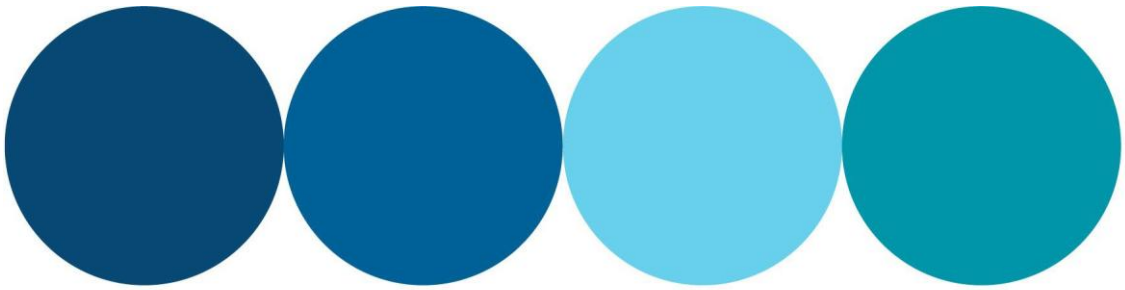
Perth Long-term Ocean Outlet Monitoring (PLOOM) Program & Sepia Depression Ocean Outlet Landline (SDOOL)

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
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
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
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Management Framework
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
PLOOM	Perth Long-term Ocean Outlet Monitoring
SHEZ	Shellfish Harvesting Exclusion Zone
TCM	Trial Compliance Monitoring
TTC	Thermotolerant Coliforms
TTM	Total Toxicity of the Mixture
TWW	Treated Wastewater
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 less dense than seawater, so it rapidly rises, mixes and dilutes into the ocean. Ocean discharges are regulated by the Department of Water and Environmental Regulation (DWER).

Water Corporation discharges treated wastewater from the Woodman Point and East Rockingham WRRFs, the Point Peron Wastewater Treatment Plant, the Kwinana Water Reclamation Plant and industry to the ocean via the Sepia Depression ocean outlet pipeline. 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 100 metres around the outlet 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.

The Perth Long-term Ocean Outlet Monitoring (PLOOM) program involves testing the marine water quality around the Sepia Depression outlet and surrounding environment to confirm the quality has returned to within the natural range expected in the HEPA, and to protect the environment and its recreational users (swimmers, boaters and fishers). Water Corporation collects samples from within the LEPA, at the boundary of the LEPA and the HEPA, and at reference sites selected to represent the background composition of waters around the outlet. Additional management considerations are applied to a Recreational Contact Exclusion Zone and Shellfish Harvesting Exclusion Zones.

Results from the monitoring are compared against nationally agreed criteria that have been adopted by Western Australia's EPA. There are two levels of criteria - a simple, conservative early warning trigger (Environmental Quality Guideline or EQG) and a more detailed, complicated assessment of potential impacts (Environmental Quality Standard or EQS). The Perth Long-term Ocean Outlet Monitoring (PLOOM) program and the Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring Program comprises of these investigations.

This annual report documents the findings of the 2024-2025 Sepia Depression monitoring as part of the PLOOM/SDOOL program. The compliance results for 2024-2025 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

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 national guideline values.
Non-bioaccumulating toxicants	Some low levels of contaminants (e.g. detergents, metals and oils) may persist in 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 national 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 national 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 TWW and demonstrate that the discharge is not harmful to the ocean environment.		The TWW plume is sufficiently diluted to achieve the No Ecological Effects Concentration at the management boundary.
Nutrient enrichment and phytoplankton blooms			
Chlorophyll-*a*	Phytoplankton are a naturally occurring part of the marine environment, but TWW 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.		Chlorophyll–*a* concentration outside the immediate area around the Sepia Depression outlet met the early warning EQG triggers and was similar to the reference sites. Phytoplankton were not increased by nutrients in the TWW.

Indicator	Indicator purpose	Result	Commentary
Light attenuation coefficient (LAC)	Increased phytoplankton can block (attenuate) light from reaching the bottom (impacting seagrass and macroalgae).		Light attenuation outside the direct vicinity of the outlet met the early warning EQG. Light transmission to the sea floor was not reduced.
Physical and chemical stressors			
Organic enrichment	Organic matter in TWW 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 DO concentration against the Environmental Protection Authority (EPA) guidelines.		DO remained >90% at all times at all sites near the outlet. DO levels near the outlet 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. TWW is fresh whereas the ocean is saline. When TWW is discharged to the ocean, salinity will be reduced in an area around the outlet until the fresher water is fully mixed with the saline seawater. Low salinity water may cause stress to marine life.		Median salinity was between the 20th and 80th percentile of the natural (reference site) salinity range at all HEPA sites.

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 outlet	The risk from bacteria to seafood safety is assessed using the indicator organism thermotolerant coliforms.		The relevant concentrations of thermotolerant coliforms near the outlet 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 outlet was very low.
Shoreline TTC[1]			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 outlet was very low.
Algal biotoxins			
Toxic phytoplankton species	In some cases, phytoplankton can include species than can taint seafood.		There were no exceedances recorded during the 2024-25 extended summer monitoring period.

Note:

1. The shoreline sites are not formally assessed against the EQC

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 top 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 outlet	The risk from bacteria to recreation contact (swimming and boating) is assessed using the indicator organism *Enterococci* spp.		*Enterococci* spp. exceeded both the early warning EQG trigger and the more vigorous EQS criteria near the outlet for primary contact. Primary contact activities (e.g. swimming, diving etc) are unlikely near the outlet due to its distance from shore (4 km). Exceedance of the EQG and EQS for primary contact recreation was reported to Department of Health and Department of Water and Environmental Regulation as per the SDOOL MMP (BMT Oceanica 2014).
			Enterococci spp. did not exceed the early warning EQG for secondary contact.
Shoreline *Enterococci* spp.			*Enterococci* spp. concentrations met the EQG near the shoreline for both primary and secondary contact.
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 15,000 cells/mL.		The chlorophyll-*a* based guidelines for phytoplankton are well below a level that would be visible as an algal bloom. The highest total phytoplankton cell concentration in the HEPA was 69 cells/mL. There were no algal blooms identified.

Aesthetics

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.		Aesthetic values of Perth coastal waters were maintained and protected.
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. Note that the fish tainting substances 2,4-Dichlorophenol, 2,4,6-Trichlorophenol and Hexachlorocyclopentadiene could not be assessed for compliance due to the lack of sensitivity of the laboratory test

Executive Summary

This report documents the findings of the 2024–2025 Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring and Management Plan (MMP; BMT Oceanica 2014) within the Perth Long-Term Ocean Outlet Monitoring (PLOOM) Program, fulfilling Commitment no. 4 of the Ministerial Statement 665. The report outlines the findings of three environmental monitoring programs:

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

The Sepia Depression Ocean Outfall has its own Monitoring and Management Plan in accordance with Ministerial Statement 665 and LEPA's are determined by the EPA (BMT Oceanica, 2014). Each ocean outfall monitored under the PLOOM program will have different site-specific dynamics which will impact the regulatory criteria. 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:

- Concentrations of bioaccumulating toxicants (specifically, cadmium and mercury) must be below their respective ANZECC & ARMCANZ (2000) 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.
- Concentrations of non-bioaccumulating contaminants must not exceed their ANZECC & ARMCANZ (2000) 99% species protection guideline at the Low Ecological Protection Area (hereafter LEPA) boundary (100 m radius from the diffuser). Concentrations of non-bioaccumulating toxicants were below their ANZECC & ARMCANZ (2000) criteria scaled based on 5th percentile dilution at the LEPA boundary (as per the EQG BMT Oceanica 2014), thus meeting the 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 the guideline of 1.0 (BMT Oceanica 2014; ANZECC & ARMCANZ 2000). The TTM following initial dilution was 0.52, which is lower than the guideline and the EQG was met.
- 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 (No Observed Effect Concentration [NOEC]) must be greater than 1.0% TWW concentration. The lowest NOEC from tests undertaken in August 2024, November 2024, February 2025 and April 2025 was 6.3% and the EQG was met.

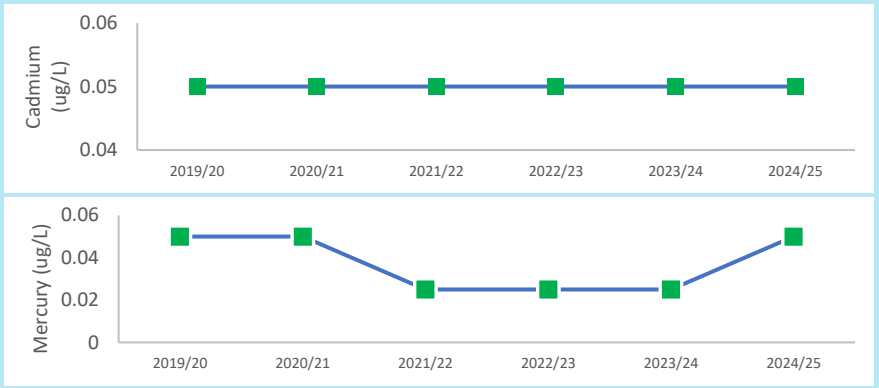
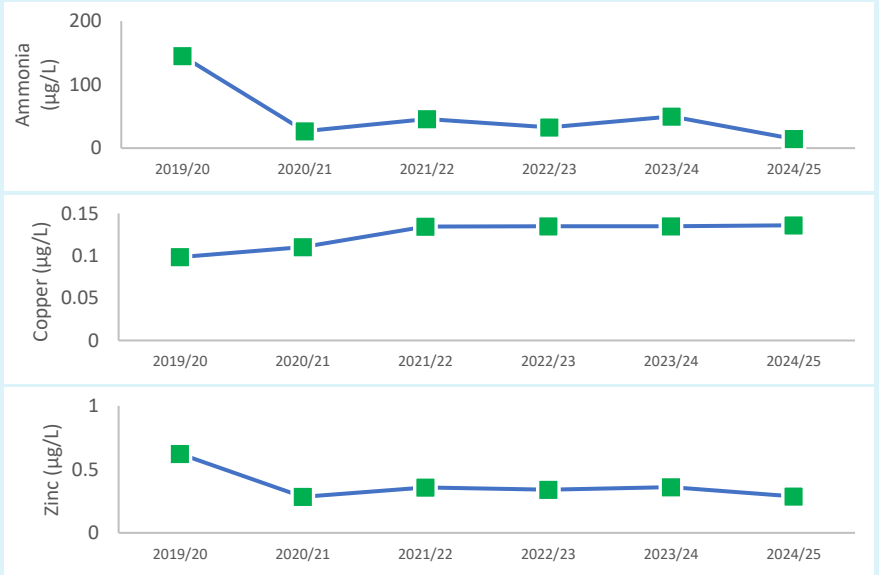
Water quality monitoring – receiving environment

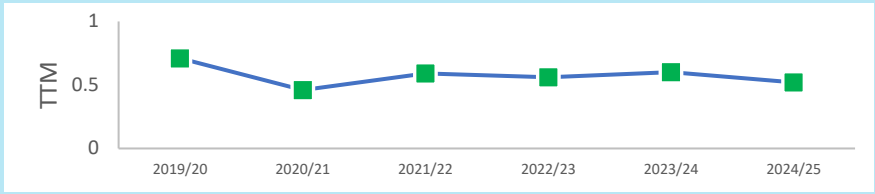
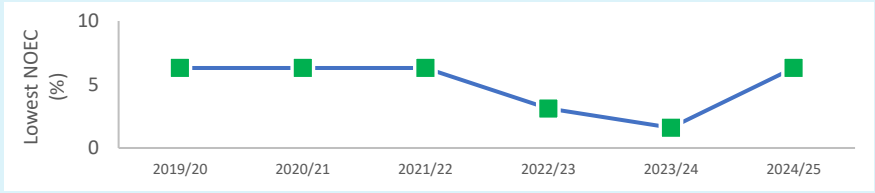
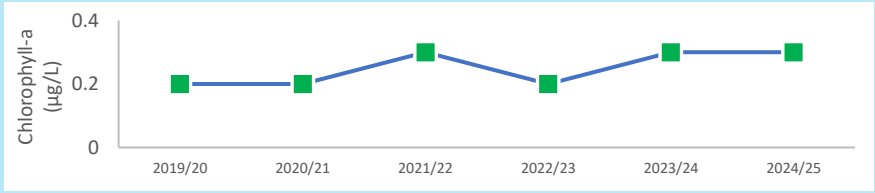
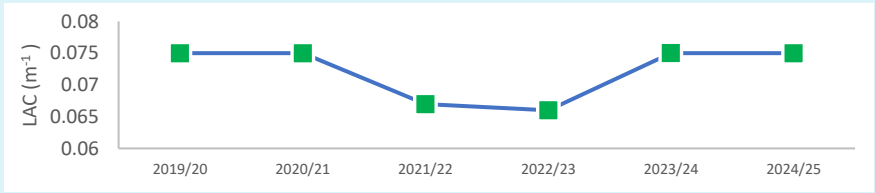
Ocean sampling was on eight occasions between December 2024 and March 2025 at fixed distance intervals down-current (determined using a drogue) of the ocean outlet. There are six EQGs based on chlorophyll–*a* concentration (a measure of phytoplankton biomass), water temperature, salinity, dissolved oxygen and light attenuation coefficient:

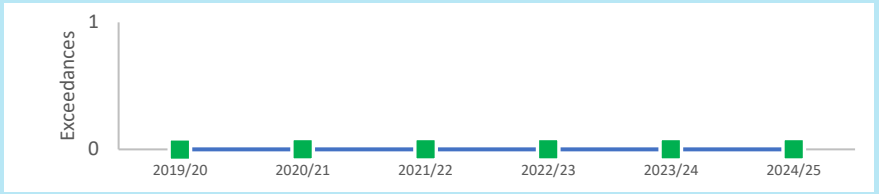
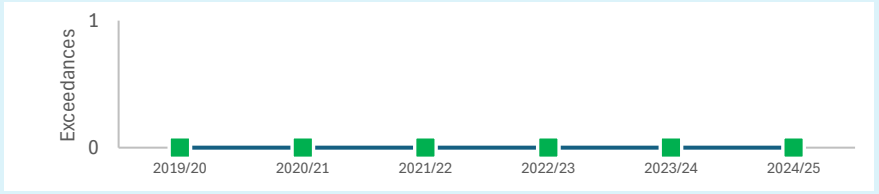
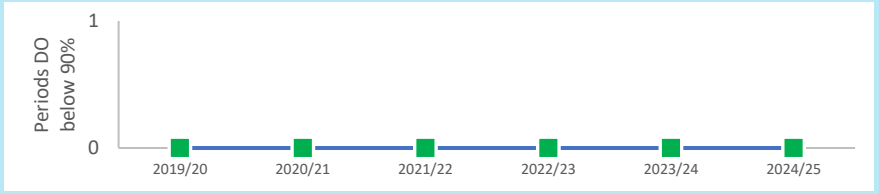
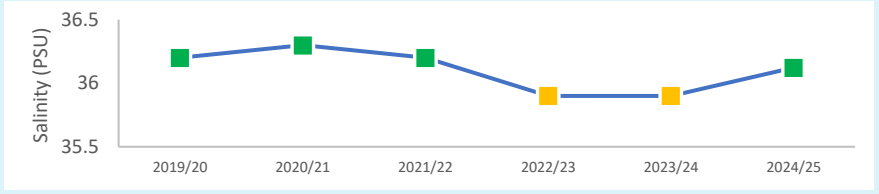
- The median chlorophyll–*a* concentration in the High Ecological Protection Area (HEPA; i.e. 100 m and greater from the diffuser) during the non-river flow period must not exceed the 80th percentile of historical reference site data. Median chlorophyll–*a* concentration within the HEPA (0.3 µg/L) was below the 80th percentile of historical reference site concentrations (0.4 µg/L) and the EQG was met.

- The median light attenuation coefficient (LAC) in the HEPA must not exceed the 80th percentile of historical reference site data. Median LAC within the HEPA (0.075 m^{-1}) was lower than the 80th percentile of historical reference sites (0.079 m^{-1}) and the EQG was met.
- Median phytoplankton biomass, measured as chlorophyll–*a*, must not exceed three times the median chlorophyll-*a* concentration of historical reference sites, on any occasion. Median chlorophyll–*a* concentrations did not exceed three times the median of reference sites on any occasion during the summer monitoring period and the EQG was met.
- Phytoplankton biomass, measured as chlorophyll–*a*, at any site must not exceed three times the median chlorophyll–a concentration of historical reference sites, on 25% or more occasions. Median phytoplankton biomass, measured as chlorophyll–*a*, exceeded three times the median of reference sites on one sampling occasion (12.5% of occasions) during the summer monitoring period and the EQG was met.
- Median dissolved oxygen in bottom waters (0 - 0.5 m above the seabed) 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.
- Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period. Median salinity did not deviate from the 20th and 80th percentile and the EQG was met.

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	Concentrations of cadmium and mercury in the undiluted TWW sample were below the ANZECC & ARMCANZ (2000) 80% species protection guideline.		
	Non-bioaccumulating toxicants and initial dilution	EQG	Contaminant concentrations were lower than the ANZECC & ARMCANZ (2000) 99% species protection guidelines after dilution equivalent to that expected at the LEPA[2] boundary.		

