkhead assets. Over the life of the DOOF there have been several periodic inspections including in July 2024. Since October 2024, inspection frequency has increased. Inspections must be timed with low tide and low flow. This can be difficult to schedule during wet periods.

In July 2024, the Production Team opened the inspection hatch on the bulkhead door at Malabar WRRF to conduct a visual inspection. At the time nothing significant was noted. There was some build-up of solid material between the stop boards and bulkhead door. This was not deemed unusual. Assets, such as the sacrificial anodes, were in an acceptable condition.

In March 2025, another regular inspection behind the bulkhead door identified a significant number of debris balls. The bulkhead was cleaned out up to the stop boards. During the inspection, a large amount of floating FOG was observed in the bulkhead area and beyond the stopboards. The production team successfully trialled a new operation involving ramping of the raw sewage pumps to increase flow and float the FOG over the stop boards into the bulkhead area from which it was removed. Assets in the bulkhead area were in good condition.

As part of ongoing investigations, the production team increased the frequency of DOOF bulkhead inspections. An inspection of the bulkhead in June 2025 noted some screenings material but no FOG build up. An inspection the following month revealed a build-up of mostly sludge and screenings with some small (~5mm) diameter white debris balls.

It is not possible to safely conduct inspections and cleaning of the channels between the stopboards and the intersection chamber of the DOOF. The DOOFs were not designed for maintenance and cleaning of the bulkhead beyond the immediate area behind the bulkhead door. There is no way of safely accessing and cleaning the channels from the outlet of the PST launders through to the conduit intersection chamber and the bulkhead door stopboards. Maintenance and cleaning by physical entry between the bulkhead door and the stopboards in the bulkhead chamber are extremely high-risk activities that can only be performed under strictly controlled conditions.

The traditional approach of cleaning behind the bulkhead door is to use vacuum trucks removing material via the ventilation shaft. Recent innovations to this method include installation of an access portal in the bulkhead door for inspections and debris removal. For more difficult to remove material and for maintenance activities entry is still required through the bulkhead door.

7. FOG accumulation potential and entrainment mechanism at the head of the DOOF

This section of the report draws together the previous sections into a plausible hypothesis for the debris ball landings.

In 2001 the designer of the DOOFs assessed the possibility of an individual riser or individual nozzles in the North Head DOOF being blocked by FOG. The investigation posed a hypothesis and several questions. The main concern was to prevent a full blockage of the DOOF and the need to take it offline for maintenance whilst diverting effluent to the cliff-face. The review also considered the potential for small amounts of FOG to accumulate and be discharged through the DOOF. While assessed for North Head and from the perspective of asset protection, the principles apply to the Malabar DOOF. Figures 16 and 17 and their text are specific to the North Head DOOF. While the Malabar DOOF dimensions and arrangement are slightly different from those shown, the logic is equally applicable. As noted in Appendix Two, recent inspections across the plant and the DOOF at North Head found no evidence of FOG and debris ball accumulation.

The following figures graphically display the two stages of the hypothesis:

- Build up and consolidation of FOG in the DOOF behind the bulkhead and upstream of the intersection point of the DOOF decline tunnel and the plant outlet channel
- Detachment of some of the accumulated material under transient flow conditions into the DOOF tunnel and risers

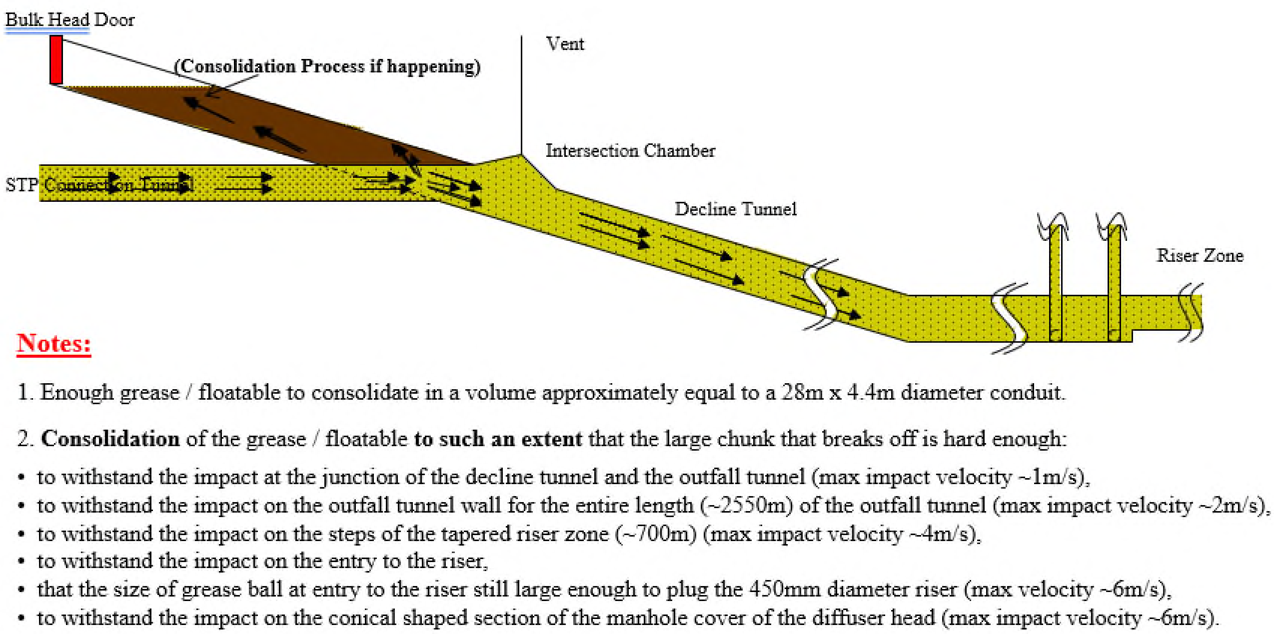

Figure 16: Hypothesised accumulation and consolidation phase (North Head design)

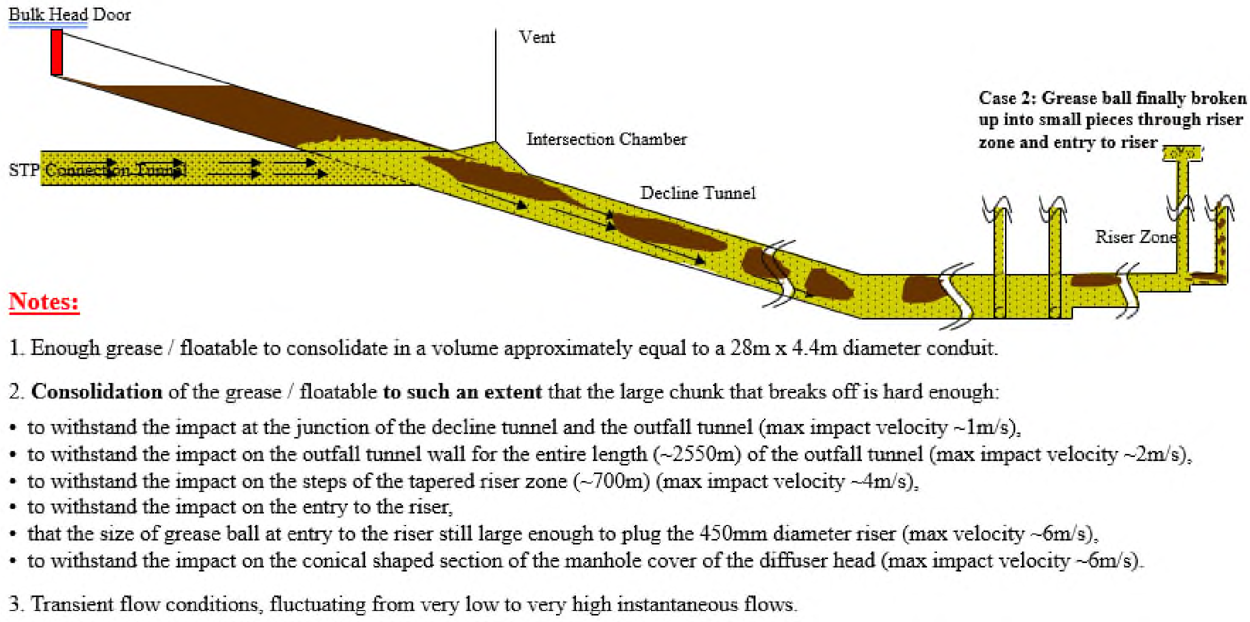

Figure 17: Hypothesised detachment and passing through the DOOF (North Head design)

The current investigation applied the principles from this earlier work, in particular, the potential for transient flow conditions, fluctuating from very low to very high instantaneous flows, drawing accumulated FOG into the Malabar DOOF.

Figure 18 is a schematic of the outlet channel, the bulkhead entry and channel down to the intersection chamber before the Decline Tunnel to the Malabar DOOF.

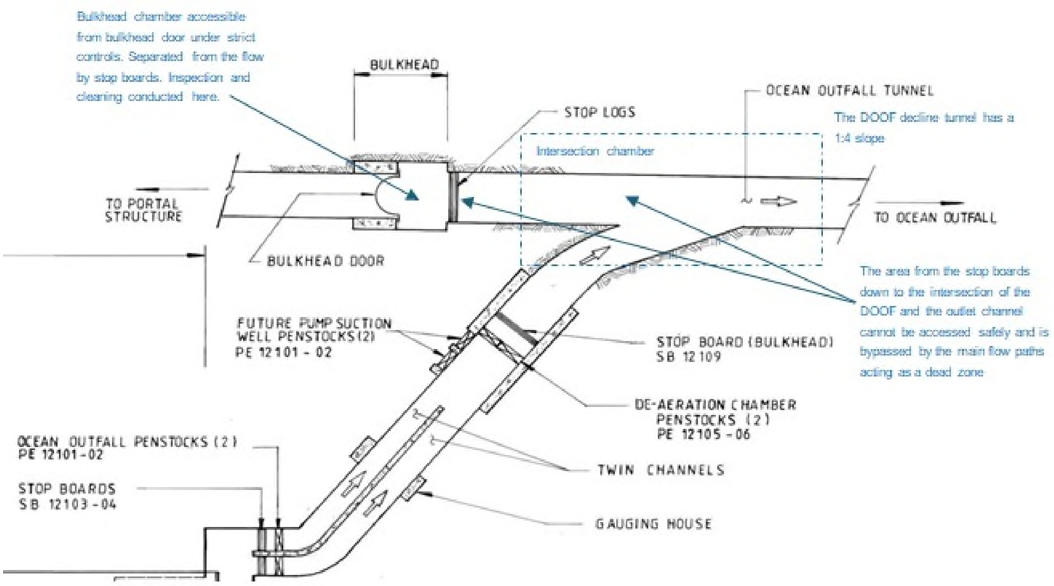

Figure 18: The bulkhead door, bulkhead chamber and intersection chamber of the Malabar DOOF with the plant outlet channel

Inspection and cleaning of the Malabar bulkhead area in April 2025 removed ~53 tonnes of accumulated FOG, including debris balls. This material had not consolidated into a large single mass such as that seen in sewer networks and commonly referred to as “fatbergs” but rather could be broken up. Knowing that an accumulation of FOG in this area is possible, the investigation identified a hypothesis that explains the debris ball landings with operation of the Malabar DOOF. The hypothesis, which is supported by the evidence available, is that:

- FOG had accumulated on the landward side of the Intersection Chamber and that this build up had been captured in a quiescent zone such as the area from the channel intersection point back up to the bulkhead door.
- That the sudden drop in flow followed by the sudden increase in flow drew this material into the main flow path and pushed it through the DOOF exiting from one or more risers, diffusers and nozzles.
- The most likely scenario is that already formed debris balls caught up in the mass of FOG in the area around the intersection chamber was expelled through the DOOF. A less likely scenario is that large amounts of congealed FOG was pushed through individual nozzles (acting like extruders) and formed into ball type shapes which were then further smoothed by the action of the ocean over the following 24 – 48 hours.
  - The assessment of likelihood is based on the relatively short duration the debris balls likely spent in the ocean and the time required to smooth them as well as the data that well-formed debris balls have been removed from the DOOF bulkhead.
- The volume of the channels between the intersection of the outlet channel and the DOOF decline tunnel and the bulkhead door stopboards is ~300 m^3, large enough to contain an accumulation of FOG, noting that much of this is occupied by water.
- Based on the volume collected from the October 2024 and January 2025 landings, the density of the grease ball samples and operational experience from cleaning, this area is large enough to hold a sufficient quantity of FOG that could generate the debris ball landings in October 2024 and January 2025.

While this hypothesis explains the proximate cause of release of debris balls or of FOG that has formed debris balls, the root cause of the build-up of FOG downstream of the PSTs is the 39% increase in FOG entering the Malabar system over the last 10 years. This is discussed further in Section 8 of this report, noting that the treatment process is currently optimised within the capability of the available assets.

Figure 19: Bin of FOG collected from the Malabar screens during wet weather

Figure 19 shows the typical material that has detached from the sewerage networks during wet weather and is removed by the screens at the plant.

In a wet weather event at the start of August 2025, the screens also removed debris balls that had formed in the sewer network. The production team has checked the coarse screens and fine screens and confirmed that they are working as designed. The coarse screens are 10mm aperture and the fine screens are 5mm band screens.

Figure 20: Example of one of several debris ball formed in the network and removed on the plant screens.

On 1 July 2025, during the first East Coast low in Sydney since July 2022, the production team saw debris balls on the scum collector trough of the PSTs. This was the first time that debris balls had been seen in the plant process. These were removed from the PST.

Figure 21: Debris balls captured in the scum systems of PST1 and PST2 on 1 July 2025.

The current hypothesis is that the increase in overall load of FOG and VOCs in the Malabar system is providing the sufficient concentrations (as measured by O&G) to enable formation of congealed FOG and debris balls throughout the system and that these are then released under the right hydraulic conditions. The current best thinking is that concentrations are so high in the system that there has been a significant increase in accumulation and that FOG is now escaping wherever possible, often in wet weather events through hydraulic relief structures in the network and less frequently as described in this report from the DOOF.

