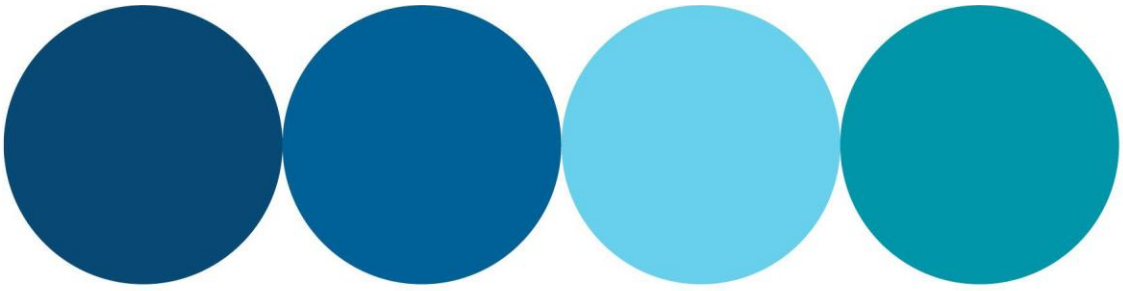
Perth Long-term Ocean Outlet Monitoring (PLOOM) Program

Beenyup Water Resource Recovery Facility

2024 - 2025 Annual Report



WATER CORPORATION

Document Management

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Hydrobiology WA Pty Ltd has prepared this report in accordance with our Integrated Management System, in compliance with ISO9001 and ISO45001.

Status

This report is 'Draft' until approved for final release, as indicated below by inclusion of signatures from: (i) the author and (ii) a Hydrobiology or their authorised delegate. A Draft report may be issued for review with intent to generate a 'Final' version but must not be used for any other purpose.

Contents

Acronyms

Acronym	Extension
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
AWRP	Advanced Water Recycling Plant
CFU	Colony Forming Unit
CTWWC	Comprehensive Treated Wastewater Characterisation (CTWWC)
DO	Dissolved Oxygen
DoH	Western Australian Department of Health
DPIRD	Western Australian Department of Primary Industries and Regional Development
EPA	Environmental Protection Authority
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guidelines
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standards
EV	Environmental Value
GWRS	Water Corporation's Groundwater Replenishment Scheme
HEPA	High Ecological Protection Area
LAC	Light Attenuation Coefficient
LEPA	Low Ecological Protection Area
LoR	Limit of Reporting
MPN	Most Probable Number
NATA	National Association of Testing Authorities
NOEC	No Observed Effect Concentration
OZE	Observed Zone of Effect
PLOOM	Perth Long-term Ocean Outlet Monitoring
RO	Reverse Osmosis
SMZ	Seafood Management Zone
TCM	Trial Compliance Monitoring (now referred to as Compliance Monitoring in 2024/25)
TTC	Thermotolerant Coliforms
TTM	Total Toxicity of the Mixture
TWW	Treated Wastewater
UF	Ultrafiltration
UV	Ultraviolet
WASQAP	Western Australian Shellfish Quality Assurance Program
WET	Whole of Effluent Toxicity
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant

What do the results in this report mean for our community?

Ocean discharge is practiced worldwide and is a safe, sustainable and cost-effective way to dispose of wastewater. Wastewater from Perth's Water Resource Recovery Facilities (WRRFs) is treated before being discharged to the ocean via ocean outlets. Treated wastewater is lighter and less dense than seawater, so it rapidly rises, mixes and dilutes into the ocean. Ocean discharges are regulated in Western Australia by the Department of Water and Environmental Regulation (DWER).

Water Corporation discharges treated wastewater from the Beenyup WRRF to the ocean via the Ocean Reef outlets. The Environmental Protection Authority (EPA; an independent authority appointed by the Governor on the recommendation of the Minister for Environment) has designated an area with a radius of 150 metres (Ministerial Statement 1219, 22 April 2024 [MS1219]) as a Low Ecological Protection Area (or LEPA). Within this area, the EPA allows for changes to marine water quality. Outside the LEPA, the EPA has designated the surrounding ocean to be a High Ecological Protection Area (HEPA) and expects there to be no detectable change in marine water quality.

Water Corporation's Perth Long-term Ocean Outlet Monitoring (PLOOM) program tests water quality around the Ocean Reef outlets to confirm it returns to the natural range expected in the High Ecological Protection Area (HEPA) and to protect the environment and recreational users (swimmers, boaters and fishers). Samples are collected within the Low Ecological Protection Area (LEPA), at the LEPA/HEPA boundary, and at reference sites representing background conditions. Results are assessed against nationally agreed criteria adopted by Western Australia's EPA: Environmental Quality Guidelines (EQG) as conservative early-warning triggers, and Environmental Quality Standards (EQS) for detailed assessment of potential impacts.

The current (2024-25) monitoring period is the first to implement the 150 m LEPA boundary around the Ocean Reef Ocean Outlets as required under MS1219. Previous monitoring used an indicative (referred to as Notional) LEPA with an approximately 100 m boundary around the outlet diffusers. To assess the implications of this change on the ability to meet the range of EQGs and EQSs at Ocean Reef, during the 2024-25 (November - March 2025) monitoring period sampling for microbiological indicators, nutrients and physical water quality was undertaken at both the Notional LEPA (100 m boundary) and the MS1219 approved LEPA (150 m boundary).

This annual report documents the findings of the 2024-25 Ocean Reef ocean monitoring as part of the PLOOM program. The compliance results for 2024-25 are summarised in report card format below. The report card contains colour-coded results with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met.

Summary report card legend

Management response[1]	Colour
Monitor: EQG & EQS met (continue monitoring)	
Investigate: EQG not met (investigate against the EQS)	
Action: EQS not met (management response required)	

Note:

1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

Summary of key indicators

The following section provides a summary of the key indicators assessed during the 2024/25 PLOOM program. Please refer to the main report for a more comprehensive overview.

Ecosystem integrity

Ecosystem Integrity aims to protect the ecosystem from potential impacts from the treated wastewater discharge and maintain the variety and quantity of marine life at a high level. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Toxicants in treated wastewater (TWW)			
Bioaccumulating toxicants	Cadmium and mercury are toxicants that can build up in the tissues of marine organisms and contaminate seafood. The concentration of these toxicants is measured in undiluted TWW against national guidelines that are designed to protect marine life.		Concentrations of cadmium and mercury were below the guideline values.
Non-bioaccumulating toxicants	Some low levels of contaminants (e.g. detergents, metals and oils) may persist in treated wastewater after treatment at the WRRF and are possibly discharged at the outlet. Monitoring ensures they are not directly toxic or likely to accumulate in marine life.		Concentrations of toxicants were below the guideline values.
Total toxicity of the mixture (TTM)	TTM measures the potential for a combined, or cumulative, effect of ammonia, copper, and zinc in the TWW after it has been diluted into the ocean. It is used as an additional interpretative tool for estimating the potential toxicity of TWW.		The total toxicity of the mixture was below the guideline value.
Whole of effluent toxicity (WET)	WET testing is another tool to test the potential toxicity of the TWW to marine life. WET testing is particularly useful for toxicants that occur in very low concentrations, or for which there are no national guidelines on safe levels. Direct tests on organisms determine the actual toxicity of the treated wastewater and demonstrate that the discharge is not		The TWW plume is sufficiently diluted to achieve the No Observed Effect Concentration at the management boundary.

Indicator	Indicator purpose	Result	Commentary
	harmful to the ocean environment.		
Nutrient enrichment and phytoplankton blooms			
Chlorophyll-*a*	Phytoplankton are a naturally occurring part of the marine environment, but treated wastewater contains nutrients (ammonia, nitrite, nitrate and orthophosphate) that can stimulate phytoplankton growth. Chlorophyll-*a* (the active constituent in phytoplankton) concentration is used as an indicator for phytoplankton abundance.		Median chlorophyll-*a* concentration within the high ecological protection area (HEPA) exceeded the 80th percentile of reference site concentrations. The EQS based upon LAC was not exceeded. Phytoplankton biomass (measured as chlorophyll-*a*) exceeded EQG 1 on one occasion but did not exceed EQS 1. Phytoplankton biomass met EQG 2.
Physical and chemical stressors			
Organic enrichment	Organic matter in treated wastewater is naturally decomposed by bacteria. Oxygen dissolved in water is used by the bacteria during the decomposition process. If the bacteria use more dissolved oxygen (DO) than they produce, the DO levels fall. Low DO levels can be harmful to marine life. We measure the dissolved oxygen concentration against the Environmental Protection Authority (EPA) guidelines.		The amount of DO was normal at all locations near the outlets. DO levels near the outlets were similar to those at the reference sites. There was a very low risk of DO levels falling below critical levels.
Salinity	Salinity refers to the 'saltiness' of water. Treated wastewater is fresh whereas the ocean is saline. When treated wastewater is discharged to the ocean, salinity will be reduced in an area around the outlets until the fresher water is fully mixed with the saline seawater. Low salinity water may cause stress to marine life.		Measurements of salinity near the outlets were similar to the salinity at reference sites. Stress to marine life from low salinity is unlikely.

Seafood safe for human consumption

Seafood safe for human consumption aims to ensure that caught or grown seafood remains safe for eating. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Microbial contaminants			
Thermotolerant coliforms (TTC) near the outlets	The risk from bacteria to seafood safety is assessed using the indicator organism thermotolerant coliforms.		The relevant concentrations of thermotolerant coliforms near the outlets were below the level where they can be detected by the laboratory. The risk to public health from bacteria via seafood in the vicinity of the outfalls was very low.
Shoreline TTC			The relevant concentrations of thermotolerant coliforms adjacent the beaches were below the level where they can be detected by the laboratory. The risk to public health from bacteria via seafood in the vicinity of the beaches was very low.
Algal biotoxins			
Toxic phytoplankton species	In some cases, phytoplankton can include species than can taint seafood.		There were no detections of potentially toxic phytoplankton species above levels that would pose a risk to seafood.

Primary and secondary contact recreation

Primary and secondary contact recreation aims to ensure that water quality is suitable for primary (e.g. swimming and diving) and secondary (e.g. fishing and boating) recreation contact activities. The indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Faecal Indicators			
Enterococci spp. near the outlets	The risk from bacteria to recreation contact (swimming and boating) is assessed using the indicator organism *Enterococci* spp.		The relevant concentrations of *Enterococci* spp. near the outlets were below the level where they can be detected by the laboratory. The risk to public health from bacteria via recreation in the vicinity of the outfalls was very low.
Shoreline *Enterococci* spp.			The relevant concentrations of *Enterococci* spp. adjacent the beaches were below the level where they can be detected by the laboratory. The risk to public health from bacteria via recreation in the vicinity of the outfalls was very low.
Algal biotoxins			
Phytoplankton cell concentration	In some cases, phytoplankton can reach concentrations that may harm swimmers (called blooms). The level that defines an algal bloom for recreational purposes is a phytoplankton cell count exceeding 10,000 cells/mL.		The highest phytoplankton cell concentration detected in the HEPA during the monitoring program was 4,545 cells/mL. This was significantly lower than the threshold of the definition for a bloom (10,000 cells/mL). This would infer there were no blooms detected that were directly attributed to the discharge of treated wastewater.

Aesthetics and fish tainting substances

Aesthetics aims to ensure that aesthetic values of the marine environment are protected. The top indicators we look at that give us an understanding of this are as follows:

Indicator	Indicator purpose	Result	Commentary
Aesthetic factors	Perth's coastal waters are aesthetically pleasing, and that aesthetic value needs to be protected. Nuisance organisms (macrophytes, scums, algal mats, blue green algae and fungus), dead organisms, dirty water, oily films, debris, or objectionable odours have the potential to reduce the aesthetic appeal.		Standardised field observations, as recorded during each monitoring event confirmed that Aesthetic Values were maintained within the criteria of the EQG and EQS.
Fish tainting substances	The guidelines for fish tainting substances are based on levels of contaminants that may make water or edible marine life unpalatable (but not toxic) to people.		Fish tainting substances were below the guideline values

Executive Summary

This report documents the findings of the 2024-2025 Ocean Reef monitoring program. The report outlines the findings of three environmental monitoring programs:

- Compliance Monitoring (TCM)
- Whole of Effluent Toxicity (WET) testing
- Comprehensive Treated Wastewater Characterisation (CTWWC).

The Ministerial Statement (MS) was updated in April 2024 for Ocean Reef from MS382 and MS569 to MS1219. MS1219 is EPA approved and sets the LEPA at 150 m. In the previous versions, the LEPA distance wasn't formally approved by EPA and therefore is stated as 'notional'. The 'notional' 100 m boundary has been informally applied since monitoring around the outfall commenced; since that time, inflow to the plant has increased. EPA has accounted for this in setting the LEPA at 150 m.

Results are reported in the context of the Environmental Quality Management Framework (EQMF) described in EPA (2017). Under the EQMF, Water Corporation should annually demonstrate achievement against Environmental Quality Objectives (EQOs):

- Maintenance of Ecosystem Integrity
- Maintenance of Seafood for Human Consumption
- Maintenance of Primary and Secondary Recreation
- Maintenance of Aesthetic Values.

The compliance results for 2024-2025 are reported in this document which contains colour-coded results with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met.

Summary report card legend

Management response[1]	Colour
Monitor: EQG & EQS met (continue monitoring)	
Investigate: EQG not met (investigate against the EQS)	
Action: EQS not met (management response required)	

Note:

1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

There are several EQC relevant to the Environmental Quality Objective (EQO) 'Maintenance of Ecosystem Integrity': the first is assessed based on the constituents of the treated wastewater (TWW) stream and their potential toxicity, while the remainder are based on monitoring of water column nutrients, phytoplankton abundance and physical-chemical stressors in the receiving environment.

Toxicants in treated wastewater

There are four Environmental Quality Guidelines (EQGs) for TWW toxicants:

- EQG: Concentrations of bioaccumulating toxicants (specifically, cadmium and mercury) must be below their respective EPA (2017) 80% species protection guidelines prior to discharge and dilution with seawater. Concentrations of bioaccumulating toxicants were below their laboratory limits of reporting and the 80% species protection guidelines in all cases, thus meeting the EQG.
- EQG: Concentrations of non-bioaccumulating contaminants must not exceed the EPA (2017) 99% species protection guideline at the Low Ecological Protection Area (hereafter LEPA) boundary (150 m radius from the diffuser). Initial dilution modelling for conditions on 19 February 2025 found that the Ocean Reef outlets were achieving a worst-case average initial dilution of 1:370. This was sufficient to dilute all contaminants to concentrations below their respective 99% species protection guidelines. The EQG 2 for toxicants in TWW was therefore met.
- EQG: The total toxicity of the mixture (TTM) for the additive effect of ammonia, copper, and zinc in the diluted TWW plume must be less than 1.0 (ANZG 2018). The TTM following initial dilution was 0.51, which is lower than the guideline and EQG 3 was met.
- EQG: The highest concentration of TWW at which there is no statistically significant observed effect on fertilisation of sea urchin gametes exposed to different concentrations of TWW (NOEC) must be greater than 1.0% TWW concentration. The lowest NOEC from tests undertaken in February 2025 and March 2025 was 6.3% and the EQG 4 was met.

Water quality monitoring – receiving environment

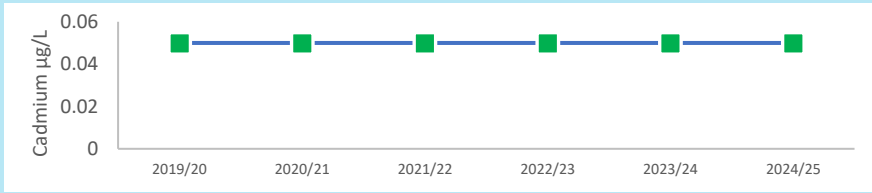
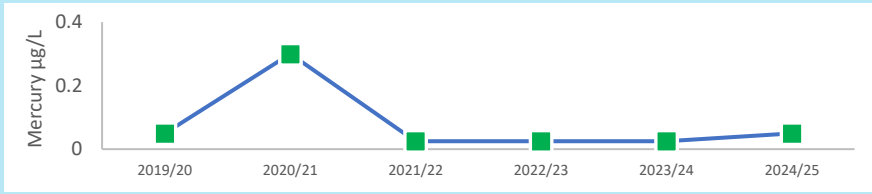
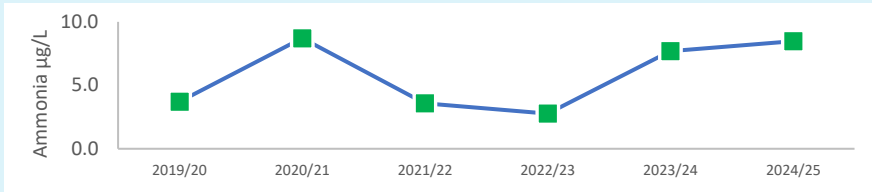
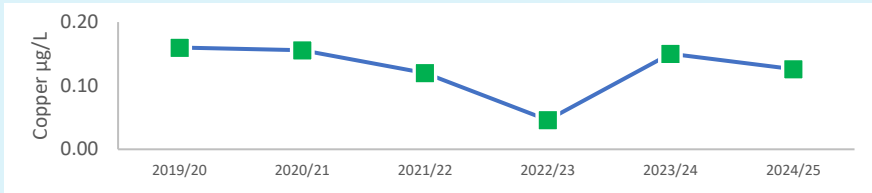
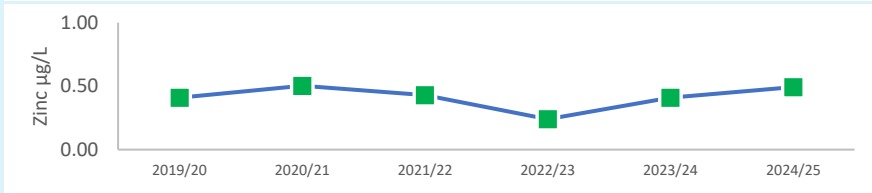
Ocean sampling was conducted on ten occasions between November 2024 and March 2025 at fixed distance intervals down-current (determined using a drogue) of the outlets. There are five EQGs based on chlorophyll-*a* concentration (a measure of phytoplankton biomass), dissolved oxygen and salinity:

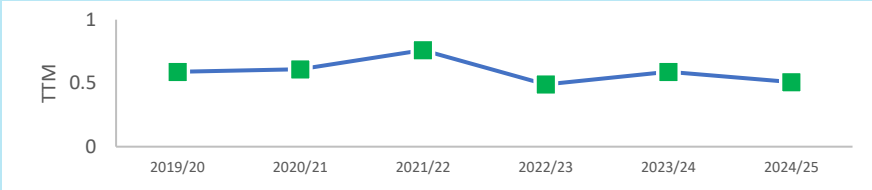
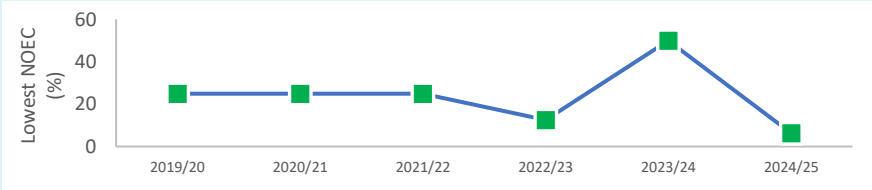
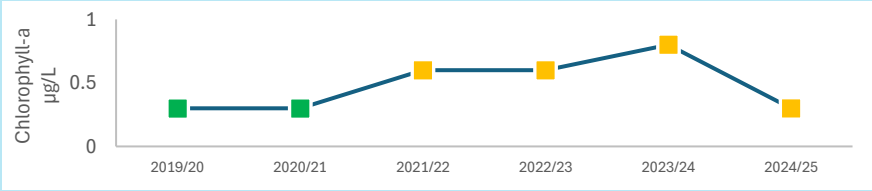
- EQG: The median chlorophyll-*a* concentration of HEPA sites (i.e., 150 m and greater from the diffuser) during the non-river flow period must not exceed the 80th percentile of reference site data during the summer monitoring period. The median chlorophyll-a concentration of sites within the high ecological protection area (HEPA) was greater than the 80th percentile of reference site concentrations (0.22 µg/L) and the EQG was not met. The EQS for LAC was therefore investigated.
  - EQS: Median light attenuation derived from pooled HEPA sites during the summer monitoring period is not to exceed the two-year rolling 80th percentile of the reference site data in two consecutive years. Median LAC pooled from HEPA sites during both the 2024-25 and 2023-24 summer monitoring periods did not exceed their respective two-year rolling 80th percentile of reference site data values. Therefore, the EQS was maintained within the threshold criteria (i.e. EQS met).