	Total Toxicity of the Mixture (TTM)	EQG	The TTM for the additive effect of ammonia, copper, and zinc after initial dilution (0.52) was below the ANZECC & ARMCANZ (2000) guideline value of 1.0.		
	Whole of Effluent Toxicity (WET)	EQG	The lowest NOEC[3] from tests undertaken in July 2024, November 2024, February 2025 and April 2025 (6.3%) was >1%.		
Nutrient enrichment	Chlorophyll-*a*	EQG	The median chlorophyll–*a* concentration in the Sepia Depression HEPA[2] (≥100 m) was 0.3 µg/L and below the 80th percentile of reference site data (0.4 µg/L).		
	Light Attenuation Coefficient (LAC)[2]	EQG	The median LAC[2] in the Sepia Depression HEPA[2] (≥100 m) was 0.075 m^{-1} and was lower than the 80th percentile of reference site data (0.079 m^{-1}).		

Phytoplankton blooms	Phytoplankton biomass (measured as chlorophyll-*a*)	EQG 1	Median chlorophyll–*a* concentration within the HEPA[2] (≥100 m) did not exceed three times the median of reference sites (0.90 µg/L) on any sampling occasion.		
		EQG 2	Phytoplankton biomass measured as chlorophyll-*a* did not exceed three times the median chlorophyll-*a* concentration of reference sites, on any occasion during non-river flow period.		
Physical-chemical stressors	Organic enrichment	EQG	Dissolved oxygen saturation within the notional HEPA[2] was maintained above 90% saturation at all times.		
	Salinity	EQG	Median salinity was within the 20th and 80th percentile of the natural salinity range at the 100 m site within the HEPA[2] (≥100 m).		

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; LAC = Light Attenuation Coefficient.
3. NOEC = No Observed Effect Concentration; the highest concentration of treated wastewater (TWW) at which there is no statistically significant observed effect on gamete fertilisation.

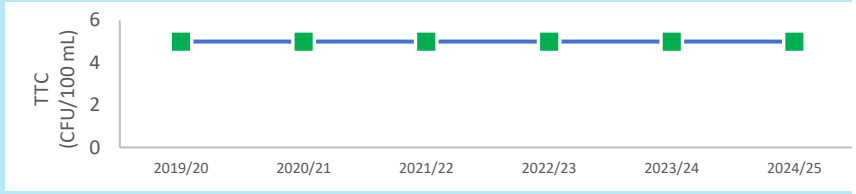
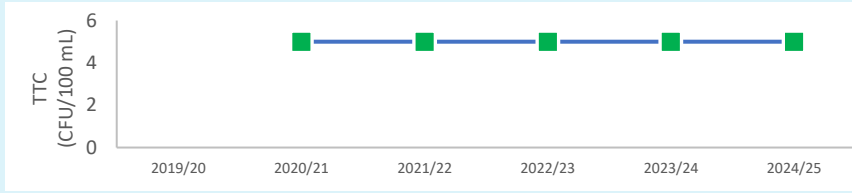
Environmental Quality Objective 'Maintenance of Seafood Safe for Human Consumption'

There are two EQC for the EQO 'Maintenance of the Seafood 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 first EQG, median TTC concentrations at sites at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ) are not to exceed 14 CFU/100 mL, with no more than 10% of the samples exceeding 21 CFU/100 mL. The median TTC concentration pooled from three sampling seasons (2022–23, 2023–24 and 2024-25) required to achieve a suitable sample size (EPA 2005)[1] was at the limit of detection (<10 CFU/100 mL) and below 14 CFU/100 mL. There were 4 instances where TTC exceeded 21 CFU/100 mL, representing 3.33% of samples. The EQG for TTC was met.
- As an informal assessment against the second (EQG for shoreline monitoring sites, the median concentration of TTC should not exceed 14 CFU/100 mL, with no more than 10% of samples exceeding 21 CFU/100 mL. The pooled median TTC concentration from two sampling seasons (2023–24 and 2024–25), combined to achieve a suitable sample size (EPA 2005), was reported at the laboratory limit of detection (<10 CFU/100 mL), which is below the guideline value of 14 CFU/100 mL. This result indicates that the informal EQG for TTC would be met.
- To meet the EQG for algal biotoxins, concentrations of potentially toxic algae at sites at the boundary of the SHEZ 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, meeting the EQG.

[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 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 159 samples collected over the 2022-23, 2023–24 and 2024-25 sampling seasons were at the limit of detection (<10 CFU/100 mL).		
Microbiological contaminants (shoreline sites)[5]		EQG	Median TTC concentrations derived from 159 samples collected over the 2023–24 and 2024-25 sampling seasons were at the limit of detection (<10 CFU/100 mL).		
Algal biotoxins	Toxic phytoplankton species	EQG	There were no exceedances recorded during the 2024-25 extended summer monitoring period, meeting the EQG.		

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 = Thermotolerant coliforms, CFU = colony forming units
3. TTC results below the analytical limit of reporting (<10 CFU/mL) were halved (= 5 CFU/mL) to calculate median value.
4. Marine Biotoxin Monitoring and Management Plan 2025 version 5: 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.

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.

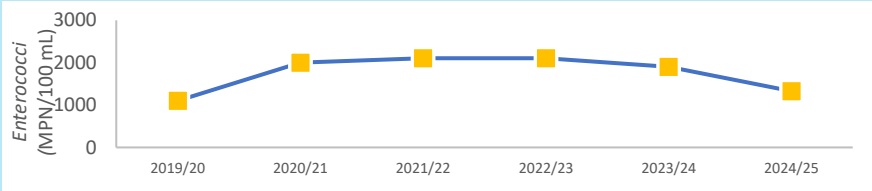
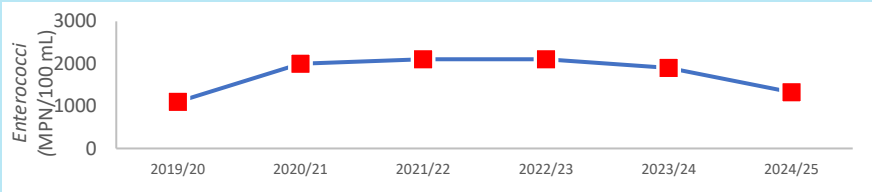
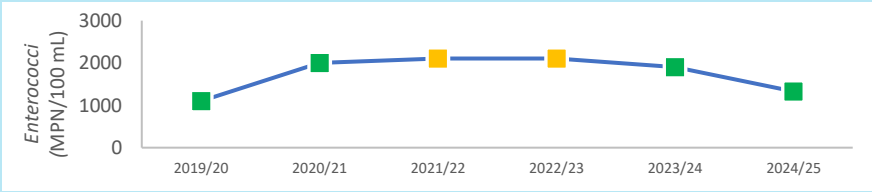
- To meet the *Enterococci* spp. EQG for outside the SHEZ, the 95th percentile value of faecal indicators (*Enterococci* spp.) outside the SHEZ boundary must not exceed 200 MPN/100 mL and 2000 MPN/100 mL for primary and secondary contact recreation, respectively. The 95th percentile of *Enterococci* spp. concentrations at the SHEZ based on pooled data from three sampling seasons (2022–2023, 2023–2024 and 2024-2025)[2] was 1,330 MPN/100 mL, exceeding the EQG primary contact recreation (EQG 1), triggering assessment against the EQS primary contact recreation (EQS). The 95th percentile value of faecal indicators (*Enterococci* spp.) at the shoreline monitoring sites was below the laboratory limit of reporting (<10 MPN/100 mL), meeting the EQG for secondary contact recreation (EQG 2).
    - Due to the exceedance of the primary contact recreation EQG 1 at the SHEZ, assessment against the EQS 1 was triggered. The 95th percentile of *Enterococci* spp. concentrations at the SHEZ based on pooled data from three sampling seasons (2022–23, 2023–24 and 2024-2025) was 1,330 MPN/100 mL, exceeding the 500 MPN/100 mL trigger level and exceeding the EQS primary contact recreation (EQS 1). Exceedance of the EQG and EQS for primary contact recreation was reported to Department of Health and Department of Water and Environmental Regulation as per the SDOOP MMP (BMT Oceanica 2014).
    - To assess performance against the informal trigger values for Enterococci spp. at shoreline monitoring sites, the 95th percentile of faecal indicator concentrations should not exceed 200 MPN/100 mL for primary contact recreation and 2,000 MPN/100 mL for secondary contact recreation. The 95th percentile of Enterococci spp. concentrations at the shoreline, based on pooled data from three sampling seasons (2023–2024 and 2024–2025), was 16.5 MPN/100 mL. This value is well below the informal trigger value for primary contact recreation (200 MPN/100 mL), indicating that the relevant Environmental Quality Guideline (EQG 2) would be met.
- To meet the algal biotoxin EQG 1, the median total phytoplankton cell count at a specified site should not exceed 15,000 cells/mL during normal plant operating conditions. The highest total phytoplankton cell concentration was 69 cells/mL and the EQG was met.
- 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 (via Department of Health) as potentially resulting from toxic algae when less than 15,000 cells/mL is present in the water column. There were no reports of skin or eye irritation or potential algal poisoning in swimmers, meeting the EQG.

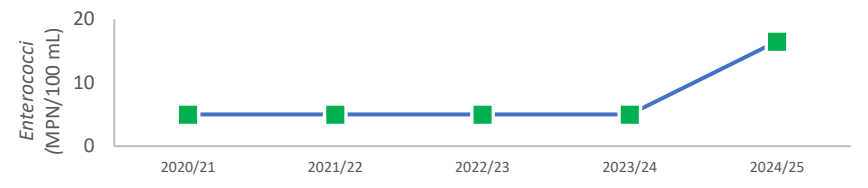
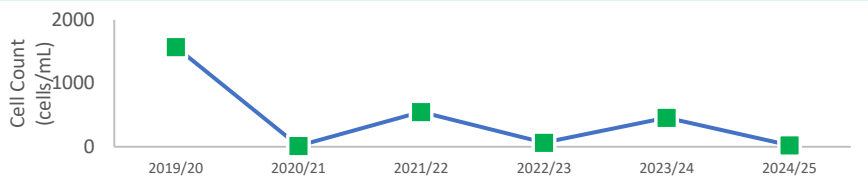
Prior to 2013/14, primary contact recreation had been managed (albeit informally) against the ANZECC (1992) criteria (median *Enterococci* spp. concentrations <35 MPN/100 mL). Development of the MMP formalised the monitoring regime and updated the approach to the contemporary and best practice

[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.*

EQMF including adopting the EPA (2005) criteria (the 95th percentile *Enterococci* spp. concentration <200 MPN/100 mL). The informal management boundaries that applied historically were not altered accordingly and exceedance of the EPA (2017) recreational contact criteria is an artefact of the change of criteria. The historical discharge footprint is unchanged, and the exceedances are not indicative of an increased risk to EQO. Water Corporation have reported and manage these exceedances on consultation with the Department of Health.

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 (1,330 MPN/100 mL) exceeded EQG 1 for primary contact (200 MPN/100 mL).		
		EQS 1	The 95th percentile of *Enterococci* spp. concentrations (1,330 MPN/100 mL) exceeded EQS 1 for primary contact (500 MPN/100 mL). Exceedance of the EQG and EQS for primary contact recreation was reported to Department of Health and Department of Water and Environmental Regulation as per the SDOOL MMP (BMT Oceanica 2014).		
		EQG 2	The 95th percentile of *Enterococci* spp. concentrations (1,330 MPN/100 mL) met EQG 2 for secondary contact (2,000 MPN/100 mL).		

Environmental Quality Indicator		EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Faecal indicators (shoreline sites)[2]		EQG 1	The 95th percentile of *Enterococci* spp. concentrations (16.5 MPN/100 mL) was below the EQG 1 for **primary contact** (200 MPN/100 mL)[3].		
		EQG 2	The 95th percentile of *Enterococci* spp. concentrations (16.5 MPN/100 mL) was below the EQG 2 for **secondary contact** (2,000 MPN/100 mL[3]).		
Algal biotoxins	Phytoplankton (cell concentration)	EQG 1	The median total phytoplankton cell count from a single site did not exceed 15,000 cells/mL.		
		EQG 2	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:

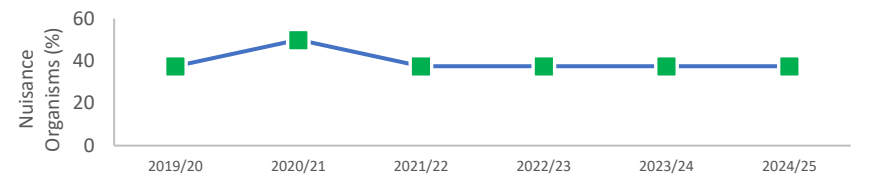
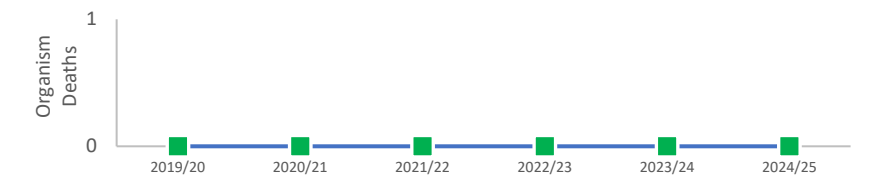
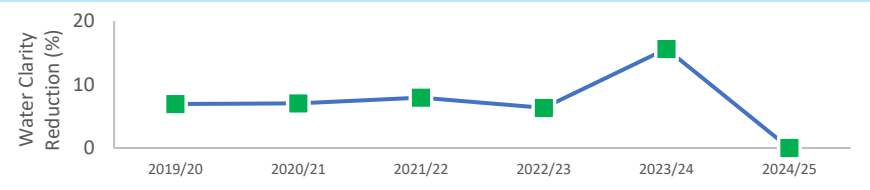
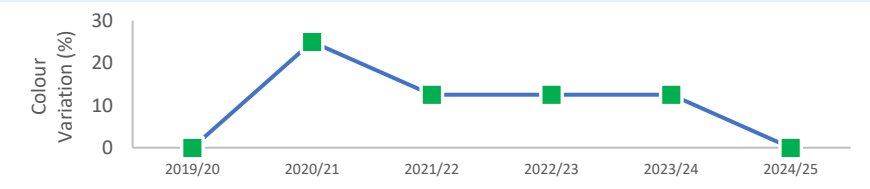
1. Green symbols indicate the Environmental Quality Guideline (EQG) was met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
2. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.
3. Half the laboratory Limit of Reporting (LoR) is applied for assessment purposes where the result was recorded at the LoR.

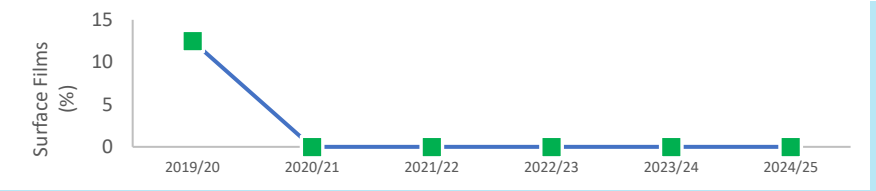
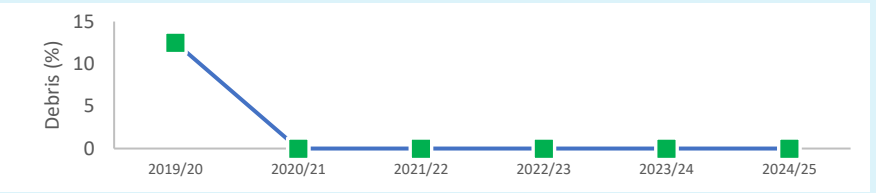
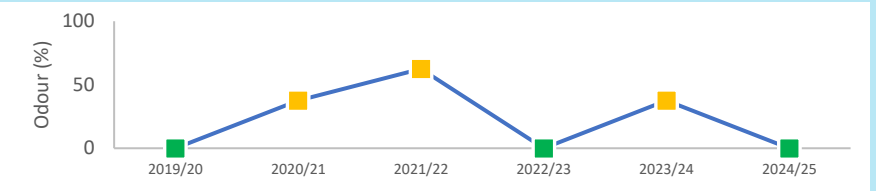
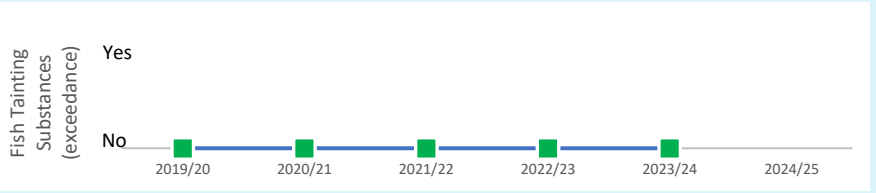
Environmental Quality Objective 'Maintenance of Aesthetic Values'

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 present on 4 (50% of) occasions 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 organisms observed and the EQG was met.
- The natural visual clarity of the water should not be reduced by more than 20%. Measurements of light attenuation determined that the natural visual clarity of the water was not reduced at all (0%) 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 no noticeable colour variation on any sampling occasions 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 Recreational Contact Exclusion Zone boundary during normal plant operating conditions. No exceedances were detected for fish tainting substances and the EQG was met. Note that the fish tainting substances 2,4-Dichlorophenol, 2,4,6-Trichlorophenol and Hexachlorocyclopentadiene could not be assessed for compliance due to the lack of sensitivity of the laboratory test.

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

Environmental Quality Indicator	EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Nuisance organisms	EQG	Nuisance organisms were present on 50% of occasions and the EQG was met.		
Faunal deaths	EQG	There were no instances of dead marine organism observed.		
Water clarity	EQG	Measurements of light attenuation determined that the natural visual clarity of the water was not reduced.		
Colour	EQG	There was no variation in water colour observed on any sampling event.		

Environmental Quality Indicator	EQC	Comments	Compliance[1]	6-year compliance trend (including current year)
Surface films	EQG	No surface films or oil were recorded on any sampling event		
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.		
Fish tainting substances	EQG	No exceedances were detected for fish tainting substances. Note that the fish tainting substances 2,4-Dichlorophenol, 2,4,6-Trichlorophenol and Hexachlorocyclopentadiene could not be assessed for compliance due to the lack of sensitivity of the laboratory test.		