8. FOG load increases in Malabar

As part of its investigations Sydney Water assessed FOG and organic load trends in the sewer networks reaching the three DOOF plants. The Assessment of Sewerage Networks provided an overview of trade waste in the DOOF systems and discussed the Bondi FOG project and its results. The Networks Assessment clearly highlights the significant contribution that non-residential sources have to concentrations of FOG in the sewer catchments.

A review of influent O&G for the Malabar system shows that over the last 10 years there has been a 39% increase in load coming into Malabar WRRF. This is attributable to growth and changes within the catchment. Figure 22 shows how the FOG loads have changed over time. Loads are increasing at a rate of approximately 4% per year since 2014. The line of best fit shows strong correlation (R^2 value of 0.76) with that rate of increase. This translates into an approximately 6% increase in the discharged load each year from 2014. As shown by the line of best fit for effluent load, with an even stronger correlation to the line of best fit, and R^2 value of >0.9. Figure 22 also shows how rapidly the discharge load for the O&G is approaching the EPA licence load limit.

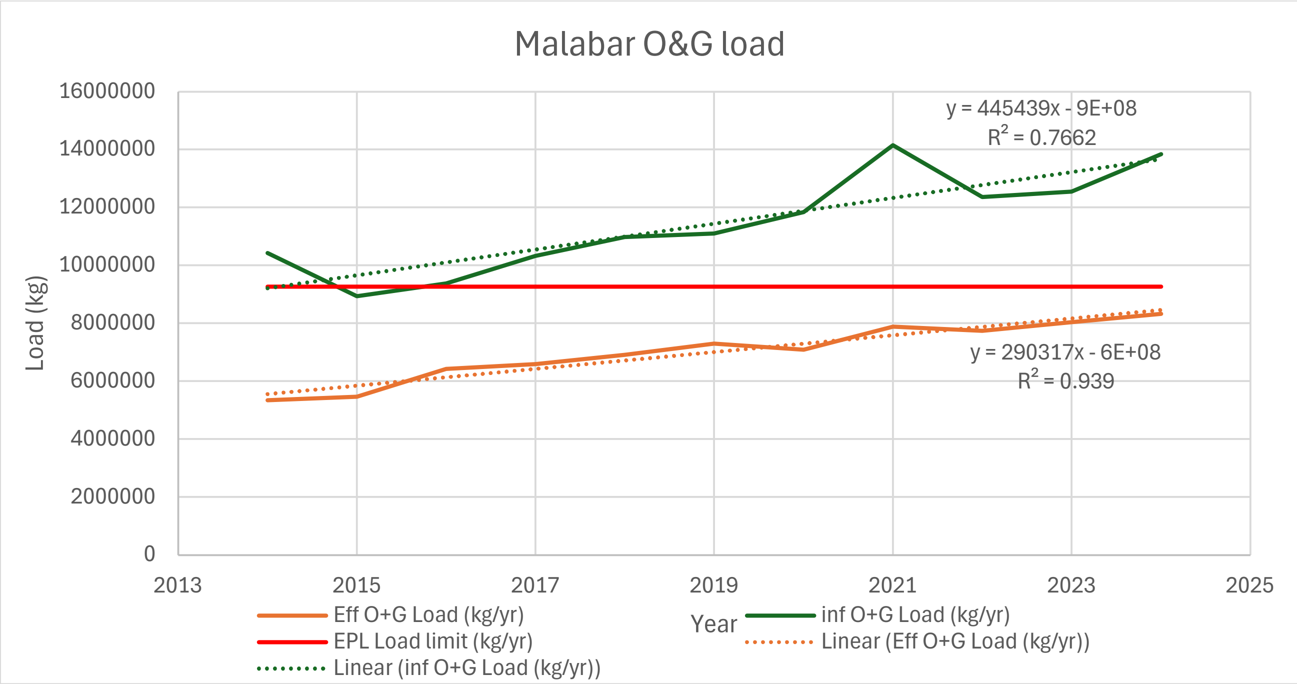

Figure 22: Malabar influent and effluent O&G load trend and EPL load limit

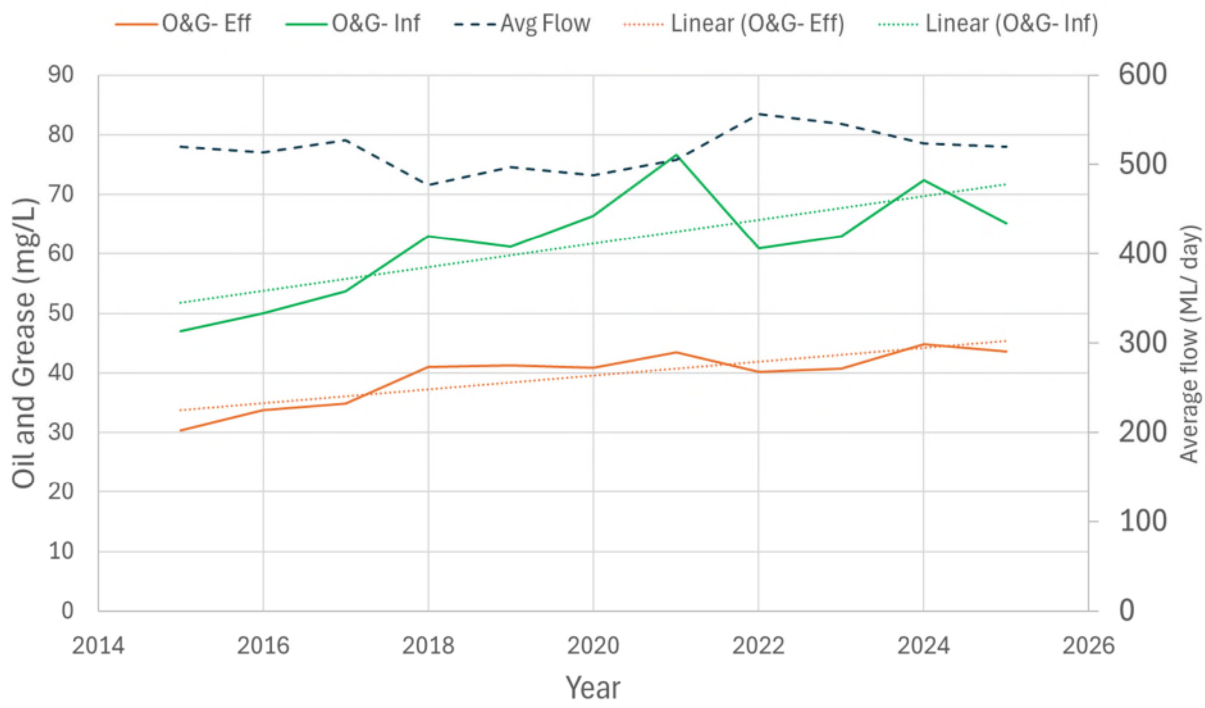

Figure 23: Malabar long-term O&G concentration trend

Figure 23 shows that the influent O&G concentration is increasing over time while the flow is constant leading to the load increases over time. Concentrations of TSS and O&G have tended to increase across all catchments. It is thought this can be attributed to a combination of catchment growth and water efficiency measures that have resulted in reduced per capita water usage in Sydney Water's operating area. When compared to the increases of the North Head and Bondi catchments, the concentration increases seen at Malabar are more significant. The reason for this, including opportunities to address the trend, is under investigation. In addition, studies in the Bondi catchment have shown that the characteristics of O&G have altered over time as people move from animal fats to vegetable oils and this will also continue to be investigated.

Figure 24 shows the correlation for influent and effluent O&G. The R 2 value of 0.9951 is a near perfect linear relationship between the influent and effluent O&G loads. This indicates that the plant is consistently (strong R2) removing ~39% of load.

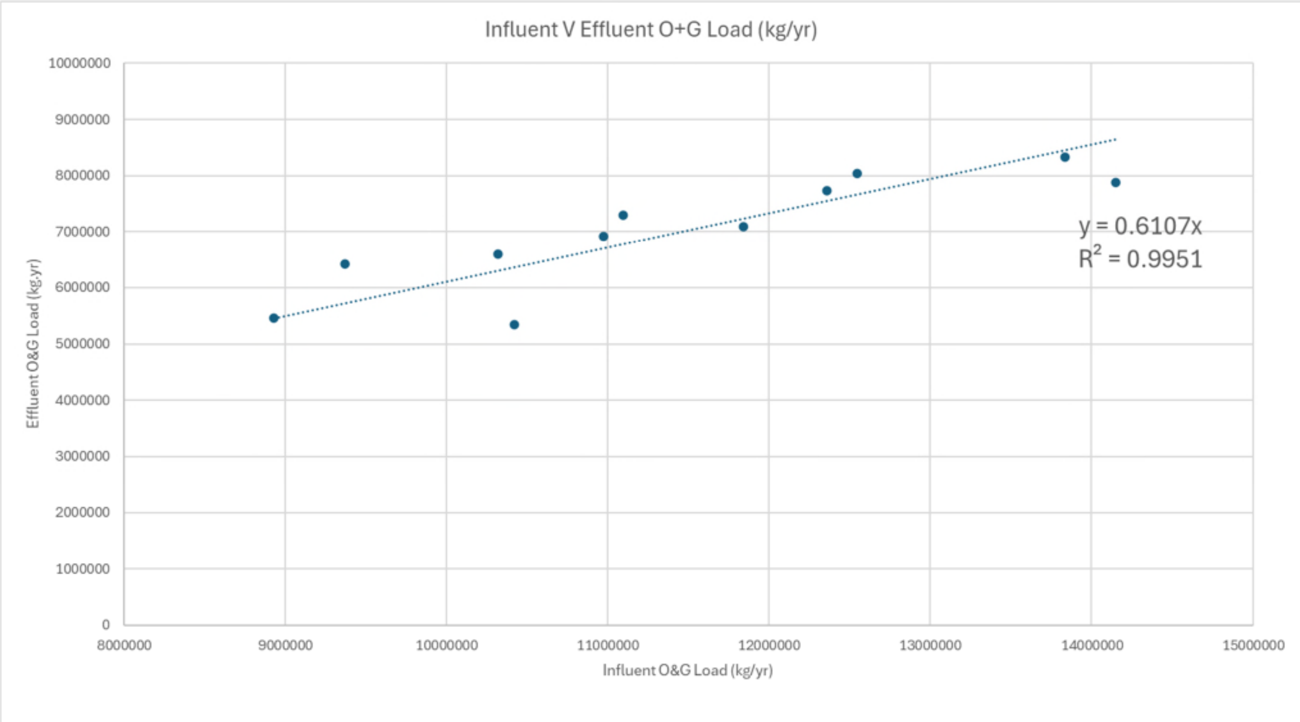

Figure 24: Influent and effluent O&G correlation for the last 10 years

VOCs in the Malabar influent have also increased over the last 10 years which is shown in Figure 25. The average influent VOC concentration has increased by 125% from 2014/15 to 2024/25. The statistics are summarised in Table 5. Combined with a reasonably steady flow, this reveals an increasing load, through higher concentrations, entering the plant over the last 10 years.

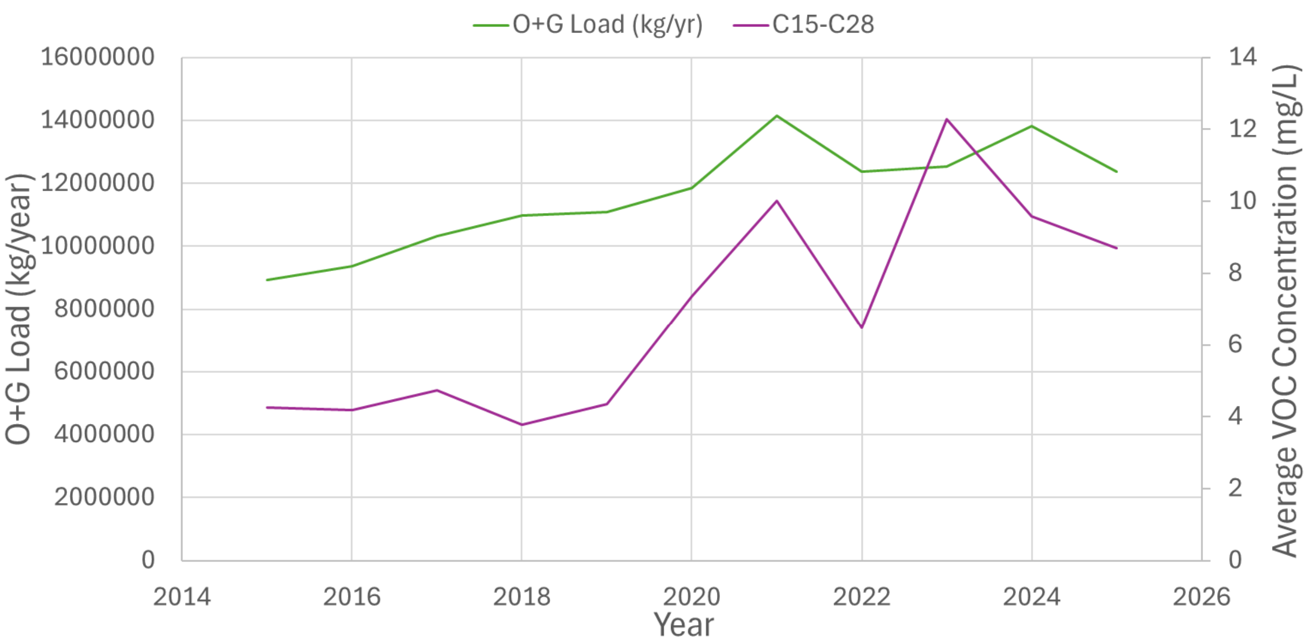

Figure 25: Malabar O&G and VOC load trend

Table 5: Malabar average influent concentration increases from 14/15 to 24/25

	TSS Influent	O&G Influent	VOC Influent
2014/15 (mg/L)	241	47	4.3
2024/25 (mg/l)	368	65	9.6
% increase	53%	39%	125%

Throughout 2020, 2021 and up to the start of 2022 the catchment and Malabar WRRF experienced uncontrolled illegal dumping discharges. These discharges led to regular incidents at Malabar WRRF where the VOCs reaching the site greatly exceeded the approved levels leading to evacuations of the underground areas and operational impacts in the PSTs. This coincided with the lockdowns caused by the Coronavirus (COVID-19) pandemic. Sydney Water could not attribute the discharge to any of the licensed trade waste discharges and started a program to further trace the discharge in the network.