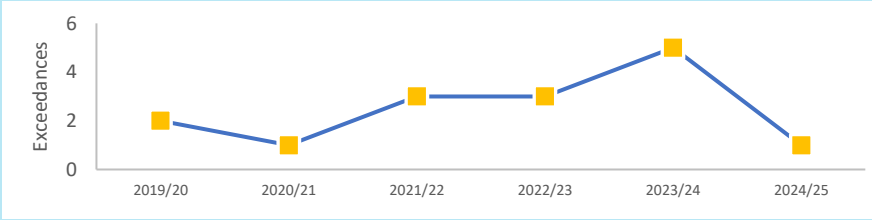
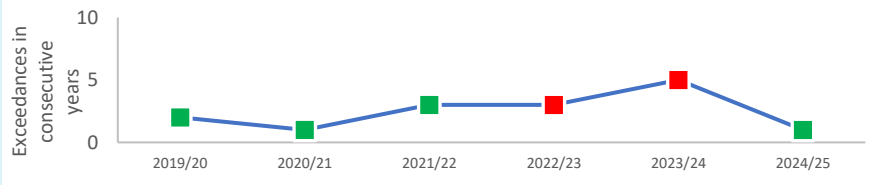
- EQG: Median phytoplankton biomass, measured as chlorophyll-*a*, at HEPA sites must not exceed three times the median chlorophyll-*a* concentration of reference sites, on any occasion during the summer monitoring period. Median chlorophyll-*a* concentrations exceeded three times the median of reference sites on one occasion (18th February 2025) and the EQG was not met, triggering assessment against the EQS.
    - EQS: Median phytoplankton biomass measured as chlorophyll-*a* exceeded three times median chlorophyll-*a* concentration of reference sites on five occasions in 2023-24 and once in 2024-25. As the exceedance did not occur on more than one occasion in both years, the EQS was met.
- EQG: Phytoplankton biomass, measured as chlorophyll-*a*, at any HEPA site must not exceed three times the median chlorophyll-*a* concentration of reference sites, on 25% or more occasions during the summer monitoring period. Phytoplankton biomass, measured as chlorophyll-*a*, exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) on 20% of occasions at HEPA sites and the EQG was met.
- EQG: Median dissolved oxygen in bottom waters (0 – 0.5 m above the sediment surface) in the HEPA must be greater than 90% saturation at any site for a defined period of not more than 6 weeks. Dissolved oxygen saturation within the HEPA was above 90% saturation at all times and the EQG was met.
- EQG: Median salinity (0.5 m below the water surface) at an individual HEPA site over any period is not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period. Median salinity was between the 20th and 80th percentiles of the natural salinity range within the HEPA (at 150, 350, 1000, and 1500 m from the outlets) and the EQG was met.

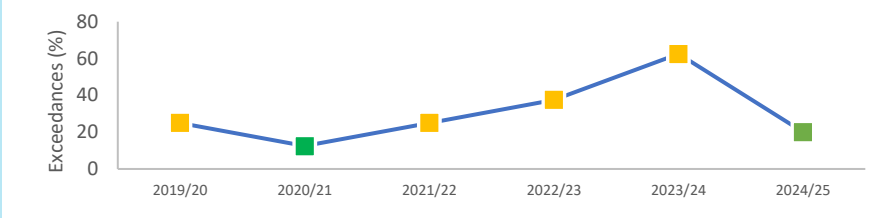
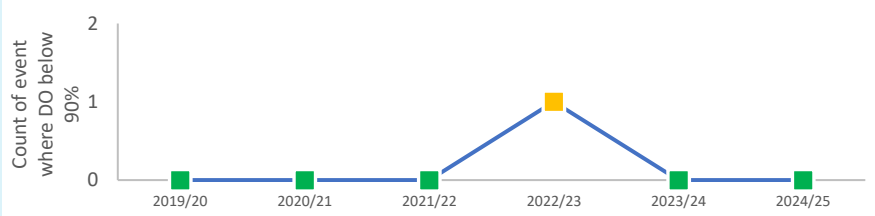
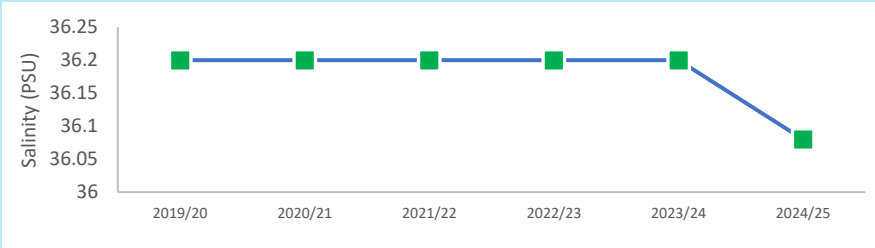
The exceedances of the EQG described above were due to a gradual increase in the background chlorophyll-*a* concentration (and associated increase in light attenuation). The EQG were met if assessed against the criteria based on the corresponding sampling period.

Summary report card for the Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Toxicants in treated wastewater (TWW)	Bioaccumulating toxicants	EQG 1	Concentrations of cadmium and mercury in the undiluted TWW stream were below their limit of reporting and the EPA (2017) 80% species protection guidelines (36 and 1.4 µg/L, respectively).		 
	Non-bioaccumulating toxicants and initial dilution	EQG 2	Initial dilution on 19/02/2025 (1:370) was sufficient to reduce non-bioaccumulating contaminant concentrations to below their EPA (2017) 99% species protection guidelines.		  

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
	Total Toxicity of the Mixture (TTM)	EQG 3	The TTM for the additive effect of ammonia, copper, and zinc after initial dilution (0.51) was below the ANZG (2018) guideline of 1.0		
	Whole of Effluent Toxicity (WET)	EQG 4	The lowest NOEC[3] during the reporting period was 6.3%. Sixteen dilutions with background seawater are required to achieve this NOEC[4], which is lower than the worst-case dilutions achieved at the LEPA[2] boundary during the monitoring period (1:370).		
Nutrient enrichment	Chlorophyll-*a*	EQG 1	Median chlorophyll-*a* concentration of sites within the high ecological protection area (HEPA[2]) exceeded the 80th percentile of reference site concentrations (0.22 µg/L)		

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
		EQS 1	Median LAC from pooled HEPA sites during the summer monitoring period (0.082 m^{-1}) did not exceed the two-year rolling 80th percentile of the reference site data for both 2024-25 and 2023-24 (0.104 m^{-1}).		
Phyto-plankton blooms	Phytoplankton biomass (measured as chlorophyll-*a*)	EQG 1	Median chlorophyll-*a* concentrations exceeded three times the median of reference sites on one occasion (18 February 2025).		
		EQS 1	Median chlorophyll-*a* concentration exceeded three times the median of reference sites on one occasion in the 2024-25 non-river flow period and five times in the 2023-24 non-river flow period.		

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
		EQG 2	Phytoplankton biomass, measured as chlorophyll-*a*, exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) on 20% of occasions at HEPA[2] sites.		
Physical-chemical stressors	Organic enrichment	EQG 1	Dissolved oxygen saturation within the HEPA[2] was above 90% saturation at all times.		
	Salinity	EQG 2	Median salinity was between the 20th and 80th percentiles of the natural salinity range within the HEPA[2] (at 150, 350, 1000, and 1500 m from the outlets).		

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. LEPA = low ecological protection area; HEPA = high ecological protection area.
3. NOEC = no observed effect concentration; the highest concentration of TWW at which there is no statistically significant observed effect on gamete fertilisation.

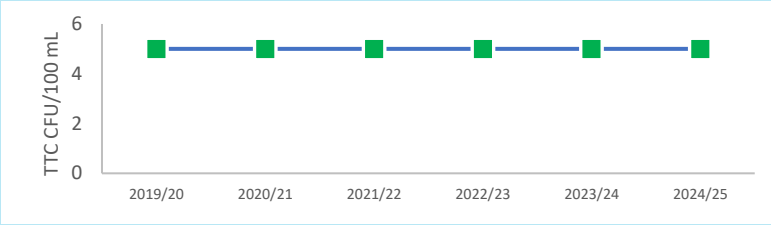
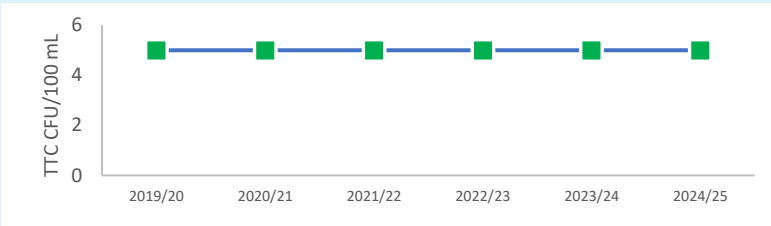
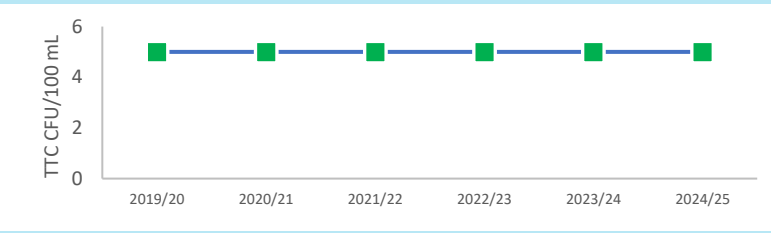
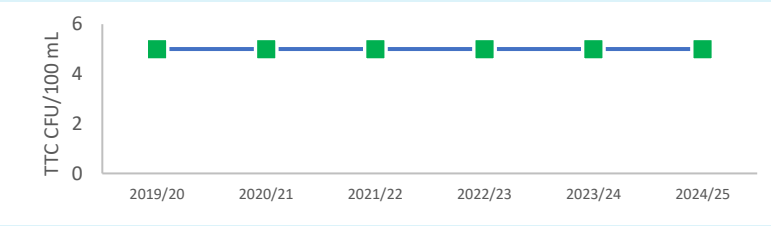
Environmental Quality Objective ‘Maintenance of Seafood Safe for Human Consumption’

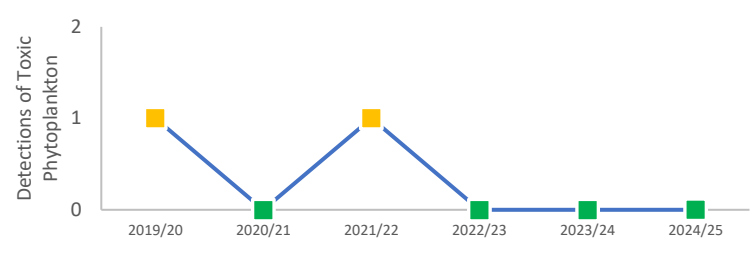
There are two EQC for the EQO 'Maintenance of the Seafood Safe for Human Consumption': the first is based on in-water concentrations of thermotolerant coliforms (TTC), and the second is based on in-water concentrations of toxic phytoplankton species (to monitor for algal biotoxins):

- To meet the EQG, median TTC counts (rolling median consisting of 100 samples) at the Seafood Management Zone (SMZ) boundary are not to exceed 14 CFU/100 mL and the 90th percentile of TTC concentrations must not exceed 21 CFU/100 mL. Median TTC concentration at SMZ sites pooled for the 2022-23, 2023-24 and 2024-25 sampling seasons[1] was at the limit of reporting (<10 CFU/100 mL) and below the 14 CFU/100 mL guideline. The 90th percentile TTC concentration was equal to the limit of reporting (<10 CFU/100 mL) and less than the 21 CFU/100 mL criteria. The EQG for TTC was met.
- Water Corporation conducts TTC monitoring additional to that required by the MMP along the shoreline. These results are informally assessed against the EQC. To meet the EQG at shoreline sites, median TTC concentrations are not to exceed 14 CFU/100 mL and the 90th percentile of TTC concentrations must not exceed 21 CFU/100 mL. Median TTC concentration at shoreline monitoring sites pooled from the 2023-24 and 2024-25 sampling seasons[1] was at the limit of reporting (<10 CFU/100 mL) and below the 14 CFU/100 mL guideline. The 90th percentile TTC concentration was equal to the limit of reporting (<10 CFU/100 mL) and less than the 21 CFU/100 mL criteria. The EQG for TTC was met.
- To meet the EQG for algal biotoxins, concentrations of potentially toxic algae at sites at the boundary of the SMZ must not exceed the Western Australian Shellfish Quality Assurance Program (WASQAP; DoH 2025) concentrations. There were no exceedances recorded during the 2024-25 extended summer monitoring period and the EQG was met.

[1] *NHMRC (2008) guidelines and EPA (2005) suggest that a minimum of 100 samples over the non-river flow period (pooled from multiple years if required) are needed for accurate assessment of microbial water quality EQC*

Summary report card for the Environmental Quality Objective 'Maintenance of Seafood Safe for Human Consumption'

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Microbiological contaminants (outlet sites)	Thermotolerant coliforms (TTC)[2, 3]	EQG	Median TTC concentrations derived from 130 samples collected over the 2024-25 sampling season was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria.		
			The 90th percentile was equal to the limit of reporting[6] (<10 CFU/100 mL) and below the 21 CFU/100 mL criteria.		
Microbiological contaminants (shoreline sites)[5]		EQG	Median TTC concentrations derived from 144 shoreline samples collected over the 2022-23 to 2024-25 sampling seasons was at the limit of reporting[6] (<10 CFU/100 mL) and below the 14 CFU/100 mL criteria.		
			The 90th percentile of TTC at the shoreline was equal to the limit of reporting[6] (<10 CFU/100 mL) and below the 21 CFU/100 mL criteria.		

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Algal biotoxins	Toxic phytoplankton species	EQG	Toxic phytoplankton species did not exceed the Western Australian Shellfish Quality Guidelines[4] during the 2024-25 monitoring period.		

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. TTC results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate median value (ANZG 2018).
3. TTC = Thermotolerant coliforms, CFU = colony forming units
4. Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025)
5. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.
6. Where results were reported at or below the laboratory Limit of Reporting (LOR), a value of 0.5 × LOR was assigned for analysis.

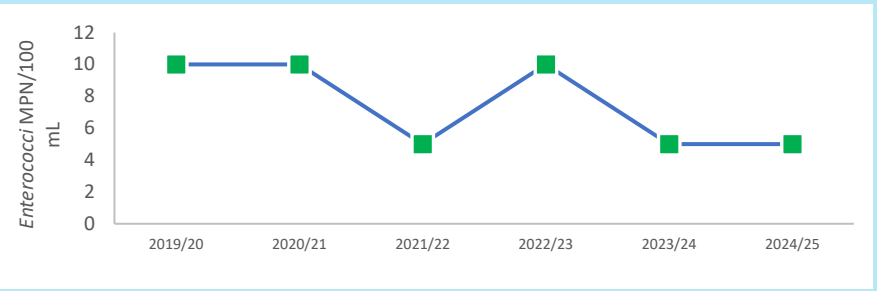
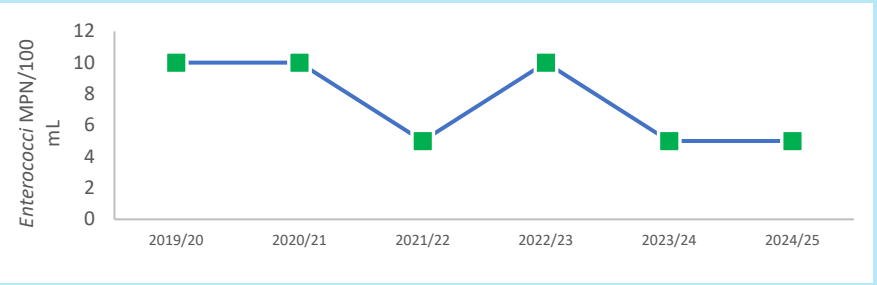
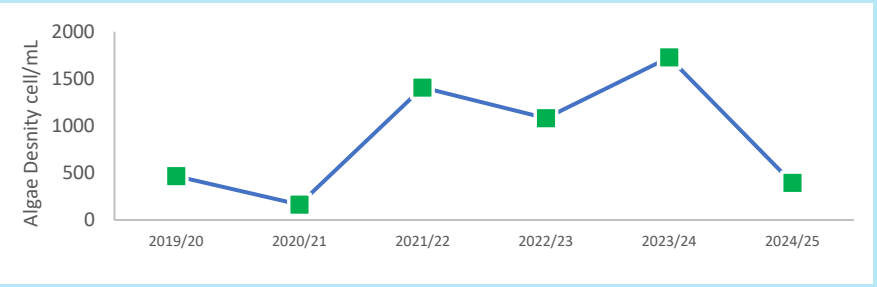
Environmental Quality Objective 'Maintenance of Primary and Secondary Recreation'

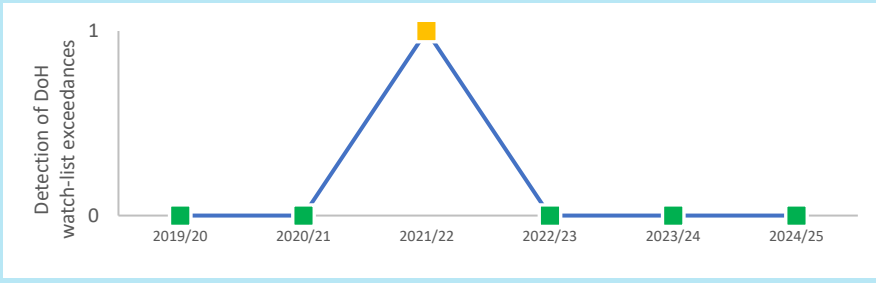
There are two EQC for the EQO 'Maintenance of Primary and Secondary Recreation': the first is based on in-water concentrations of faecal indicators (*Enterococci* spp.), and the second is based on in-water measures of total phytoplankton cell densities.

- To meet the *Enterococci* spp. EQGs, the 95th percentile value of faecal indicators (*Enterococci* spp.) outside the Observed Zone of Effect (OZE) boundary must not exceed 200 MPN/100 mL and 2,000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95th percentile of *Enterococci* spp. concentrations outside the OZE, based on pooled data from three sampling seasons (2022–23, 2023–24 and 2024-25)[3], was <10 MPN/100 mL, meeting the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation.
- To meet the *Enterococci* spp. EQGs, the 95th percentile value of faecal indicators (*Enterococci* spp.) at monitoring sites along the shoreline must not exceed 200 MPN/100 mL and 2,000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95th percentile of *Enterococci* spp. concentrations at shoreline sites, based on pooled data from two sampling seasons (2023–24 and 2024-25)[2], was <10 MPN/100 mL, meeting the EQGs for both primary (EQG 1) and secondary (EQG 2) contact recreation.
- To meet the toxic algae EQG 1, the median total phytoplankton cell count at a specified site should not exceed 10,000 cells/mL during normal plant operating conditions. Additionally, any watch-list species as defined by the Department of Health (DoH; 2022) should not exceed their trigger levels. The highest median total phytoplankton cell concentration was 4,545 cells/mL and the EQG was met. Watch list species did not exceed their respective trigger levels during the monitoring period (DoH; 2022).
- To meet the algal biotoxin EQG 2, there should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column. Water Corporation did not receive any reports of skin or eye irritation or potential algal poisoning in swimmers, meeting the EQG.

[2] *NHMRC (2008) guidelines and EPA (2005) suggest that a minimum of 100 samples over the non-river flow period (pooled from multiple years if required) are needed for accurate assessment of microbial water quality EQC*

Summary report card for the Environmental Quality Objective 'Maintenance of Primary and Secondary Contact Recreation'

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Faecal Indicators Outlet sites	*Enterococci* spp.	EQG 1	The 95th percentile of *Enterococci* spp. concentrations (<10 MPN/100 mL) was lower than the primary and secondary contact EQGs (200 and 2000 MPN/100 mL, respectively).		
		EQG 2			
Faecal Indicators Shoreline sites[2]		EQG 1	The 95th percentile of *Enterococci* spp. concentrations (<10 MPN/100 mL) was lower than the primary and secondary contact EQGs (200 and 2000 MPN/100 mL, respectively).		
		EQG 2			
Algal biotoxins	Phytoplankton (cell concentration)	EQG 1	During the 2024-25 monitoring period, there were no median total phytoplankton cell concentrations exceeding 10,000 cells/mL, and no detections of DoH watch-list species exceeding their guidelines.		

					
		EQG 2[3]	During the 2024-25 monitoring period, there were no reports from the Department of Health to Water Corporation about any skin or eye irritation or potential algal poisoning in swimmers on any occasion.		

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.
3. Monitoring for EQG2 for algal biotoxins commenced in the 2024-25 sampling season in accordance with Ministerial Statement 1219.

Environmental Quality Objective 'Maintenance of Aesthetic Values'

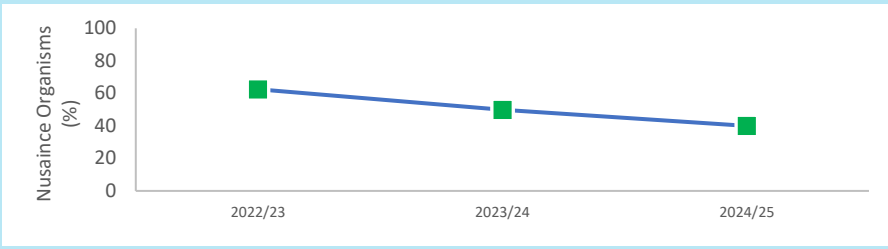
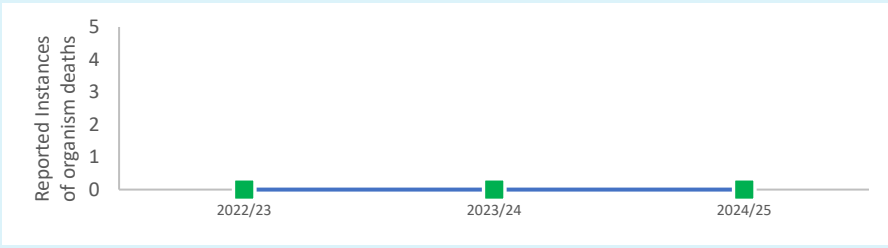
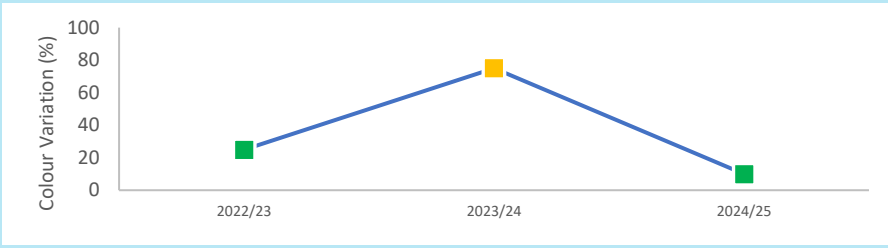
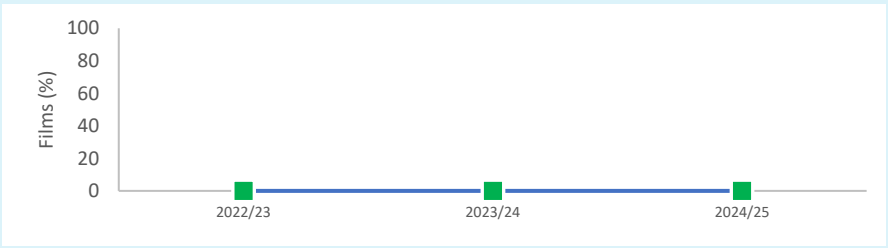
The EQO 'Maintenance of Aesthetic Values' is to ensure that Perth's coastal waters are aesthetically pleasing and that the aesthetic value is protected.