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.

1 Introduction

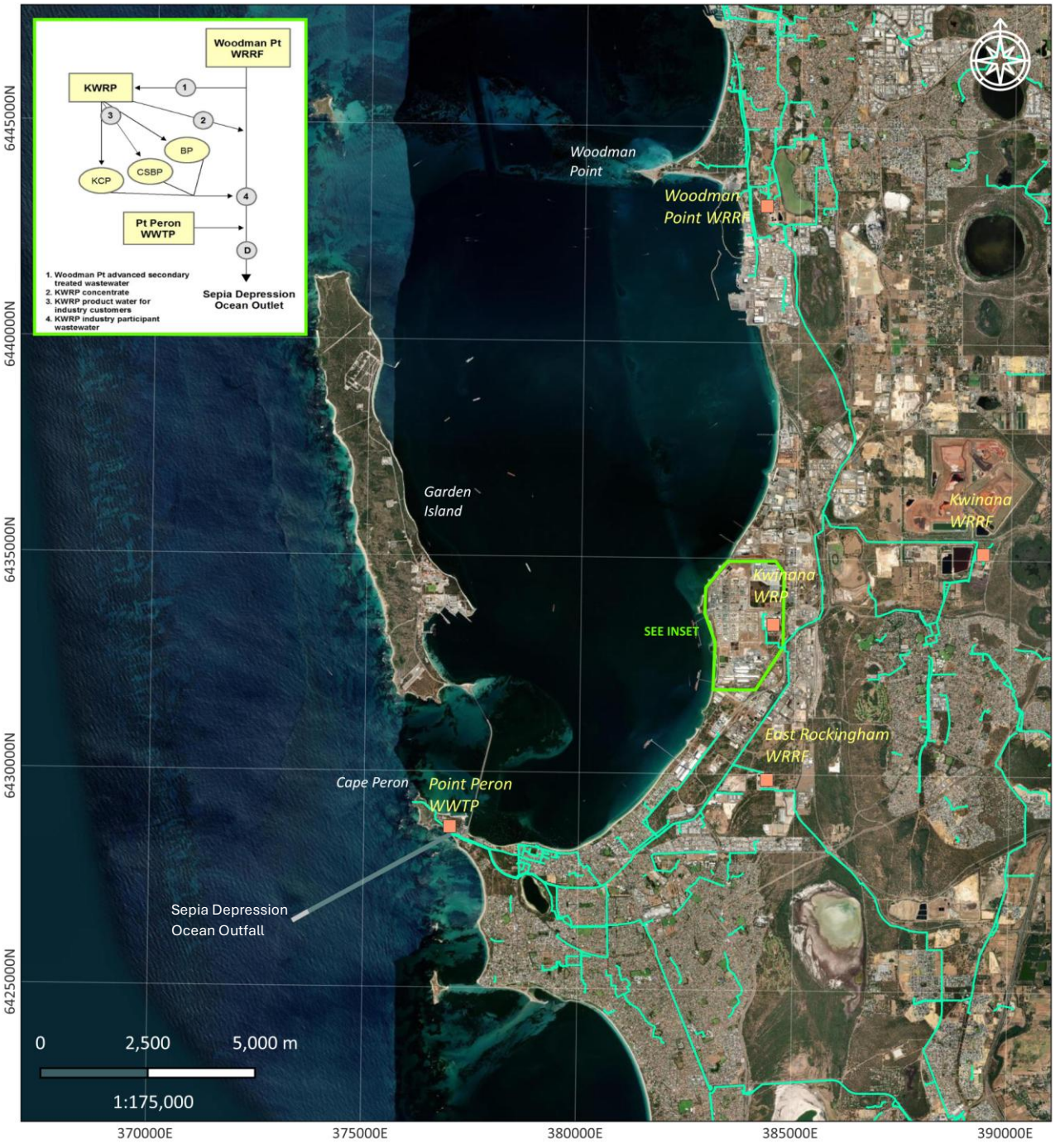
1.1 Document purpose

This annual report documents the findings of the 2024–2025 Sepia Depression ocean monitoring program, completed as part of the Perth Long-term Ocean Outlet Monitoring (PLOOM) Program. Monitoring was completed according to the Sepia Depression Ocean Outlet Landline (SDOOL) Monitoring and Management Plan.

1.2 Wastewater treatment plant infrastructure and discharge

Treated wastewater (TWW) discharged through the Sepia Depression ocean outlet comes from the Woodman Point Water Resource Recovery Facility (WRRF), East Rockingham WRRF, Kwinana WRRF, Point Peron Wastewater Treatment Plant (WWTP), and the Kwinana Water Reclamation Plant (KWRP). Most TWW discharged to the Sepia Depression outlet is from the Woodman Point WRRF.

The Woodman Point WRRF services the southern Perth metropolitan area and receives predominantly domestic wastewater (from kitchen, bathroom, toilet and laundry uses), with ~8% received from light industrial wastewater. A small volume of primary TWW is discharged from the Point Peron WWTP, located downstream of the Woodman Point WRRF (Figure 1). The KWRP processes secondary TWW from the Woodman Point WRRF to a quality suitable for use as high-grade industrial processing water by industries in the Kwinana industrial area. This high-grade industrial water is supplied to industry participants to reduce consumption of potable scheme water. The KWRP process concentrate is disposed of via the SDOOL (refer to Figure 1).



Legend

Sepia Depression Ocean Outfall
Diffuser
Pipe
Sewer Pressure Main (WCORP-069)
WWTP/WRRF
Kwinana Waste Reclamation Plant (KWRP)

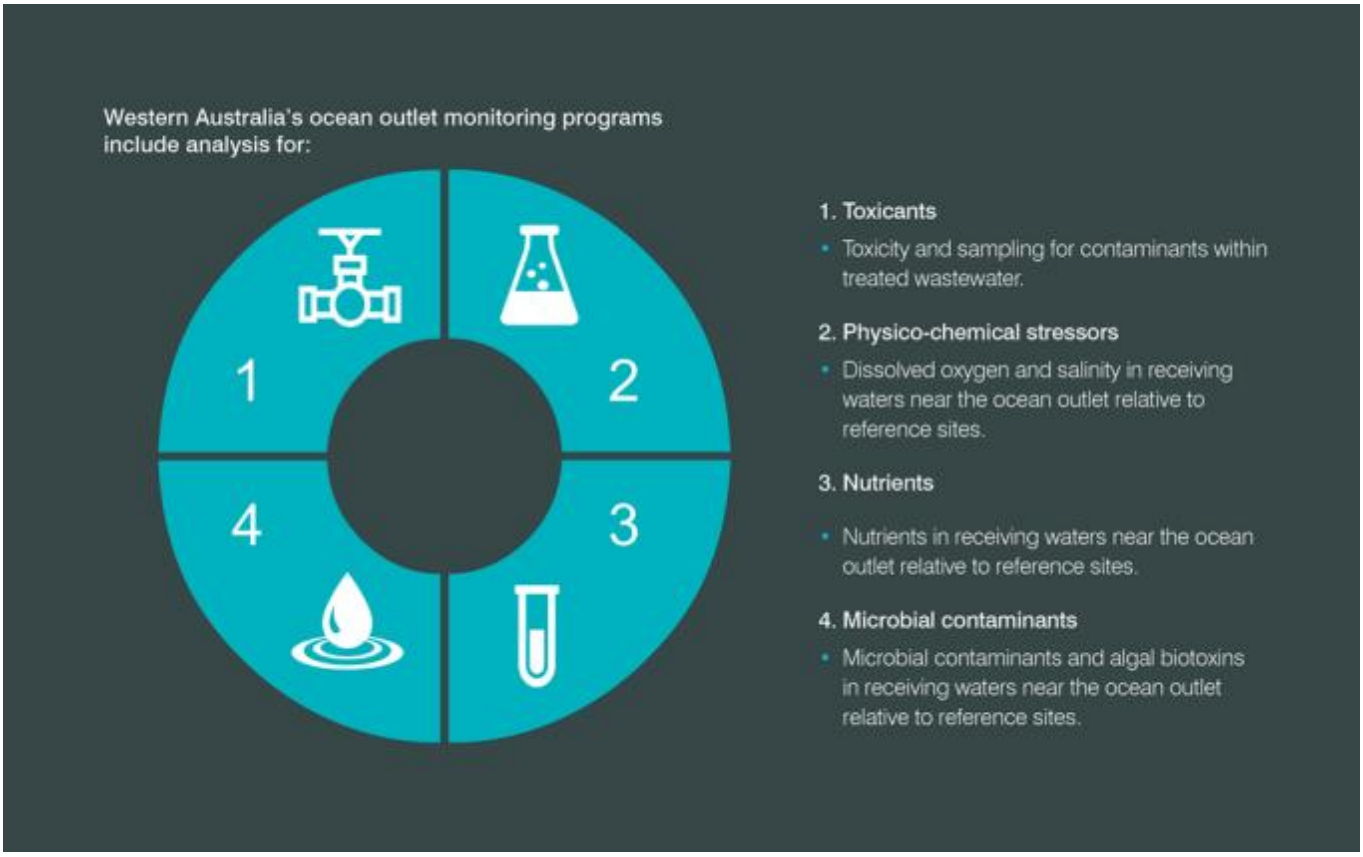
Notes:

Title: Sepia Depression - Contributing Waste Streams
Version: 1.1 26/09/2025
Drawn: Hydrobiology GIS
Approved: Keating
CRS: GDA 2020 MGA Zone 50
Basemap: ESRI Satellite (no date)
WWTP: Waste Water Treatment Plant
WRRF: Waste Resource Recovery Facility
WRP: Water Reclamation Plant

WATER CORPORATION
Hydrobiology
www.hydrobiology.com

Figure 1 Location of Sepia Depression Ocean Outlet Landline (SDOOL) and contributing waste streams (see inset figure)

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 (also known as direct toxicity assessment).

1.3.2 Physico-chemical stressors

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

Reduced salinity near the outlet, resulting from freshwater in the TWW plume, may cause osmotic stress in marine biota. Measurements of salinity in receiving waters near the outlet are compared to the salinity at appropriate reference sites. The comparison allows evaluation of whether salinity near the outlet 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) and light attenuation (a measure for water clarity).

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.

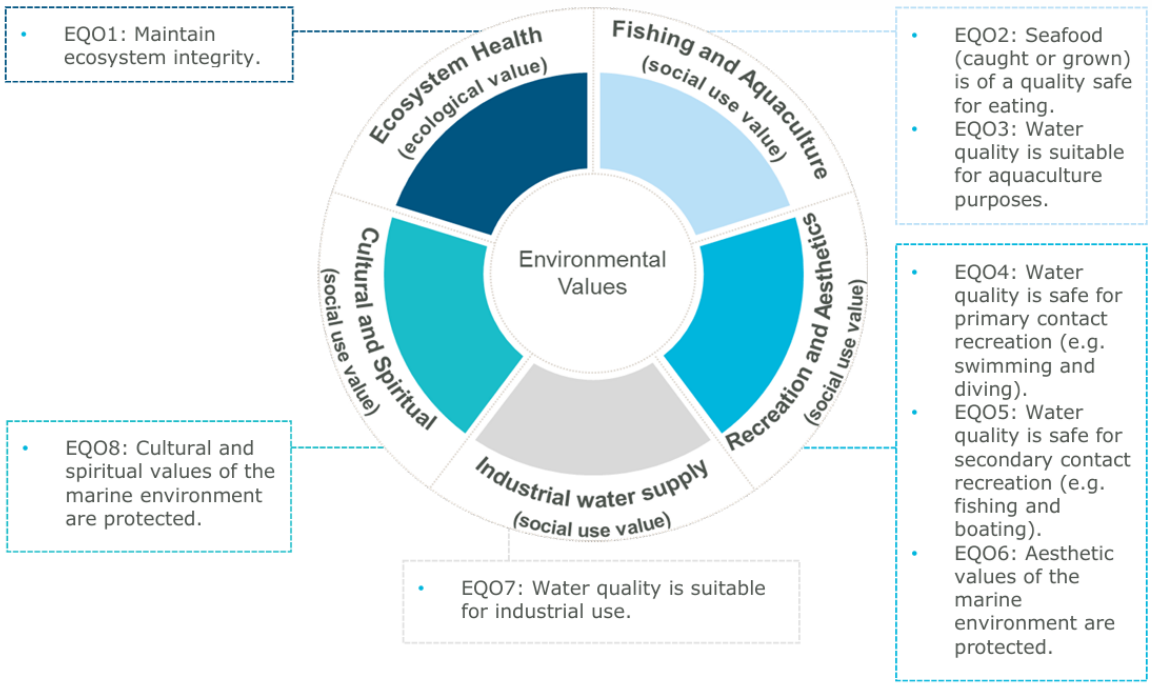
1.4 Environmental Quality Management Framework (EQMF)

The SDOOL and PLOOM programs are underpinned by the State Government's EQMF, which is applied to Western Australia's coastal waters (EPA 2017). The EQMF is based on:

- Identifying Environmental Values (EVs) (Figure 2).
- Establishing and spatially defining Environmental Quality Objectives (EQOs) that need to be maintained to ensure the associated EVs are protected (Figure 2).
- 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 2 Environmental Values and Environmental Quality Objectives (EQO) for the marine waters of Western Australia.

The compliance results for 2024-2025 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.

1.4.1 ‘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 3). A Low Ecological Protection Area (LEPA) has been established at the Sepia Depression outlet and occupies the area within a 100 m radius of the diffusers (Figure 4). Waters outside the LEPA are maintained to a High level of Ecological Protection (HEPA; Figure 4).

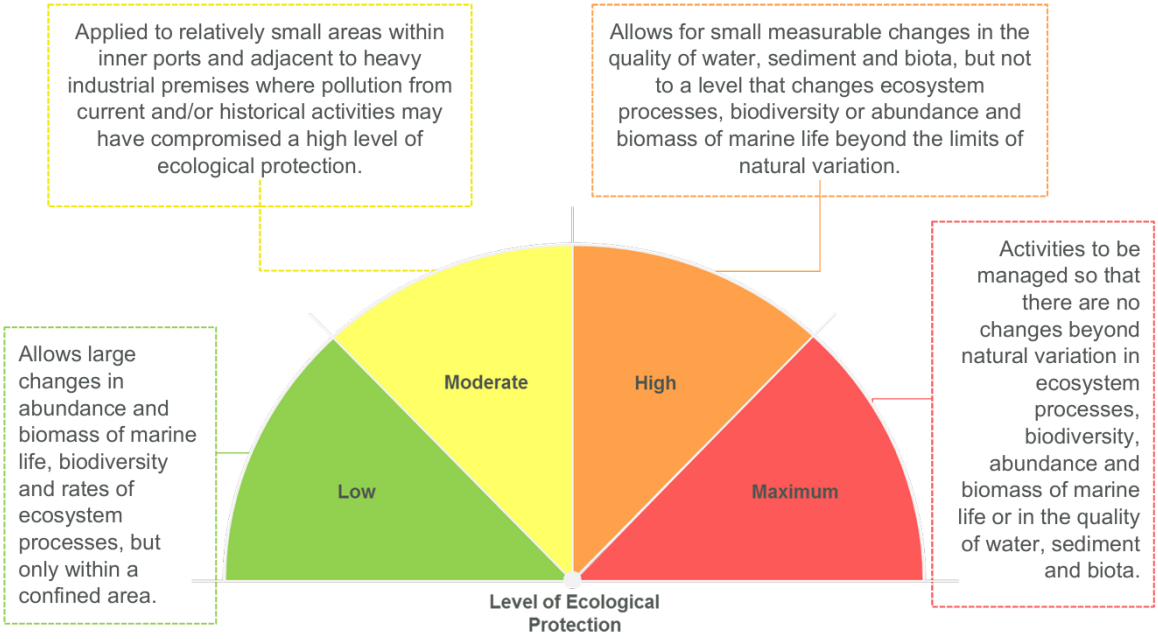


Figure 3 Level of Ecological Protection

1.4.2 ‘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 outlet where EQO 2 may not be achieved, and seafood may be unsafe to eat. Formal management zones have been established for the Sepia Depression ocean outlet (Figure 4). Microbiological contaminants and algal biotoxins are monitored at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ), to ensure the EQO is being met.