In response to this, a new "Early Warning" system was installed in the network to alert the WRRF when such a discharge enters the network, to prepare the plant for the impact. No significant incident has occurred since May 2022.

Historical data analysis at that time revealed increased variability and frequent spikes of VOC since 2018. Data showed high concentrations of petroleum and diesel-based hydrocarbons in the samples.

Sydney Water notified the EPA at that time and collaboratively worked to identify sources and address the trade waste events coming into the SWSOOS. Sydney Water and the EPA established a working group to agree on data and methodologies, share intelligence and monitoring as well as outcomes of investigations. The EPA and Sydney Water conducted one joint inspection. Sydney Water sent out targeted communications to industries involved in the production, use or transport of these types of products to raise awareness and trigger behavioural change.

Evidence from targeted investigations like the Bondi FOG project, confirms that a significant number of businesses are operating without the required trade waste approvals. The Bondi FOG project identified over 300 new customers that were discharging trade waste without approval, representing a 13% increase in known retail food trade waste contributors in that catchment. When extrapolated across Sydney Water's total area of operations, this suggests a conservative estimate of at least 1,500 retail food businesses discharging FOG illegally. However, this conservative estimate excludes the range of non-retail food trade waste sources of FOG and doesn't consider the diversity and scale of businesses operating in catchments other than Bondi. A more recent database analysis suggests that up to 12,000 retail food businesses could be operating without approval in the Malabar catchment alone. Further on-the-ground investigation would be required to determine how many of these customers are producing significant quantities of FOG and require trade waste pre-treatment and approval to operate from Sydney Water.

As noted, previous reports on the chemical analysis of the debris balls and parts of the DOOF systems, highlighted the Malabar DOOF system as the most likely origin of debris balls. This led Sydney Water to a more focussed investigation in this system. As part of the more detailed review of FOG in the Malabar catchment, Sydney Water assessed VOCs. VOCs are typically represented by results in the C15-C28 carbon chains. It is known that C15-C28 carbon chains can originate from petrochemicals, including heavy fuels, detergents, industrial-type products, such as surfactants and from common cooking oils which contain a range of fatty acids such as palmitic acid, stearic acid, oleic acid, myristic acid and linoleic acid. O&G and C15-C28 carbon chains can therefore originate from both residential customers (large number of sources) and commercial/industrial customers (can be a greater volume from individual industrial/ commercial sources and/or a more concentrated source).

Sydney Water commenced a targeted wastewater sampling program to compare wastewater from a largely residential catchment against a mixed-use catchment. This program will allow Sydney Water to better categorise wastewater quality from residential and mixed-use catchments within Malabar and understand the opportunities and priority areas to target to reduce incoming loads of FOG and other contaminants.

A preliminary review of the results from this program indicates that there were typically higher average concentrations of C15-C28 carbon chains originating from the selected mostly residential catchment versus the mixed-use catchment, while oil and grease concentrations were higher in the mixed-use catchment. Preliminary results from this sampling program are shown in below Table 6.

The results do highlight that there are greater variations in both VOC and FOG results from the mixed-use catchment, which may be indicative of commercial and industrial processes (e.g. variations in cleaning and production cycles). Further analysis of the total load from residential versus non-residential catchments would be required to understand the relative impact of each source. The significance of these changes in VOCs on formation potential for debris balls is unclear at this time and is one current line of enquiry.

Table 6: Concentrations of hydrocarbons and FOG in the Malabar Catchment

Sampling location	Average Concentration of C15-C28 (mg/L)	Maximum concentration of C15-C28 (mg/L)	Average concentration of O&G (mg/L)	Maximum concentration of O&G (mg/L)
Mixed use catchment	7.1	14.3	54.9	80.0
Largely residential catchment	9.4	13.7	42.7	56

Sydney Water recognises that, currently, the main lever to improve the quality of wastewater from residential customers is through education and awareness campaigns. In July 2025, Sydney Water launched a media campaign, "Save Our Sinks," to remind residential customers to dispose of only water, detergent, and soap in sinks. The campaign seeks to educate customers about the environmental and financial impacts of pouring food waste with high oil and grease content down sinks. Sydney Water developed this initiative based on data regarding environmental and system impacts, as well as research into customer understanding and perceptions. The campaign's goal is to reduce the amount of fats, oils, grease and milk entering Sydney Water’s network from residential sources. The campaign has resulted in 14 interviews across television, print and radio channels.

Sydney Water is also cognisant that other pending programs, such as the NSW EPA’s food organics and garden organics (FOGO) mandate, may drive a significant reduction in the volume of cooking oils that customers currently pour down their sinks. We are currently reviewing options to carry out a wastewater sampling and analysis program to test this hypothesis.

From a trade waste perspective, Sydney Water is currently reviewing the potential costs and benefits of establishing a Bondi FOG type program in the Malabar catchment to target a reduction in the discharge of FOG and other contaminants to the wastewater system from non-residential customers that are operating without

Sydney Water's approval and that are unlikely to have appropriate pre-treatment in place. We also note an emerging industry of home-based food businesses, where people produce meals, bake bread etc to sell commercially. While this type of enterprise is carried out from a residential property, it is a trade waste process. Sydney Water is developing a position on the management of these types of businesses to ensure FOG discharge is appropriately managed.

Recent sampling within the Malabar wastewater catchment has shown that increasing concentrations of C15-C28 VOCs may be originating from both residential and non-residential sources, but that there are typically higher concentrations of oil and grease originating in mixed catchments.

It is common during wet weather events for the screens at Malabar to remove large amounts of FOG that are dislodged and washed down the SWSOOS. Figure 21 shows a photo of such material.

9. Conclusions and next steps

9.1 Conclusions

The DOOFs at North Head, Bondi, and Malabar have operated successfully since the early 1990s, significantly improving beach water quality. These systems have operated effectively for over 35 years and the presence of debris balls on Sydney beaches is a new phenomenon.

Following the debris ball events between October 2024 and January 2025, the NSW EPA formally issued a Preliminary Investigation Notice on 30 April 2025 requesting four investigative reports from Sydney Water:

- Oceanographic Modelling - provided 30 May 2025. Identified the possible sources of debris balls as the Mill Stream ERS for Botany Bay beaches and the DOOFs for the coastal beaches.
- Laboratory Analysis of WRRF, Network, and Debris Samples – provided 13 June 2025. Identified chemical markers particular to the Malabar system downstream of Sydney Airport, not to the other DOOF systems.
- Sewerage Network Assessment – provided 30 June 2025. Identified that sewer debris is found on Foreshore Beach following the activation of the Mill Stream ERS and is also reaching the inlet of Malabar WRRF. The assessment also noted that discharge of FOG has only been noted for the Mill Stream ERS.
- Deep Ocean Outfall System Assessment – this report

The combined insights from the investigations indicate that the most likely origin of debris balls on Sydney's beaches was from the Malabar system - the Mill Stream Emergency Relief Structure on the Networks for the Botany Bay beach landings and the Malabar DOOF for the Sydney coastal beach landings. This assessment is based on chemical markers (e.g. consistent with aviation fuel potentially from Sydney Airport), oil and grease analysis and comparison taken from the DOOF plants and the physical evidence of formation. A review of the Malabar WRRF and DOOF performance has confirmed the plant is operating in compliance with NSW EPA Licence and operations & maintenance (O&M) requirements.

- The Malabar plant and DOOF are fully compliant with its NSW EPA limits for Oil and Grease (O&G) and Total Suspended Solids (TSS) and DOOF monitoring requirements for Hydraulic Grade Line (HGL) monitoring and 6 monthly ROV diffuser inspections.
- DOOF diffuser availability averages 93% against an EPL target of >76%.
- DOOF performance confirms that plume dilution and submergence have outperformed design criteria every year.
- DOOF O&M review confirms 100% of guideline requirements are being met.
- Preventative maintenance effectiveness for liquid stream process units is 92% exceeding the target of >80%.

The working hypothesis is FOG accumulation in an inaccessible dead zone between the Malabar bulkhead door, and the decline tunnel has potentially led to sloughing events, releasing debris balls. The exact formation mechanism is still not clearly determined. This chamber was not designed for routine maintenance and can only be accessed by taking the DOOF offline and diverting effluent to the cliff-face for an extended period (months) which would close Sydney Beaches.

There has been a 39% increase in O&G load and a 125% increase in VOCs coming into the Malabar system over the last 10 years, whilst the capacity of the SWSOOS and plant assets has not been increased. VOCs first became really noticeable during the COVID years. The plant's removal efficiency remains consistent.

The investigations have confirmed the likely source of the debris ball landings on Sydney Beaches, with this investigation identifying the following:

- The inaccessibility of the dead zone between the bulkhead door and the DOOF decline tunnel, poses a long-term maintenance challenge as this area was never designed to enable safe inspection and cleaning.
- Oil and Grease, and specifically VOCs have increased in the Malabar catchment over the last 10 years.
- A recent database analysis has identified up to 12,000 retail food businesses operating within the Malabar catchment, potentially without the necessary trade waste approvals from Sydney Water, contributing to increasing FOG loads.

9.2 Next steps

Sydney Water's proposed next steps are to:

- Continue targeted FOG removal in the Malabar DOOF bulkhead area. This will involve the scheduling of regular cleans every year (e.g. 24 cleans over 3 years) during low tide/flow conditions.
- Continue to investigate formation mechanisms for debris balls in the Malabar system.
- Initiate a proactive trade waste program for food businesses, review how aviation fuel is potentially entering the system, partner with Councils and the NSW EPA on FOGO mandates and waste oil collection programs and continue public education campaigns like "Save Our Sinks" to reduce household FOG contributions.
- Complete three in progress business critical projects for the Malabar PSTs to improve their reliability and availability by December 2028.
- Complete the Georges River plant upgrades under the Malabar System Investment Program (MSIP) by 2029 to take 10% load off the Malabar system.
- Review the long-term investment plan for the Malabar System to address debris ball risk and O&G compliance obligations. This would include assessing options such as removing additional flows upstream of Malabar WRRF or removal of additional O&G at Malabar WRRF. Strategic options will be assessed considering other drivers, including growth, data centre water demands, the opportunity for PRW and future regulatory requirements.

10. References

Besley, C. (2025). *Results from laboratory analysis of WRRF, network and debris ball samples.* Sydney Water.

Besley, C. H., & Birch, G. F. (2019). Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): Influence of deepwater ocean outfalls on shelf benthic infauna. *Marine Pollution Bulletin*(145), 724-738.

Besley, C. H., & Birch, G. F. (2019). Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): Influence of deepwater ocean outfalls on shelf sediment chemistry. *Marine Pollution Bulletin*(145), 707-723.

Besley, H. C., & Birch, G. F. (2019). Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): A synthesis. *Marine Pollution Bulletin*(145), 675-677.

Crawford, L., Gardner, S., & McCulloch, J. (2025). *Assess Sewerage Networks.* Sydney Water.

Crawford, L., Gardner, S., & McCulloch, J. (2025). *Assess Sewerage Networks.* Sydney: Sydney Water.

Fitzhenry, A. (2024). *Sydney Water Deep Ocean Outfalls Inspections Diffusers and Pipelines Inspection.* Sydney: Land and Marine Consultants Pty Ltd.

Fitzhenry, A. (2025, August 6). Pers Comm. Sydney, NSW, Australia.

Fitzhenry, A. (July 2025). *Sydeny Water Deep Ocean Outfalls Inspections Diffusers and Pieplines Report.* Sydney: Land and Marine Consultants Pty Ltd.

Furner, C., & Ison, J. (2024). *Source Control and Education Program for Oil and Grease.* Sydney Water.

Manning, S. S., Dixon, J. P., Birch, G. F., & Besley, C. H. (2019). Deepwater ocean outfalls: A sustainable solution for sewage discharge for mega-coastal cities (Sydney, Australia): Influences on beach water quality. *Marine Pollution Bulletin*(145), 691-701.

Sydney Water. (2020). *Ocean Sediment Program 2020 assessment year report.* Sydney: Sydney Water.

Tate, P. (2025). *Supplementary Information on Debris Balls Observed on Sydney Beaches in January 2025 Oceanographic Modelling.* Sydney: Water Quality Data.

Tate, P. M., Holden, C. J., & Tate, D. J. (2019). Influence of plume advection and particle settling on wastewater dispersion and distribution. *Marine Pollution Bulletin, 145*, 678-690.

Tate, P., & Li, R. (2025). *Oceanographic Modelling: The Origin of Debris Balls on Sydney and NSW South Coast Beaches.* WQ Data Pty Ltd.

11. Appendix One – North Head and Bondi

This appendix follows the main body of the report covering the North Head and Bondi WRRFs and their DOOFs.