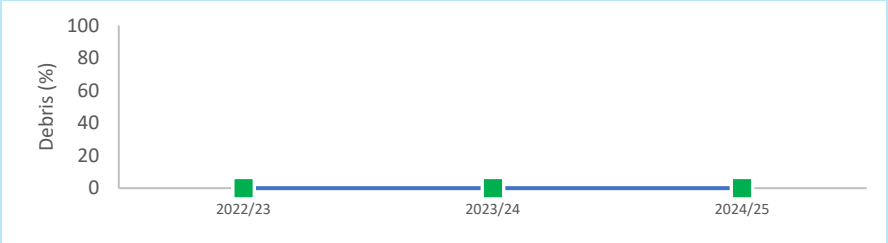
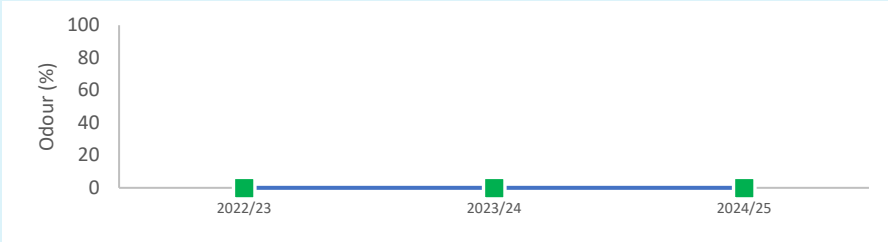
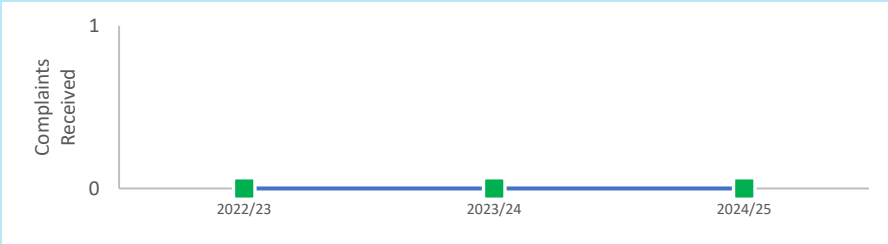
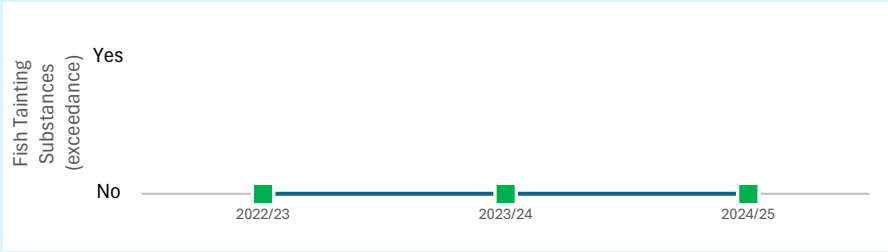
There are a series of EQGs that ensure this EQO is being met:

- Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, and sewage fungus should not be present in excessive amounts. Nuisance organisms were not present in excessive amounts and the EQG was met.
- There should be no reported incidents of large-scale deaths of marine organisms relating from unnatural causes. There were no instances of dead marine organism observed and the EQG was met.
- The natural visual clarity of the water should not be reduced by more than 20% at the Primary Contact Recreation boundary. Measurements of light attenuation determined that the natural visual clarity of the water was reduced by ~10% (i.e. <20%) and the EQG was met.
- The natural hue of the water should not be changed by more than ten points on the Munsell scale. There was a noticeable colour variation (brown tones) on one (10%) sampling occasion and the EQG was met.
- Oil and petrochemicals should not be noticeable as a visible film on the water or detectable by odour. No surface films or oil were recorded on any sampling event and the EQG was met.
- Water surfaces should be free of floating debris, dust and other objectionable matter, including substances that cause foaming. No floating debris or matter was visible on the surface on any sampling occasion and the EQG was met.
- There should be no objectionable odour. No noticeable odour was detected on any sampling occasion and the EQG was met.
- Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Primary Contact Management Zone boundary during normal plant operating conditions. None of the parameters assessed exceeded their respective guidelines, and the EQG for fish tainting substances was met.

A recent independent report commissioned by the Department of Water and Environmental Regulation has shown there is no evidence that the community should be concerned about the outfall discharge affecting water quality at Mullaloo beach (O2 Marine, 2024).

Summary report card for the Environmental Quality Objective 'Maintenance of Aesthetic Values'

Environmental Quality Indicator[2]	EQC	Comments	Compliance[1]	3-year compliance trend (including current year)
Nuisance organisms	EQG	Nuisance organisms were not present in excessive amounts.		
Faunal deaths	EQG	There were no instances of dead marine organism observed.		
Colour	EQG	There was a noticeable colour variation (brown tones) on one (10%) sampling occasions.		
Surface films	EQG	No surface films or oil were recorded on any sampling event		

Environmental Quality Indicator[2]	EQC	Comments	Compliance[1]	3-year compliance trend (including current year)
Surface debris	EQG	No floating debris or matter was visible on the surface on any sampling occasion.		
Odour	EQG	No noticeable odour was detected on any sampling occasion.		
Overall aesthetic water quality values of the marine receiving environment	EQS	Water Corporation did not receive any direct complaints during the summer monitoring period (November 2024 – April 2025).		
Fish Tainting Substances	EQG	Fish tainting substances, as measured in the comprehensive treated wastewater characterisation did not exceed the guideline values		

Notes:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Aesthetics monitoring commenced in the 2022-23 sampling season.

1 Introduction

1.1 Document purpose

This annual report documents the findings of the 2024–25 Ocean Reef ocean monitoring program, completed as part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) Program. Monitoring was completed according to Western Australia's Environmental Quality Management Framework (EQMF; EPA 2016) and the Beenyup Ocean Outlets Monitoring and Management Plan, under Ministerial Statement 1219 (BMT, 2023).

1.2 Water Resource Recovery Facility (WRRF) infrastructure and discharge

Water Corporation operates the Beenyup Water Resource Recovery Facility (WRRF) in metropolitan Perth, which treats approximately 116 ML wastewater per day to produce advanced secondary treated wastewater (TWW). The TWW is traditionally discharged to the sea through two ocean outlets at Ocean Reef (Figure 1). The outlets are 1.65 km (Outlet A) and 1.85 km (Outlet B) in length and located in ~10 m of water (Figure 1). Discharge commenced from Outlet A in 1978 and Outlet B in 1992.

Stage 1 of Water Corporation's Perth Groundwater Replenishment Scheme (GWRS) consists of a 14 GL/year capacity plant. Secondary TWW from the Beenyup WRRF is diverted into the Advanced Water Recycling Plant (AWRP) and further treated via ultrafiltration (UF), reverse osmosis (RO) and ultraviolet (UV) disinfection processes to drinking water standard for recharge of the confined aquifers.

The AWRP reduces the environmental impact of potable water extraction from the aquifer but with a corresponding reduction in the volume and change to the composition of the TWW being discharged to the marine environment through the ocean outlets. Stage 2 of the GWRS increased the capacity of the AWRP to 28 GL/year to have the ability to treat a larger proportion of the secondary TWW from the Beenyup WRRF for groundwater recharge and further reduce/alter the discharge to the ocean (Figure 1).

1.2.1 Independent Review into Water Quality and Local Current Flows at Mullaloo

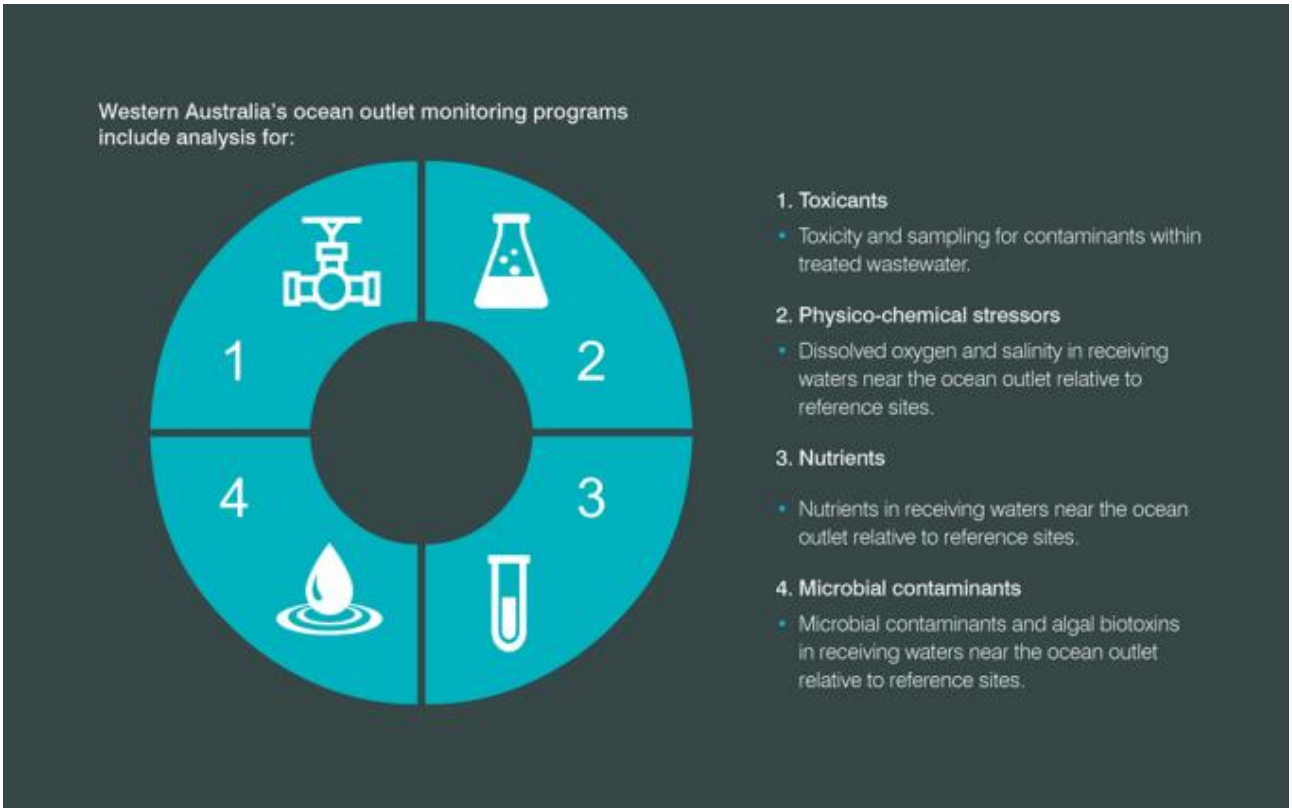
Water Corporation acknowledges the broader community interest in the aesthetic values of the marine environment in the Ocean Reef area. During the summer monitoring period (November 2024 – April 2025), no complaints were received directly by Water Corporation.

A recent independent report commissioned by the Department of Water and Environmental Regulation[3] has shown there is no evidence that the community should be concerned about the outfall discharge affecting water quality at Mullaloo beach (O2 Marine, 2025).

[3] https://www.wa.gov.au/service/environment/pollutant-prevention/algal-events-and-water-quality-issues-mullaloo-and-ocean-reef-beaches

Figure 1 Location of the Beenyup Water Resource Recovery Facility (WRRF; includes the Advanced Water Recycling Plant, AWRP) and Ocean Reef ocean outlets

1.3 Potential stressors in treated wastewater



1.3.1 Toxicants

Metals and persistent organic compounds may be directly toxic to marine biota and/or may accumulate in marine biota at concentrations sufficient to pose a risk to humans if consumed. Under the PLOOM program, TWW is screened for bioaccumulating and non-bioaccumulating toxicants, and the concentrations are compared to relevant EPA guidelines. To account for the synergistic effects of multiple toxicants and toxicants without guidelines, the overall toxicity of the TWW is determined using whole effluent toxicity (WET) testing.

1.3.2 Physico-chemical stressors

TWW contains organic matter, the decomposition of which by microorganisms uses oxygen. If more dissolved oxygen (DO) is consumed than is produced, DO levels decline. Measurements of DO saturation in receiving waters near the outlets, relative to measurements at reference sites, provide an indication of the risk posed by deoxygenation.

Reduced salinity near the outlets, resulting from freshwater in the TWW plume, may cause osmotic stress in marine biota. Measurements of salinity in receiving waters near the outlets are compared to the salinity at appropriate reference sites. The comparison allows evaluation of whether salinity near the outlets is within the range of natural variation.

1.3.3 Nutrients

TWW contains elevated concentrations of biologically available nutrients such as ammonia, nitrite, nitrate and orthophosphate. At times, the addition of nutrients may stimulate phytoplankton growth beyond natural levels, which can lead to shading of photosynthetic organisms such as seagrasses and/or macroalgae. The potential for shading is measured using in-water measures of chlorophyll-a (a proxy for phytoplankton biomass).

Although most algal blooms are harmless, some contain species that produce toxins that may be harmful to swimmers (via ingestion or skin contact) or contaminate seafood. Phytoplankton species composition and cell concentrations are monitored to ensure concentrations are within acceptable limits.

1.3.4 Microbial contaminants

Disease-causing organisms in the TWW pose a risk to humans if exposed during primary and/or secondary contact activities (i.e. swimming and boating). The same organisms, if ingested by marine fauna, may reduce their suitability for human consumption. To assess the risk, concentrations of indicator organisms are routinely compared to the Environmental Protection Authority's (EPA's) criteria for primary and secondary contact, and the criteria for seafood safe for human consumption.

1.4 Environmental management approach

Water Corporation's formal environmental commitments pertaining to this report are outlined in Ministerial Statement 1219. Ministerial Statement 1219 implements the Beenyup Ocean Outlets Monitoring and Management Plan (Water Corporation 2023) which aligns the management framework with the contemporary Department of Water and Environmental Regulation policy (EPA 2017) and establishes formal management areas around the outlets.

To maintain consistency with the other metropolitan ocean outlet programs, the Ocean Reef outlets (Figure 2) were monitored as part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) program. The ocean monitoring program is consistent with the approach advocated under the State Government's EQMF, which is applied to Western Australia's coastal waters (EPA 2016).

Figure 2 Aerial image of the Ocean Reef outlets.

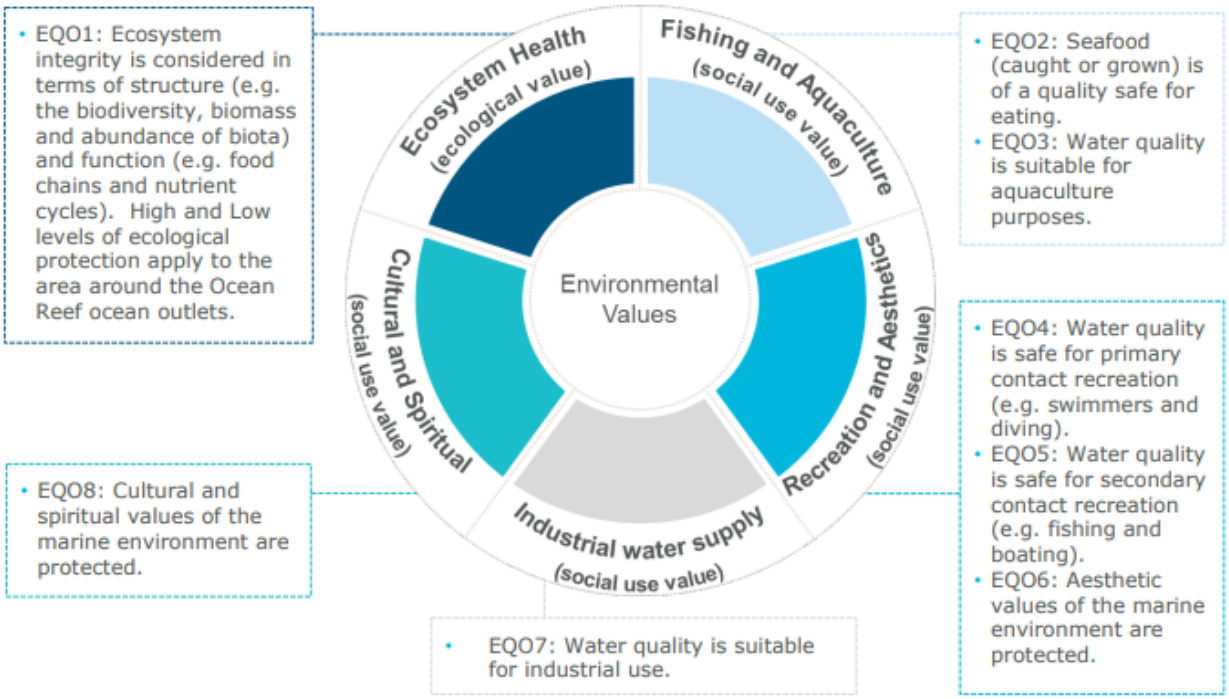
1.5 Environmental Quality Management Framework (EQMF)

The EQMF is based on:

- Identifying Environmental Values (EVs) (Figure 3).
- Establishing and spatially defining Environmental Quality Objectives (EQOs) that need to be maintained to ensure the associated EVs are protected (Figure 3).
- Monitoring and managing to ensure the EQOs are achieved and/or maintained in the long-term in the areas they have been designated.
- Establishing Environmental Quality Criteria (EQC), which are quantitative benchmarks or 'guidelines' against which monitoring results can be compared.

There are two levels of EQC:

1. **Environmental Quality Guidelines (EQGs)** are quantitative investigative guidelines which, if met, indicate there is a high degree of certainty that the associated EQO has been achieved. If the guideline is not met a more detailed assessment against the EQS is triggered.
2. **Environmental Quality Standards (EQSs)** are management guidelines which, if exceeded, signify that the EQO is at risk of not being met and that a management response may be required.



Source: EPA (2016)

Figure 3 Environmental Values and Environmental Quality Objectives (EQO) for the marine waters of Western Australia.

The compliance results for 2024-25 are summarised in Report Card format (Table 1). The report card contains colour-coded results with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met.

Table 1 Report card legend

Management response[1]	Colour
Monitor: EQG & EQS met (continue monitoring)	
Investigate: EQG not met (investigate against the EQS)	
Action: EQS not met (management response required)	

Note:

1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

1.5.1 Maintenance of Ecosystem Integrity EQO

The intent of this EQO is to maintain a healthy and diverse ecosystem. There are four levels of ecological protection, with each applied depending on the designated level required: low, moderate, high or maximum (Figure 4).