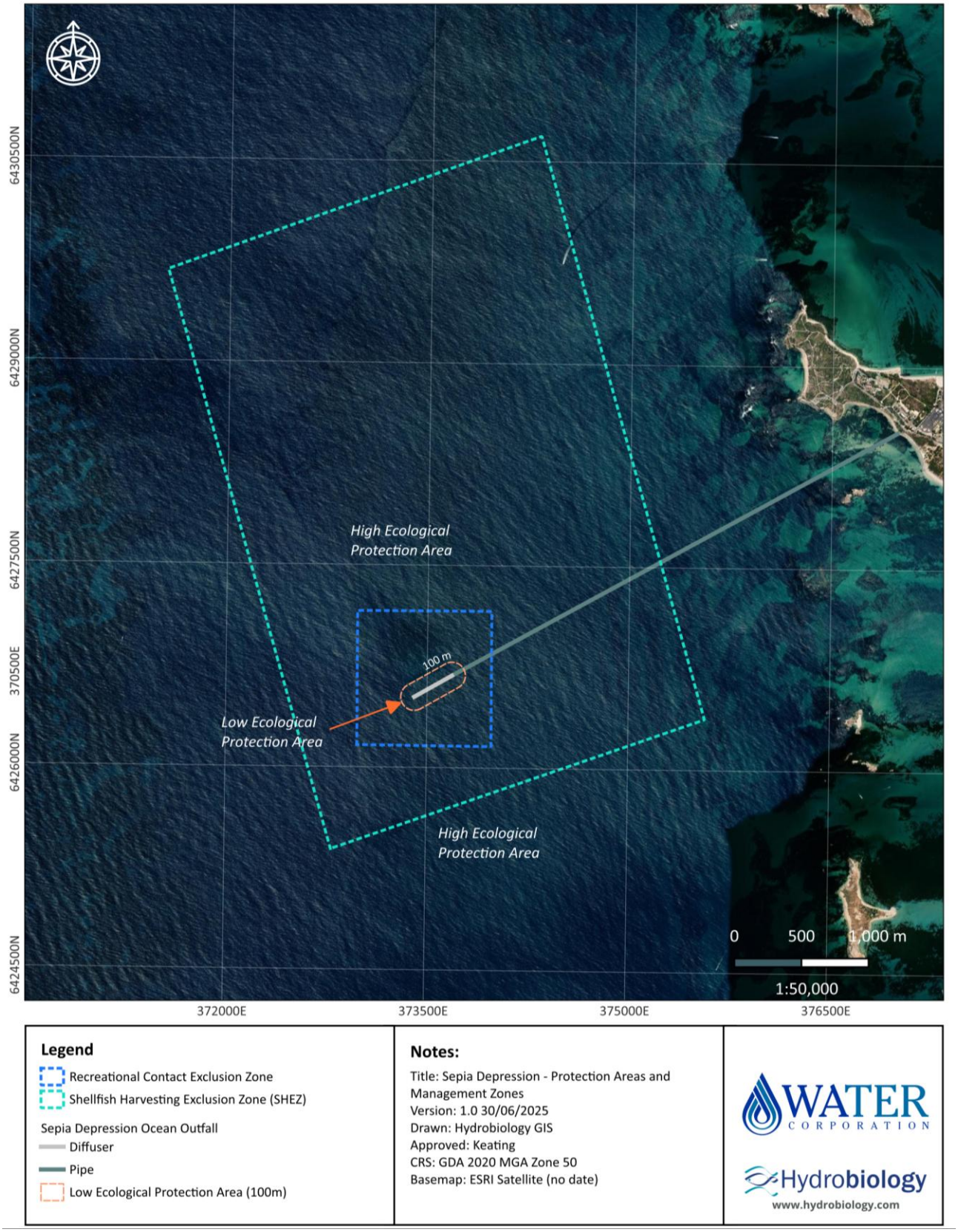


Figure 4 Sepia Depression ocean outlet, LEPA and management zones

1.4.3 ‘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 outlet, where water quality may not be suitable for swimming. An area where primary contact recreation is not recommended has been established for the Sepia Depression ocean outlet. This is known as the Recreational Contact Exclusion Zone (Figure 4).

1.4.4 ‘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.

2 Toxicants in treated wastewater

2.1 Comprehensive treated wastewater characterisation (CTWWC)

Treated wastewater (TWW; final effluent) from the SDOOL was analysed for a suite of parameters comprising the major contaminants of concern for the Sepia Depression ocean outlet:

- nutrients (total nitrogen, ammonia, nitrate + nitrite [NO_x], total phosphorus, orthophosphate)
- microbiological contaminants (thermotolerant coliforms [TTC] 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.

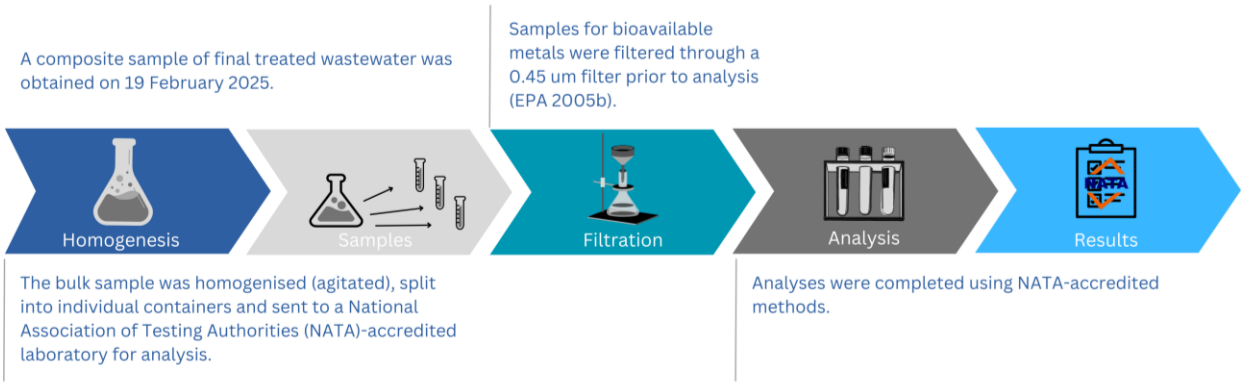


Figure 5 Treated wastewater sampling and analysis process

2.1.1 Bioaccumulating toxicants

Concentrations of cadmium and mercury (i.e. bioaccumulating toxicants) in the undiluted TWW sample were both below their analytical limit of reporting (LoR; <0.1 µg/L for cadmium and <0.1 µg/L for mercury) and the EQG for cadmium and mercury as bioaccumulating toxicants (36 and 1.4 µg/L, respectively) was met (Table 2; Table 3). Concentrations of bioaccumulating toxicants in the discharge have been consistent over time (Figure 6).

Table 2 Environmental Quality Guideline for bioaccumulating toxicants

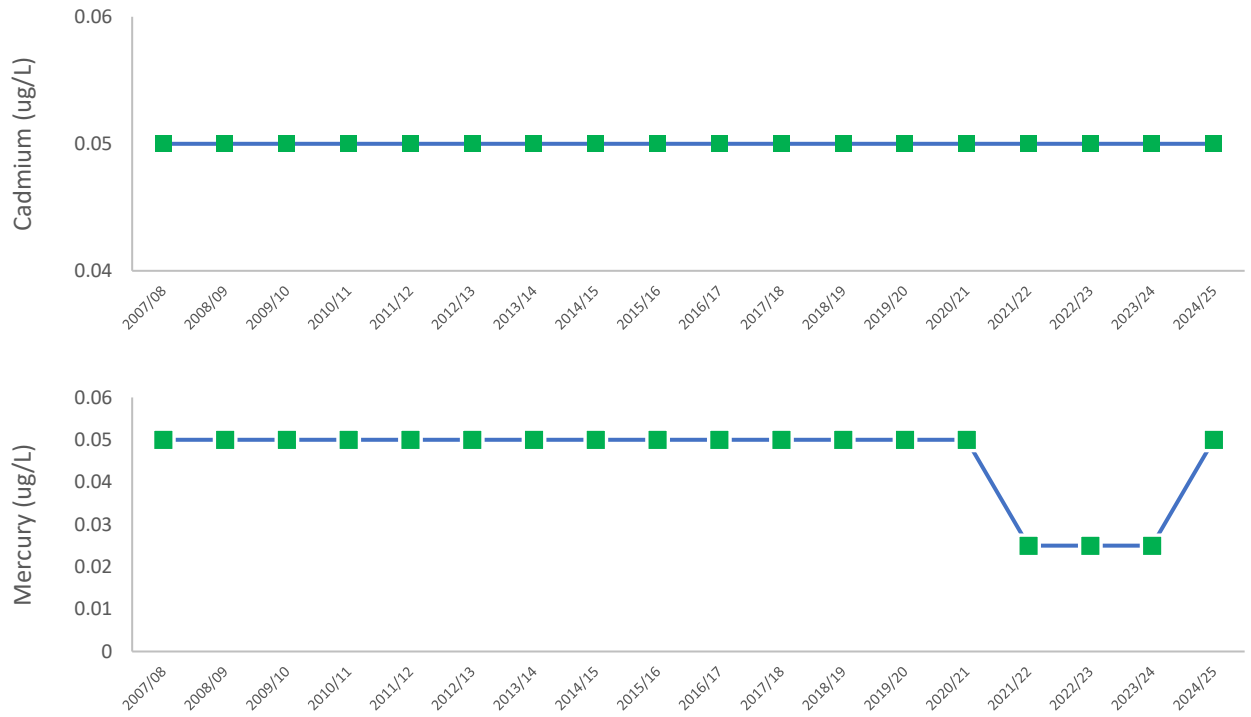
EQG[1]	Concentrations of bioaccumulating contaminants in the treated wastewater stream will not exceed the ANZECC & ARMCANZ (2000) 80% species protection guidelines.

Note:
1. EQG = Environmental Quality Guideline.

Table 3 Bioaccumulating toxicants in the Sepia Depression treated wastewater stream

Toxicant	Sepia Depression TWW concentration (µg/L)	ANZECC & ARMCANZ (2000) 80% species protection guideline (µg/L)
Cadmium	<0.1	36
Mercury	<0.1	1.4

Note:
1. TWW = treated wastewater



Note:
1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Cadmium and mercury concentrations below the detection limit are assigned a value half that of the laboratory Limit o Reporting (LoR) for reporting purposes (i.e. concentrations below the detection limit of 0.1 µg/L are assigned a value of 0.05 µg/L).
3. The LoR for mercury in the 2021/22 to 2023/24 monitoring seasons was different to previous years due to a change in laboratory.

Figure 6 Historical compliance of concentrations of bioaccumulating toxicants, cadmium and mercury

2.1.2 Non-bioaccumulating toxicants

Contaminant concentrations were below their waste stream triggers based on the ANZECC & ARMCANZ (2000) 99% species protection guidelines scaled for dilution equivalent to that expected at the LEPA boundary (BMT Oceanica 2014). Therefore, the EQG (Table 4) was met (Table 5). Initial dilution modelling for conditions on 14th January 2025 found that the Sepia Depression Ocean outlets were achieving a worst-case average initial dilution of 1:357. The initial dilution performance (Figure 7) has been sufficient to reduce the concentration of non-bioaccumulating toxicants to below their EQG concentrations (Figure 8).

Table 4 Environmental Quality Guideline for non-bioaccumulating toxicants

EQG[1]	Treated wastewater contaminant concentration corrected for minimum dilution at the LEPA[1] boundary will ensure the ANZECC & ARMCANZ (2000) 99% species protection guidelines for toxicants are being achieved at the boundary of the LEPA[1] (i.e. a high level of protection is met beyond a 100 m radius of the diffuser).

Note:

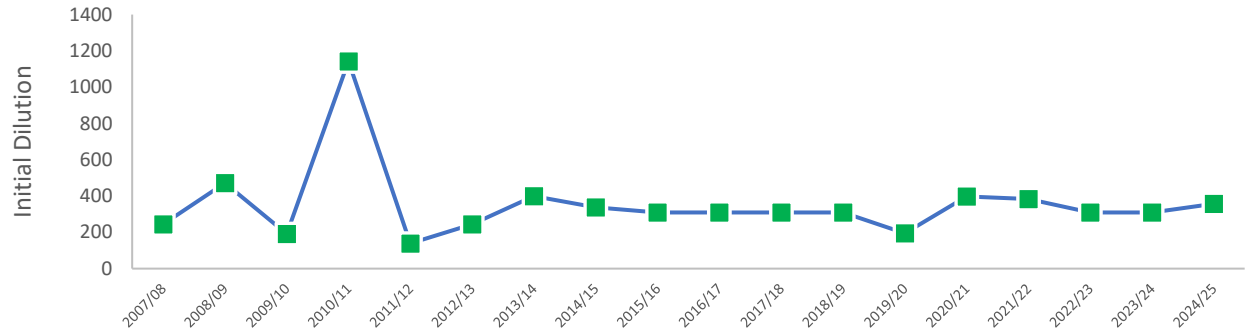
1. EQG = Environmental Quality Guideline; LEPA = Low Ecological Protection Area.

Table 5 Toxicants in the Sepia Depression treated wastewater stream compared with relevant trigger levels

Toxicant	Sepia Depression TWW[2,3] concentration (µg/L)	Waste stream trigger (µg/L)[1,4,6]
Ammonia-N	4,600	154,537
Chromium*	< 1	43
Copper*	20	68
Lead*	< 1	679
Nickel*	2.6	2,016
Silver*	< 0.8	248
Zinc*	49	2,124
Chlorpyrifos[5]	< 0.1	0.16
Endrin	< 0.001	1.24
Endosulfan sulfate[6]	< 0.001	1.55
Benzene	< 1	110,890
Naphthalene	<0.01	15,485
Benzo(g,h,i)perylene	<0.01	15,485

Notes:

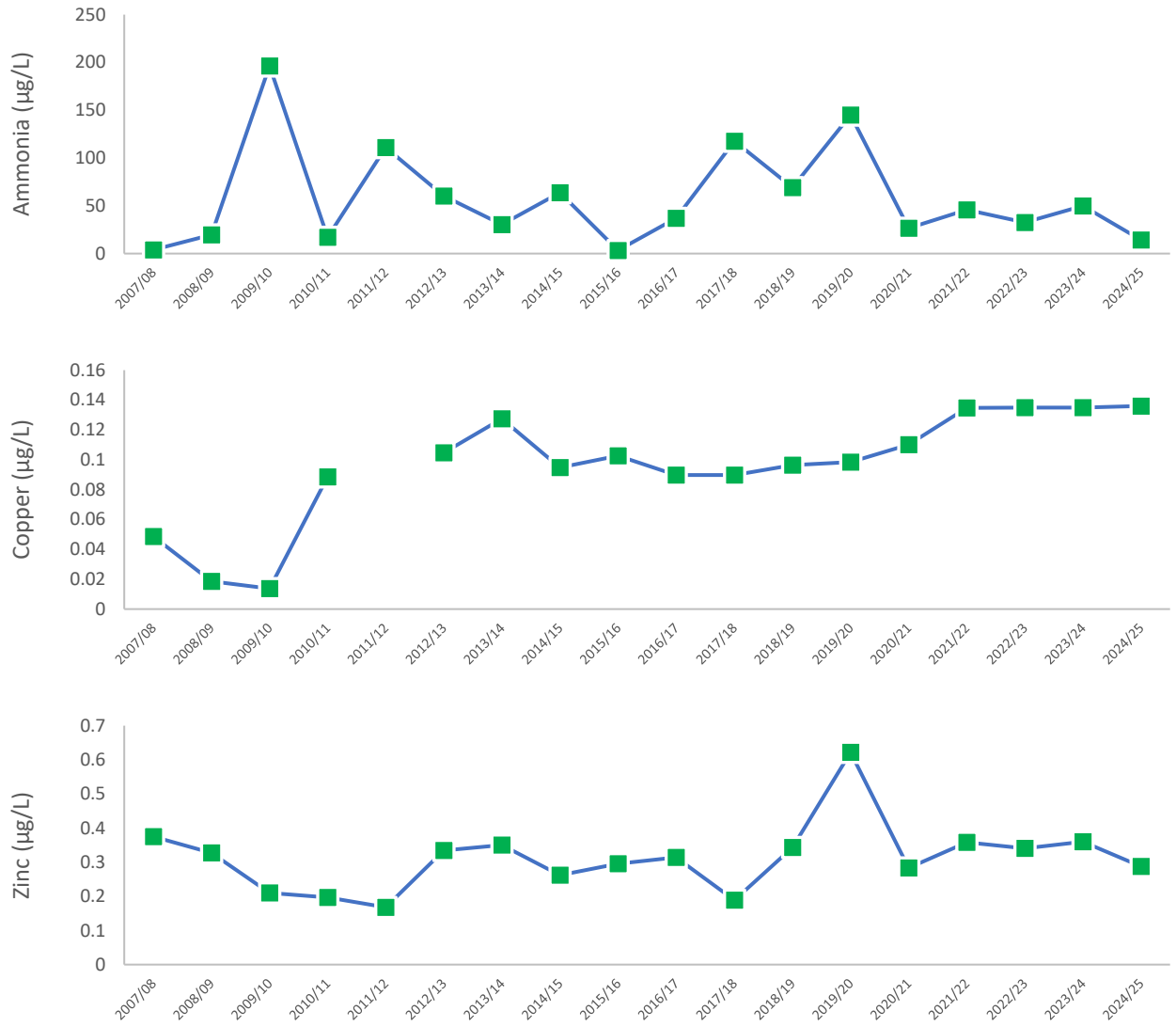
1. ANZECC & ARMCANZ (2000) guidelines used as per SDOOL MMP (BMT Oceanica 2014)
2. TWW = treated wastewater.
3. Initial dilution = 1:357 (predicted worst case value for metocean conditions on 14/01/2025). Contaminant dilution calculations were not applied on any toxicants where concentrations were below the analytical limit of reporting (indicated by <).
4. 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. Analytical limits for chlorpyrifos were not low enough to confirm compliance with the ANZECC & ARMCANZ (2018) guidelines.
6. Trigger values are for endosulfan, not endosulfan sulfate; ANZECC & ARMCANZ (2018).
7. * = dissolved metals 0.45 µm filtered.



Note:

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

Figure 7 Historical initial dilution modelling predictions (2007 - 2025)



Note:

1. Green symbols indicate the Environmental Quality Guideline (EQG) was met.
2. Copper was not reported during the 2011/12 summer monitoring period.

Figure 8 Historical compliance of concentrations of the highest risk (concentration relative to guidelines) non-bioaccumulating toxicants

2.1.3 Total toxicity of the mixture (TTM)

The 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 following initial dilution (1:357) as per the management plan, the TTM (0.52, Table 7) was less than the ANZECC & ARMCANZ (2000) guideline value of 1.0 and the EQG for TTM (Table 6) was met. TTM has not exceeded the EQG criteria over time (Figure 9).