11.1 North Head and Bondi key information

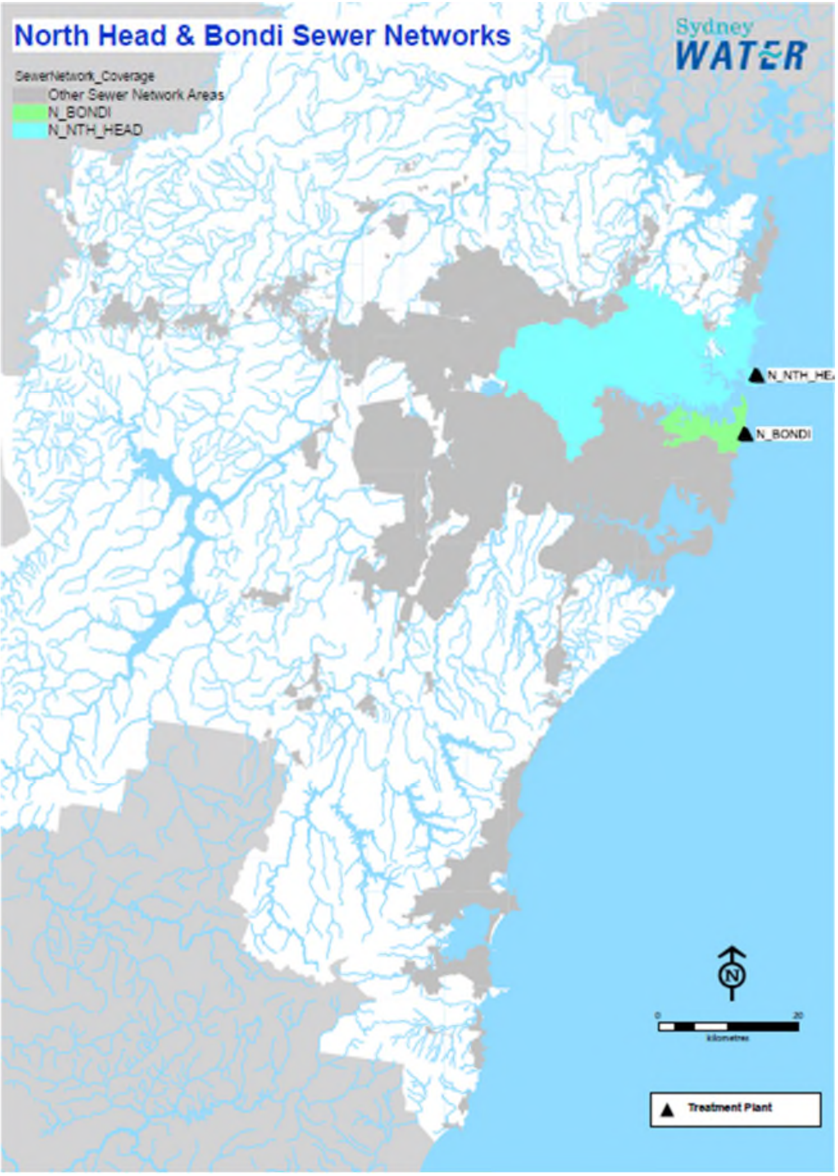

Figure 26: Sydney's wastewater system highlighting the North Head and Bondi systems

North Head Water Resource Recovery Facility (WRRF) receives flows from the Northern Suburbs Ocean Outfall Sewer that starts in Blacktown in the west, extending south to Greystanes and Auburn and across through Parramatta then north of the Parramatta River to Manly. The catchment, shown in Figure 26, receives flows from as far north as Hornsby, Frenchs Forest and Narrabeen. The North Head catchment has approximately 574,000 customers and an equivalent population of approximately 1.4 million.

Bondi WRRF receives flows from Sydney city and surrounding suburbs west to Rozelle, Birchgrove and parts of Lilyfield and Camperdown. The catchment, shown in Figure 26, extends south to Paddington where it borders the Malabar catchment. The Bondi catchment has approximately 175,000 customers and an equivalent population of approximately 780,000.

North Head and Bondi are high-rate primary treatment plants. The treatment train for these plants is essentially the same as Malabar: screenings and grit removal followed by primary sedimentation and discharge via the DOOFs. North Head pumps flow after screening and prior to the grit capture process. Bondi is the only plant which requires pumped head to drive the effluent through the DOOF after the PSTs.

All plants have solids treatment for the primary sludge including digestion and cogeneration which produces electricity utilised in the plants. Bondi can also export excess power to the grid. Each plant has treatment of air before discharge as well as internal recycled water streams and other ancillary equipment. As for Malabar, these plants produce biosolids which are 100% beneficially reused.

The EPL for North Head is Licence No. 378 and for Bondi is Licence No. 1688. The Process Flow Diagrams for each of the WRRFs appear below in Figure 27 and Figure 28.

North Head and Bondi both have extensive underground works where large portions of the plants have been built in caverns excavated from the rock. Parts of the North Head plant are 160m below ground level. Prior to the commissioning of the DOOFs, Bondi and North Head discharged to the near shore approximately 7 m below sea level.

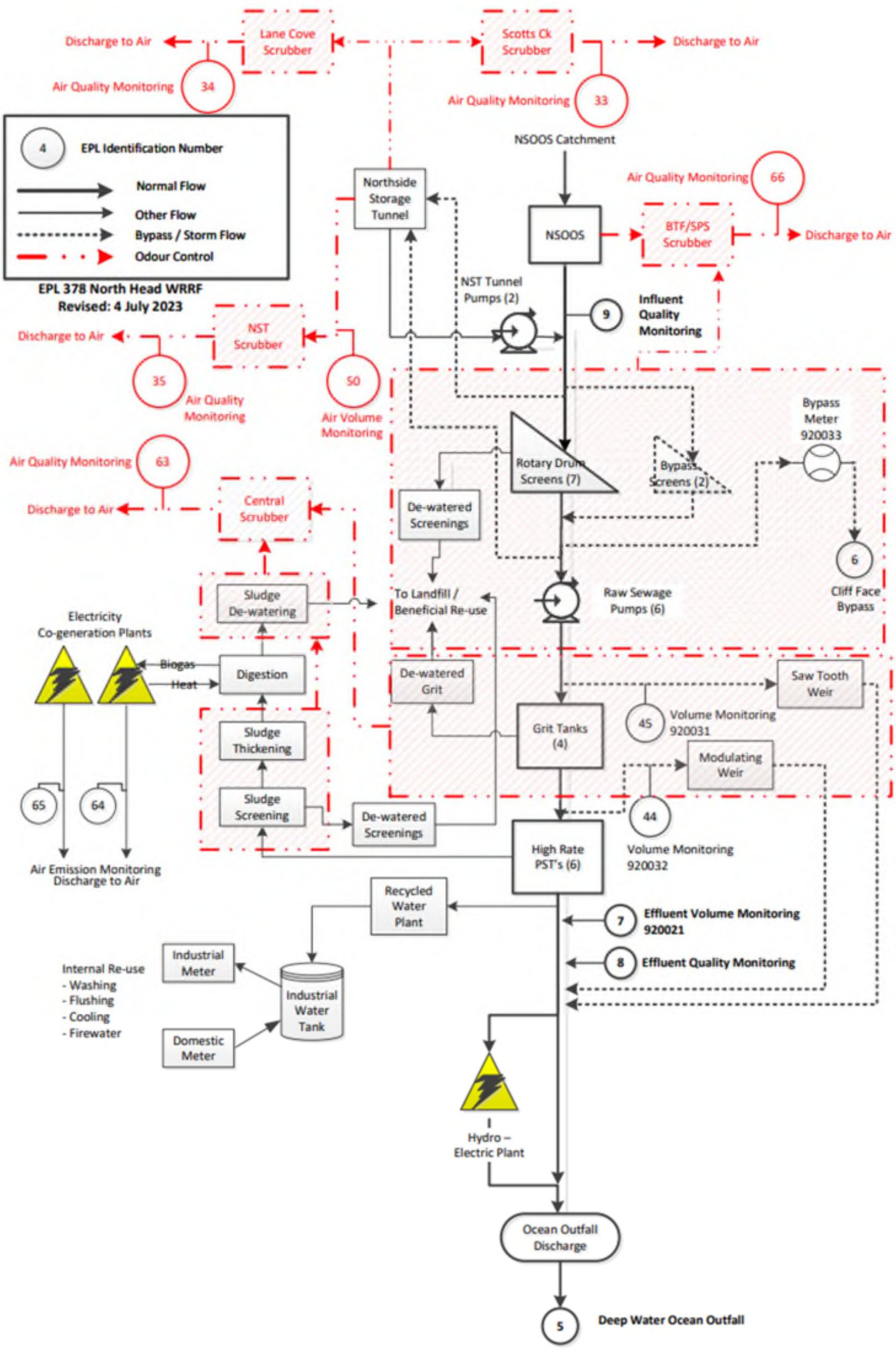

Figure 27: North Head WRRF Process Flow Diagram

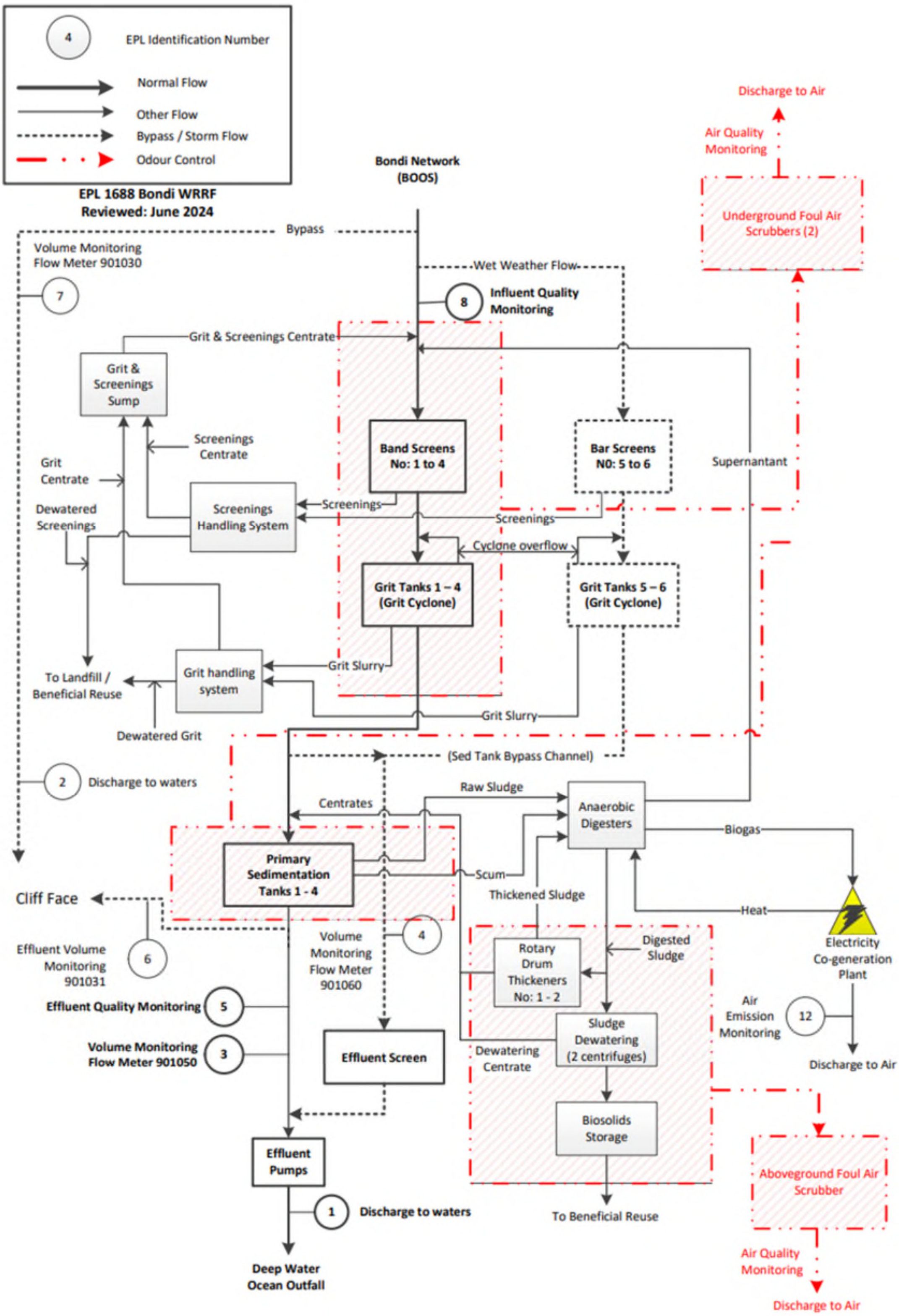

Figure 28: Bondi WRRF Process Flow Diagram

The North Head DOOF came online in December 1990 and the Bondi DOOF in May 1991. Upon commissioning, the beneficial improvement of the DOOFs on beach and ocean waters was immediate and substantial. As for Malabar, the DOOFs have operated continuously with no major interruptions and no asset failures for 35 years.

Some key information regarding the North Head and Bondi DOOFs is presented in Table 7.

Table 7: North Head and Bondi DOOF key data

Design	North Head	Bondi
Ultimate Capacity (ML/d)	2,400	700
Current Average Dry Weather Flow (ADWF) (ML/d)	332	112
Current Peak Wet Weather Flow (PWWF) (ML/d)	1,400	680
Minimum flow to prevent seawater ingress (ML/d)	100	70
Minimum flow to purge seawater ingress (for 45 min) (ML/d)	300	180
Tunnel internal diameter (m)	3.48	2.25
Riser zone distance to shore (approx.) (km)	3.1	1.6
Length of diffuser section (m)	762	510
Minimum cover to seabed (m)	45	45
Maximum water depth over diffusers (m)	60	60
Number of risers	36	26
Number of ports per riser	6	4

The measures of DOOF condition and performance are the same as those listed for Malabar.

The three ocean outfall systems service the majority of Sydney's population as shown in Figure 1, currently treating about 70% of Sydney's wastewater. Schematic representations, design description and maintenance approach of the DOOFs are the same as those presented for Malabar.

As for Malabar, the North Head DOOF can be opened at the bulkhead door for inspection and assessment of the assets in this part of the DOOF. The bulkhead doors allow for access to the DOOFs. For these two plants, the bulkhead doors can be under water level depending on tide heights and flows. The Bondi DOOF bulkhead door is permanently submerged and cannot be opened. Bondi Inspections are therefore limited to external assets.

Maintaining the structures behind the bulkhead door requires work on hydraulically live assets under confined space, hazardous gas conditions with limited time windows. Careful coordination with Network operations is required. The assets were not designed to enable maintenance and cleaning tasks of the DOOF without taking the DOOF offline and diverting effluent to the cliff face. Opening and entering the bulkhead area of the DOOFs is a very high safety risk task requiring tight controls. The assets behind the Bondi bulkhead cannot be accessed without taking the DOOF offline and diverting treated effluent to cliff face discharge for extended periods.