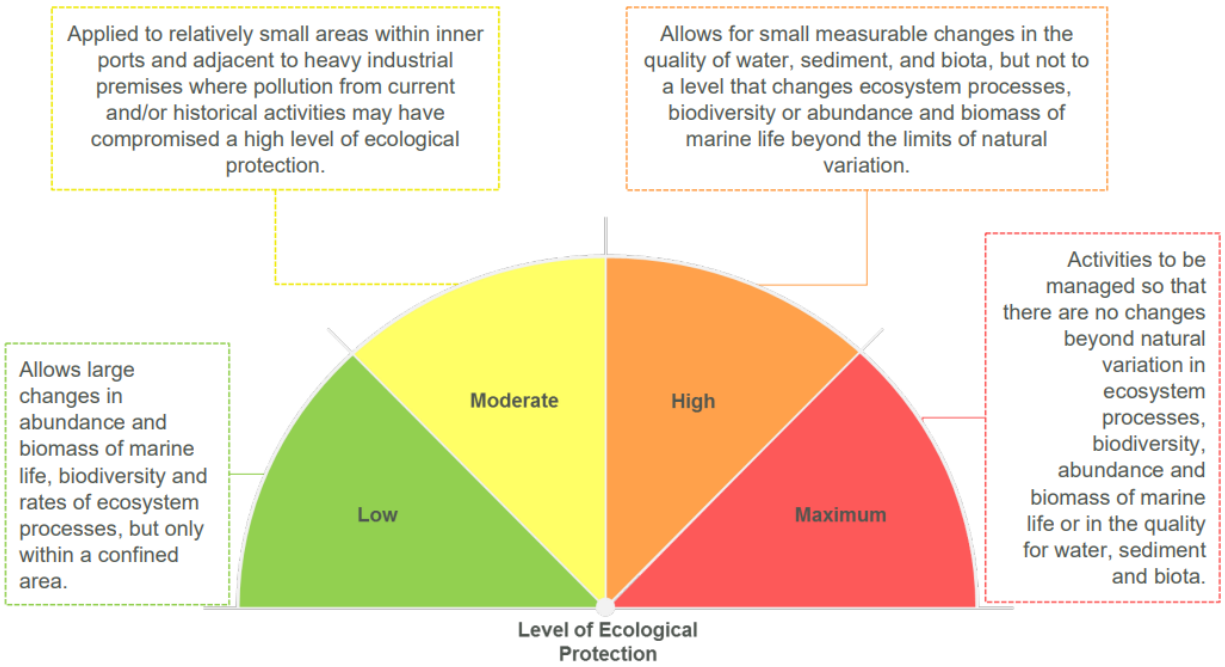


Figure 4 Levels of Ecological Protection

A Low Ecological Protection Area (LEPA) has been established around the Ocean Reef outlets and occupies the area within a 150 m radius of the diffusers (Figure 5; Ministerial Statement 1219 in April 2024). Waters outside the LEPA are maintained to a High Level of Ecological Protection (HEPA). The

current 2024-25 monitoring period is the first to implement the 150 m LEPA boundary around the Ocean Reef Ocean Outlets as required under MS1219. Previous monitoring used an informal or Notional LEPA with an approximately 100 m boundary around the outlet diffusers.

1.5.2 Maintenance of Seafood Safe for Human Consumption EQO

The intent of this EQO is to maintain seafood safe for human consumption (a social value) outside a small area surrounding the ocean outlets where EQO 2 may not be achieved, and seafood may be unsafe to eat. A formal zone has been developed for the Ocean Reef outlets encompassing the management area for seafood safe for human consumption based on microbiological observations from historical ocean monitoring data (Figure 5). The zone represents the area where microbiological organism concentrations are most likely to exceed the EPA's criteria for seafood safe for human consumption under worst-case conditions.

1.5.3 Maintenance of Primary and Secondary Contact Recreation EQOs

The primary and secondary contact EQOs support swimming and boating activities, respectively. The EQOs apply throughout Perth's coastal waters except for areas immediately surrounding the ocean outlets, where water quality may not be suitable for swimming. A formal zone has been developed for the Ocean Reef outlets encompassing the management area for primary and secondary contact recreation (Figure 5).

1.5.4 Maintenance of Aesthetic Value EQO

The objective of this EQO is to ensure that the aesthetic value of Perth's coastal waters is protected. To ensure this EQO is being met, monitoring routinely assesses the quality of the surface water appearance.

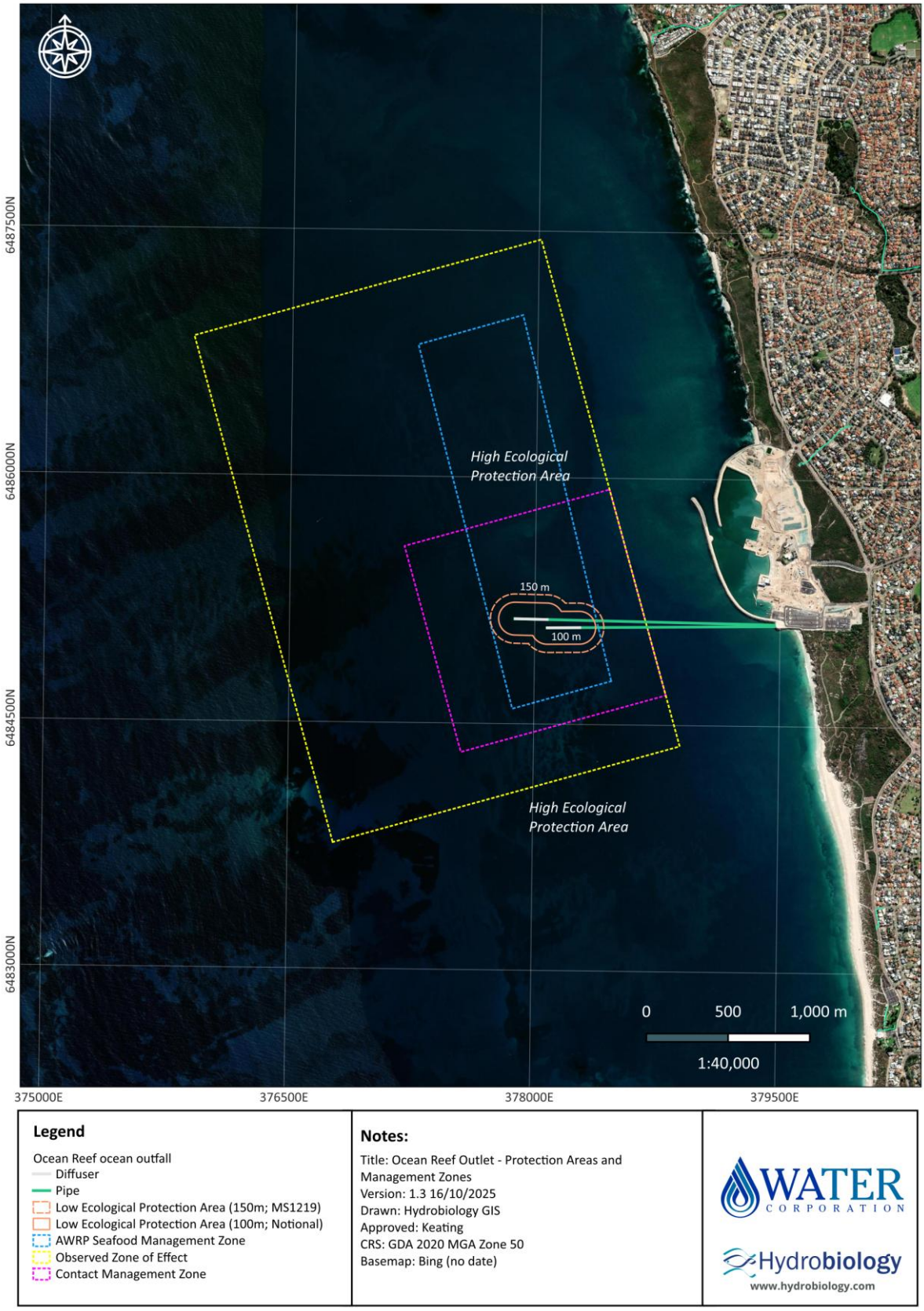


Figure 5 Ocean Reef ocean outlet protection area and management zones

2 Toxicants in treated wastewater

2.1 Comprehensive treated wastewater characterisation (CTWWC)

Treated wastewater (TWW; final effluent) from both outlet A and outlet B was analysed for a suite of parameters comprising the major contaminants of concern for the Ocean Reef ocean outlets:

- nutrients (total nitrogen, ammonia, nitrate + nitrite [NO_x], total phosphorus, orthophosphate)
- microbiological contaminants (thermotolerant coliforms and *Enterococci* spp.)
- bioavailable metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc)
- pesticides and herbicides (organophosphate pesticides, organochlorine pesticides, triazine herbicides)
- polyaromatic hydrocarbons
- phthalates
- polychlorinated biphenyls
- benzene, toluene, ethylbenzene, and xylenes
- petroleum hydrocarbons
- surfactants
- dissolved organic carbon.

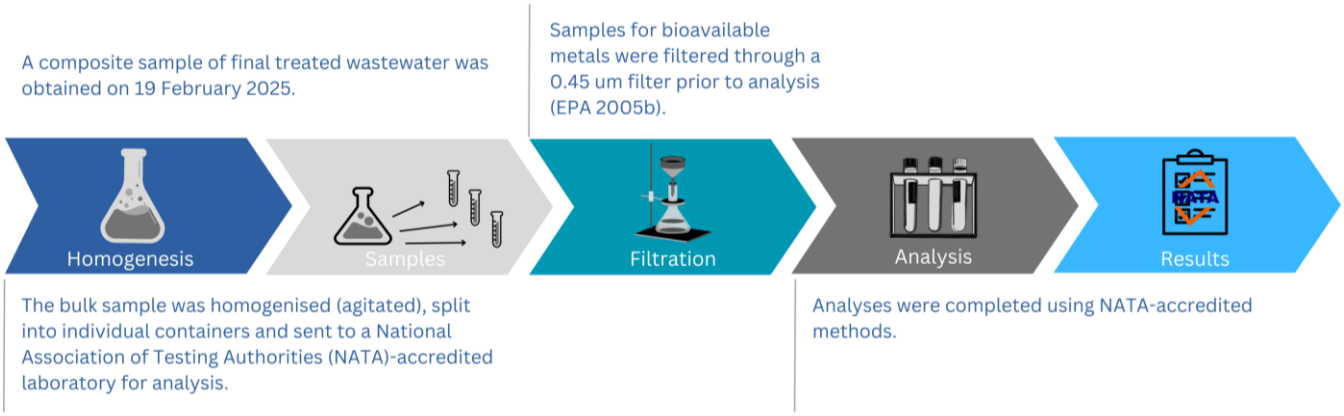


Figure 6 Treated wastewater sampling and analysis process

2.1.1 Bioaccumulating toxicants

Concentrations of both cadmium and mercury (i.e. bioaccumulating toxicants) in the TWW sample were below their analytical limit of reporting (LoR; 0.1 µg/L) and the EQG concentrations for cadmium and mercury as bioaccumulating toxicants (36 and 1.4 µg/L, respectively) were met (Table 3). Concentrations of bioaccumulating toxicants in the discharge have been consistent over time and generally reflect the Limit of Reporting (Figure 7).

Table 2 Environmental Quality Guideline (EQG) for bioaccumulating toxicants

EQG	Concentrations of bioaccumulating toxicants (cadmium and mercury) will not exceed the EPA (2017) 80% species protection guideline.

Note:

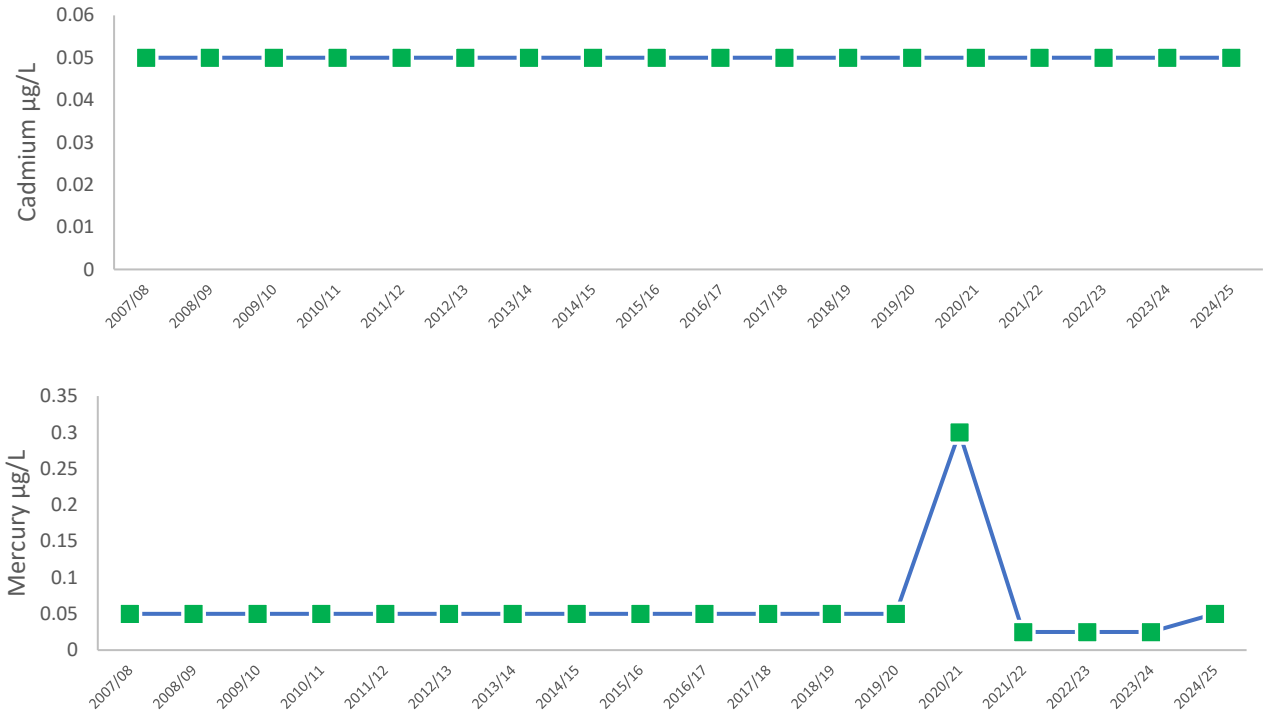
1. EQG = Environmental Quality Guideline

Table 3 Bioaccumulating toxicants in the Ocean Reef treated wastewater stream

Toxicant	Ocean Reef TWW concentration (µg/L)	Value used for assessment (half the LoR)	EPA (2017) 80% species protection guideline (µg/L)
Cadmium	< 0.1	0.05	36
Mercury	< 0.1	0.05	1.4

Note:

1. TWW = treated wastewater
2. Cadmium concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L (half the LoR) for reporting purposes.



Note:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Cadmium concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L (half the LoR) for reporting purposes.
3. LoR for mercury in 2024/25 was different to previous years due to a change in laboratory, therefore the LoR was reported as 0.1 µg/L.

Figure 7 Historical compliance of concentrations of bioaccumulating toxicants, cadmium and mercury

2.1.2 Non-bioaccumulating toxicants

Modelling predicted an average initial dilution of 1:370, based on metocean conditions observed on 19th February 2025. Contaminant concentrations after the initial dilution of 1:370 were below the EPA (2017) 99% species protection guidelines (Table 4), and the EQG for non-bioaccumulating toxicants (Table 5) was met. Historical initial dilution predictions are provided in Figure 8. Variability over time can be attributed to changes in the physical properties of the effluent and/or local metocean conditions.

Historical compliance of concentrations of the highest risk (concentration relative to guidelines) non-bioaccumulating toxicants are presented in Figure 9.

Table 4 Environmental Quality Guideline for non-bioaccumulating toxicants

EQG	Concentrations of contaminants will not exceed the EPA (2017) 99% species protection guideline for toxicants after initial dilution equivalent to that between the discharge point and the boundary of the Low/High Ecological Protection Area.

Note:

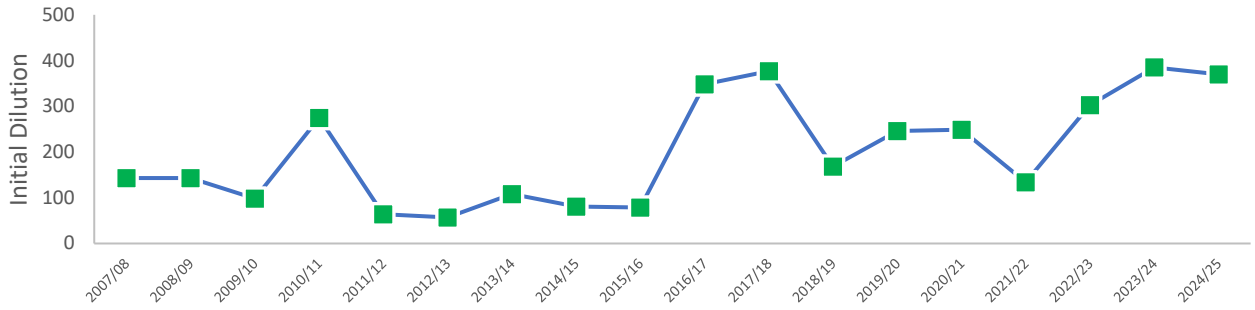
1. EQG = Environmental Quality Guideline

Table 5 Non-bioaccumulating toxicant concentrations in the Ocean Reef TWW stream compared with relevant guideline levels after initial dilution

Toxicant	TWW[2] concentration (µg/L)	Concentration after initial dilution (µg/L)[3,4]	ANZG (2018) 99% species protection guideline (µg/L)[1,5,7]
Nutrients			
Ammonia-N	2,580	7.0	500
Dissolved metals (0.45 µm filtered)			
Chromium VI	0.001		0.14
Copper*	17	0.046	0.3
Lead*	<1	-	2.2
Nickel*	4	0.011	7
Silver*	<1	-	0.8
Zinc*	127	0.34	3.3
Organophosphate pesticides			
Chlorpyrifos[6]	<0.02	-	0.0005
Organochlorine pesticides			
Endrin	<0.01	-	0.004
Endosulfan sulfate[7]	<0.01	-	0.005
Phenols			
Phenol	<0.1	-	270
Pentachlorophenol (PCP)	<0.05	-	11
Chlorinated hydrocarbons			
1,2,4-Trichlorobenzene	<2	-	20
BTEX			
Benzene	<1	-	500
Polyaromatic hydrocarbons (PAHs)			
Naphthalene	<0.02	-	50
Benzo(g,h,i)perylene	<0.02	-	50
Chlorination by-products			
Residual chlorine	0.06	0.00016	-

Notes:

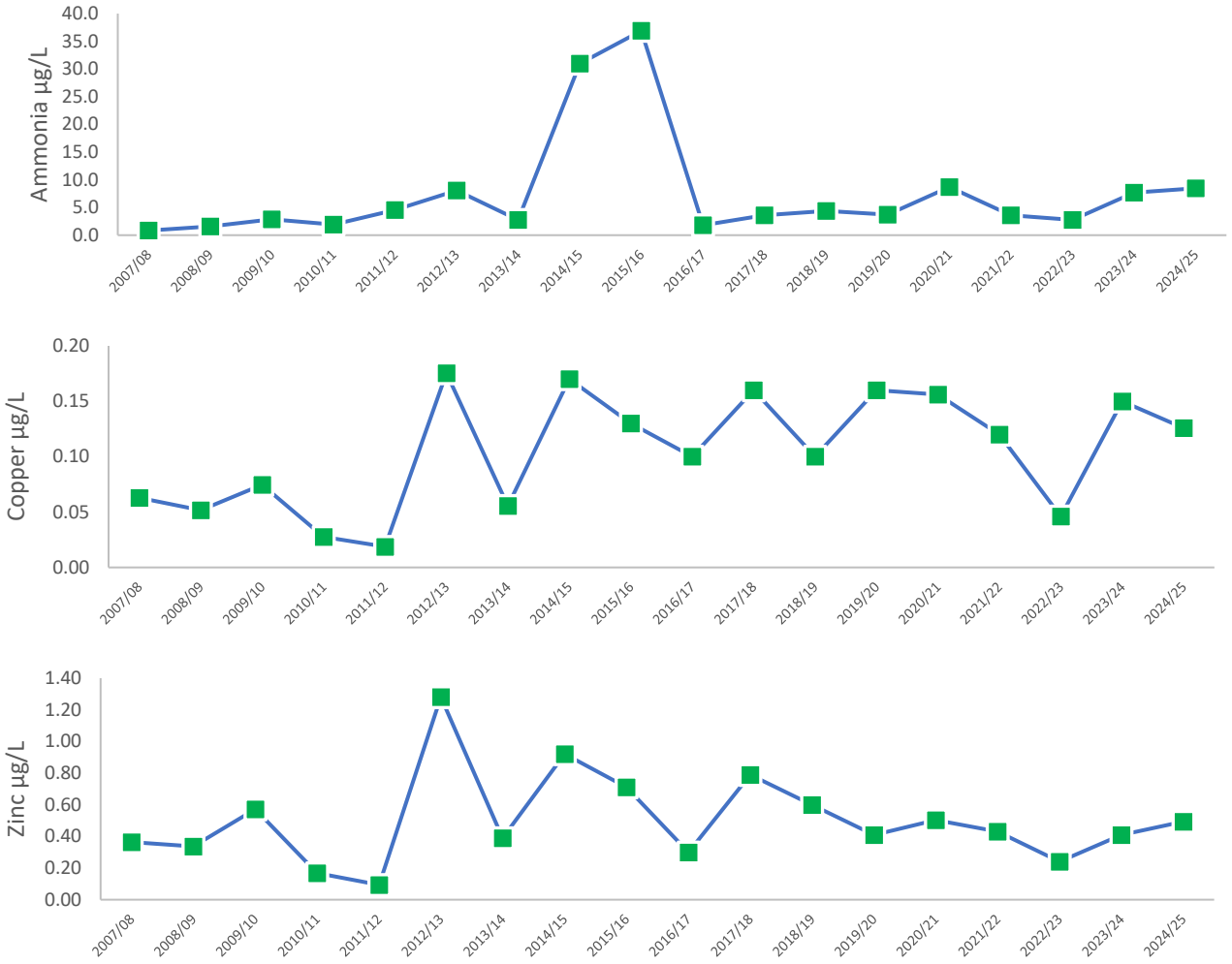
1. Assessment against EPA (2017) 99% species protection guidelines was undertaken only for those toxicants where guideline levels were available.
2. TWW = treated wastewater.
3. Initial dilution = 1:370 (predicted average value). Contaminant dilution calculations were not performed (-) on any toxicants where concentrations were below the analytical limit of reporting.
4. The guidelines for marine waters are from EPA (2017) The EPA has provided advice that in WA waters where a high level of protection applies, the 99% species protection levels should be used.
5. The bioaccumulating toxicants cadmium and mercury must meet the 80% species protection guidelines at the diffuser (i.e. prior to initial dilution), and therefore a diluted concentration was not calculated.
6. Analytical limits for chlorpyrifos were not low enough to confirm exceedance of, or compliance with, the EPA (2017) guidelines. Until reporting limits required for direct comparison can be attained by commercial laboratories, WET Testing will provide a test of the toxicity of the treated wastewater stream.
7. Trigger values are for endosulfan, not endosulfan sulfate; EPA (2017)
8. * = dissolved metals 0.45 µm filtered.