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

EQG[1]	The total toxicity of the mixture (TTM)[1,2,3] for the additive effect of ammonia, copper and zinc, calculated as per ANZECC & ARMCANZ (2000), will not exceed the guideline of 1.0.

Notes:

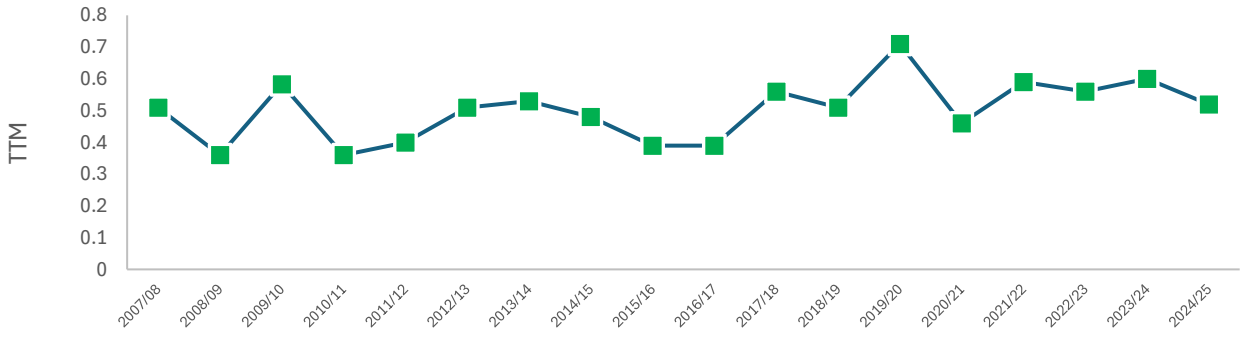
1. EQG = Environmental Quality Guideline; TTM = total toxicity of the mixture.
2. TTM = Σ(Ci/EQGi) where Ci is the concentration of the relevant component (i) in the mixture and its associated EQG for that component.
3. Assessment is based on bioavailable concentrations of metals in the treated wastewater (i.e. concentrations after filtering through a 0.45 µm filter).

Table 7 Total Toxicity of Treated Wastewater at the edge of the initial mixing zone associated with the Sepia Depression ocean outlet

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	4,600	1.5	1:357	14.38	0.10	0.52
Copper[4]	20	0.08		0.14	0.45	
Zinc[4]	49	0.15		0.29	0.05	

Notes:

1. Background concentrations for copper and zinc from McAlpine et al. (2005); Perth marine waters (pp.19). Surface background concentrations for ammonia calculated as median of reference site data from 2003–2024 (BMT; unpublished data).
2. Guideline values are from Table 5.
3. TTM = total toxicity of the mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline, TWW = treated wastewater.
4. Assessment is based on bioavailable concentrations of metals in the treated wastewater (i.e. concentrations after filtering through a 0.45 µm filter).



Note:

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

Figure 9 Historical compliance of total toxicity of the mixture

2.2 Quarterly treated wastewater characterisation

Quarterly sampling was conducted of the final SDOOL treated wastewater stream from Sample Point D (Figure 1). Quarterly samples are analysed for a smaller set of the key contaminants of concern that are most likely to be present in the waste stream. Quarterly sampling occurred in July 2024, October 2024, January 2025, and April 2025.

On each sample occasion, a composite sample (time-weighted) was obtained from Sample Point D (Figure 1). This sample represents an average of the TWW discharged to the Sepia Depression ocean outlet for the 24-hours prior to and during the sample collection. The bulk sample was homogenised and split into separate sample containers for the various analyte groups. Samples were handled and analysed according to the National Association of Testing Authorities (NATA)-accredited laboratory requirements.

The bioaccumulating toxicants cadmium and mercury were below the LoR on all four dates and met the 80% species protection guidelines (36 µg/L and 1.4 µg/L, respectively) in the TWW stream prior to dilution on each sample (Table 8).

Contaminants measured quarterly in the TWW at Sample Point D were all below their respective BMT Oceanica (2014) waste stream triggers (based on the ANZECC & ARMCANZ (2000) 99% species protection scaled for dilution equivalent to that occurring at the LEPA boundary) (Table 8; Table 9).

Table 8 Toxicants measured quarterly in the Sepia Depression treated wastewater compared with relevant guideline trigger levels after initial dilution

Toxicant[1] (µg/L)	July 2024	October 2024	January 2025	April 2025	Waste stream trigger[2] (µg/L)
Ammonia	11,000	4,800	4,700	3,800	154,537
Cadmium[4]	<0.1	<0.1	<0.1	<0.1	36
Chromium	<2	<2	<2	<2	43
Cobalt	<1	<1	<1	<1	307
Copper	60	12	27	27	68
Lead	<1	<1	<1	1	679
Mercury[4]	<0.1	<0.1	<0.1	<0.1	1.4
Nickel	5	3	3	3	2,016
Silver	<1	<1	<1	<1	248
Vanadium	<10	<10	<10	<10	14,913
Zinc	58	63	63	62	2,124
Phenols	<50	50	50	<50	83,685

Note:

1. Assessment is undertaken only for toxicants with ANZECC & ARMCANZ (2000) guideline values.
2. ANZECC & ARMCANZ (2000) trigger scaled according to the inferred initial dilution at the LEPA (1:357, predicted worst case value for metocean conditions on 14/01/2025). Dilution calculations were not applied on any toxicants where concentrations were below the analytical limit of reporting (indicated by <).
3. TWW = treated wastewater
4. Bioaccumulating toxicants cadmium and mercury based on the ANZECC & ARMCANZ (2000) 80% species protection guidelines (of 36 and 1.4 respectively) at the diffuser (i.e. prior to dilution).

Table 9 Total toxicity of the quarterly treated wastewater characterisation for the Sepia Depression treated

Quarterly sampling dates	Natural background concentration in Perth's coastal waters (µg/L)[1]			Dilution	Total toxicity of the mixture (TTM)[2]
	Ammonia	Copper	Zinc		
July 2024	1.5	0.08	0.15	1:357	0.94
October 2024					0.44
January 2025					0.61
April 2025					0.6

Notes:

1. Background concentrations for copper and zinc from McAlpine et al (2005); Perth marine waters (p.19). Surface concentrations for ammonia calculated as a median of reference site data from 2003–2024 (BMT; unpublished data).
2. Total toxicity of mixture = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline scaled for dilution and background factored.

2.3 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 (0.5, 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).

In July 2024, sea urchin fertilisation was significantly lower in samples exposed to 6.3%, 12.5% and 25% TWW dilutions than the artificial seawater control (Figure 10). In October 2024, sea urchin fertilisation was significantly lower in samples exposed to 12.5%, 25%, and 50% TWW dilutions than the artificial seawater control (Figure 10). In February 2025, sea urchin fertilisation was significantly lower in samples exposed to 12.5% TWW dilutions than the artificial seawater control (Figure 10). In April 2025, sea urchin fertilisation was significantly lower in samples exposed to 12.5% and 25% TWW dilutions than the artificial seawater control (Figure 10). For all 4 sampling dates, the equivalent NOEC was greater than 1% TWW (Table 11) and the EQG for WET testing (Table 10) was met. The lowest annual NOEC (and highest apparent toxicity) has been variable over time exceeding the EQG on just one occasion and without an identifiable trend (Figure 11).

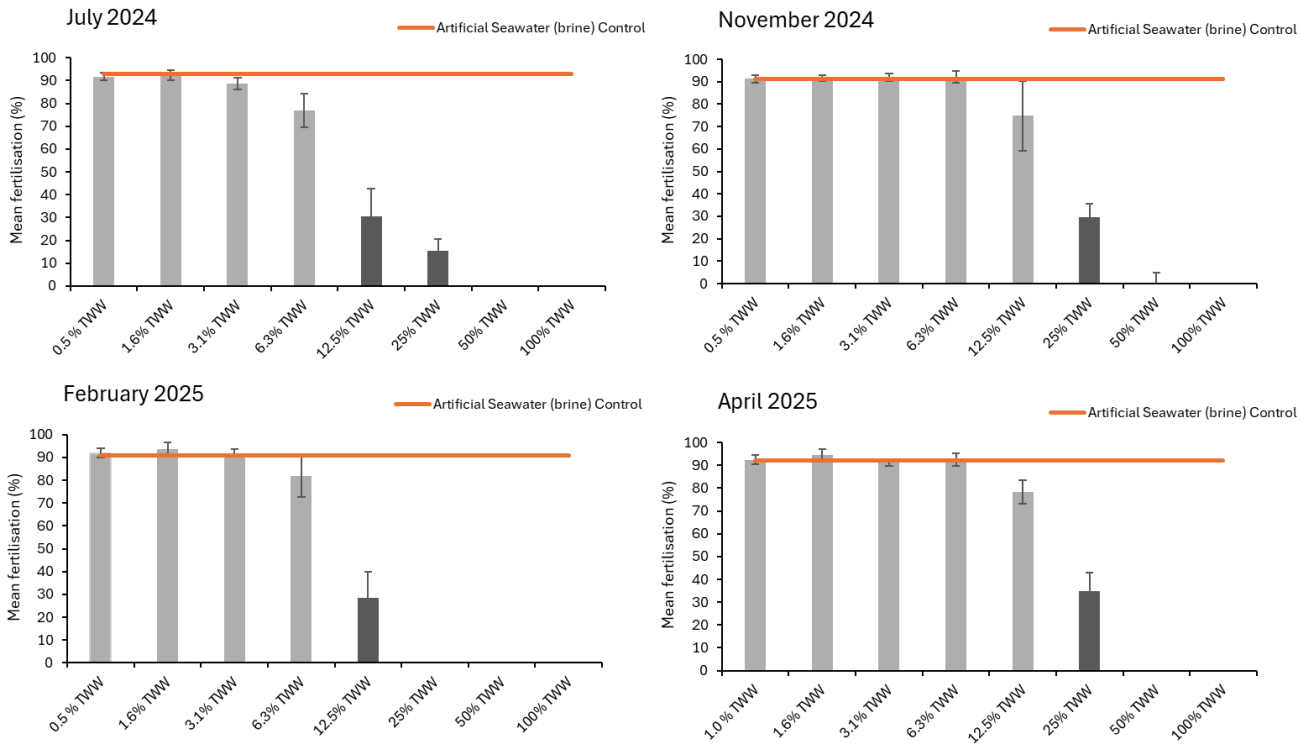
Table 10 Environmental Quality Guideline for WET testing

EQG[1]	The EQG[1] for WET[1] will be exceeded where: $$\frac{TDA}{DRNOEC} \leq 1.0$$ Where TDA[1] is Typical Dilutions Achieved (constant based on 200-fold dilution) and DRNOEC[1] is the number of Dilutions Required to achieve the NOEC[1]. Where this EQG[1] is breached an investigation into the EQS[1], comprising of the full suite of WET[1] tests (minimum of five species from four other tropic groups), will be triggered.

Source: BMT Oceanica 2014

Note:

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

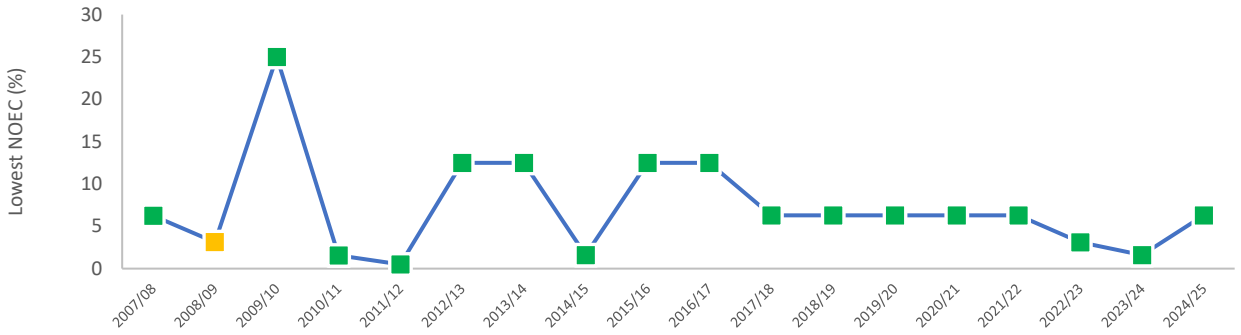
Figure 10 Comparison of WET TWW dilution to artificial seawater control for Sepia Depression treated wastewater

Table 11 Calculated parameters from WET tests

Indicator	July 2024	October 2024	February 2025	April 2024
NOEC[1] (%)	6.3	6.3	6.3	6.3
Dilutions required to meet the NOEC[1]	16	16	16	16
Dilutions required/dilution achieved	0.04	0.04	0.04	0.04
Under ≤1	Yes	Yes	Yes	Yes

Notes:

1. NOEC = No Observed Effect Concentration



Note:

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

Figure 11 Historical Compliance of No Observed Effect Concentration

2.4 Diffuser performance

Diffuser performance was calculated by comparing discharge concentrations at 0 m (initial dilution), 100 m, 350 m, 1000 m and 1500 m (Table 12). Concentrations for each parameter at each distance were averaged from the 8 individual sampling events (December 2024 – March 2025). Each parameter was observed to meet ambient (reference) conditions by approximately 1,500 m from the diffuser (Figure 12).

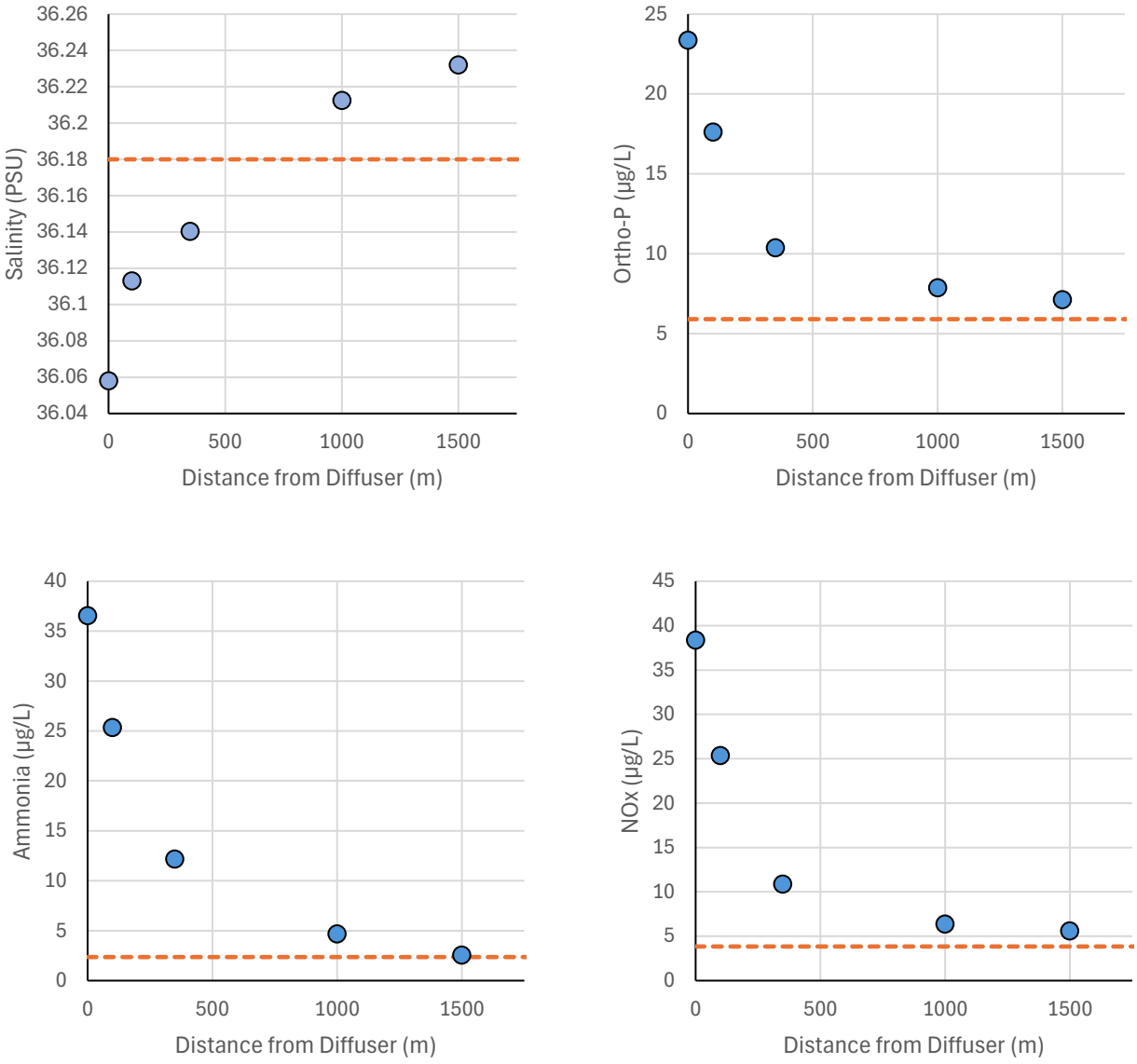
Table 12 Diffuser performance results for Sepia Depression treated wastewater

Site	Salinity (PSU)	Ammonia (µg/L)	Ortho-P (µg/L)[1]	NOx (µg/L)[2]
Reference	36.18	2.36	5.91	3.84
0 m	36.06	36.56	23.38	38.38
100 m	36.11	25.38	17.63	25.38
350 m	36.14	12.19	10.38	10.88
1,000 m	36.21	4.70	7.90	6.38
1,500 m	36.23	2.56	7.13	5.62

Notes:

1 Ortho-P = orthophosphate

2. NO_x = nitrate + nitrite.



Notes:

1 Concentrations for each parameter at each distance were averaged from the 8 individual sampling events (December 2024 – March 2025)

Figure 12 Diffuser performance for salinity, Ortho-P, Ammonia and Nox. Orange line indicates the average for the four reference sites

3 Water Quality Monitoring – Receiving Environment

Nutrients, phytoplankton biomass and physical and chemical stressors were monitored on eight occasions from mid December 2024 to late March 2025 (coinciding with the summer non-river flow period) along a down-current gradient away from the diffuser (Table 13).