11.2 North Head and Bondi WRRF and DOOF performance

A review of WRRF EPA compliance for both plants confirms that the effluent Oil and Grease (O&G) and Total Suspended Solids (TSS) are fully compliant with 50%ile and 90%ile oil and grease and total suspended solids EPL Licence discharge limits over the last 4 years. Please see Figure 29 to Figure 32.

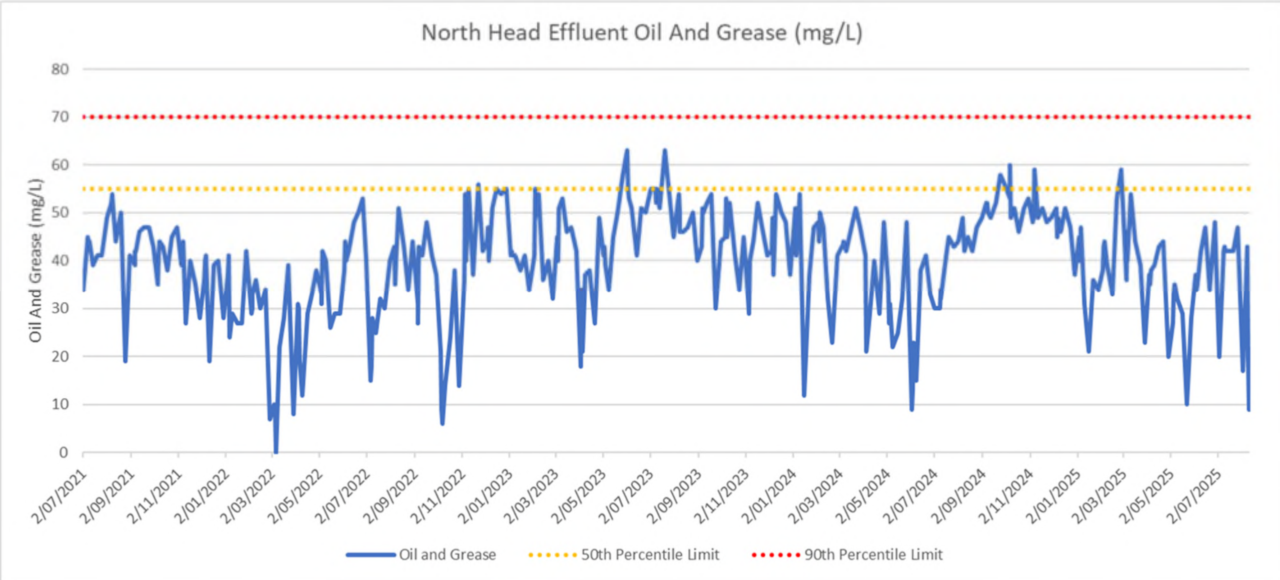

Figure 29: North Head Effluent O&G compliance

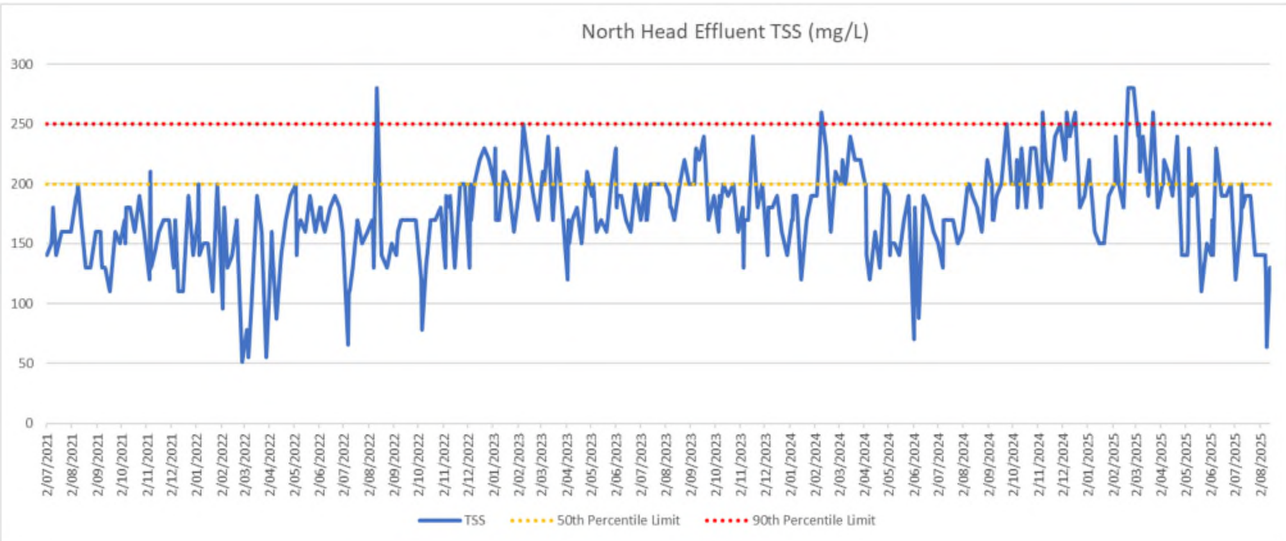

Figure 30: North Head TSS compliance

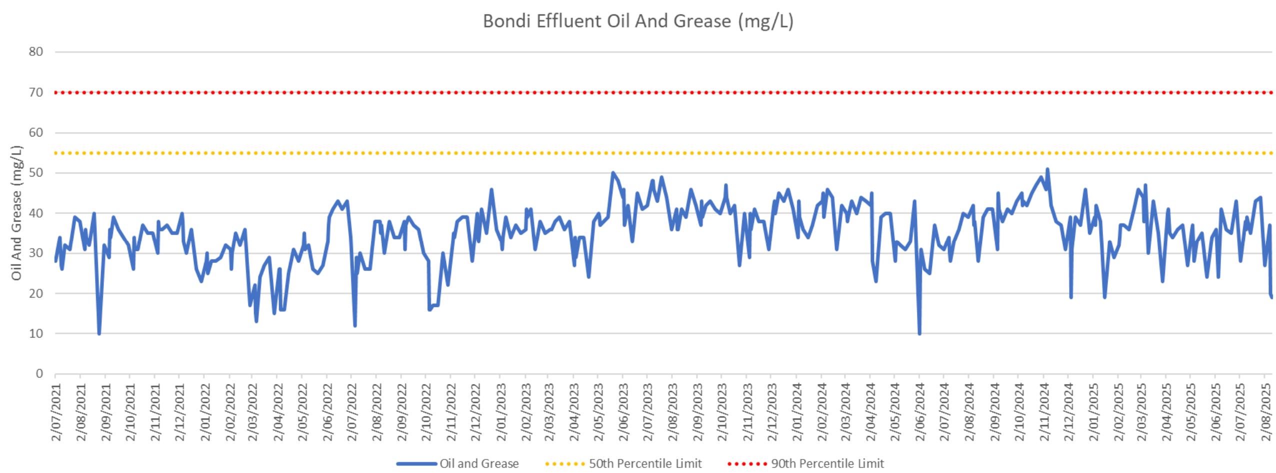

Figure 31: Bondi Effluent O&G compliance

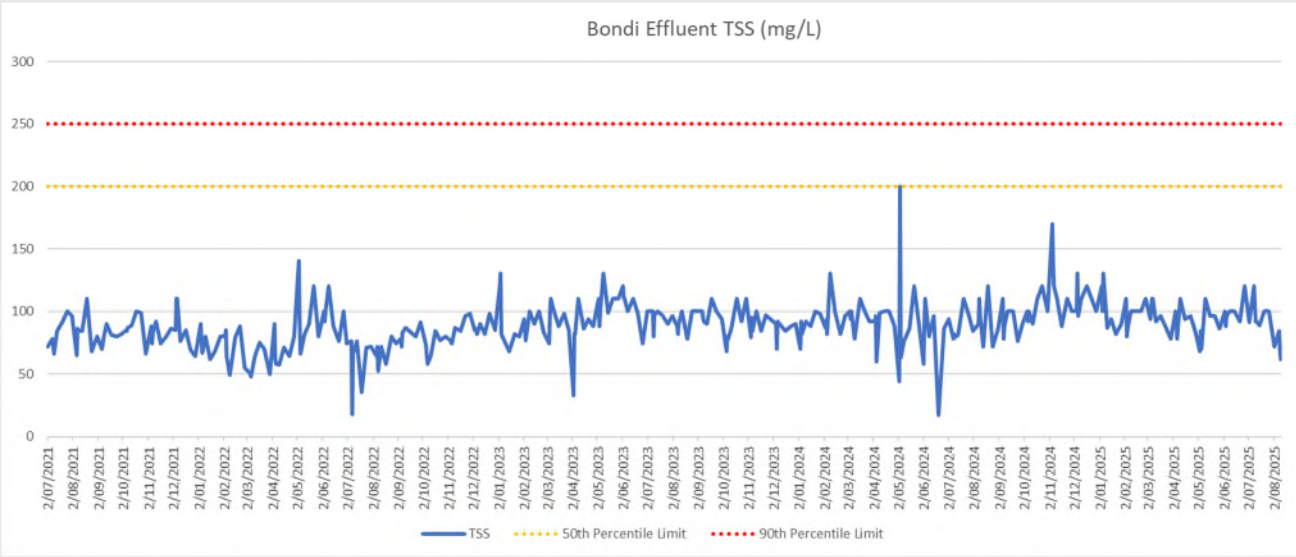

Figure 32: Bondi Effluent TSS compliance

As for Malabar, the licence parameter used to quantify FOG at the influent and effluent discharge points of North Head and Bondi WRRFs is O&G.

A review of EPA monitoring requirements for the DOOFs confirms that operating characteristics and underwater diffuser inspections are being monitored in line with EPL Licence requirements over the past 4 years.

Table 8: DOOF compliance with EPL

EPL Clause	Requirement	Compliance	
		North Head	Bondi
M10.7 **Note: For NH M10.7 a)**	The licensee must collect the following information on the operating characteristics of the deepwater ocean outfall as necessary and in a manner approved by the EPA: i. tide height at the end of the outfall; ii. head loss through the outfall; iii. flow rate over time through the outfall.	✓	✓
M10.8 **Note: For NH M10.7 b)**	The licensee must undertake an underwater inspection of the following components of the outfall as necessary: i. each individual diffuser nozzle, while discharge is occurring; ii. external components of the riser and those parts of the diffuser not covered by (a) above; and iii. the sacrificial anodes.	✓	✓
For NH M10.7 c)	The licensee must provide monthly to the EPA unit head of Metropolitan Infrastructure (Water) (or nominee): i. all data describing oceanographic variables produced from its ocean reference station; ii. wind speed and direction data from a shore-based station located in the vicinity of the ocean reference station; iii. data from a waverider buoy located in the Sydney region; iv. the hourly effluent flow from each of the deep ocean outfalls operated by the licensee; and v. hourly near field model results including dilutions and plume positions after initial mixing based on the above information in i) to iv) to be supplied annually.	✓ Data collected by Oceanographic Field Services and supplied monthly from the Ocean Reference Station by SW Laboratory Services	Not applicable

All data required under M10.7 was collected and utilised to assess performance. Inspections as required under M10.8 have been completed by ROV every 6 months. These reports are provided in Appendix Two.

A review of Deepwater Ocean Outfall diffuser availability confirms excellent availability against an EPL licence target of >76% over the past 4 years.

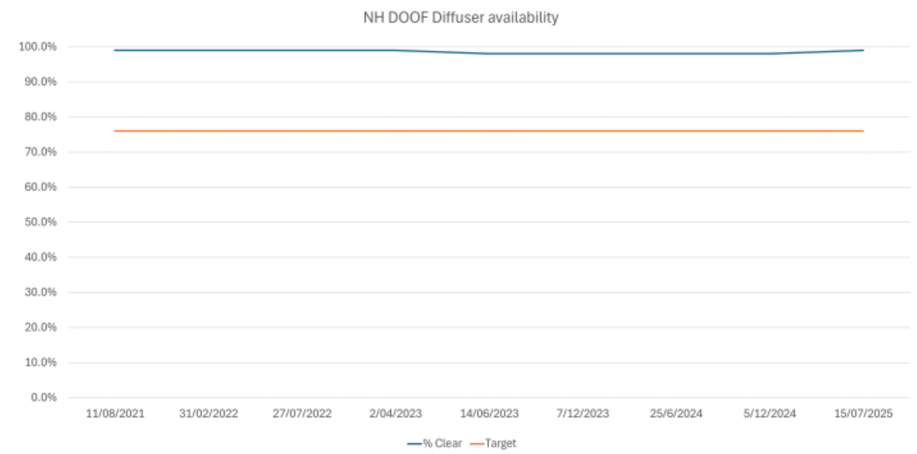

Figure 33: North Head DOOF compliance with diffuser availability

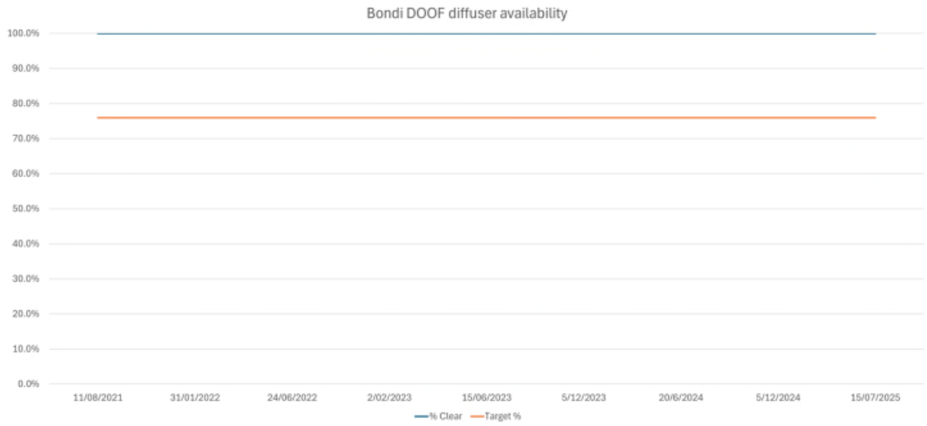

Figure 34: Bondi DOOF compliance with diffuser availability

O5.3 of the North Head EPL requires 76% of diffusers to be ‘on-line’. Sydney Water has assumed that this requirement applies to all three DOOF plants. Data here is taken from the 6 monthly ROV surveys.