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 8 Initial dilution modelling predictions (2007/08 - 2024/25)



Note: Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 9 Historical compliance of concentrations of the highest risk (concentration relative to guidelines) non-bioaccumulating toxicants following initial dilution

2.1.3 Total toxicity of the mixture

The total toxicity of the mixture (TTM) is an indicator of the potential for cumulative toxic effects on marine organisms (Table 6). For the combined effect of ammonia, copper and zinc (historically the contaminants with the highest concentrations relative to their guidelines) following dilution, the TTM (0.51, Table 7) was less than the ANZG (2018) guideline of 1.0 and the EQG (Table 6) was met. Total toxicity of the mixture has exceeded the EQG criteria on one occasion (2012-13) but has generally been consistent over time (Figure 10).

Table 6 Environmental Quality Guideline for the Total Toxicity of the Mixture

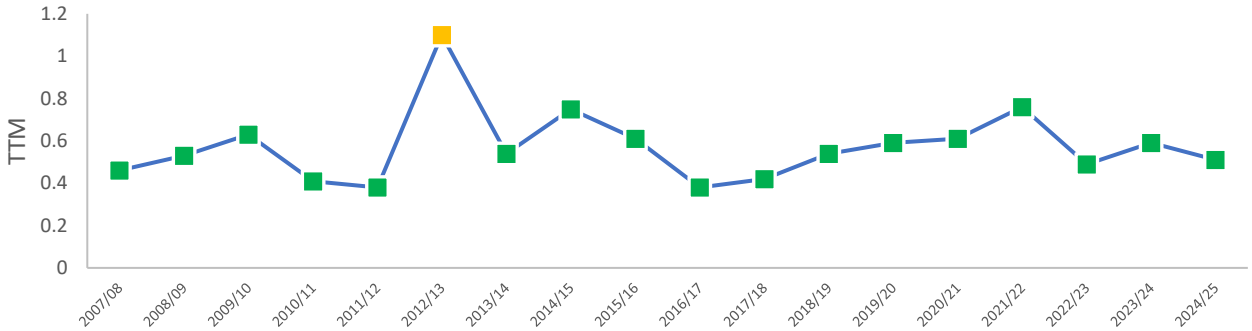
EQG	The total toxicity of the mixture (TTM[1,2]) for the additive effect of ammonia, dissolved copper and dissolved zinc following initial dilution, as per ANZG (2018) guidelines, will be less than 1.0.

Notes:
1. EQG = Environmental Quality Guideline; TTM = Total Toxicity of the Mixture
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the 'i'th component in the mixture and the EQGi is the guideline for that component.

Table 7 Total toxicity of treated wastewater at the edge of the initial mixing zone associated with the Ocean Reef ocean outlets

Toxicant	TWW concentration (µg/L)	Background concentration (µg/L)[1]	Dilution	Concentration after dilution (µg/L)	Contaminant concentration/ guideline (µg/L)[2]	TTM[3]
Ammonia	2580	1.5	1:370	8.47	0.02	0.51
Copper	17	0.08		0.13	0.42	
Zinc	127	0.15		0.49	0.07	

Notes:
1. Background concentrations for copper and zinc from McAlpine et al. (2004); Perth marine waters (pp.19). Surface background concentrations for ammonia calculated as median of reference site data from 2003–2023 (BMT Oceanica, unpublished data).
2. Guideline values are from Table 6.
3. TTM = total toxicity of the mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline, TWW = treated wastewater.



Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

Figure 10 Historical total toxicity of the mixture (TTM)

2.2 Whole of Effluent Toxicity (WET) testing

WET testing is useful for assessing the toxicity of potential contaminants without guidelines, or where the effects may be cumulative. Fertilisation success in sea urchins (*Heliocidaris tuberculata*) exposed to salt-adjusted dilutions (1.0, 1.6, 3.1, 6.3, 12.5, 25, 50 and 100%) of TWW was used to calculate a No Observed Effect Concentration (NOEC; the highest concentration where no significant effect is observed).

The frequency and timing of WET testing was revised for the 2024-25 monitoring period as part of a review of the ongoing requirements for this activity and sensitivity of the testing. In previous years WET testing was undertaken on TWW samples from the Beenyup WRRF on three occasions across the summer monitoring period (e.g. for 2023-24 WET testing was undertaken in October, January and March). Testing was reduced to two occasions during the 2024-25 program (February and March 2025).

In February and March 2025, sea urchin fertilisation in samples exposed to 100%, 50% and 25% TWW were significantly lower than the artificial seawater control. Additionally, in February 2025 the 12.5% TWW test was also significantly lower than the artificial seawater control. Fertilisation in all other dilutions were not significantly different to the control (Figure 11). For both sampling dates, the NOEC was greater than 1% TWW (Table 9) and the EQG for WET testing was met (Table 8). The lowest annual NOEC (and highest apparent toxicity) has been variable over time without an identifiable trend (Figure 12). The February 2025 TWW sample exhibited the lowest historic NOEC at 6.3% TWW, requiring ~16 dilutions to reduce toxicity to background (equal to seawater) conditions (Figure 12). The achieved dilutions at Ocean Reef were a minimum of 1:370 in February 2025, indicating dilution factors were well above those required to mitigate TWW toxicity.

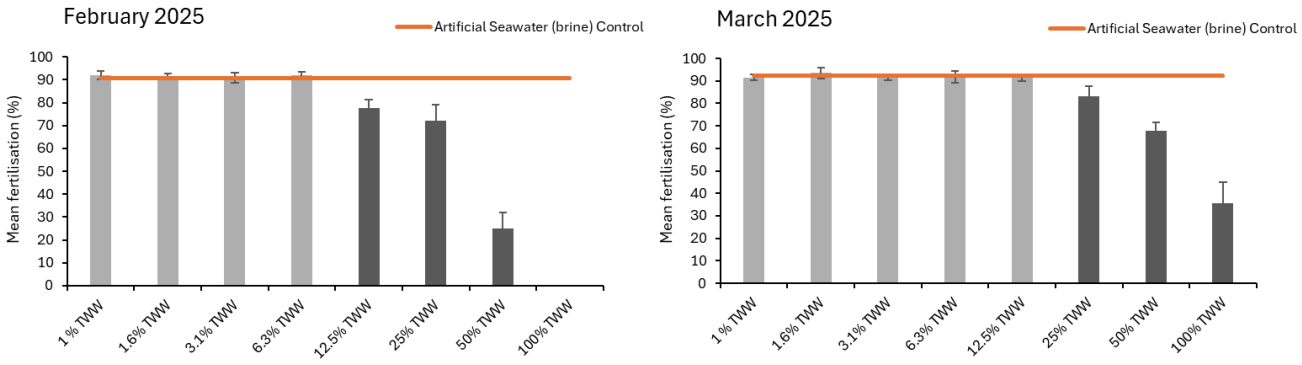
Table 8 Environmental Quality Guideline for Whole of Effluent Toxicity testing

EQG	The typical dilutions achieved at the LEPA boundary will be greater than the number of dilutions required to achieve the No Observed Effects Concentration in a 1-hour sea urchin test after application of a 0.1 assessment factor.

Source: BMT Oceanica 2014

Note:

1. EQG = Environmental Quality Guideline; WET = Whole of Effluent Toxicity; TDA = Typical Dilutions Achieved; DRNOEC = Dilutions Required to achieve the No Observed Effects Concentration.



Note:

1. Error bars represent ± 1 standard deviation; n = 4
2. TWW = treated wastewater
3. Light grey bars represent concentrations of TWW at which there is no observed significant effect on fertilisation. Dark grey bars represent a significantly lower percentage fertilised eggs compared with the ASW Control (Dunnett's Test, 1-tailed, p = 0.05)

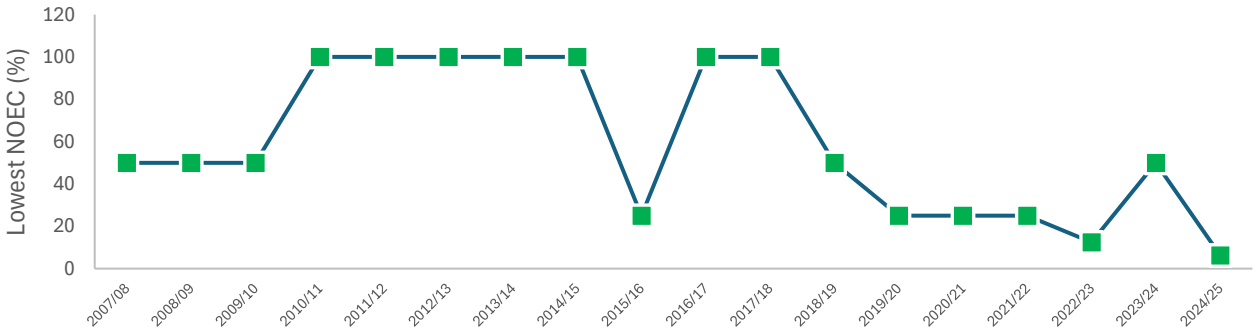
Figure 11 Comparison of whole effluent toxicity TWW dilution to artificial seawater control for Ocean Reef treated wastewater

Table 9 Calculated parameters from Whole of Effluent Toxicity tests

Indicator	February 2025	March 2025
NOEC[1] (%)	6.3	12.5
Dilutions required to meet the NOEC[1]	16	8
Dilutions required/dilution achieved	0.04	0.02
Under ≤1	Yes	Yes

Notes:

1. NOEC = No Observed Effect Concentration



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. NOEC = No Observed Effect Concentration.

Figure 12 Historical No Observed Effect Concentration (NOEC)

3 Water quality monitoring – Receiving Environment

Nutrients, phytoplankton biomass and physical and chemical stressors were monitored on ten occasions from early November 2024 to late March 2025 (coinciding with the summer non-river flow period) along a down-current gradient away from the diffuser (Table 10). Wind direction, strength, current grid direction and cloud cover were recorded on the day of sampling (Table 11).

Table 10 Water quality monitoring dates near the Ocean Reef ocean outlets between November 2024 and March 2025.

Sampling Event	Sampling Month	Date
1	November	4/11/2024
2	November	18/11/2024
3	December	10/12/2024
4	December	16/12/2024
5	January	15/1/2025
6	January	20/1/2025
7	February	18/2/2025
8	February	24/2/2025
9	March	10/3/2025
10	March	25/3/2025

Table 11 Weather and current grid during water quality monitoring near the Ocean Reef ocean outlets

Date	Wind Direction[1,2,3]	Wind Strength (knots)[3]	Cloud cover (%)	Current grid[2]
4/11/2024	SW	3 to 9	10	N
18/11/2024	E – ENE	5 to 20	20 – 40	SW
10/12/2024	SE	10 to 15	0	NW
16/12/2024	SW	10 to 16	20 - 80	NE
15/1/2025	SE – ESE – S	2 to 10	0	W
20/1/2025	ENE – E	8 to 18	30 - 60	SW
18/2/2025	ESE	12 to 21	50 - 90	W
24/2/2025	NNW – NW - WNW	4 to 10	100	SE
10/3/2025	E - ESE	9 to 15	0	SW
25/3/2025	SE - SW	1 to 6	0	NE

Notes:

1. NW = northwest, NNW = north northwest, WNW = west northwest, S = south, E = east, SW = southwest, SE = southeast, ENE = east northeast, ESE = east southeast.
2. Winds are designated by the direction they come from while currents are designated by the direction they flow to.
3. Wind direction and strength are obtained from field observations.

3.1.1 Nutrient enrichment

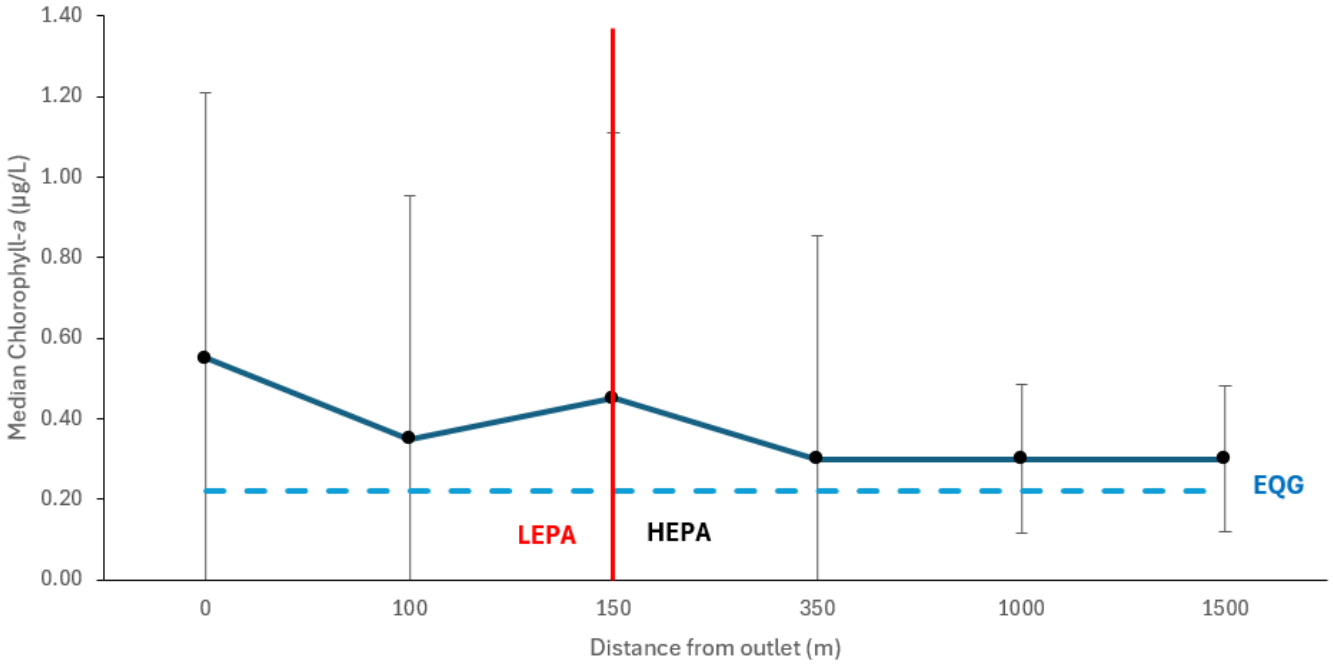
Median chlorophyll-*a* concentrations at each site outside of the LEPA (150, 350, 1,000 and 1,500 m from the outlets) in 2024-25 (0.30 µg/L) were above the 80th percentile of reference site data (0.22 µg/L;) exceeding the EQG and prompting assessment against the EQS (Figure 13, Figure 14 and Table 12).

Median Light Attenuation Coefficient (LAC) data pooled from sites outside of the LEPA from the 2024-25 extended summer monitoring period (0.082 m^{-1}) was below the rolling two-year (2023-24 and 2024-25) 80th percentile of reference site data (0.104 m^{-1}). Consecutive exceedances were not recorded, therefore the EQS was met at both the formal 150 m and the notional 100 m LEPA (Figure 15).

Table 12 Environmental Quality Guideline for nutrients

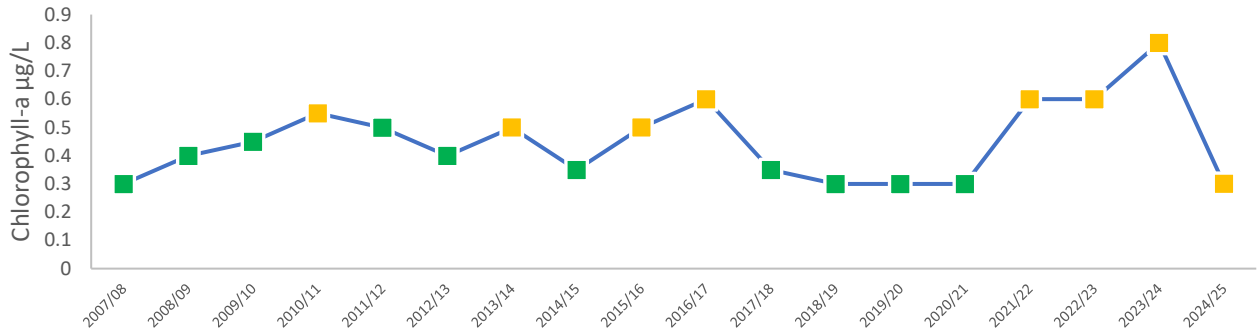
EQG	Median chlorophyll-*a* of HEPA sites down current of the LEPA boundary during the summer monitoring period not to exceed the 80th percentile of reference site data.
EQS	Median light attenuation (LAC m^{-1}) derived from pooled HEPA sites down current of the LEPA boundary during the summer monitoring period not to exceed the two-year rolling 80th percentile of the reference site data in two consecutive years.

Note:
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard



Notes:
1. Data at each distance were pooled from November 2024 to March 2025. This includes 8 sampling events for ORT-150 m, and 10 sampling events for the remaining sites. Error bars represent ± 95% confidence intervals.
2. Blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of reference site data (0.22 µg/L chlorophyll-*a*).
3. LEPA = low ecological protection area; HEPA = high ecological protection area.

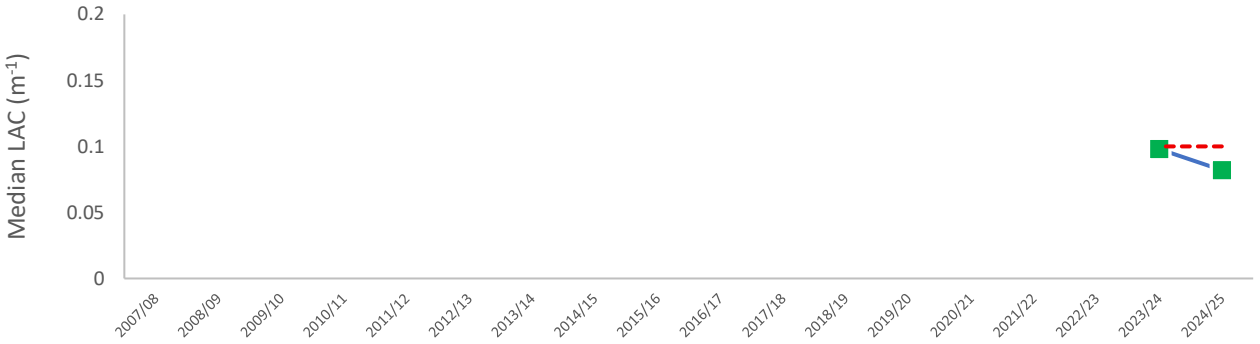
Figure 13 Median chlorophyll-a concentrations down-current of the Ocean Reef outlets during the summer monitoring period



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber represent an exceedance of the EQG.

Figure 14 EQG assessment; median chlorophyll-a concentration



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 15 EQS assessment; median LAC from pooled HEPA sites compared against two-year rolling 80th percentile of reference site LAC (Red dashed line, 0.104 m^{-1})

3.2 Phytoplankton biomass

Median phytoplankton biomass measured as chlorophyll-*a* exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) on one occasion (2.1 µg/L on 18 February 2025; Figure 16) exceeding EQG 1 (Table 13; Figure 17) and triggering assessment against EQS 1.

Median phytoplankton biomass measured as chlorophyll-*a* at HEPA sites did not exceed three times median chlorophyll-*a* concentration of reference sites on more than one occasion and in two consecutive years and thus EQS 1 was met (Figure 18).