Table 13 Water quality monitoring dates near the Sepia Depression ocean outlet between December 2024 and March 2025

Sampling Event	Sampling Month	Date
1	December	13/12/2024
2	December	20/12/2024
3	January	02/01/2025
4	January	16/01/2025
5	February	10/02/2025
6	February	17/02/2025
7	March	12/03/2025
8	March	26/03/2025

Wind direction, strength, current grid direction and cloud cover were recorded on the day of sampling (Table 14).

Table 14 Weather and current grid during water quality monitoring near the Sepia Depression ocean outlet

Date	Wind direction[1,2,3]	Wind strength (knots)[3]	Cloud cover (%)	Current grid[2]
13/12/2024	WNW – NW	2 to 10	80-100	S
20/12/2024	SE	8 to 12	0	S
02/01/2025	SW	2 to 12	30-100	NE
16/01/2025	E – ENE	4 to 10	0	S
10/02/2025	WNW – W	5 to 7	80-100	SE
17/02/2025	N – NW - W – SW	0 to 6	20-30	N
12/03/2025	W	5 to 7	100	NW
26/03/2025	E – NE	1 to 8	0	NE

Notes:

1. W = west, WNW = west north west, SE = south east, SW = south west, E = east, ENE = east north east, N = north, NE = north east, NW = north west.
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 Nutrient enrichment

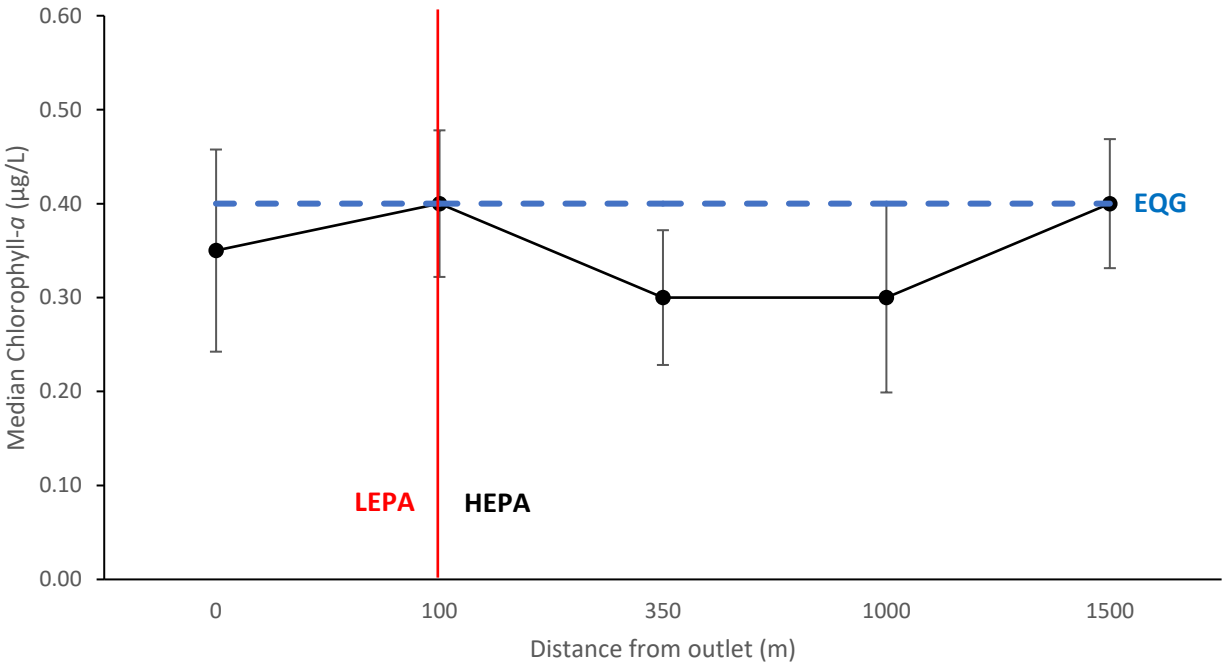
The median chlorophyll-*a* concentration in the Sepia Depression HEPA (100, 350, 1000 and 1500 m) in 2024-25 was 0.3 µg/L and was lower than the 80th percentile of reference site data (0.4 µg/L; Figure 13), which met the EQG (Table 15).

Table 15 Environmental Quality Criteria for nutrients

EQG[1]	The median chlorophyll-a concentration in the HEPA[1] (100 m and greater from the diffuser) during the non-river flow period is not to exceed the 80th percentile of reference site data.
	The median light attenuation coefficient in the HEPA[1] during the non-river flow period is not to exceed the 80th percentile of reference site data.
EQS[1]	EQGs[1] are not to be exceeded in a second consecutive year.

Note:

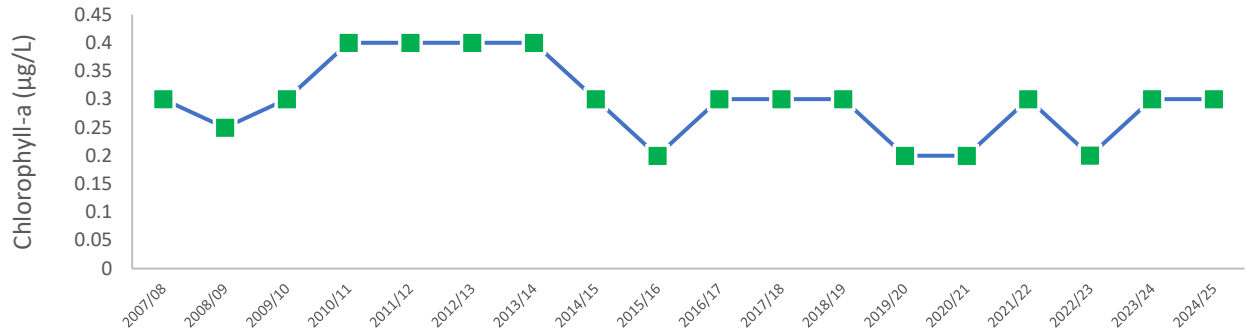
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard; HEPA = High Ecological Protection Area



Notes:

1. Error bars represent ± 95% confidence intervals n = 8.
2. Blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data (0.4 µg/L chlorophyll-*a*).
3. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area .
4. Data at each distance were pooled across eight sampling days from December 2024 to March 2025.

Figure 13 Median chlorophyll-*a* concentrations down-current of the Sepia Depression outlet during the summer monitoring period

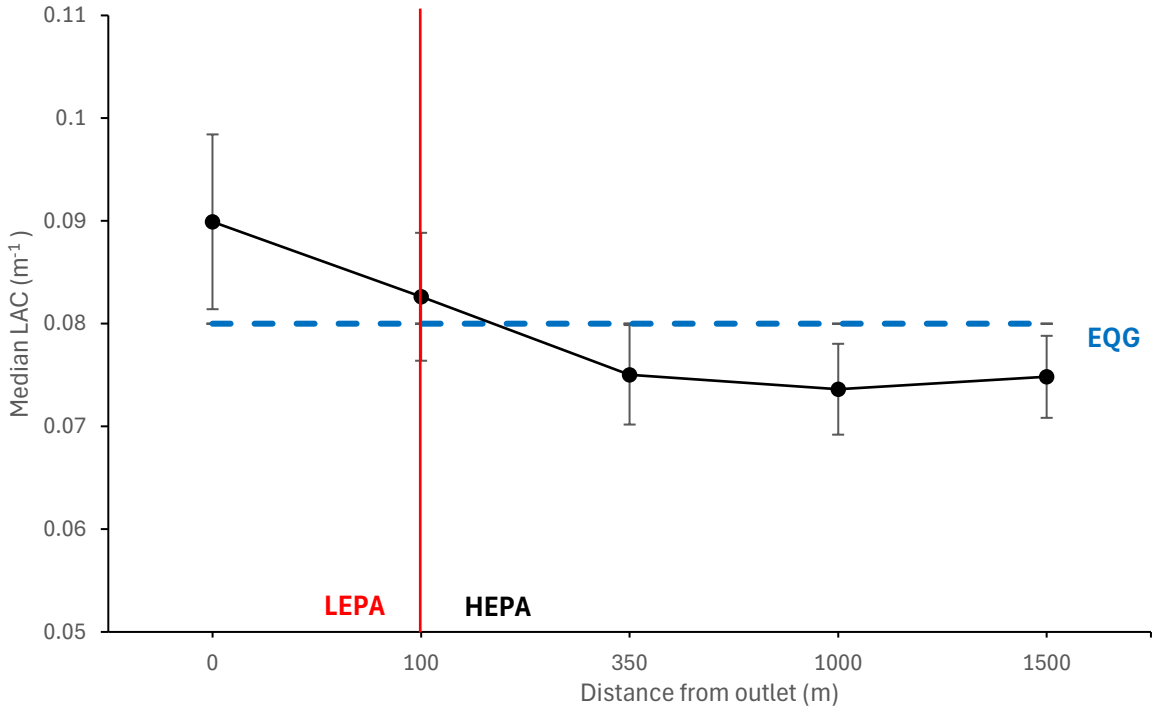


Note:

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

Figure 14 Median chlorophyll-*a* concentration (assessment against the EQG)

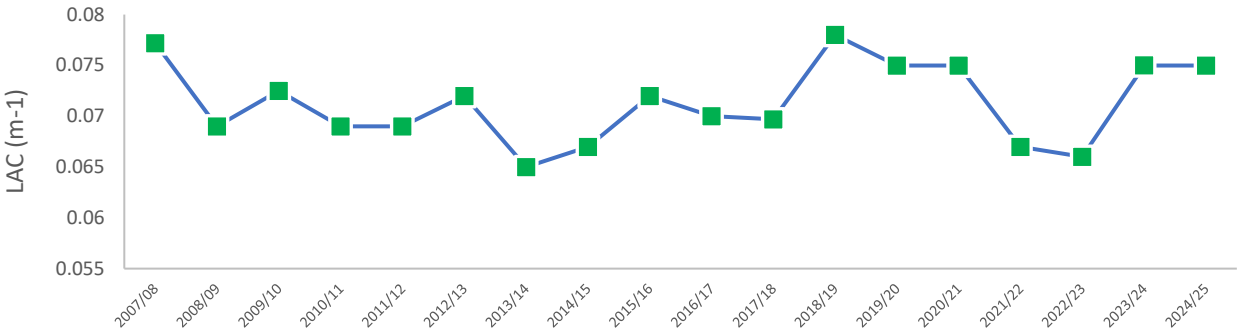
The median light attenuation coefficient (LAC) in the Sepia Depression HEPA (100, 300, 1000 and 1500 m) was 0.08 m^{-1}, which did not exceed the 80th percentile of reference site data (0.08 m^{-1}; Figure 15) and the EQG was therefore met.



Notes:

1. Error bars represent ±95% confidence intervals; n = 8
2. Dark blue dashed line = Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data (0.08 m^{-1}).
3. LEPA = Low Ecological Protection Area; HEPA = High Ecological Protection Area
4. Data at each distance were pooled across eight sampling days from December 2024 to March 2025.

Figure 15 Median light attenuation coefficient down current of the Sepia Depression outlet during the summer monitoring period



Note:

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

Figure 16 Median light attenuation coefficient (assessment against the EQG)

3.2 Phytoplankton biomass

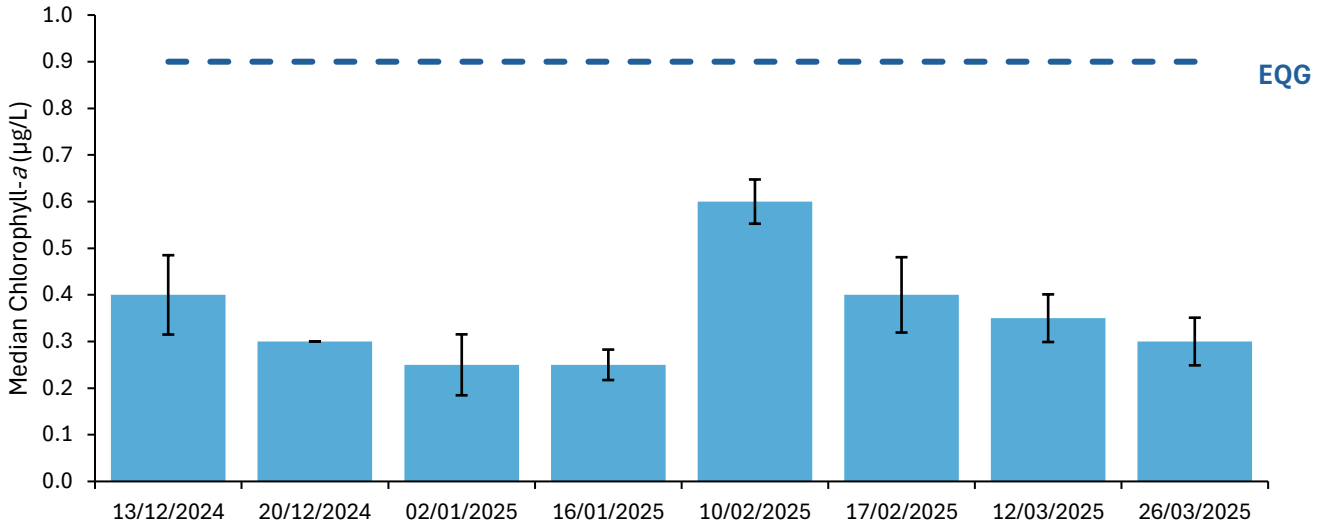
Median chlorophyll–*a* concentration within the HEPA did not exceed three times the median of reference sites (0.90 µg/L) on any sampling occasions during the summer monitoring period and EQG 1 (Table 16; Figure 17) was met (Figure 18). Phytoplankton biomass, measured as chlorophyll-*a*, did not exceed three times the median chlorophyll-a concentration of reference sites (0.90 µg/L) on any sampling occasions, meeting EQG2 (Figure 19).

Table 16 Environmental Quality Criteria for phytoplankton in receiving waters

EQG[1] 1	Median phytoplankton biomass, measured as chlorophyll-*a,* does not exceed three times the median chlorophyll-*a* concentration of reference sites, on any occasion during the non-river flow period.
EQS[1] 1	Median phytoplankton biomass, measured as chlorophyll-*a*, does not exceed three times median chlorophyll-a concentration of reference sites, on more than one occasion during non-river flow period and in two consecutive years.
EQG[1] 2	Phytoplankton biomass measured as chlorophyll-*a* at any site does not exceed three times the median chlorophyll-a concentration of reference sites, on 25% or more occasions during the non-river flow period.
EQS[1] 2	Phytoplankton biomass measured as chlorophyll-*a* at any site does not exceed three times the median chlorophyll-a concentration of reference sites, on 25% or more occasions during the non-river flow period and in two consecutive years.

Note:

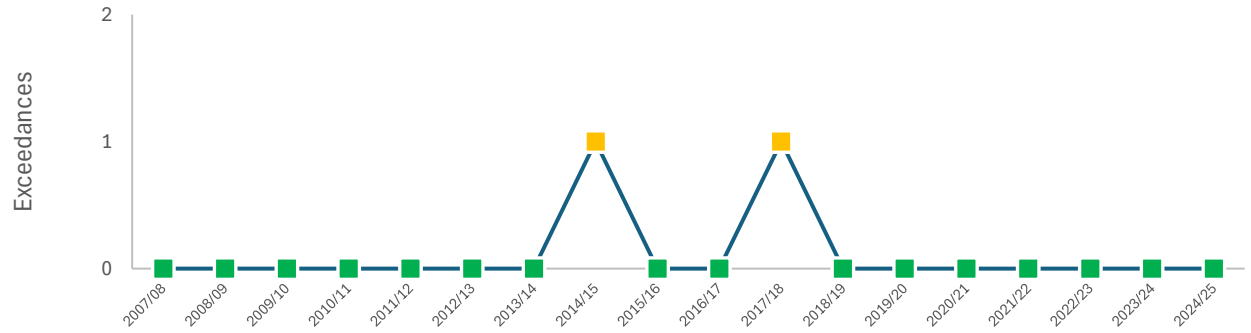
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard



Notes:

1. Error bars represent ±95% confidence intervals; n = 8
2. Blue dashed line = Environmental Quality Guideline (EQG) is 3-times the median chlorophyll-*a* concentration of reference site data (0.9 µg/L chlorophyll-*a*).
3. Data pooled from fixed sites ≥ 100 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 at the LEPA/HEPA boundary.

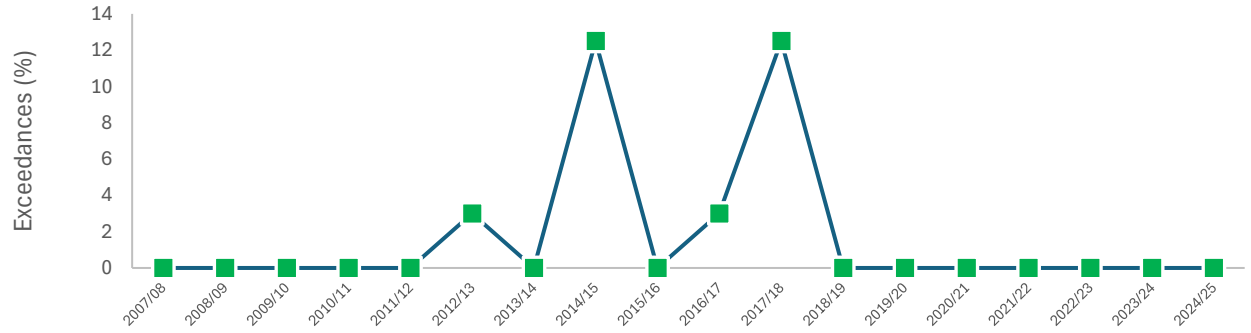
Figure 17 Median phytoplankton biomass during the 2024-25 summer monitoring period



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 18 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 Guideline (EQG) was met.