A review of Deepwater Ocean Outfall performance versus design criteria since 2006, confirms that plume dilution has outperformed design criteria every year.

The plume dilution should exceed the minimum design criterion of 40:1 98% of the time. The following graphs show plume dilution for 98% of the time criteria.

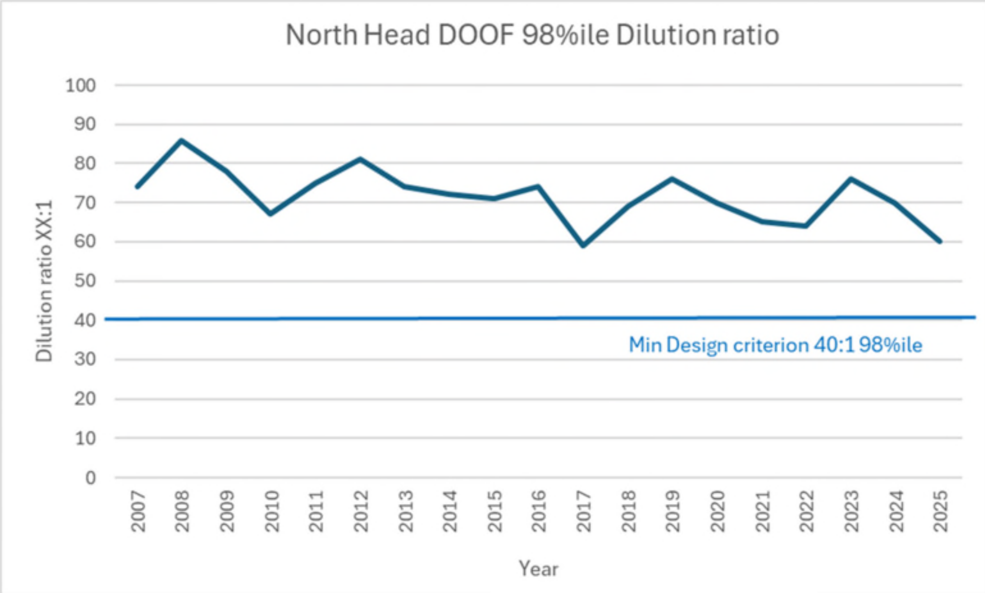

Figure 35: North Head plume dilution for the 98% of time criteria

The way to read this graph is that in the year 2025 The North Head DOOF achieved a dilution ratio of 60:1 98% of the time, significantly exceeding the 98% design criterion of 40:1.

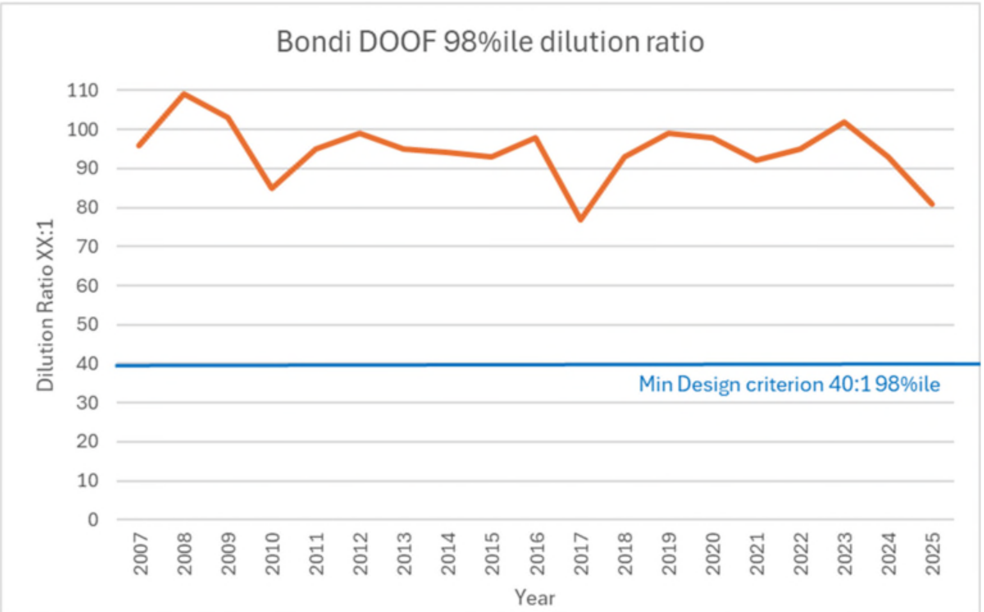

Figure 36: Bondi plume dilution for the 98%

In 2025, the Bondi DOOF achieved a dilution ratio of 80:1, 98% of the time, significantly exceeding the 98% design criterion of 40:1.

A review of Deepwater Ocean Outfall performance versus design criteria since 2006, confirms that submergence of the plumes at North Head and Bondi have outperformed design criteria every year. This is the percentage of time in summer that the plume remains submerged (does not surface).

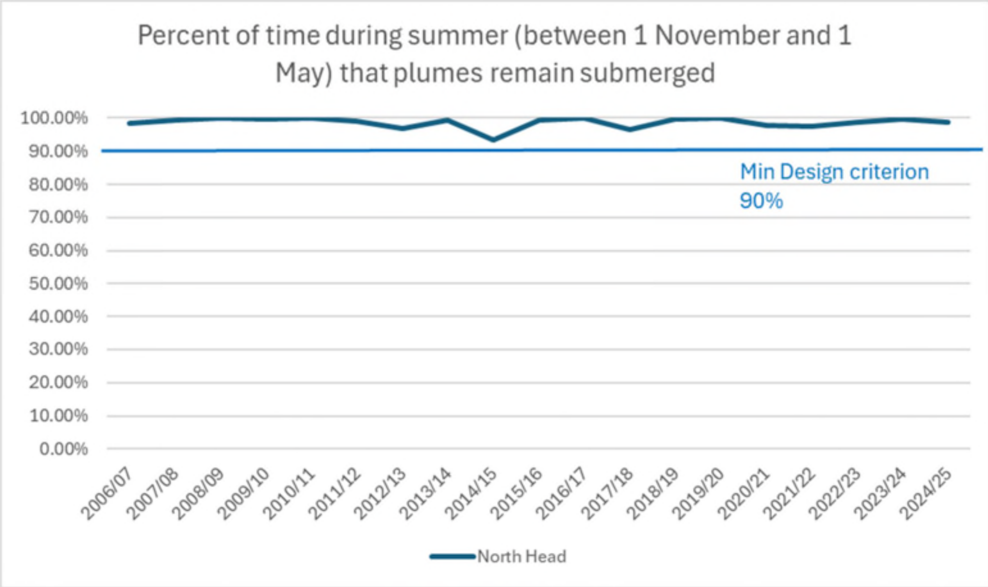

Figure 37: Percentage of time the North Head DOOF plume is submerged in summer

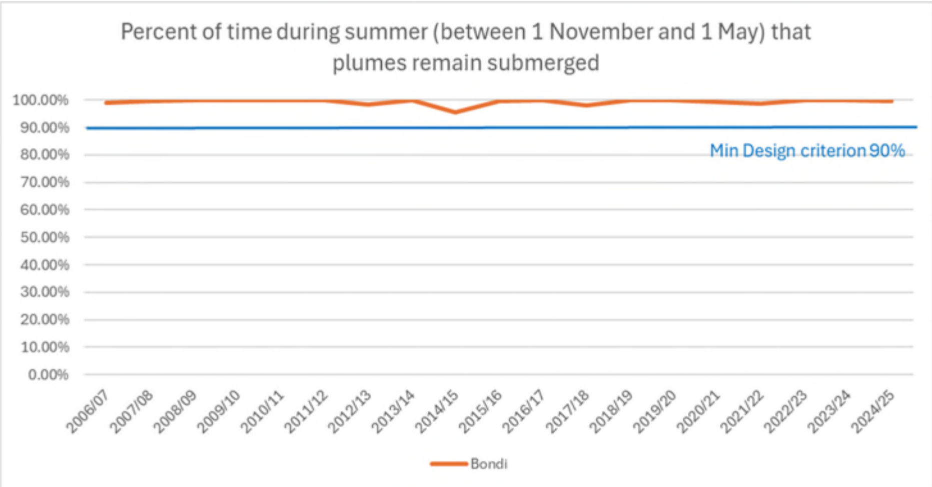

Figure 38: Percentage of time the Bondi DOOF plume is submerged in summer

A review of Deepwater Ocean Outfall Operating and Maintenance Guidelines for North Head and Bondi confirms that all guideline requirements are being met.

Sydney Water reviews DOOF performance against its Unit Process Guideline (UPG). The following table confirms that the DOOF has been operated and maintained in accordance with the design requirements and guidelines.

Table 9: Operation of the North Head and Bondi DOOFs against UPG guidelines

UPG requirement	Frequency	Requirement met	
		North Head	Bondi
Borehole flushing should be carried out by jetter	Not specified	✓	✓
The outfalls were originally designed to be taken offline for inspection at a frequency similar to that of major sewer carriers, with flows discharging through the original cliff-face outfalls while the DOOF was offline. However, … this is now deemed to only be acceptable if no other course of action is available…	Not specified	✓	✓
6-monthly inspections of the diffusers and nozzles are undertaken by a contracted remotely operated vehicle (ROV). Still and video pictures are taken of all nozzles and observations made about their condition / performance, with a corresponding report. Also, the report indicates the condition of sacrificial anodes placed around the circumference of each of the risers, the condition of the manhole at the top and makes comment about visible sea life. …	6 monthly	✓	✓
Each riser is fitted with numerous sacrificial anodes and ROV inspection will indicate the need or otherwise for replacement.	6 monthly	✓	✓

UPG requirement	Frequency	Requirement met	
		North Head	Bondi
Inspection and maintenance of the bulkhead doors and the anodic protection system, as well as cleaning and removal of scum and screenings from behind the bulkhead door.	Intermittent/ Periodic	Partial	✓
It is an Environmental protection licence (EPL) requirement to monitor the DOOF performance. All three DOOF EPLs have the following monitoring clauses. M10.7 Monitoring of Deepwater Ocean Outfall The licensee must collect the following information on the operating characteristics of the deepwater ocean outfall as necessary and in a manner approved by the EPA: a) tide height at the end of the outfall; b) head loss through the outfall; and c) flow rate over time through the outfall. Note: Deepwater Ocean Outfall monitoring data is analysed in accordance with Condition M5.1 of the licence in the Sewage Treatment System Impact Monitoring Program: Interpretative Report.	Online monitoring and annual reporting	✓	✓
M10.8 The licensee must undertake an underwater inspection of the following components of the outfall as necessary: a) each individual diffuser nozzle, while discharge is occurring; b) external components of the riser and those parts of the diffuser not covered by (a) above; and c) the sacrificial anodes.	6 monthly	✓	✓
O7.1 Appropriate flushing procedures must be used if saltwater intrusion into the deepwater outfall occurs or considered to have occurred	As required	✓	✓
O7.2 The licensee must have at least 76 percent of the diffusers installed on the deepwater ocean outfall online unless the prior written approval of the EPA has been received [Note, while this only appears in the NH EPL, SW assumes this applies to all DOOFs.	At all times (inferred)	✓	✓
Flushing or cleaning of borehole sensors (not possible at Bondi) will clear the sensor of any build up and ensure they are reading accurately. … At Malabar the Maintenance can be performed on the sensors as they are accessible without needing to enter the DOOF.	Not specified	✓	✓
The Hydraulic Grade Line (HGL) should be within a target range of ± 20% of the design HGL and If this flow isn't achieved during the daily diurnal flow pattern, ponding of the influent sewage may be required to build up enough volume to force purging flowrates	Continuously then as required	✓	Partial

Figure 39 and Figure 40 show North Head and Bondi plant flows overlaid with the minimum flow required to prevent saltwater intrusion and the flow required for purging saltwater intrusions. Note that these are instantaneous flowrates for short durations and are different from the totalised flow for a given 24-hour period. Figure 41 and Figure 42 show the HGL curves over time for the same plants for the 24/25 year.