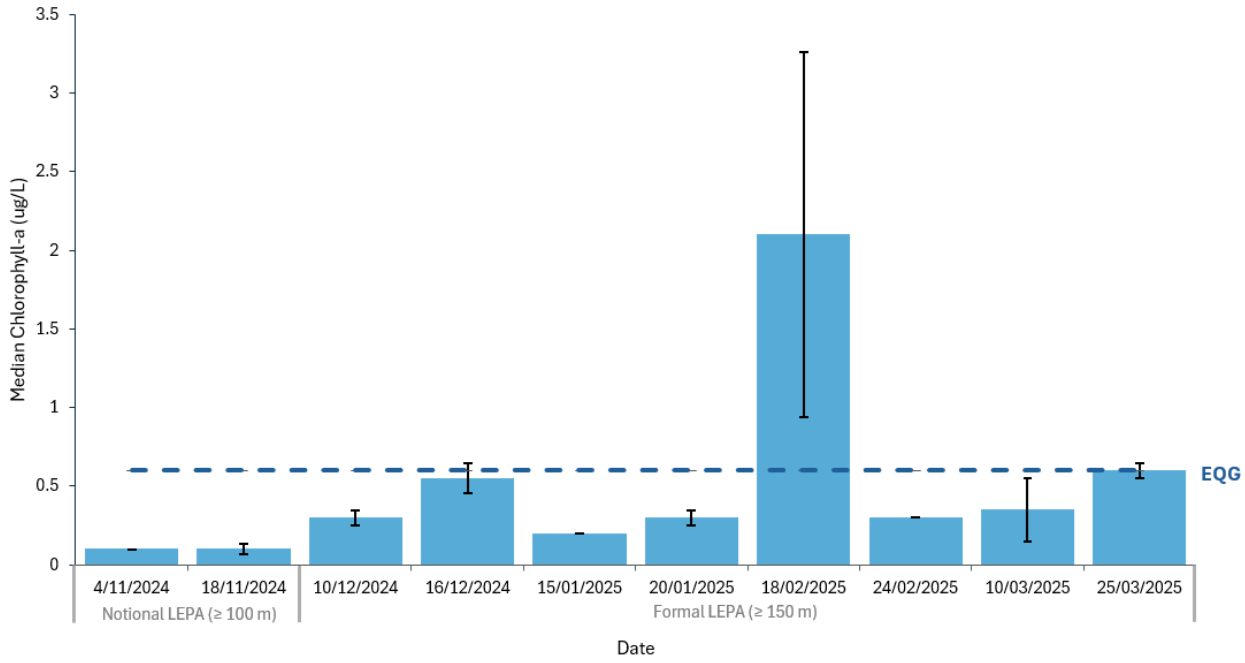
Informal assessment against the previous notional LEPA found that the median phytoplankton biomass at HEPA sites (≥ 100 m from the outlets), measured as chlorophyll-*a*, exceeded three times the median chlorophyll-a concentration of reference sites (0.6 µg/L) once, on 18 February 2025 (3.1 µg/L). EQS 1 was met as the exceedance did not occur more than once in two consecutive years.

Table 13 Environmental Quality Criteria for phytoplankton in receiving waters

EQG1	Median phytoplankton biomass measured as chlorophyll-*a* at the HEPA sites down current of the LEPA boundary not to exceed 3 times median chlorophyll-*a* concentration of reference sites, on any occasion during the summer monitoring period.
EQS1	Median phytoplankton biomass measured as chlorophyll-*a* at HEPA sites down current of the LEPA boundary will not exceed 3 times median chlorophyll-*a* concentration of reference sites, on more than one occasion during the summer monitoring period and in two consecutive years.
EQG2	Phytoplankton biomass measured as chlorophyll-*a* at any HEPA site down current of the LEPA boundary does not exceed 3 times median chlorophyll-*a* concentration of reference sites, on 25% or more occasions during the summer monitoring period.

Note:

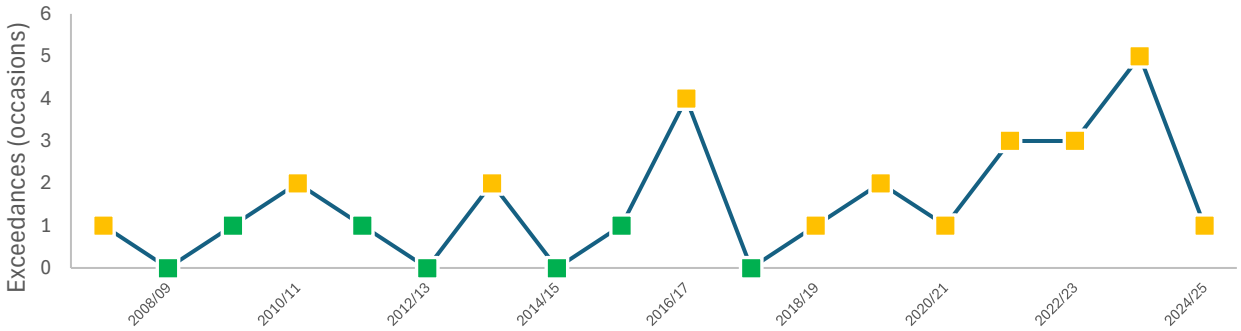
1. EQG = Environmental Quality Criteria; EQS = Environmental Quality Standard



Notes:

1. Error bars represent ± 95% confidence intervals: n = 3 for the first two dates, n = 4 for the remaining dates.
2. The variability in the 95% confidence interval recorded on 18/02/2025 is attributed to relatively high values observed at ORT-150m and ORT-350m (3.1 ug/L), almost 8 times the average concentrations recorded at all other sites in the 2024/25 monitoring program, as well as the small sample size (n = 4).
3. The notional LEPA (≥ 100 m) was utilised for the first two sampling events, and the formal LEPA (≥ 150 m) utilised for the remaining sampling events.
4. Blue dashed line = Environmental Quality Guideline (EQG) is 3-times the median chlorophyll-*a* concentration of reference site data (0.6 µg/L chlorophyll-*a*).
5. Data pooled from fixed sites ≥ 150 m down-current of the outlets. Concentrations at 0 m and 100 m are not included in the figure or EQC assessment, as the 0 m site is situated directly above the outlets within the low ecological protection area (LEPA), and the 100 m site is inside the LEPA.

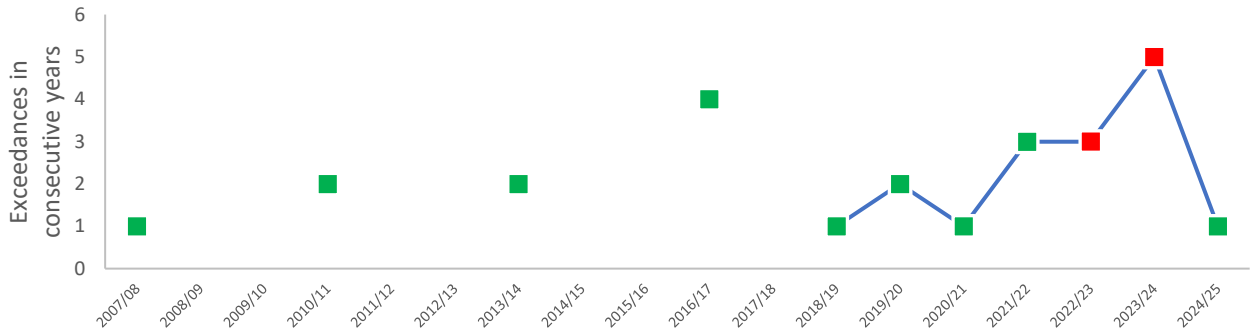
Figure 16 Median phytoplankton biomass during the 2024-25 summer monitoring period



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

Figure 17 Exceedance of three times the median chlorophyll-*a* concentration of reference sites on any occasion



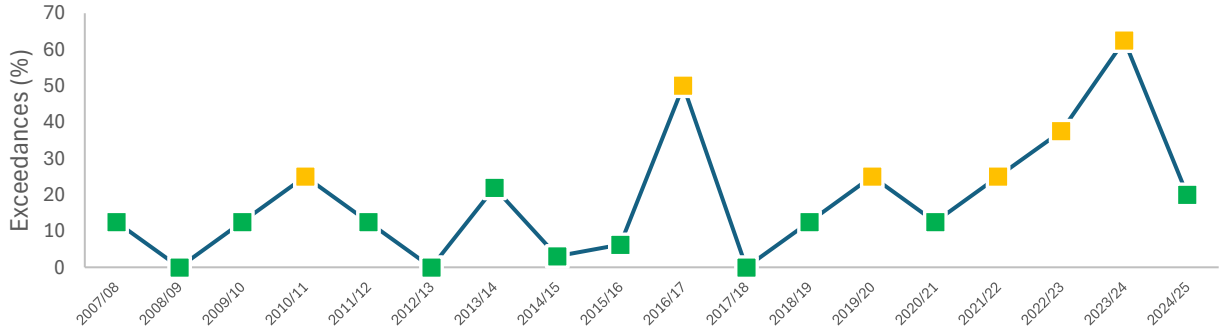
Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQS) was met red symbols represent an exceedance of the EQS.

Figure 18 Exceedance of three times the median chlorophyll-a concentration of reference on more than one occasion and in two consecutive years

Phytoplankton biomass (measured as chlorophyll-*a*) exceeded three times the median chlorophyll-*a* concentration of reference sites (0.6 µg/L) at HEPA sites on two occasions (Figure 19). EQG 2 was met (i.e. < 25% of sampling occasions during the non-river flow period). The individual exceedances occurred at two sites (ORT-0 m and ORT-1500 m) on 16 December 2024 and seven sites (ORT-100 m, ORT-150 m, ORT-350 m, ORT-1000 m, ORT-1500 m in addition to reference site OR2) on 18 February 2025.

Assuming a notional LEPA of 100 m, chlorophyll-*a* concentrations down-current of HEPA sites would have exceeded 3 times the reference-site median on three sampling occasions (30%) during summer 2024/25. This would be above the ≤25% allowance in the guideline in a consecutive year of non-compliance (2023/24 recorded 62.5% exceedances). Following this informal assessment, EQG 2 would not have been met and EQS 2 would be exceeded.



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQG) was met, amber symbols represent an exceedance of the EQG.

Figure 19 Exceedance of three times the median chlorophyll-a concentration of reference sites on 25% or more occasions

3.3 Physical-chemical stressors

3.3.1 Dissolved oxygen (DO)

The median of bottom (0–0.5 m) dissolved oxygen saturation at HEPA sites (150, 350, 1000 and 1500 m from the outlets) was >90% at all sites and times throughout the summer survey period (Figure 20), and the EQG for organic enrichment (Table 14) was met. Historically, DO has fallen below 90% in at least one 6-week period on two occasions (Figure 21).

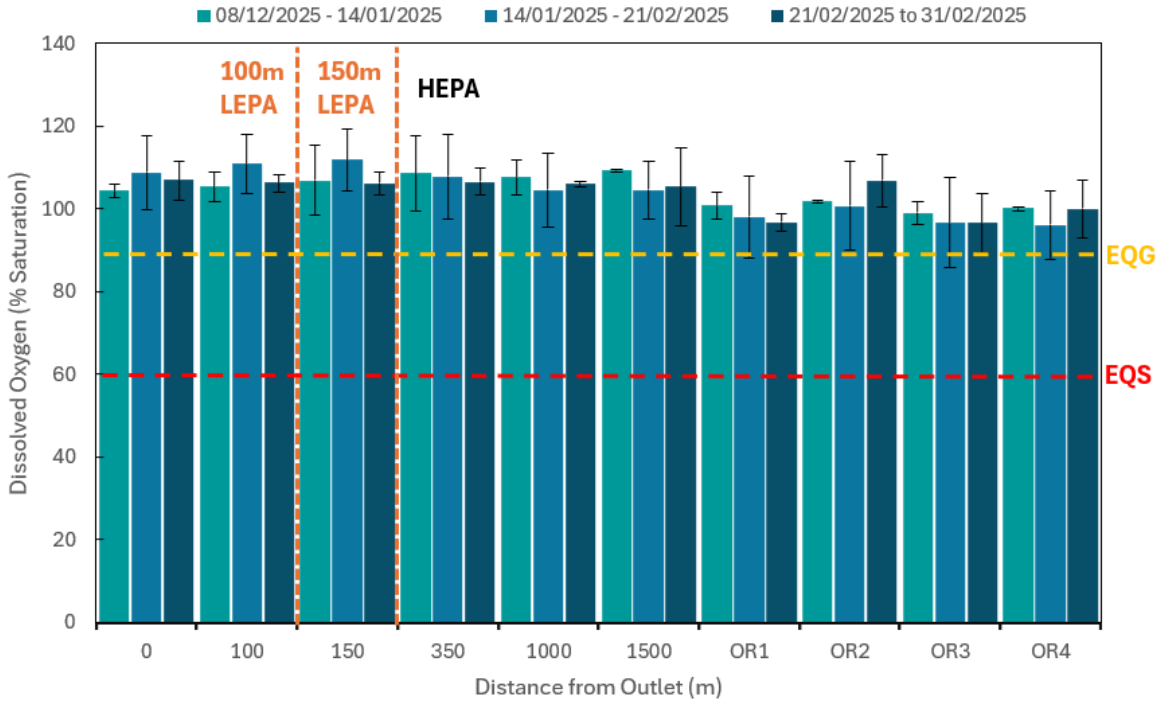
The EQG was met for the notional LEPA, with the median of bottom dissolved oxygen saturation at HEPA sites (≥ 100 m from the outlets) being >90% at all sites and periods throughout the summer survey period.

Table 14 Environmental Quality Guideline for dissolved oxygen

EQG	**Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) greater than 90% saturation at any HEPA site down current of the LEPA boundary for a defined period of not more than one week.**

Note:

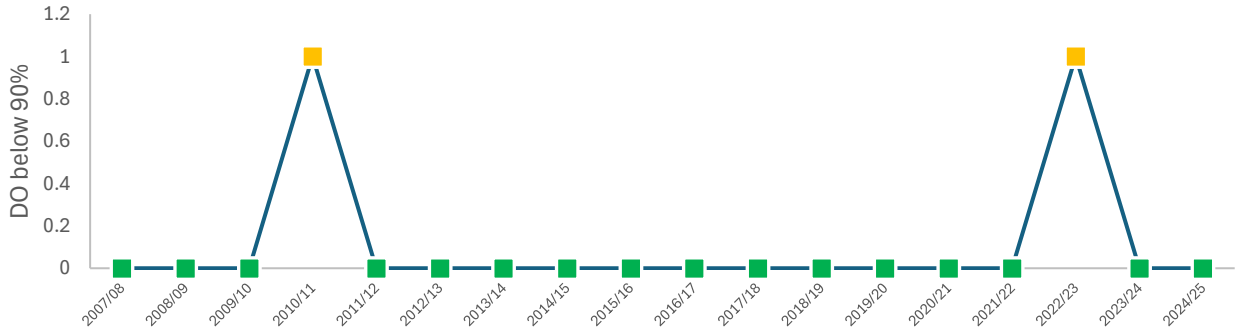
1. EQG = Environmental Quality Guideline.



Notes:

1. Error bars ±95% confidence intervals [n = 2 for the first period (two sampling trips), n = 3 for the remaining periods (three sampling trips each)].
2. Dissolved oxygen (DO) measure 0-0.5m above the seabed.
3. Yellow dashed line = Environmental Quality Guideline (EQG) = 90% DO saturation.
4. Red dashed line = Environmental Quality Standard (EQS) = 60% DO saturation.
5. LEPA = low ecological protection area; HEPA = high ecological protection area. The previous notional 100m LEPA is indicated for reference only.
6. Reference site data (OR1–OR4) are compared against EQG for contextual purposes only.

Figure 20 Median dissolved oxygen for defined periods of ≤6 weeks during the summer monitoring period



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

Figure 21 Number of 1-week periods where DO was below 90% (EQG)

5.3.2 Salinity

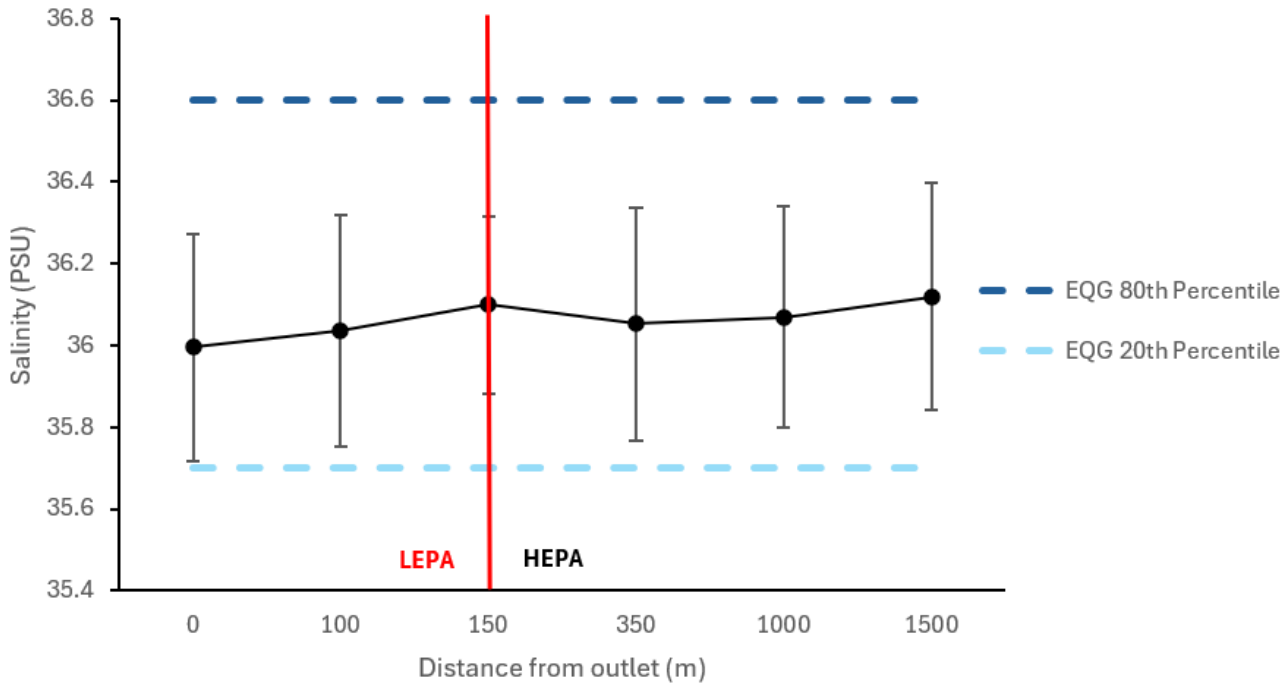
Median salinity was between the 20th and 80th percentile of the natural (reference site) salinity range (35.7 and 36.6 PSU, respectively) at all HEPA sites (150, 350, 1,000 and 1,500 m from the outlets) across the summer monitoring period, meeting the EQG (Table 15 and Figure 22). In the past, median salinity has fallen below the 20th percentile of the natural salinity range for the same period and the EQG has been exceeded on two occasions (Figure 23).

Informal assessment against the previous notional LEPA found that the median salinity at all HEPA sites (≥ 100 m from the outlets) was between the 20th and 80th percentile of the natural (reference site) salinity range across the summer monitoring period, meeting the EQG.

Table 15 Environmental Quality Guideline for salinity

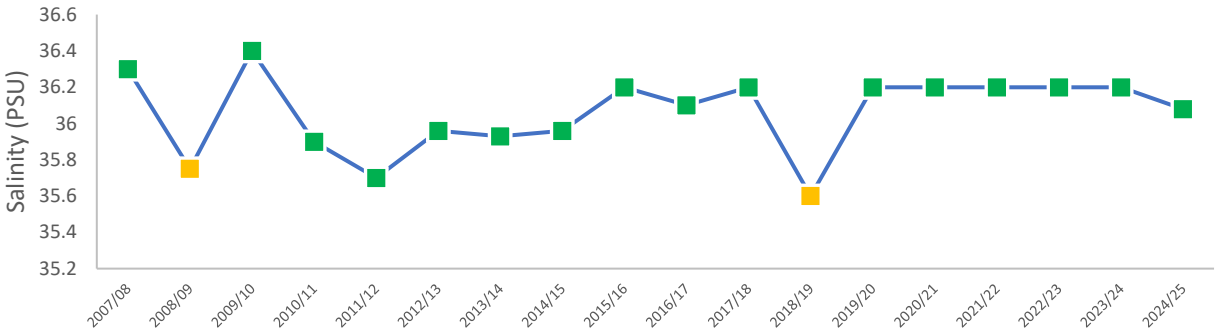
EQG	Median salinity (0.5 m below the water surface) at an individual HEPA site down current of the LEPA boundary over the summer monitoring period not to deviate beyond the 20th and 80th percentile of reference site salinity over the same period.

Note:
1. EQG = Environmental Quality Guideline



Notes:
1. Error bars ± 95% confidence intervals; n = 8 for ORT-150 m, n = 10 for remaining sites.
2. Salinity measured ~0.5 m below the sea surface (closest measurement to 0.5 m depth taken for each distance, for each trip November 2024 – March 2025).
3. Dark blue line = 80th percentile of reference sites over the same period; light blue dashed line = 20th percentile of reference sites over the same period.
4. LEPA = low ecological protection area; HEPA = high ecological protection area.

Figure 22 Median salinity compared to the 20th and 80th percentile of reference sites data during the extended summer monitoring period



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Standard (EQG) was met; and amber symbols represent an exceedance of the EQG.

Figure 23 Median salinity down current of the Ocean Reef outlets

4 Microbiological contaminants and algal biotoxins

4.1 Thermotolerant coliforms (TTC)

TTC were sampled 10 times over the 2024 – 25 extended summer period (yielding a total of 50 samples) at the boundary of the SMZ. NHMRC (2008) guidelines and EPA (2005) require a minimum of 100 samples for an accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have not changed (NHMRC, 2008). Assuming local pollution conditions have not changed data from the past three summers (summer of 2022–23, 2023–24 and 2024–25) were pooled to yield 130 samples. It should be noted that monitoring in 2024–25 was undertaken against the newly implemented AWRP Seafood Management Zone boundary and sites, while earlier monitoring periods were assessed using the inner Observed Zone of Influence. The EQG for primary and secondary contact recreation are outlined in Table 16.

The median and 90th percentile TTC concentrations derived from the past three summers (2022-23, 2023-24, and 2024-25 extended monitoring period) samples were both equal to the limit of reporting (<10 CFU/100 mL) and less than the 14 and 21 CFU/100 mL criteria, respectively, meeting the EQG (Table 17). Median (Figure 24) and 90th percentile (Figure 25) TTC concentrations have generally been equivalent to the limit of reporting over time and have never exceeded the 14 or 21 CFU/100 mL criteria, respectively.