Figure 19 Percentage of occasions where exceedance of three times the median chlorophyll-a concentration of reference sites occurred, with greater than 25% or more occasions triggering EQG2

3.3 Physical-chemical stressors

3.3.1 Dissolved oxygen (DO)

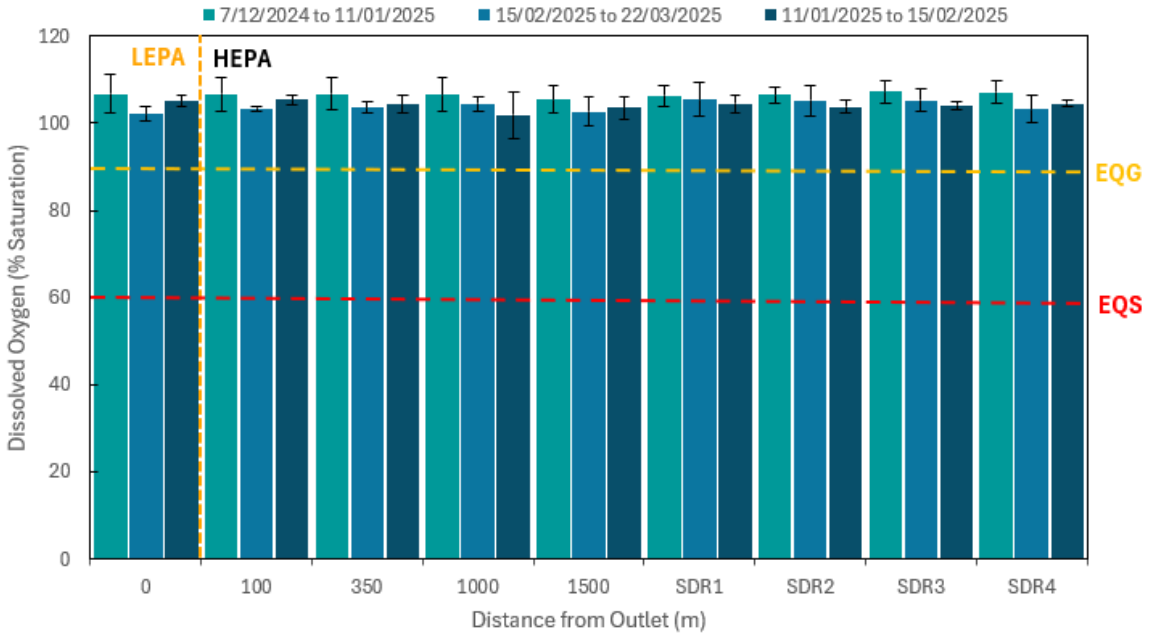
Table 17 presents the EQG and EQS for dissolved oxygen. The median of bottom (0 - 0.5 m) dissolved oxygen saturation was >90% at all sites and times throughout the summer survey period (Figure 20) and the EQG was met. This aligns with historical observations for this indicator (Figure 21).

Table 17 Environmental Quality Criteria for dissolved oxygen

EQG[1]	Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) must be greater than 90% saturation at any site for a defined period of not more than 6 weeks during the non-river flow period.
EQS[1]	Median dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) must be greater than 60% saturation at any site for a defined period of not more than 6 weeks during the non-river flow period.

Note:

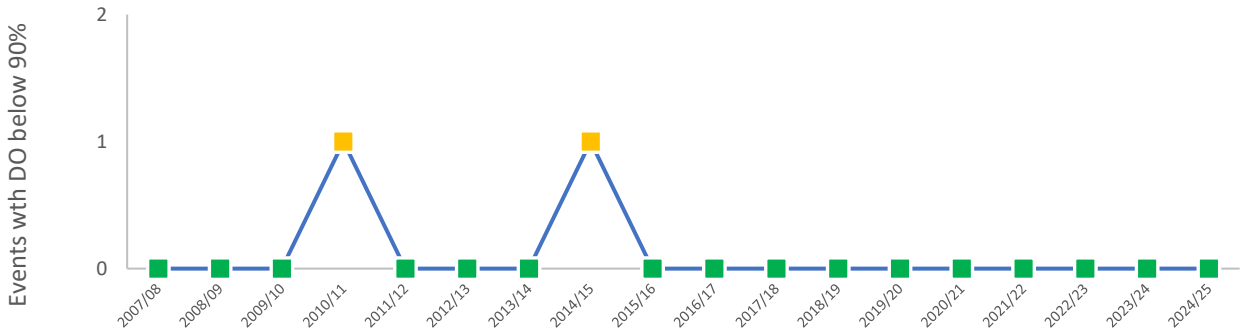
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard; HEPA = High Ecological Protection Area



Notes:

1. Error bars ±95% confidence intervals (n = 8).
2. Dissolved oxygen (DO) measure 0-0.5 m 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
6. Reference site data (SDR1–SDR4) are compared against EQG for contextual purposes only.

Figure 20 Median dissolved-oxygen (DO) saturation in bottom waters (0 - 0.5 m above the seabed) for all HEPA sites during the summer monitoring program.



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 periods where DO was below 90% (EQG)

3.3.2 Salinity

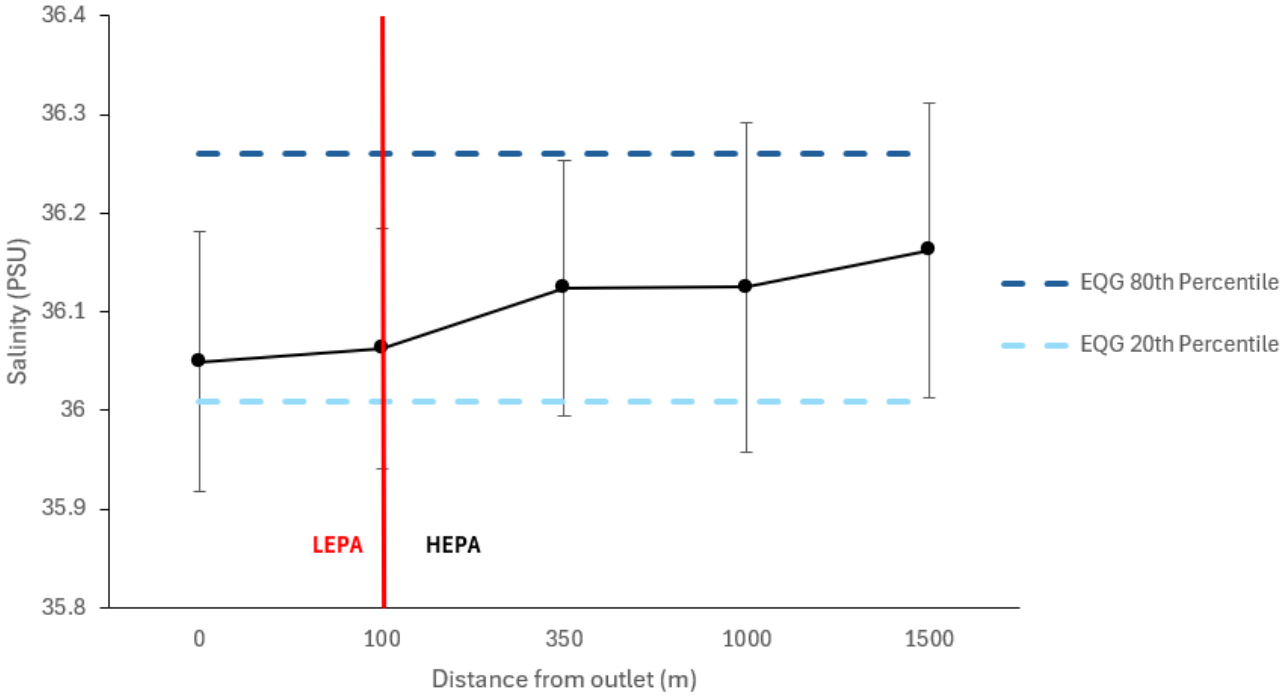
Median salinity was between the 20th and 80th percentile of the natural (reference site) salinity range (35.9 and 36.04 PSU, respectively) at all HEPA sites (100, 350, 1000 and 1500 m from the outlet), across the summer monitoring period, meeting the EQG (Table 18 and Figure 22). Historically, median salinity has fallen below the 20th percentile of the natural salinity range at one or more sites within the HEPA on five occasions (Figure 23).

Table 18 Environmental Quality Criteria for salinity

EQG[1]	Median salinity (0.5 m below the water surface) at an individual site over any period is not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period.

Note:

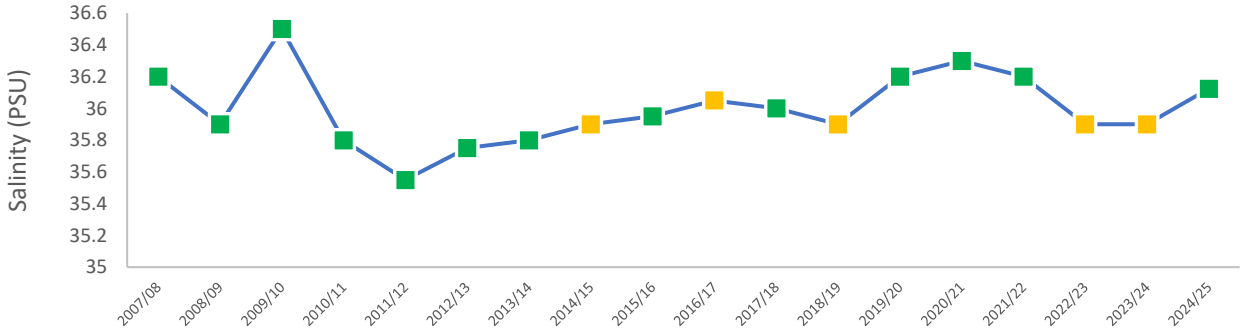
1. EQG = Environmental Quality Guideline.



Notes:

1. Error bars ± 95% confidence intervals; n = 8.
2. Salinity measured ~0.5 m below the sea surface (closest measurement to 0.5 m depth taken for each distance, for each trip December 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 summer monitoring period



Note:

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

Figure 23 Median salinity down-current of the Sepia Depression outlet

4 Microbiological contaminants and algal biotoxins

4.1 Thermotolerant coliforms

TTC were sampled eight times over the 2024 – 25 summer monitoring period (yielding a total of 40 samples) at the boundary of the Shellfish Harvesting Exclusion Zone (SHEZ). NHMRC (2008) and EPA (2005) guidelines require a minimum of 100 samples for accurate assessment of the EQC. Data from multiple years can be pooled where there are <100 samples, provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over three summer monitoring periods (2022–23, 2023–24, and 2024-25) were pooled to yield 120 samples.

The median TTC concentrations derived from three years of pooled samples was equal to the limit of reporting, meeting the EQG (<10 CFU/100 mL; Table 19 and Table 20). Median concentration of TTC has never exceeded the limit of reporting (Figure 24). Over the three sampling periods, there were 4 instances where TTC exceeded 21 CFU/100 mL, representing 3.33% of samples and thus meeting the EQG (Table 19 and Table 21).

Table 19 Environmental Quality Guideline for Thermotolerant Coliforms

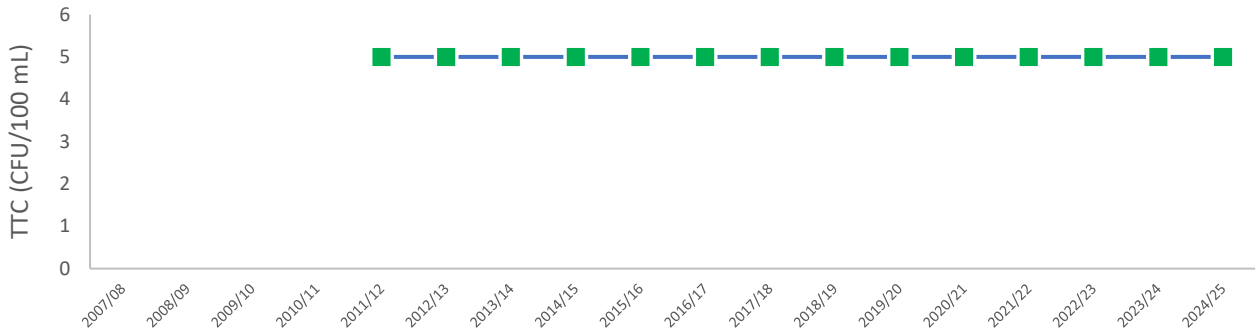
EQG[1]	Median TTC[2,3] concentrations at sites at the boundary of the SHEZ[1] are not to exceed 14 CFU[2]/100 mL, with no more than 10% of the samples exceeding 21 CFU[2]/100 mL.

Notes:
1. EQG = Environmental Quality Guideline; SHEZ = Shellfish Harvesting Exclusion Zone
2. CFU = colony forming units;; TTC = thermotolerant coliforms.
3. TTC concentrations are measured using the membrane filtration method.

Table 20 Median thermotolerant coliform concentration at the boundary of the Shellfish Harvesting Exclusion Zone for the Sepia Depression outlet pooled over 2022–25 sampling periods

Sampling period	Median[2,3]	Compliance[1]
Dec 2022 – Mar 2023	<10 CFU/100 mL	
Dec 2023 – Mar 2024		
Dec 2024 – Mar 2025		

Notes:
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. Thermotolerant coliform results below the analytical detection limit (<10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median.
3. CFU = colony forming units



Note:

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

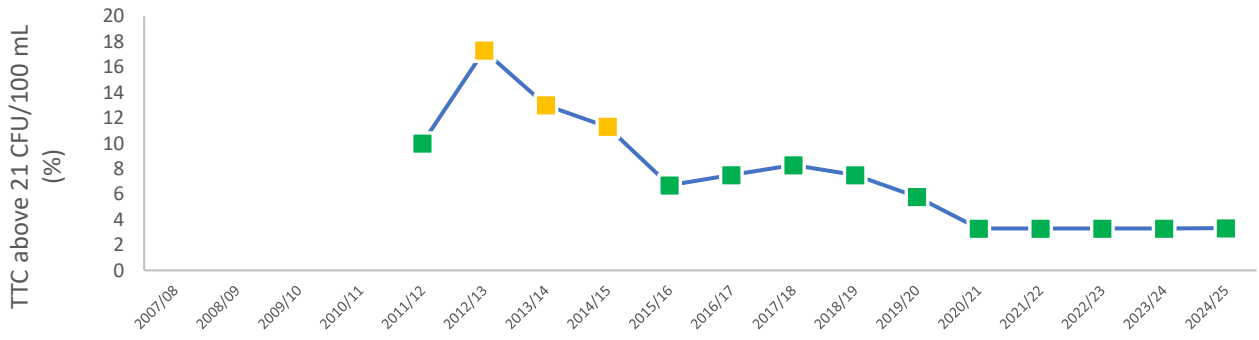
Figure 24 Historical compliance of median thermotolerant coliforms (2011/12 - 2024/25)

Table 21 Thermotolerant coliforms at sites on the boundary of the Shellfish Harvesting Exclusion Zone for the Sepia Depression ocean outlet pooled over 2022–25 summer sampling periods that exceeded 21 CFU/100 mL

Sampling period	Date	Site	TTC concentration (CFU/100 mL)[2]	Compliance[1]
Dec 2022 – Mar 2023	24/03/2023	SD28	60	
Dec 2023 – Mar 2024	20/03/2023	SD23	50	
Dec 2024 – Mar 2025	13/12/2024	SD30	100	
	12/03/2025	SD25	90	
% total samples (n = 120) >21 CFU/100 mL = 3.33%				

Notes:

1. Green symbols indicate the Environmental Quality Criteria (EQC) were met.
2. CFU = colony forming units; EQG = Environmental Quality Guideline; SHEZ = Shellfish Harvesting Exclusion Zone; TTC = thermotolerant coliforms.



Note:

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

Figure 25 Historical compliance of percentage of thermotolerant coliform samples over 21 CFU/100 mL (2011/12 - 2024/25)

4.2 *Enterococci* spp.

Samples were collected eight times over the 2024-2025 summer monitoring period (yielding a total of 40 samples) for faecal indicator analyses. NHMRC (2008) guidelines 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 (2022-2023, 2023-2024, and 2024-2025) were pooled to yield 120 samples. The EQG for primary and secondary contact recreation are outlined in Table 22).

The 95th percentile of *Enterococci* spp. concentrations based on 120 samples was 1,330 MPN/100 mL, exceeding the EQG for primary contact recreation (200 MPN/100 mL) and triggering assessment against the EQS (Table 25). The 95th percentile of *Enterococci spp*. (1,330 MPN/100 mL) also exceeded the EQS for primary contact recreation (500 MPN/100 mL) (Table 23). Exceedance of the EQG and EQS for primary contact recreation was reported to Department of Health and Department of Water and Environmental Regulation as per the SDOOL MMP (BMT Oceanica 2014).

Worst case (95th percentile) concentrations of *Enterococci* spp. appear to have begun to decrease since the 2022-23 summer sampling period but remain in exceedance of the EQC. The 95th percentile concentrations have always exceeded both the primary contact EQG (Figure 26) and EQS (Figure 27). The 95th percentile concentrations did not exceed the secondary contact EQG (Figure 28) nor trigger assessment against the EQS.