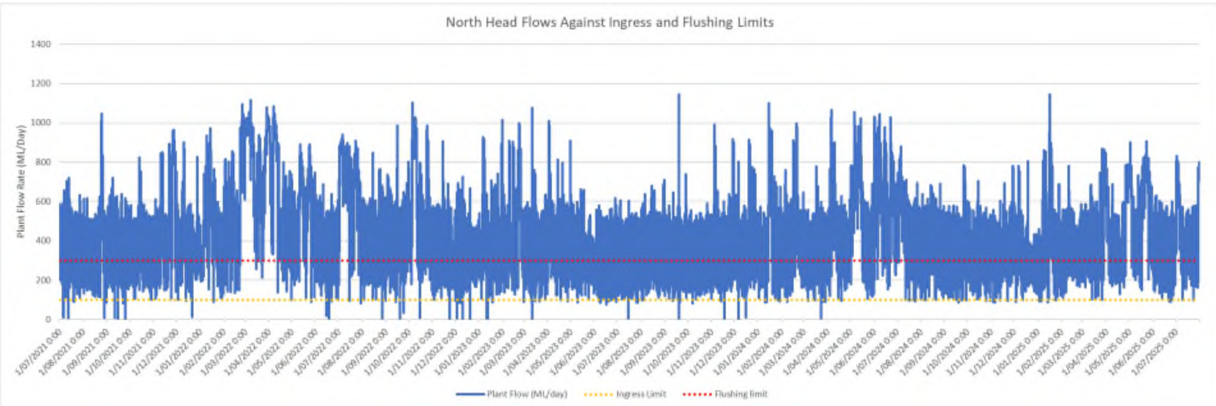

Figure 39: North Head flows and hydraulic limits

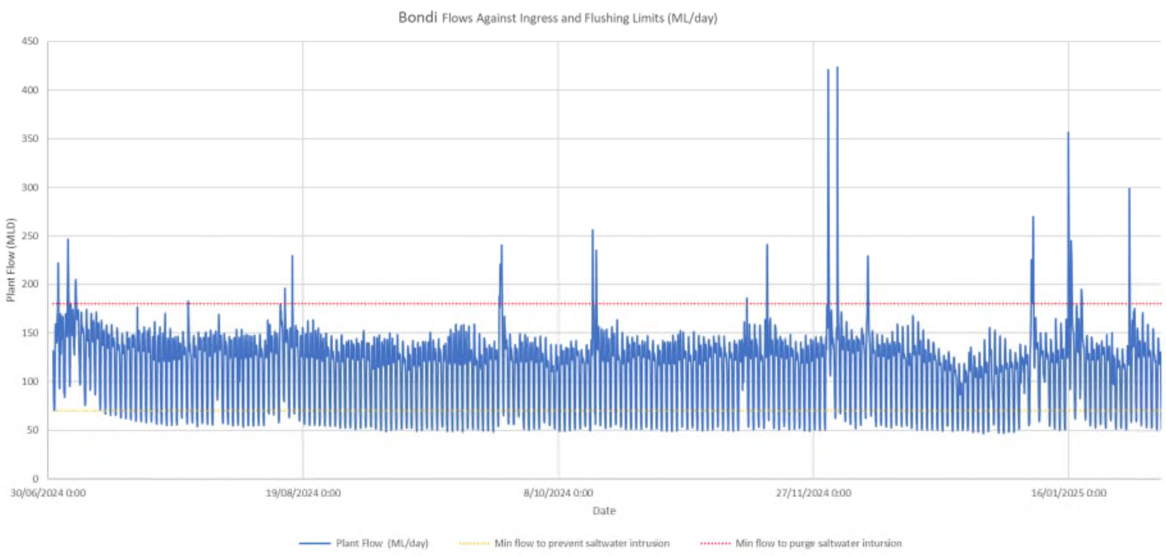

Figure 40: Bondi flows and hydraulic limits

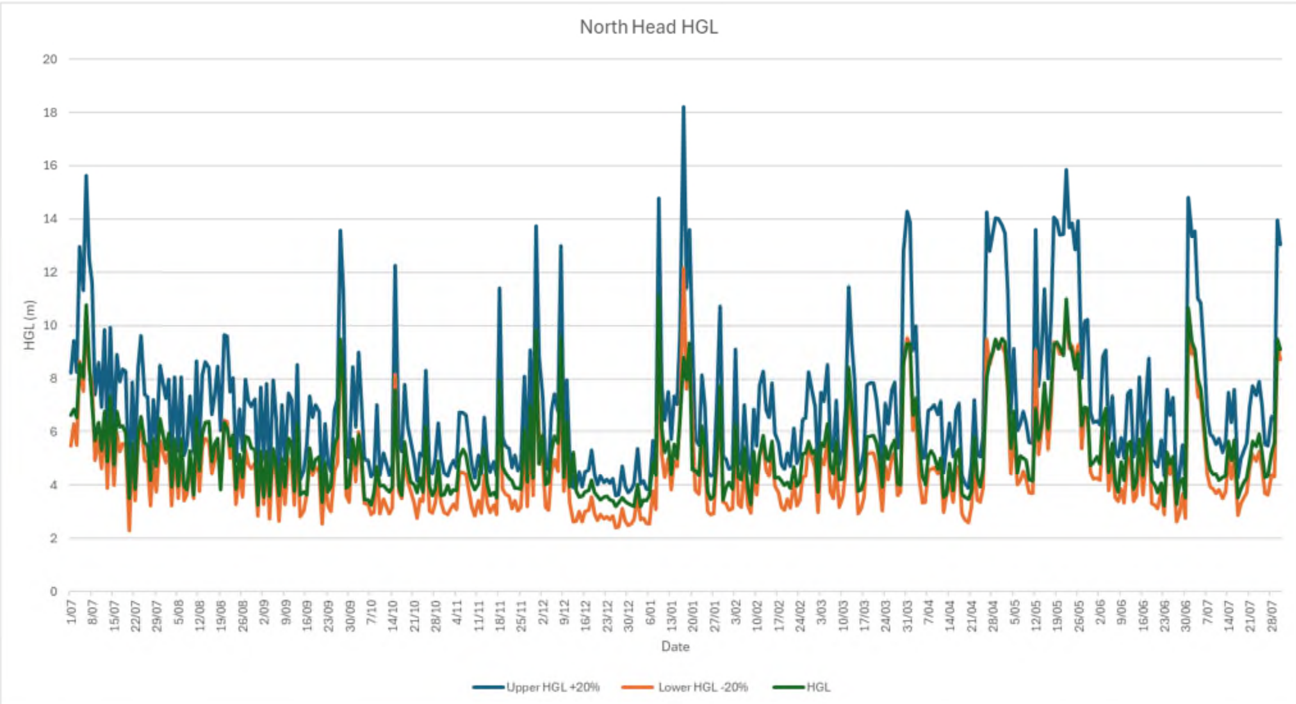

Figure 41: North Head DOOF performance against the HGL criteria over the period of interest

Should the DOOF flow drop below 100 ML/d saltwater ingress is possible and a purging flow is recommended for at least 45 minutes. The North Head DOOF drops below 100 ML/d regularly due to minimum diurnal flows or maintenance activities and regularly achieves the purging flow of 300 ML/d, typically on a daily basis. There is no impact on DOOF operation from the instances when the flow goes below 100 ML/d.

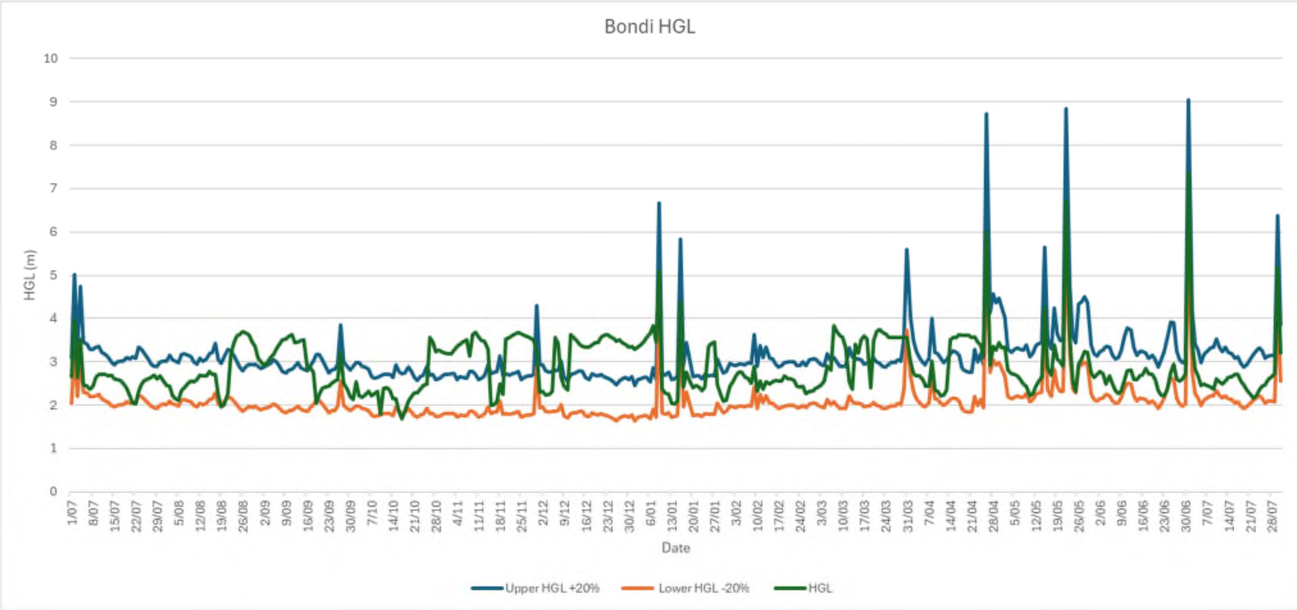

Figure 42: Bondi DOOF performance against the HGL criteria

The Bondi DOOF was designed for the initial flow conditions of 165 ML/d ADWF, a minimum flow to prevent saltwater intrusion of 70 ML/d and a saltwater purging flow of 180 ML/d. The Bondi DOOF is regularly dropping below the minimum flow to prevent seawater intrusion and only exceeding the purging flow during wet weather. This appears to be related to the significantly reduced flows during Covid and that post Covid flows have not returned to pre-Covid levels. The reduced flows from Sydney CBD are consistent with corresponding increases in flows in outer suburban catchment areas.

In general, the HGL trends for the Bondi DOOF are more variable showing periods where the DOOF is operating outside of its HGL parameters. A low HGL could theoretically be indicative of a major failure of the DOOF resulting in free flow. A high HGL could theoretically be indicative of a blockage. While both are seen for the Bondi DOOF at times, the 6 monthly ROV inspections confirm excellent asset condition. Hydraulic performance is otherwise very good with no capacity constraints as could be expected with a high HGL. The physical monitoring and actual hydraulic performance suggest that the DOOF is operating correctly.

The guidance of the DOOF designer for assessing performance is that a combination of HGL monitoring from real time flow and tide data and the six monthly ROV monitoring need to be evaluated along with other measures such as plume dilution. The ROV monitoring data, plume dilution, plume submergence data and other plant flow data show no impact on plant performance. Based on this, although the Bondi HGL is outside of limits for significant periods of time and the flows are regularly below the minimum flow for saltwater intrusion, the Bondi DOOF is functioning well.

This notwithstanding, Sydney Water has identified that the Bondi outfall experiences seawater ingestion for certain low flow periods of the day. There are no operational activities that plant staff can implement to address the regular drop in flows below the minimum required to prevent seawater intrusion and to achieve purging flows through the Bondi DOOF. Furthermore, based on all other measures available, this transient seawater ingestion does not appear to be adversely affecting the overall performance of the Bondi DOOF. However, Sydney Water has initiated an engineering review of the hydraulics of the Bondi DOOF to determine if there should be any operational and/ or asset changes.

In summary, the investigations into plant and DOOF performance show that:

- WRRF EPA compliance confirms that the effluent Oil and Grease and Total Suspended Solids are fully compliant with 50%ile and 90%ile EPL Licence discharge limits.
- EPA monitoring requirements for the DOOF confirms that operating characteristics and underwater diffuser inspections are being monitored in line with EPL Licence requirements.
- Deepwater Ocean Outfall diffuser availability confirms average required availability against an EPL licence target of >76%.
- DOOF performance versus design criteria since 2006, confirms that plume dilution and submergence have outperformed design criteria every year.
- Deepwater Ocean Outfall Operating and Maintenance Guidelines confirms 100% of guideline requirements are being met.

11.3 DOOF inspections

The six monthly ROV monitoring over the period from June 2024 to July 2025 indicated that the DOOF assets were in generally good condition and that the DOOFs were all working with some minor works required to clear some diffuser blockages.

Figure 33 and Figure 34 trend the data from these reports showing the number of available diffusers well exceeds the minimum required. A small number of blockages in the DOOF diffuser nozzles is common and these are generally cleared using a jetter attached to the ROV. HGL monitoring (Figure 41 and Figure 42) shows that the small number of blockages does not affect the performance of the DOOF and as noted earlier in the report, the average diffuser availability against the target of >76% over the past 4 years is good for North Head and excellent for Bondi. In the July 2025 inspection there was only one partially blocked nozzle for the North Head DOOF.

11.4 Examining pressure changes and abnormalities at North Head and Bondi WRRFs

Based on oceanographic modelling and prior to the work which further identified the Malabar system as the most likely origin of the debris balls, Sydney Water reviewed the performance of the North Head and Bondi WRRFs and DOOFs at those times identified by the oceanographic modelling. The following graphs show the HGL curves for those times. For both North Head and Bondi DOOFs no flow or pressure abnormalities were identified at the times identified by the oceanographic modelling.

Combined with the six monthly ROV monitoring and other data from clean out of the North Head bulkhead, the conclusion is that these DOOFs were unlikely to be the origin of the debris balls for the October 2024 and January 2025 debris ball landings.