Table 16 Environmental Quality Guideline for Thermotolerant Coliforms

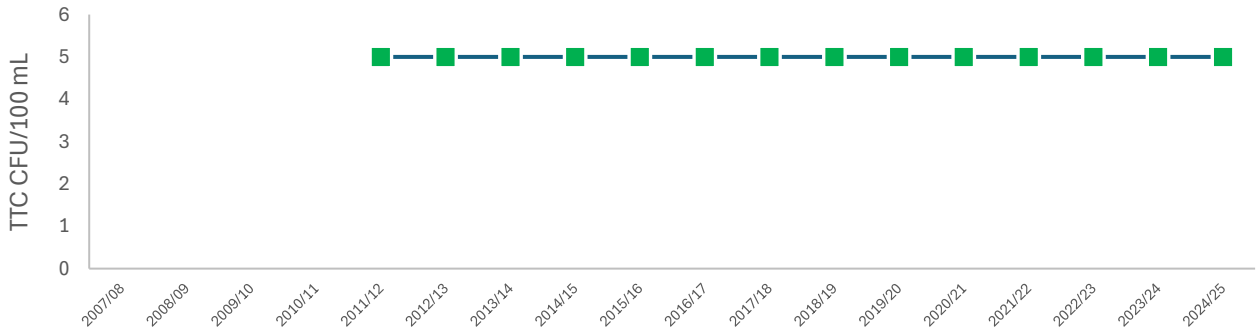
EQG	**Median thermotolerant coliform (TTC) counts (rolling median consisting of 100 samples) at sites at the Seafood Management Zone (SMZ) boundary are not to exceed 14 CFU/100 mL and the estimated 90th percentile concentration will not exceed 21 CFU/ 100 mL as measured using the membrane filtration method during normal plant operating conditions.**

Notes:
1. EQG = Environmental Quality Guideline.

Table 17 Median and 90th percentile of thermotolerant coliform concentrations at the fixed monitoring sites for the Ocean Reef outlets pooled from the 2022–25 period and comparison to the EQC

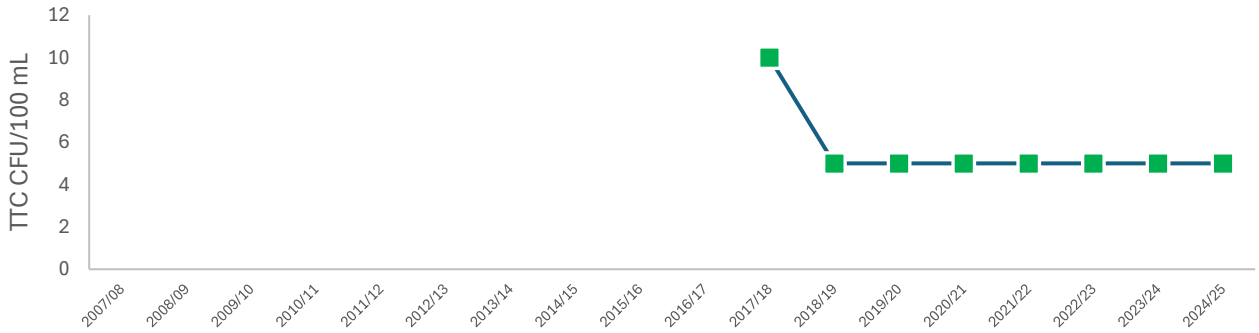
Sampling period	Median	90th percentile	Compliance (EQC)
Dec 2022 – Mar 2023 Dec 2023 – Mar 2024 Nov 2024 – Mar 2025	<10 CFU/100 mL	<10 CFU/100 mL	

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90th percentile.
3. Environmental Quality Criteria are based on EPA (2017).



Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 24 Median thermotolerant coliforms (TTC)



Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 25 90th percentile thermotolerant coliforms (TTC)

4.2 *Enterococci* spp.

Samples were collected at the Primary Contact Management Zone boundary 10 times over the 2024–25 extended summer monitoring period (yielding a total of 50 samples) for faecal indicator analyses (measured as *Enterococci* spp.). NHMRC (2008) guideline and EPA (2005) require a minimum of 100 samples over the monitoring period for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have not changed (NHMRC, 2008). Assuming conditions have not changed data from the past three summers (summer of 2022–23, 2023–24 and 2024–25) were pooled to yield 130 samples. The EQG for primary and secondary contact recreation are outlined in Table 18.

Over the past three summers, the 95th percentile of *Enterococci* spp. concentrations at the boundary of the observed zone of effect (contact recreation management zone) for the Ocean Reef ocean outlets was equal to the limit of reporting (<10 MPN/100 mL), and the EQG for faecal indicators (Table 19) in the water were met. The 95th percentile *Enterococci* spp. concentrations have varied little over time and have never exceeded the contact EQG (Figure 26).

Table 18 Environmental Quality Guidelines (*Enterococci* spp.) for contact recreation

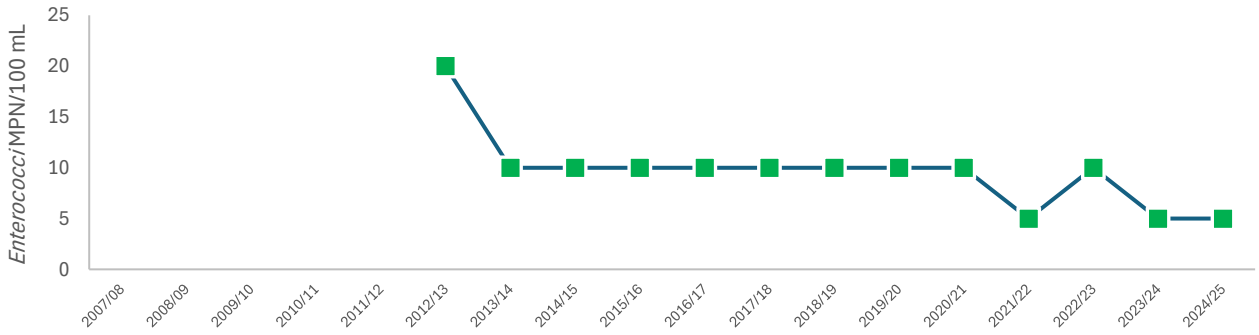
EQG	The 95th percentile concentration of *Enterococci* spp. (rolling Hazen 95th percentile consisting of 100 samples) taken over the bathing season not to exceed 200 MPN/100 mL, outside the Primary Contact Management Zone boundary during normal plant operating conditions.

Notes:
1. EQG = Environmental Quality Guideline
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).

Table 19 The 95th percentile of *Enterococci* spp. concentrations at the boundary of the Primary Contact Management Zone for the Ocean Reef ocean outlets

Sampling period	Median[1,2]	95th percentile[1,2]	Compliance (EQC)[3,4]
Dec 2022 – Mar 2023 Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	<10 MPN/100 mL	<10 MPN/100 mL	

Notes:
1. MPN = most probable number of *Enterococci* spp.
2. *Enterococci* spp. concentrations below the analytical limit of reporting (<10 *Enterococci* spp. MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95th percentile and median.
3. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
4. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.



Note:
1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 26 95th percentile *Enterococci* spp. concentrations

4.3 Algal biotoxins

The EQG for algal biotoxins states that concentrations of potentially toxic algae are not to exceed the WASQAP (DoH 2025) guideline concentrations in any Seafood Management Zone (SMZ) boundary samples (sites OR-1 to OR-16). Table 20 lists the phytoplankton species known to produce toxins that may be concentrated in shellfish and their WASQAP (DoH 2025) guideline concentrations (alert level to initiate flesh testing) for all sites. There were no exceedances recorded during the 2024-25 extended

summer monitoring period (Table 21). The historic assessment of the EQG for algal biotoxins is presented in Figure 27.

Table 20 Environmental Quality Guideline for toxic phytoplankton species

EQG[1,2,3]	Concentrations of potentially toxic algae in any sample at the Seafood Management Zone boundary are not to exceed the WASQAP[4] guideline concentrations for any of the following during normal plant operating conditions: Paralytic shellfish poison: • *Alexandrium catenella*[5] (100 cells/L) • *Alexandrium minutum*[5] (100 cells/L) • *Alexandrium ostenfeldii*[5] (100 cells/L) • *Alexandrium tamarense*[5] (100 cells/L) • *Gymnodinium catenatum* (1,000 cells/L) Diarrhoetic shellfish poison: • *Dinophysis acuminata* (1,000 cells/L) • *Dinophysis acuta* (1,000 cells/L) • *Dinophysis caudata* (1,000 cells/L) • *Dinophysis fortii* (1,000 cells/L) • *Prorocentrum lima* (500 cells/L) • *Prorocentrum rathymum*[10] Amnesic shellfish poison: • *Psuedo-nitzschia seriata* group[6,7] (500,000 cells/L) • *Pseudo-nitzschia delicatissima* group[6,8] (500,000 cells/L) Neurotoxic shellfish poison: • *Karenia* cf. *brevis* (1,000 cells/L) *Karenia, Karlodinium* and *Gymnodinium* group[9] (250,000 cells/L)
EQS	Following an exceedance of the EQG, sentinel mussels will be deployed at sites along the Seafood Management Zone boundary. The shellfish tissue concentration of the following algal toxins will be assessed: • Paralytic shellfish poison (0.8 mg Saxitoxin eq/kg) • Diarrhoetic shellfish poison (0.2 mg/kg) • Neurotoxic shellfish poison (200 mouse units/kg) • Amnesic shellfish poison (domoic acid; 20 mg/kg) • Yessotoxins (1 mg Yessotoxin eq./kg)

Notes:

1. EQG = Environmental Quality Guideline
2. If this EQG is breached, assessment of sentinel mussel tissues against the EQS will be conducted.
3. The cell levels within each toxin group are cumulative (e.g. 600 cells/L of both *D. acuta* and *D. fortii* in the diarrhoetic shellfish poison group are totalled to 1,200 cells/L, exceeding the critical level to initiate flesh testing).
4. Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025).
5. *Alexandrium* species may be difficult to identify when numbers are low, and they are being treated as potentially toxic.
6. Species within the *Pseudo-nitzschia* groups are difficult to identify, and they are being treated as potentially toxic.
7. The *Pseudo-nitzschia seriata* group includes: *P. australis, P. pungens* and *P. multiseries*.
8. The *Pseudo-nitzschia delicatissima* groups includes *P. turgidula, P. fraudulenta, P. delicatissima, P. pseudodelicatissima* and *P. multistriata*.
9. The *Karenia, Karlodinium* and *Gymnodinium* group includes *Karenia bidigitata, Karenia brevisulcata, Karenia mikimotoi, Karenia papilionacea, Karenia selliformis, Karlodinium micrum* and *Gymnodinium impudicim*.
10. Trigger levels have not been established for *P. rathymum*, but presence and cell density are to be reported.

Table 21 Estimated cell densities of phytoplankton species known to produce toxins at Ocean Reef outfall sites.

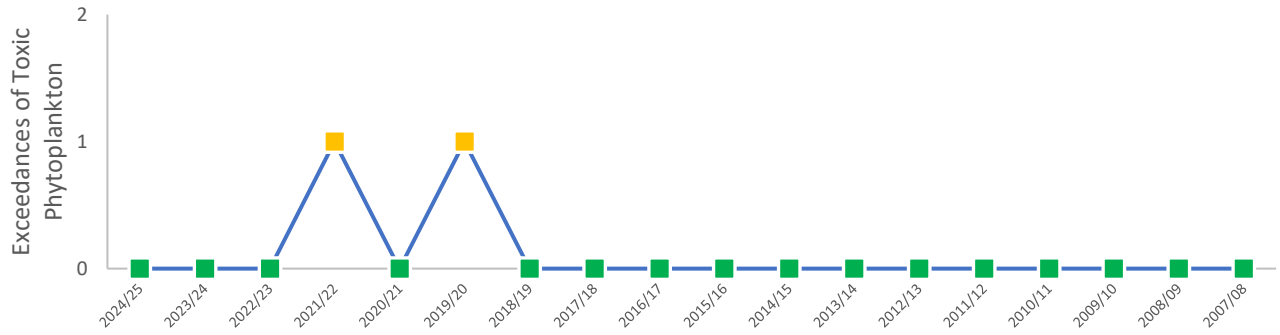
Date	Site[2]	Species[6]	Estimated density (cells/L)[5]	WASQAP Guideline[4,6] (cells/L)	Compliance[1,3]
4/11/2024	OR-7	*Dinophysis* spp.	80	1,000	
18/11/2024	OR	No toxic species detected.	-	-	
10/12/2024	OR-11	*Pseudo-nitzschia* "*delicatissima*" group	640	500,000	
		Dinophysis spp.	80	1,000	
		Trichodesmium erythraeum	80	-	
16/12/2024	ORR4	*Pseudo-nitzschia* "*delicatissima*" group	1,360	500,000	
		Oscillatoria spp.	80	-	
	OR-3	*Pseudo-nitzschia* "*delicatissima*" group	240	500,000	
		Oscillatoria spp.	80	-	
	OR-19	*Pseudo-nitzschia* "*delicatissima*" group	80	500,000	
		GK Complex (*Gymnodinium-Karenia* Complex)	80	250,000	
15/01/2025	ORR3	*Pseudo-nitzschia* "*delicatissima*" group	800	500,000	
	OR-13	*Pseudo-nitzschia* "*delicatissima*" group	1,680	500,000	
	OR-29	*Pseudo-nitzschia* "*delicatissima*" group	1,920	500,000	
		Pseudo-nitzschia "*seriata*" group	320		
20/01/2025	ORR1	*Pseudo-nitzschia* "*delicatissima*" group	960	500,000	
		Pseudo-nitzschia "*seriata*" group	240		
	OR-10	*Pseudo-nitzschia* "*delicatissima*" group	2,080	500,000	
		Pseudo-nitzschia "*seriata*" group	1,040		
	OR-30	*Pseudo-nitzschia* "*delicatissima*" group	1,600	500,000	
		Pseudo-nitzschia "*seriata*" group	640		
18/02/2025	ORR3	*Pseudo-nitzschia* "*delicatissima*" group	4,480	500,000	
		Pseudo-nitzschia "*seriata*" group	4,080		
	OR-11	*Pseudo-nitzschia* "*delicatissima*" group	26,880	500,000	

Date	Site[2]	Species[6]	Estimated density (cells/L)[5]	WASQAP Guideline[4,6] (cells/L)	Compliance[1,3]
		Pseudo-nitzschia "*seriata*" group	367,360		
		Trichodesmium erythraeum	1,120	-	
		GK Complex (*Gymnodinium-Karenia* Complex)	240	250,000	
	OR-28	*Pseudo-nitzschia* "*delicatissima*" group	11,920	500,000	
		Pseudo-nitzschia "*seriata*" group	224,720		
		Trichodesmium erythraeum	7,520	-	
		GK Complex (*Gymnodinium-Karenia* Complex)	80	250,000	
24/02/2025	ORR3	*Pseudo-nitzschia* "*delicatissima*" group	80	500,000	
		Pseudo-nitzschia "*seriata*" group	1,520		
		Trichodesmium erythraeum	240	-	
	OR-14	*Pseudo-nitzschia* "*delicatissima*" group	160	500,000	
		Pseudo-nitzschia "*seriata*" group	960		
	OR-30	*Pseudo-nitzschia* "*delicatissima*" group	80	500,000	
		Pseudo-nitzschia "*seriata*" group	240		
		Trichodesmium erythraeum	400	-	
10/03/2025	ORR3	*Pseudo-nitzschia* "*seriata*" group	320	500,000	
	OR-13	*Pseudo-nitzschia* "*delicatissima*" group	880	500,000	
		Pseudo-nitzschia "*seriata*" group	1,920		
	OR-30	*Pseudo-nitzschia* "*delicatissima*" group	320	500,000	
		Pseudo-nitzschia "*seriata*" group	560		
		Trichodesmium erythraeum	160	-	
25/03/2025	ORR1	*Pseudo-nitzschia* "*delicatissima*" group	12,640	500,000	
		Pseudo-nitzschia "*seriata*" group	10,400		
		Trichodesmium erythraeum	480	-	
	OR-6	*Pseudo-nitzschia* "*delicatissima*" group	5,920	500,000	
		Pseudo-nitzschia "*seriata*" group	12,080		
	OR-19	*Pseudo-nitzschia* "*delicatissima*" group	20,800	500,000	

Date	Site[2]	Species[6]	Estimated density (cells/L)[5]	WASQAP Guideline[4,6] (cells/L)	Compliance[1,3]
		Pseudo-nitzschia "*seriata*" group	19,440		
		GK Complex (*Gymnodinium-Karenia* Complex)	80	250,000	

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Samples were analysed for one monitoring site and one reference site per sampling occasion.
3. Compliance to the EQG only applies for Seafood Management Zone boundary sites (OR-1 to OR-16). Results for reference sites (ORR1 to ORR4) and other monitoring sites (OR-17 to OR-32) are not applicable to compliance assessment, but are provided for comparison.
4. Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025).
5. Limit of reporting = 80 cells/L
6. Phytoplankton species that do not have a guideline described in the MMP (2023) but are described by the lab as being potentially toxic have been included in this table; *Trichodesmium erythraeum* and *Oscillatoria* spp.



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

Figure 27 Detections of toxic phytoplankton species at the SMZ assessed against the EQG

4.4 Toxic algae

There are two EQC associated with compliance for toxic algae in marine recreational waters (Table 22).

The first EQC is based upon median total phytoplankton cell count and the levels of any DoH (2022) watch list species. The second EQC examines whether any cases of skin or eye irritation, or suspected algal poisoning in swimmers, have been reported by a medical professional to the DoH as potentially linked to toxic algae when phytoplankton counts are below 10,000 cells/mL.

Table 22 Environmental Quality Criteria for toxic algae

EQG 1	Median total phytoplankton cell count for the area of concern (either from one sampling run or from a single site over agreed period of time) should not exceed 10,000 cells/mL during normal plant operating conditions or detect DoH watch list species exceeding their trigger levels: Cyanobacteria • *Lyngbya majuscula* (any detection) • *Trichodesmium* spp. (≥ 5,000 cells/mL) Dinoflagellates • *Alexandrium* spp. (≥ 1 cells/mL) • *Karenia brevis* (≥ 5 cells/mL) • *Karenia* spp. (≥ 50 cells/mL) • *Pfiesteria* spp. (any detection)
EQG 2	There should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column.
EQS1	The phytoplankton cell count from a single site should not exceed 50 000 cells/mL or exceed DoH watch list action levels and there should be no visual presence of algal scums or relatively widespread visible presence of *Lyngbya majuscula* filaments (NHMRC 2008).

Notes:

1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard.

During the 2024-25 monitoring period, the densities of phytoplankton at the individual monitoring sites remained below 10,000 cells/mL (Table 23). The Environmental Quality Guideline (EQG) for phytoplankton concentrations was therefore met. Historically, algal density has never exceeded 10,000 cells/mL at any site (Figure 28).

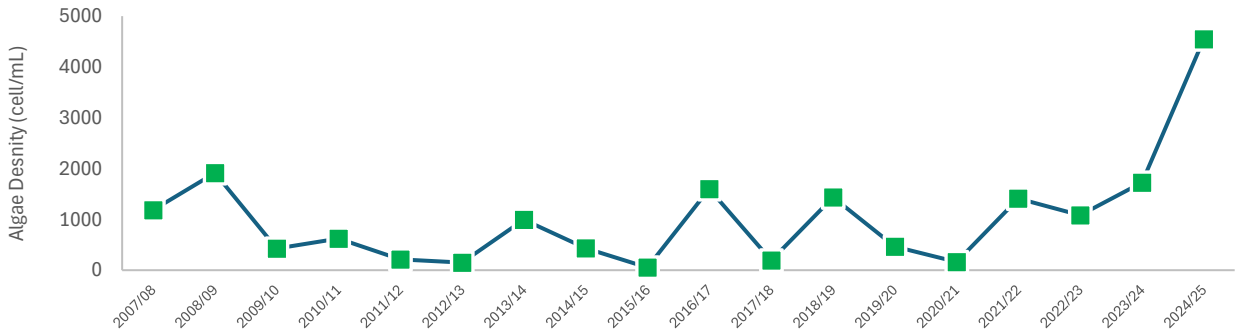
No DoH algal watchlist species were detected at levels exceeding their trigger values during the 2024-25 extended summer monitoring period, meeting the EQG (Table 24; Figure 29). Additionally, Water Corporation did not receive any reports from DoH concerning skin or eye irritation, or potential algal poisoning in swimmers at Ocean Reef during the monitoring period, thus meeting the EQG (Figure 30).