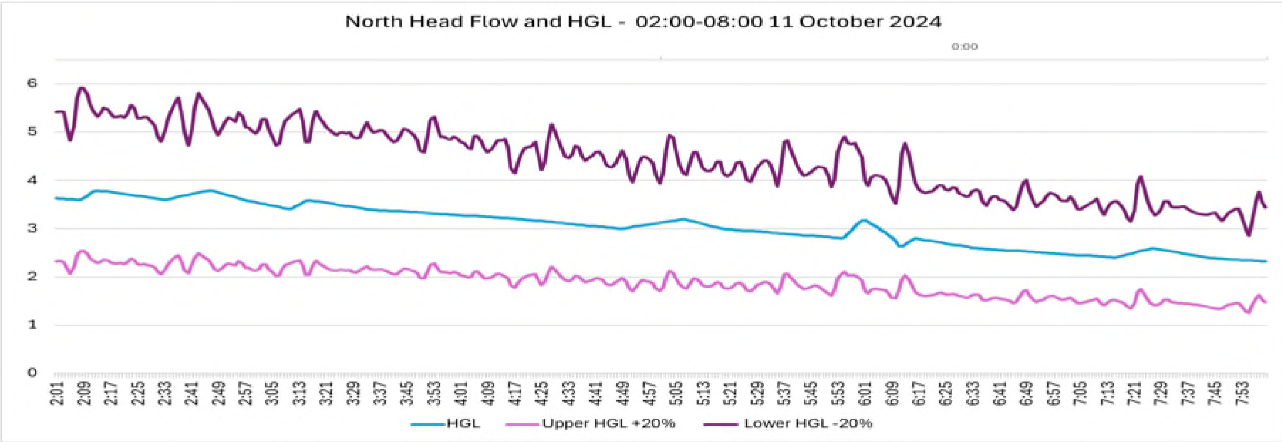

Figure 43: North Head HGL trend 11/10/2024

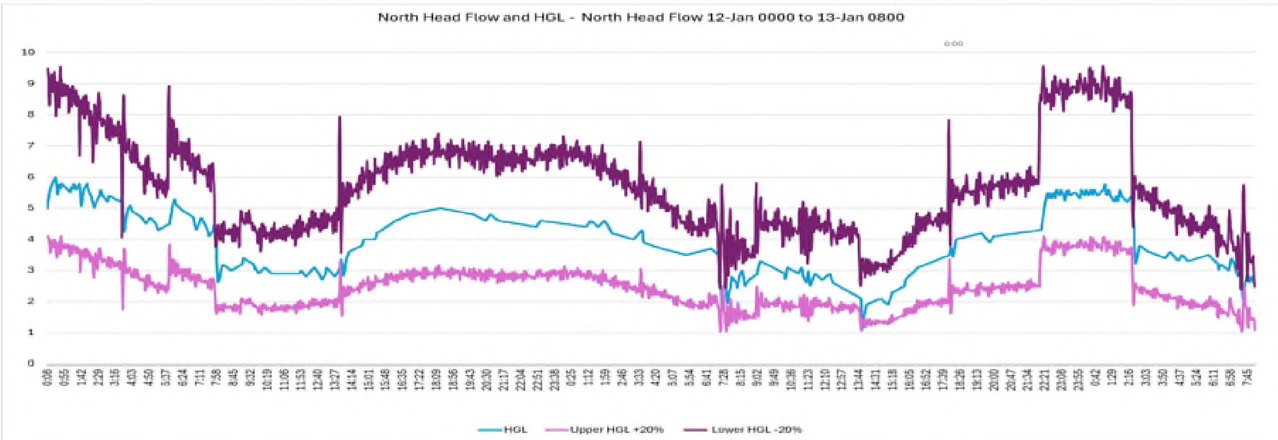

Figure 44: North Head HGL trend 13/01/2025

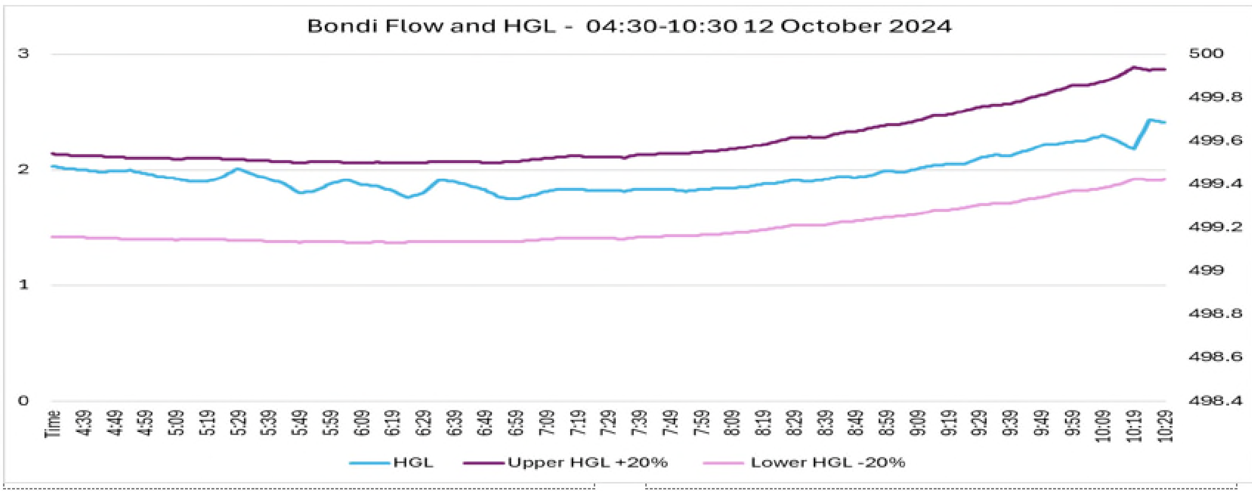

Figure 45: Bondi HGL trend 12/10/2024

During this time Sydney Water also completed inspections and maintenance activities for the North Head bulkhead. Note that the Bondi bulkhead is permanently underwater and cannot be opened without taking the

DOOF offline and discharging via cliff face for a period of several months. No internal inspection is possible. External condition assessments of the Bondi DOOF bulkhead indicate good condition.

No debris balls were found behind the North Head bulkhead door. There was an accumulation of screenings material, notably plastic cotton bud sticks which have a sufficiently low diameter to pass through the 6mm apertures of the North Head fine screens. This material has been removed and the DOOF assets (bulkhead door, cathodic protection, door seals, etc) condition assessed. Minor repairs and replacements have been completed, including replacing the door seal as per the design specification.

Figure 46 shows the type of material removed from the North Head bulkhead area. It was primarily material that had passed through the screens including plastics and grit along with FOG coated on the material. There were no large accumulations of FOG deposits.

Subsequent figures illustrate some of the challenges in performing the inspections and cleaning operations within this part of the DOOF. Figure 49 shows the outcome of the cleaning of the area behind the North Head DOOF bulkhead door.

Figure 46: Material removed from behind the North Head bulkhead door

Figure 47: Example of the difficult access conditions for entering the DOOF bulkhead door

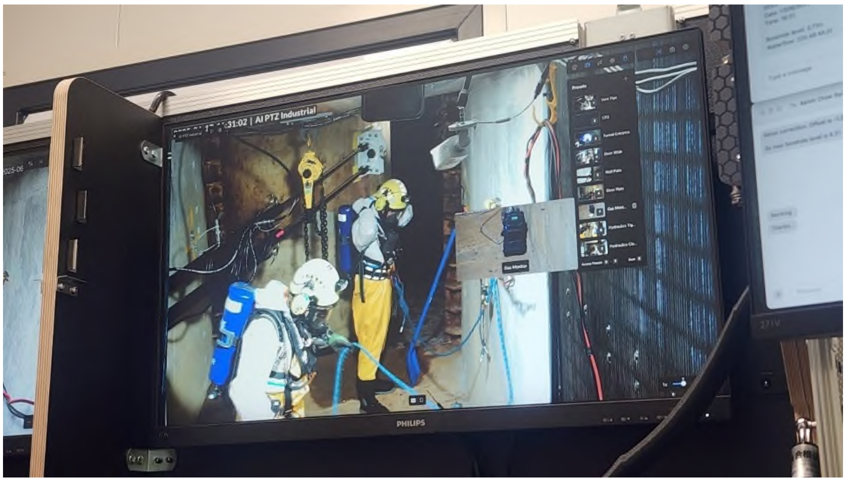

Figure 48: Example of the access when entering the DOOF bulkhead door

Figure 49: The decline tunnel to the North Head DOOF on the inside of the bulkhead door once cleaning had been completed

11.5 FOG in the North Head and Bondi systems

Sydney Water reviewed the potential for FOG accumulation in both the North Head and Bondi systems – networks and plants. Influent and effluent O&G results indicated less potential than for the Malabar WRRF. For North Head, the inspection of its DOOF bulkhead found no significant build-up of FOG. For Bondi, the previously implemented FOG program in the networks and the influent and effluent sampling data also identified no significant build up. A review of influent and effluent sampling demonstrated that both WRRFs were performing to requirements and that there was no substantial increase in FOG load in the catchments.

Inspections across the plant at North Head during this time also found no evidence of FOG and debris ball accumulation. Similar inspections across the Bondi plant found no evidence of FOG accumulation and debris balls.

At North Head, the FOG concentration has increased by 20% on the 2014-15 influent concentrations to 2024/25. Noting since 2022, as average flows have decreased, concentrations have increased suggesting reasonably constant load. The influent and effluent concentrations correlate showing consistent removal performance.

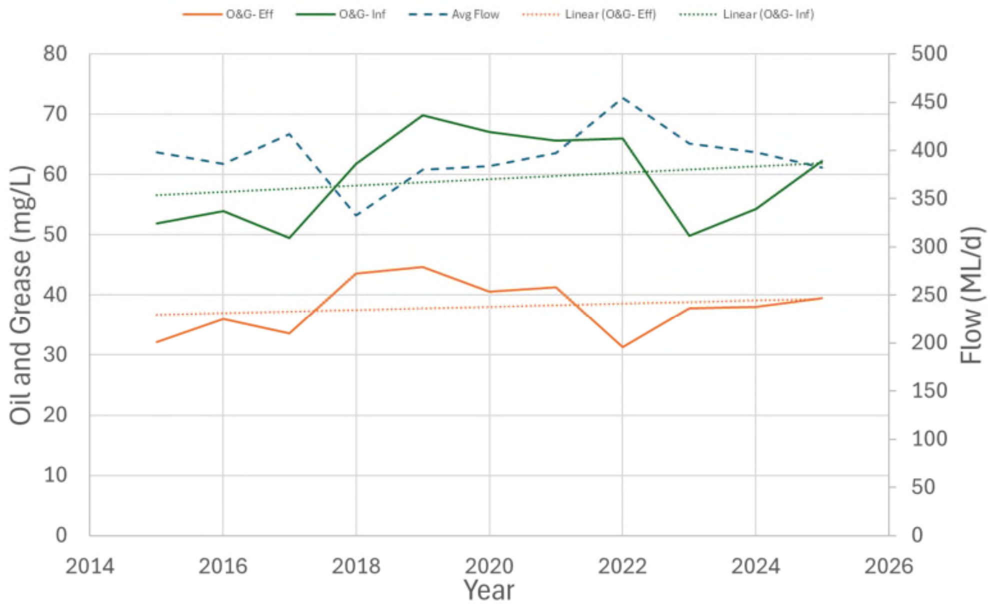

Figure 50: North Head long term O&G concentration trend

O&G concentrations in the Bondi plant influent are reasonably consistent. Note the impact of Covid on decreasing flows in the Bondi system, with more people working from home in outer catchments and fewer working and eating in the CBD.

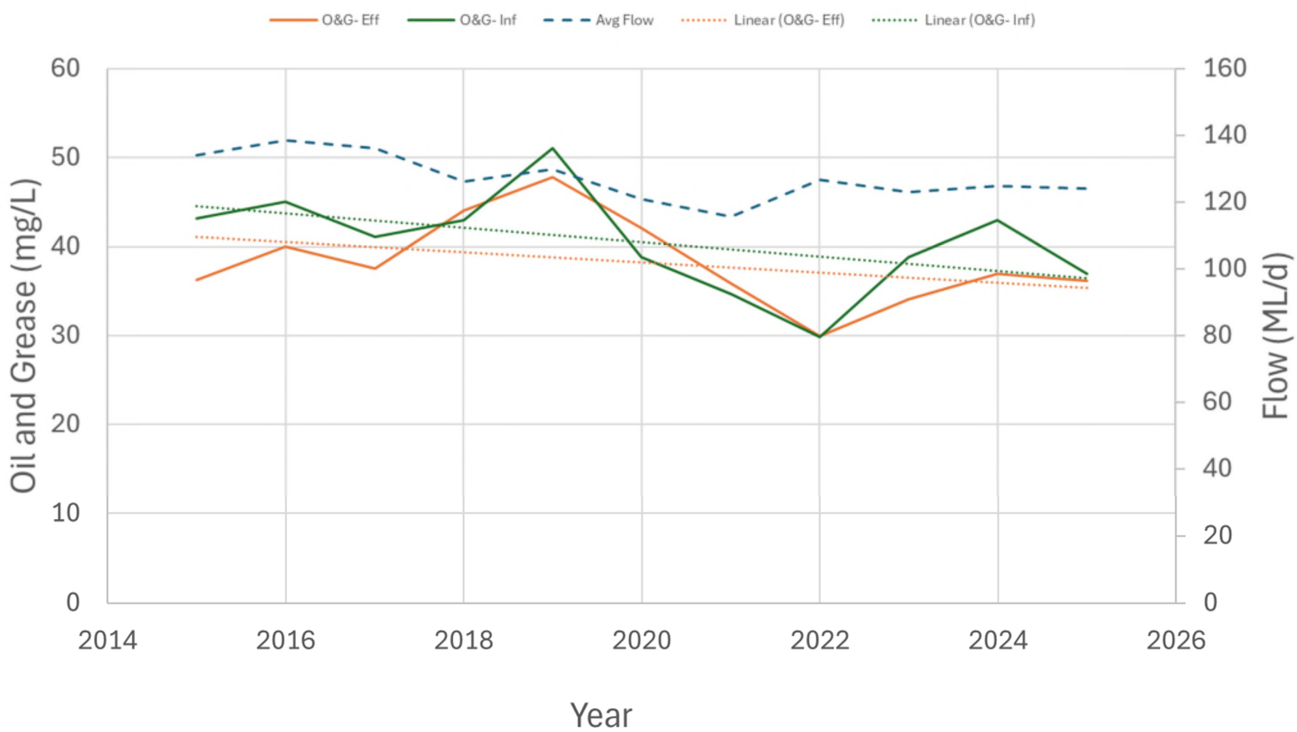

Figure 51: Bondi long term O&G concentration trend

11.6 Future actions – North Head and Bondi

In light of the outcomes of this investigation future actions for the North Head and Bondi plants focus on projects underway and ongoing operation of the assets to their EPL requirements and asset specifications. For example, delivery of the North Head biosolids upgrade will enable some additional optimisation of O&G capture and processing within the growth profile.

As noted above, in response to the hydraulic anomalies identified in the Bondi DOOF, Sydney Water has commenced an engineering project to review the hydraulic operation of the Bondi DOOF. While performance has been acceptable and the six monthly ROV monitoring has consistently identified full availability of diffuser nozzles and good operation of the DOOF, reports have noted sea water ingestion at low flows. Therefore, as a matter of prudence, Sydney Water is assessing the DOOF operation against its original design.

12. Appendix Two ROV DOOF monitoring

Recent ROV Monitoring Reports of the DOOFs

- July 2024
- November 2024
- December 2024
- July 2025