Table 23 Estimated phytoplankton total cell densities collected at one of the fixed monitoring sites for contact recreation down-current of the Ocean Reef outlets

Date	Site	Median total phytoplankton density (cells/mL)	Compliance
4/11/2024	OR7	25	
18/11/2024	OR13	22	
10/12/2024	OR11	15	
16/12/2024	OR19	19	
15/01/2025	OR29	24	
20/01/2025	OR10	19	
18/02/2025	OR11	4,545	
24/02/2025	OR14	6	
10/03/2025	OR13	11	
25/03/2025	OR19	377	

Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met;



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met;

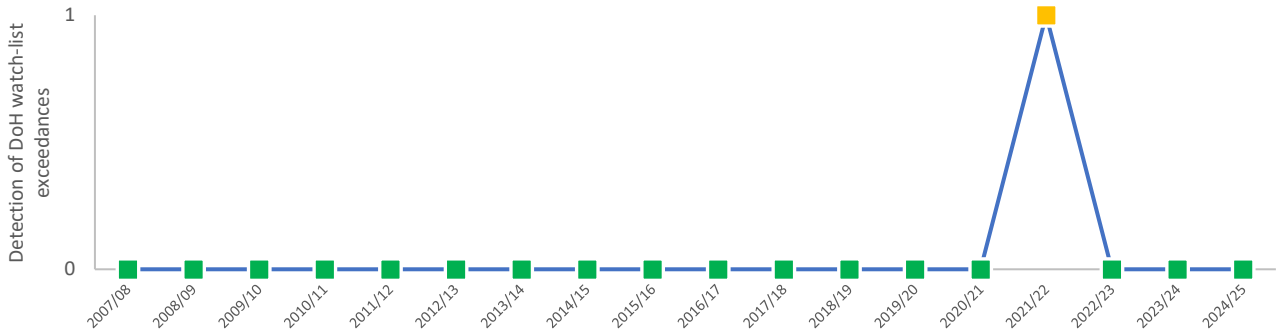
Figure 28 Median algal density

Table 24 Estimated cell densities of DoH watch-list phytoplankton species at Ocean Reef outfall sites.

Date	Site[2]	Species[3]	Estimated density (converted to cells/mL)[4,5]	DoH Guideline[3] (cells/mL)	Compliance[1]
10/03/2025	OR	No watch-list species detected.	-	-	
25/03/2025	OR	No watch-list species detected.	-	-	
10/12/2024	OR-11	*Trichodesmium erythraeum*	0.08	5,000	
16/12/2024	ORR4	*Trichodesmium* spp.	0.08	5,000	
	OR-3	*Trichodesmium* spp.	0.08	5,000	
	OR-19	*Trichodesmium* spp.	0.16	5,000	
15/01/2025	OR-13	*Trichodesmium* spp.	0.08	5,000	
	OR-29	*Trichodesmium* spp.	0.08	5,000	
20/01/2025	OR	No watch-list species detected.	-	-	
18/02/2025	OR-11	*Trichodesmium erythraeum*	1.12	5,000	
	OR-28	*Trichodesmium erythraeum*	7.52	5,000	
24/02/2025	ORR3	*Trichodesmium erythraeum*	0.24	5,000	
	OR-30	*Trichodesmium erythraeum*	0.4	5,000	
10/03/2025	OR-30	*Trichodesmium erythraeum*	0.16	5,000	
25/03/2025	ORR1	*Trichodesmium erythraeum*	0.48	5,000	

Notes:

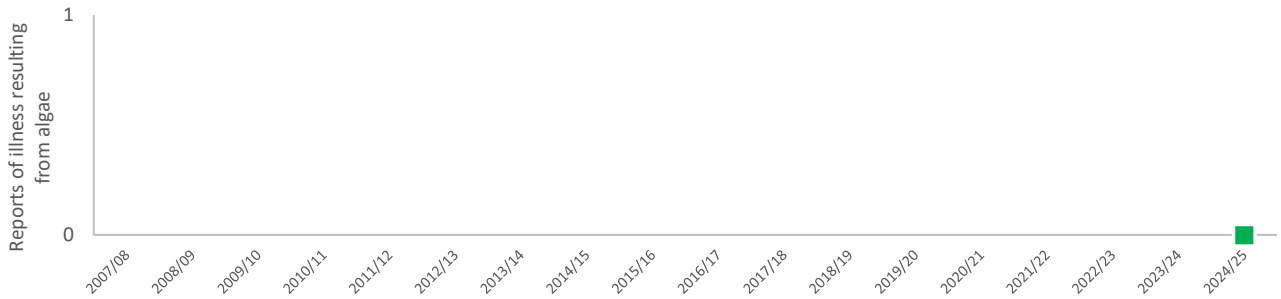
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Samples were analysed for one monitoring site and one reference site per sampling occasion.
3. Department of Health watch-list species (DoH 2022).
4. Cell density has been converted from cells/L used in laboratory reports to cells/mL for assessment against the guidelines.
5. Limit of reporting = 80 cells/L (0.008 cells mL)



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber symbols represent an exceedance of the EQG.

Figure 29 Detections of DoH (2022) watch-list species in exceedance of guideline values



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Monitoring for this EQC commenced in the 2024/25 summer monitoring period.

Figure 30 Reports from DoH of skin or eye irritation, or potential algal poisoning in swimmers (when less than 10,000 cells/mL is present in the water column).

4.5 Toxic chemicals

The recreational guidelines for toxic chemicals (EPA 2017) are relatively high (less conservative) compared to the ANZG guidelines for ecosystem protection. An initial assessment for toxic chemicals was made against the ANZG (2018) 99% species protection (i.e. most conservative) guidelines in the first instance, with no exceedances detected (i.e. Table 25), therefore the EQG was met.

Refer to Table 5 and Figure 9 for a comprehensive summary of toxic chemicals as assessed against the ANZG 2018 guidelines.

Table 25 Environmental Quality Guidelines for Toxic Chemicals in Primary Contact Recreation Area

EQG	Toxic chemicals are not to exceed the ANZG (2018) 99% species protection (most sensitive) guidelines.
EQS	Toxic chemicals are not to exceed human health guidelines.

5 Shoreline Monitoring

5.1 Thermotolerant coliforms (TTC)

Water Corporation conducts TTC monitoring additional to that required by the MMP along the shoreline. These results are informally assessed against the EQC.

TTC were sampled at eight shoreline monitoring sites ten times over the 2024–25 extended summer period (yielding a total of 80 samples). NHMRC (2008) guidelines and EPA (2005) recommend that a minimum of 100 samples is required for accurate assessment of the EQG. Data from multiple years can be pooled where there are less than 100 samples, provided local pollution conditions have not changed (NHRMC, 2008). Assuming conditions have not changed, data collected over two summers (summer 2023–24, and 2024–25) were pooled to yield 144 samples.

Table 26 Informal Environmental Quality Guideline for Thermotolerant Coliforms at shoreline monitoring sites

EQG	Median thermotolerant coliform (TTC) counts (rolling median consisting of 100 samples) at shoreline monitoring sites are not to exceed 14 CFU/100 mL and the estimated 90th percentile concentration will not exceed 21 CFU/ 100 mL as measured using the membrane filtration method during normal plant operating conditions.

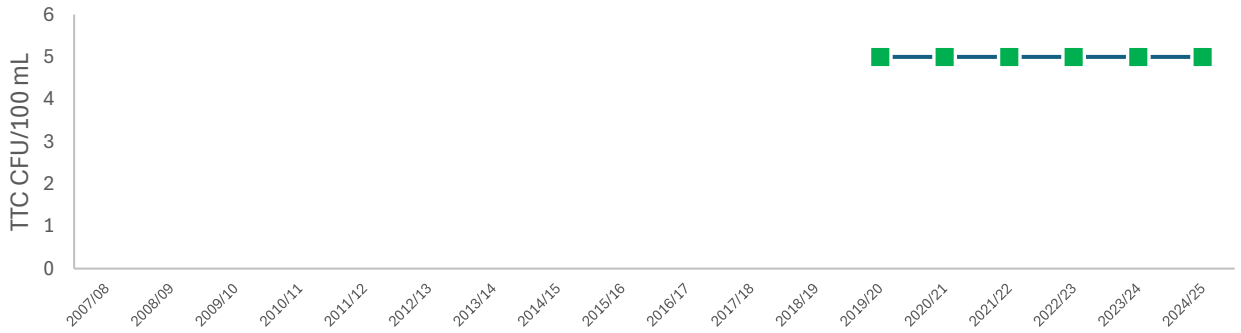
Notes:
1. EQG = Environmental Quality Guideline.

The shoreline sites are not formally assessed against the EQC, but the median and 90th percentile TTC concentrations derived from 144 samples were at the limit of reporting (<10 CFU/100 mL; Table 27) and less than the 14 and 21 CFU/100 mL criteria, respectively meeting the EQG criteria (Figure 31 and Figure 32).

Table 27 Median and 90th percentile thermotolerant coliform concentrations at the shoreline monitoring sites for the Ocean Reef outlets for the 2023–2025 period and comparison to the EQG

Sampling period	Median (CFU/100 mL)[1,3]	90th percentile[1,3]	Compliance[1,4]
Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	<10 CFU/100 mL	<10 CFU/100 mL	

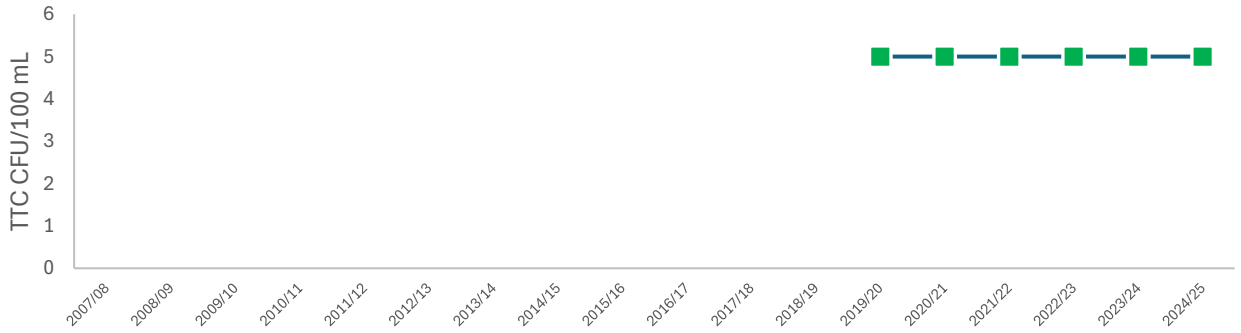
Notes:
1. CFU = Colony Forming Unit
2. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
3. Thermotolerant coliform results below the analytical limit of reporting (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median and 90th percentile.
4. Environmental Quality Criteria are based on EPA (2017).



Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline monitoring first assessed in 2019-2020.

Figure 31 Median shoreline TTC concentration



Notes:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Shoreline monitoring first assessed in 2019-2020.

Figure 32 90th percentile shoreline TTC concentration

5.2 *Enterococci* spp.

Water Corporation conducts faecal indicator (*Enterococci* spp.) monitoring additional to that required by the MMP along the shoreline. These results are informally assessed against the EQS.

Samples were collected ten times at eight monitoring sites over the 2024–25 extended summer monitoring period (yielding a total of 80 samples) for faecal indicator analyses. NHMRC guideline (2008) and EPA (2005) recommends minimum of 100 samples over the monitoring period are required for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples, provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over the past two summers (summer of 2023–24 and 2024–25) were pooled to yield 146 samples.

Table 28 Informal Environmental Quality Guidelines (*Enterococci* spp.) for contact recreation

EQG	The 95th percentile concentration of *Enterococci* spp. (rolling Hazen 95th percentile consisting of 100 samples) taken over the bathing season not to exceed 200 MPN/100 mL, at the shoreline monitoring sites during normal plant operating conditions.

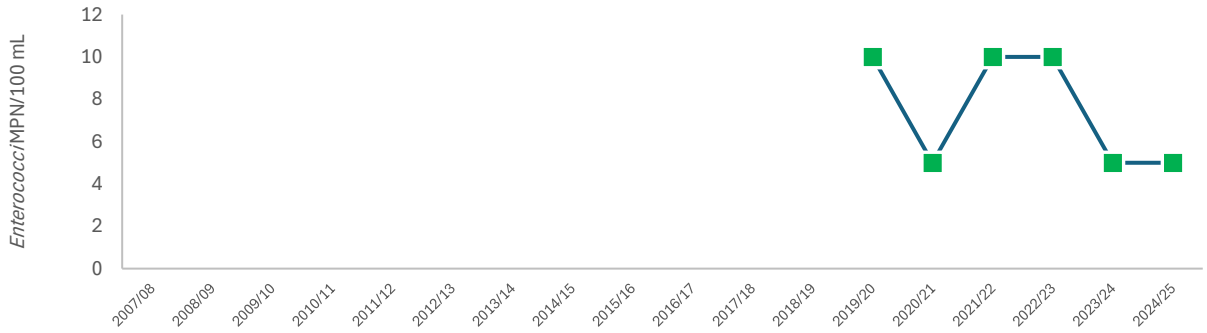
Notes:
1. EQG = Environmental Quality Guideline
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).
3. Secondary contact recreation = activities where humans are in secondary contact with the water (e.g. boating and fishing).

Shoreline sites are not formally assessed against the EQC, however the 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Ocean Reef ocean outlets was 15 MPN/100 mL, and met the primary (<200) contact recreation EQGs (Table 29).

Table 29 The 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Ocean Reef outlets for 2023 – 25 and comparison to the EQG

Sampling period	95th percentile[1,2]	Compliance (EQC)[3,4] Primary contact
Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	15 MPN/100 mL	

Notes:
1. MPN = most probable number of *Enterococci* spp.
2. *Enterococci* spp. concentrations below the analytical limit of reporting (<10 *Enterococci* spp. MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95th percentile.
3. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
4. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.

Figure 33 95th percentile shoreline *Enterococci* spp. concentration

6 Aesthetics and Fish tainting substances

6.1 Aesthetic monitoring

The Environmental Quality Criteria for aesthetic quality (Table 30) was assessed on each field sampling event via a questionnaire completed by field personnel on ten occasions during the non-river flow period. On each occasion, the questionnaire was completed at one location on the recreation contact boundary down-current of the ocean outlets. Water clarity around the outlets (mean LAC at 350 m from the diffuser, pooled from all days) was compared against water clarity at a greater distance from the outlets (mean LAC at 1,500 m from the diffuser, pooled from all days) to assess whether aesthetic differences exist. Water Corporation also maintains a complaints register for the Ocean Reef PLOOM program.

The results of the aesthetic monitoring are presented in Table 31. The field surveys found algae/plant material visible on the surface on 40% of occasions. No dead marine organisms were visible on any occasion. There was noticeable colour variation on 10% of occasions. There were no films, oil or floating debris on the surface on any sampling occasion. There was no noticeable odour associated with the water on any of the sampling occasions.

Mean LAC at 350 m from the ocean outlets (0.091 Log1 m-1) was slightly higher than at 1500 m distance from the outlets (0.082 m-1) suggesting that light was more quickly attenuated at 350 m than 1,500 m (Table 32). Overall water clarity was decreased by ~10% and therefore the EQG that the natural visual clarity of the water should not be reduced by more than 20% was met.

Based on the EQC assessment, there was no observed decrease in the aesthetic water quality values of Ocean Reef during the field sampling events and the EQG was met. A recent independent report commissioned by the Department of Water and Environmental Regulation has shown there is no evidence that the community should be concerned about the outfall discharge affecting water quality at Mullaloo beach (O2 Marine, 2025).

Table 30 Environmental Quality Criteria for Recreation and Aesthetics

Indicator	Environmental Quality Criteria for Aesthetic Quality	
	EQG	EQS
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus should not be present in excessive amounts.	There should be no overall decrease in the aesthetic water quality values of the marine receiving environment using direct measures of the community's perception of aesthetic value.
Faunal deaths	There should be no reported incidents of large-scale deaths of marine organisms relating from unnatural causes.	
Water clarity	The natural visual clarity of the water should not be reduced by more than 20%.	
Colour	The natural hue of the water should not be changed by more than ten points on the Munsell scale.	
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water or detectable by odour.	
Surface debris	Water surfaces should be free of floating debris, dust and other objectionable matter, including substances that cause foaming.	
Odour	There should be no objectionable odour.	
Fish tainting substances	Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Shellfish Harvesting Safety Zone boundary.	There should be no detectable tainting of edible fish harvested outside the Shellfish Harvesting Safety Zone boundary.

Notes:

1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard

Table 31 Aesthetic observations and measurements near the Ocean Reef ocean outlets from November 2024 to March 2025.

Date	Site	Algae/plant material?	Dead marine organisms?	Secci depth (m)	Colour variation?	Oil or other films?	Floating debris?	Odour?	Cotton buds?
4/11/2024	OR7	No	No	7.5	No	No	No	No	No
18/11/2024	OR13	No	No	9.0	No	No	No	No	No
10/12/2024	OR8	Yes (algae)	No	6.0	No	No	No	No	No
16/12/2024	OR5	Yes	No	5.5	No	No	No	No	No
15/01/2025	OR12	Yes (seagrass, macrophytes)	No	7.5	No	No	No	No	No
20/01/2025	OR12	Yes (seagrass)	No	6.0	No	No	No	No	No
18/02/2025	OR11	Yes (seagrass, wrack)	No	3.8	Yes	No	No	No	No
24/02/2025	OR14	No	No	8.9	No	No	No	No	No
10/03/2025	OR14	No	No	5.5	No	No	No	No	No
25/03/2025	OR6	No	No	7.0	No	No	No	No	No

Table 32 Light attenuation coefficient at sites 350 m and 1500 m from the Ocean Reef ocean outlets from November 2024 to March 2025.

Date	Light attenuation coefficient (Log_{10}/m)	
	350 m (site ORT-350 m)	1,500 m (site ORT – 1500 m)
4/11/2024	0.080	0.074
18/11/2024	0.088	0.071
10/12/2024	0.086	0.081
16/12/2024	0.118	0.118
15/1/2025	0.084	0.073
20/1/2025	0.090	0.071
18/2/2025	0.124	0.103
24/2/2025	0.070	0.073
10/3/2025	0.098	0.075
25/03/2025	0.074	0.079
Average	**0.091**	**0.082**

6.2 Fish tainting substances

The EQC for fish tainting substances states that the concentrations of contaminants in a 24-hour composite sample are not to exceed the ecological guidelines. These guidelines are not specified in the Beenyup Ocean Outlets Marine Environmental Management Plan. Fish tainting guideline values have been adapted from those applied to the Sepia Depression monitoring program (as adapted from EPA, 2017; Table 33). Additional parameters, which were measured in the comprehensive TWW characterisation were also assessed, where a guideline was provided (EPA, 2017).

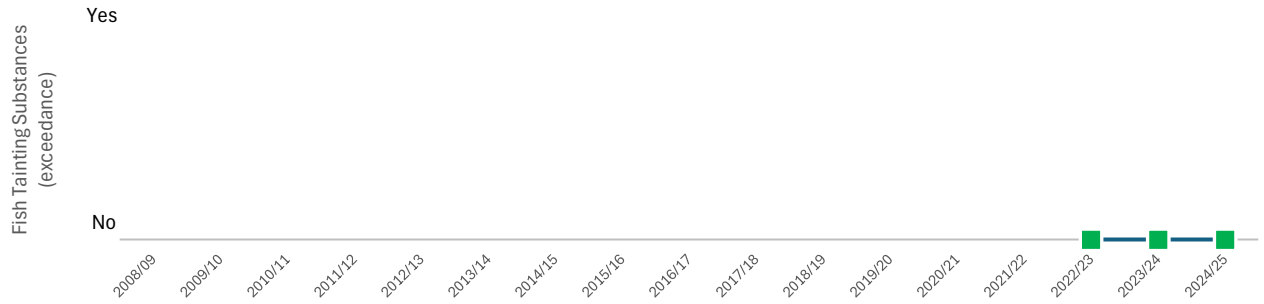
All units have been converted to ug/L for consistency and a dilution factor of 1:370 (worst case) applied. Where a result was below detection limits (<), the limit was already below the guideline before dilution, thus no exceedance is reported. Results are presented in Table 34.

Table 33 Environmental Quality Guidelines and Standards for Fish Tainting Substances

EQG	Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Primary Contact Management Zone boundary during normal plant operating conditions.
EQS	There should be no detectable tainting of edible fish harvested outside the Seafood Management Zone boundary.

Table 34 Assessment of fish tainting substances

Fish tainting substances	Observed TWW Concentration µg/L	Concentration after 1:370 initial dilution µg/L	EPA (2017) guideline for fish tainting substances µg/L	Exceedance
Acenaphthene	<0.02	*Below detection*	20	No
Copper	17	0.046	1,000	No
m-cresol	<0.1	*Below detection*	200	No
o-cresol	<0.1	*Below detection*	400	No
p-cresol	<0.1	*Below detection*	100	No
2,4-dichlorophenol	<0.1	*Below detection*	0.3	No
2,6-dichlorophenol	<0.1	*Below detection*	0.2	No
Pentachlorophenol	<0.05	*Below detection*	30	No
Phenol	<0.1	*Below detection*	300	No
2,3,4,6-tetrachlorophenol	<0.1	*Below detection*	1	No
2,3,5-trichlorophenol	<0.1	*Below detection*	1	No
2,4,6-trichlorophenol	<0.1	*Below detection*	2	No
2,4-dimethylphenol	<0.1	*Below detection*	400	No
Ethylbenzene	<2	*Below detection*	250	No
Hexachlorocyclopentadiene	<10	*Below detection*	1	No
Naphthalene	<0.02	*Below detection*	1,000	No
Nitrobenzene	<2	*Below detection*	30	No
Toluene	<2	*Below detection*	250	No
Zinc	127	0.34	5,000	No



Note:

1. Environmental Quality Criteria (EQC): Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Fish Tainting Substances have only been analysed since 2022/23

Figure 34 Environmental Quality Guideline assessment for fish tainting substances

7 References

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