Table 22 Environmental Quality Guidelines (*Enterococci* spp.) for contact recreation

Primary[2]	**EQG[1]**	The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 200 MPN/100 mL.
	EQS[1]	The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 500 MPN/100 mL.
Secondary[3]	**EQG[1]**	The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 2000 MPN/100 mL.
	EQS[1]	The 95th percentile bacterial content (*Enterococci* spp.) of marine waters should not exceed 5000 MPN/100 mL

Notes:

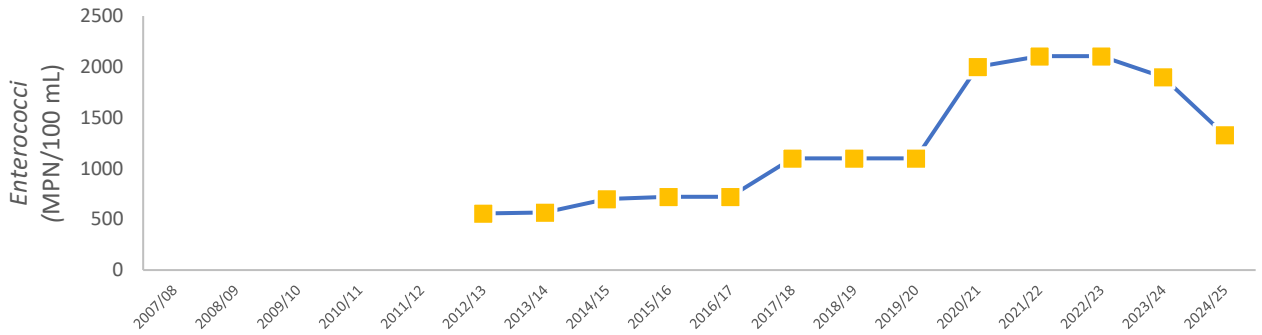
1. EQG = Environmental Quality Guideline; EQS = Environmental Quality Standard
2. Primary contact recreation = activities where humans are in direct contact with the water (e.g. swimming, snorkelling and diving).
3. Secondary contact recreation = activities where humans are in secondary contact with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

Table 23 The 95th percentile of *Enterococci* spp. concentrations at the boundary Recreational Contact Exclusion Zone for the Sepia Depression ocean outlet

Sampling period	95th percentile[1]	Environmental Quality Criteria[1,2,4]		Compliance[3]
Dec 2022 – Mar 2023 Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	1,330 MPN/100 mL	EQG (primary contact)	95th percentile < 200 MPN/100 mL	
		EQS (primary contact)	95th percentile < 500 MPN/100 mL	
		EQG (secondary contact)	95th percentile < 2,000 MPN/100 mL	

Notes:

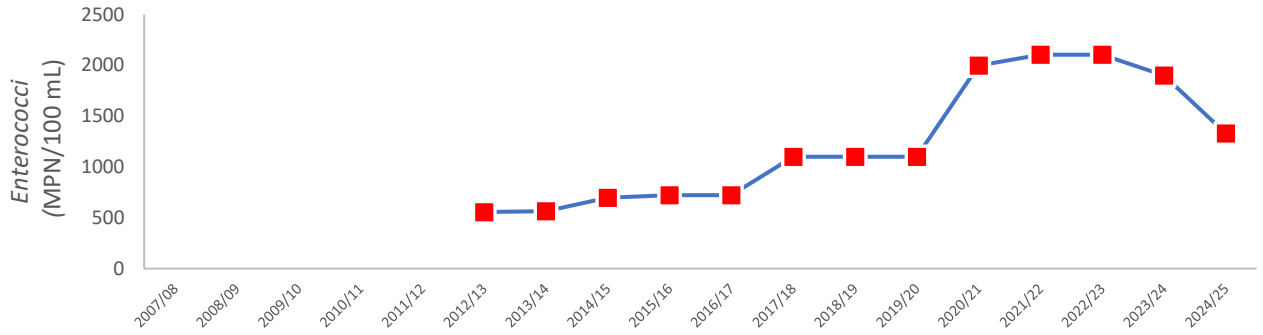
1. MPN = most probable number of *Enterococci* spp.
2. *Enterococci* spp. concentrations below the analytical limit of reporting (<10 *Enterococci* spp. MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95th percentile.
3. Green symbols indicate the Environmental Quality Criteria (EQC) were met; amber and red symbols represent an exceedance of the EQG or Environmental Quality Standard (EQS), respectively.
4. Environmental Quality Criteria (EQC) based on EPA (2017) water quality guidelines for recreation waters.



Note:

1. Amber symbols represent an exceedance of the Environmental Quality Criteria (EQC)

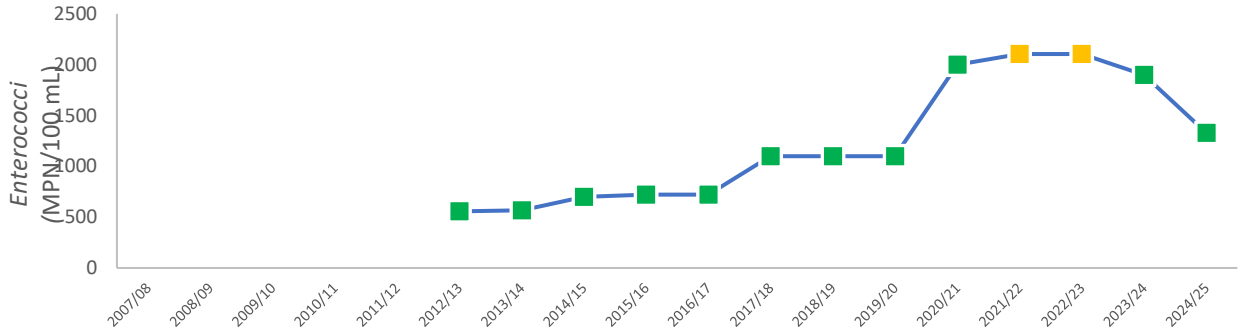
Figure 26 Historical compliance of the 95th percentile *Enterococci* spp. (with assessment against the primary contact EQG; 2012/13 – 2024/25)



Note:

1. Red symbols represent an exceedance of the Environmental Quality Standard (EQS)

Figure 27 Historical compliance of the 95th percentile *Enterococci* spp. (with assessment against the primary contact EQS; 2012/13 – 2024/25)



Note:

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

Figure 28 Historical compliance of the 95th percentile *Enterococci* spp. (with assessment against the secondary contact EQG; 2012/13 – 2024/25)

4.3 Toxic phytoplankton species

The EQG for toxic phytoplankton species states that concentrations of potentially toxic algae are not to exceed the WASQAP guideline concentrations at sites along the Shellfish Harvesting Exclusion Zone boundary (DoH 2025). Table 24 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).

There were no exceedances recorded during the 2024-25 extended summer monitoring period. Toxic phytoplankton exceeding WASQAP concentrations have been present on 2 occasions historically (Figure 29).

Table 24 Environmental Quality Guideline for toxic phytoplankton species

EQG[1,2,3]	Concentrations of potentially toxic algae in any sample at the Shellfish Harvesting Exclusion 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)

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 25 Estimated cell densities of phytoplankton species known to produce toxins at Sepia Depression outlet sites.

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP Guideline[2] (cells/L)	Compliance[1]
13/12/2024	SDR2	*Pseudo-nitzschia* "*delicatissima*" group	1,520	500,000	
	SD15	*Pseudo-nitzschia* "*delicatissima*" group	2,560	500,000	
	SD30	*Pseudo-nitzschia* "*delicatissima*" group	4,400	500,000	
		Pseudo-nitzschia "seriata" group	320	500,000	
20/12/2024	SDR1	*Pseudo-nitzschia "delicatissima*" group	400	500,000	
	SD1	*Pseudo-nitzschia "delicatissima*" group	1,040	500,000	
	SD32	*Pseudo-nitzschia "delicatissima*" group	1,120	500,000	
02/01/2025	SDR1	*Pseudo-nitzschia* "*delicatissima*" group	4,240	500,000	
	SD4	*Pseudo-nitzschia "delicatissima*" group	640	500,000	
		Oscillatoria spp.	80	-	
		GK Complex (*Gymnodinium-Karenia* Complex)	160	250,000	
	SD20	*Pseudo-nitzschia "delicatissima*" group	160	500,000	
		GK Complex (*Gymnodinium-Karenia* Complex)	80	250,000	
16/01/2025	SDR1	*Pseudo-nitzschia "delicatissima"* group	240	500,000	
		Pseudo-nitzschia "seriata" group	160	500,000	
		Oscillatoria spp.	80	-	
		GK Complex (*Gymnodinium-Karenia* Complex)	80	250,000	
	SD13	*Pseudo-nitzschia "delicatissima"* group	720	500,000	
		Pseudo-nitzschia "seriata" group	80	500,000	
	SD30	*Pseudo-nitzschia "delicatissima*" group	1,200	500,000	

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP Guideline[2] (cells/L)	Compliance[1]
		Pseudo-nitzschia "seriata" group	160	500,000	
		Karenia spp.	80	1,000	
10/02/2025	SDR2	*Pseudo-nitzschia "delicatissima"* group	480	500,000	
		Pseudo-nitzschia "seriata" group	6,320	500,000	
	SD2	*Pseudo-nitzschia "seriata"* group	1,280	500,000	
		Dinophysis spp.	80	1,000	
	SD31	*Pseudo-nitzschia "delicatissima"* group	4,480	500,000	
		Pseudo-nitzschia "seriata" group	5,920	500,000	
17/02/2025	SDR3	*Pseudo-nitzschia "delicatissima"* group	720	500,000	
		Pseudo-nitzschia "seriata" group	1,120	500,000	
		Trichodesmium erythraeum	80	-	
	SD7	*Pseudo-nitzschia "delicatissima"* group	1,440	500,000	
		Pseudo-nitzschia "seriata" group	5,440	500,000	
		Dinophysis spp.	80	1,000	
	SD22	*Pseudo-nitzschia "delicatissima"* group	400	500,000	
		Pseudo-nitzschia "seriata" group	3,440	500,000	
12/03/2025	SDR1	*Pseudo-nitzschia "delicatissima"* group	480	500,000	
		Pseudo-nitzschia "seriata" group	400	500,000	
	SD10	*Pseudo-nitzschia "delicatissima"* group	160	500,000	
		Pseudo-nitzschia "seriata" group	240	500,000	
		Prorocentrum spp.	80	500	
	SD25	*Pseudo-nitzschia "delicatissima"* group	80	500,000	

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP Guideline[2] (cells/L)	Compliance[1]
		Pseudo-nitzschia "seriata" group	960	500,000	
		Trichodesmium erythraeum	80	-	
26/03/2025	SDR1	*Pseudo-nitzschia "delicatissima*" group	2,080	500,000	
		Pseudo-nitzschia "seriata" group	560	500,000	
		Trichodesmium erythraeum	80	-	
	SD4	*Pseudo-nitzschia "delicatissima*" group	4,880	500,000	
		Pseudo-nitzschia "seriata" group	560	500,000	
		Trichodesmium erythraeum	240	-	
	SD21	*Pseudo-nitzschia "delicatissima"* group	3,680	500,000	
		Pseudo-nitzschia "seriata" group	560	500,000	
		Trichodesmium erythraeum	560	-	

Notes:

1. Samples were analysed for one monitoring site and one reference site per sampling occasion. Reference results are not applicable (N/A) to compliance.
2. Marine Biotoxin Monitoring and Management Plan 2025 version 5: Western Australian Shellfish Quality Assurance Program (WASQAP) (DoH 2025).
1. Green symbols indicate the Environmental Quality Criteria (EQC) were met; amber symbols represent an exceedance of the EQG.
2. *Karenia/Karlodinium/Gymnodinium* group trigger for DoH (2025)

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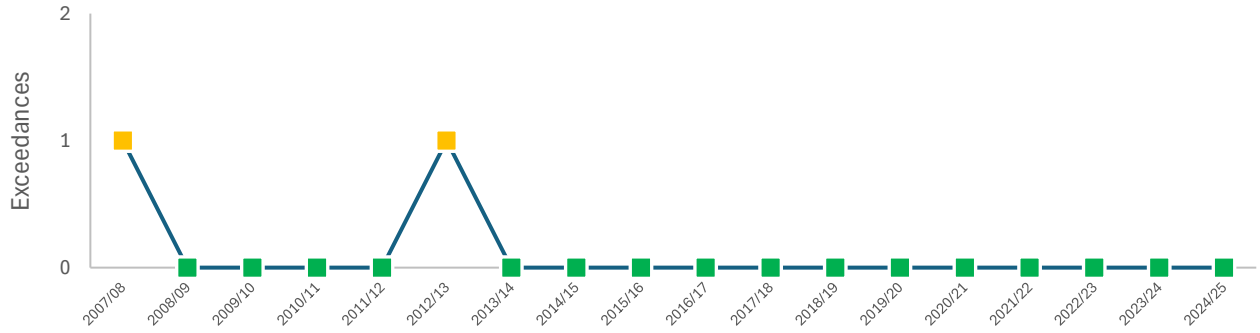


Note:

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 Number of cell counts of toxic phytoplankton at the SHEZ exceeding the WASQAP guideline (EQG)

4.4 Phytoplankton cell concentrations

The concentrations of phytoplankton cells are determined based on the Environmental Quality Criteria (EQC) for toxic algae in marine recreational water. Table 26 presents the specific EQC values for toxic algae in marine recreational water as outlined in EPA (2017) and the approach with respect to watch list species described by DoH (2022).

During the 2024-2025 monitoring period, the densities of phytoplankton at the individual monitoring sites remained below 15,000 cells/mL (Table 27). The EQG for phytoplankton concentrations was therefore met. Historically, algal density has never exceeded 15,000 cells/mL at any site (Figure 30).

Table 26 Environmental Quality Criteria for phytoplankton cell counts

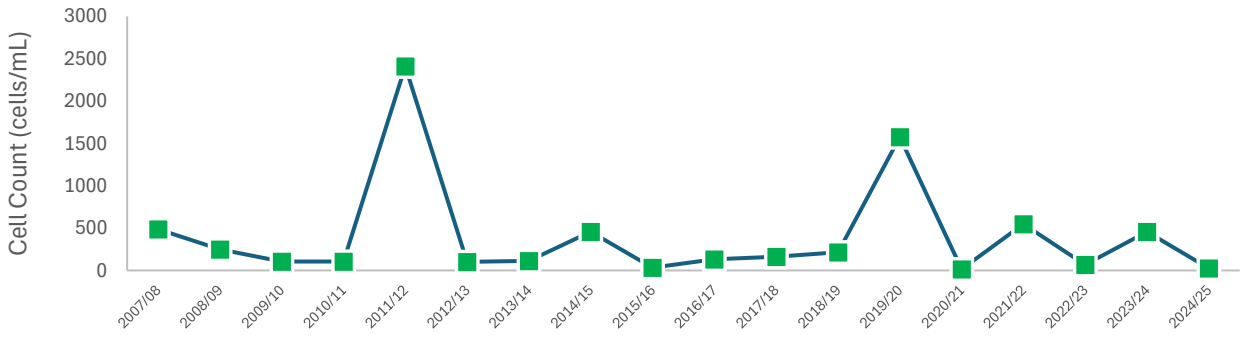
EQG[1]	Median total phytoplankton cell count for the area of concern (either from one sampling run or from a single site over agreed period of time) should not exceed 15,000 cells/mL. OR There should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner (via Department of Health) as potentially resulting from toxic algae when less than 15,000 cells/mL is present in the water column.
EQS[1]	There should be no confirmed incidences (via the Department of Health) of skin or eye irritation caused by toxic algae, or of algal poisoning in recreational users.

Notes:

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

Table 27 Estimated phytoplankton total cell densities collected at one of the fixed monitoring sites for contact recreation down-current of the Sepia Depression outlet

Date	Site	Total density (cells/mL)	Compliance
13/12/2024	SD15	69	
20/12/2024	SD32	21	
02/01/2025	SD4	11	
16/01/2025	SD13	55	
10/02/2025	SD2	19	
07/03/2025	SD7	68	
12/03/2025	SD25	30	
26/03/2025	SD4	11	
Median (all data)		**25**	



Note:

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

Figure 30 Median algal cell density

5 Shoreline Monitoring

5.1 Thermotolerant coliforms (TTC)

TTC were sampled at eight shoreline monitoring sites eight times over the 2024–2025 summer period (yielding a total of 64 samples). NHMRC (2008) guidelines and EPA (2005) recommend that a minimum of 100 samples is needed for accurate assessment of the EQG. Data from multiple years can be pooled where there are <100 samples provided local pollution conditions have not changed (NHRMC, 2008). Assuming conditions have not changed, data collected over two summers (2023-24 and 2024-25) were pooled to yield 128 samples.

The shoreline sites are not formally assessed against the EQC but the median TTC concentrations derived from the 128 samples were less than the limit of detection (<10 CFU/100 mL; Table 28) and less than the 14 CFU/100 mL criteria. Additionally, less than 10% of the samples exceeded 21 CFU/100 mL meeting the EQG (Table 19).

Table 28 Median thermotolerant coliform concentrations at the shoreline monitoring sites for the Sepia Depression outlet for 2023-25 and comparison to the EQG

Sampling period	Median[3]	Compliance[2,4]
Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	<10 CFU[1]/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.
4. Environmental Quality Criteria are based on EPA (2017).

5.2 *Enterococci* spp.

Samples were collected eight times at eight shoreline monitoring sites over the 2024–2025 summer monitoring period (yielding a total of 64 samples) for faecal indicator analyses. NHMRC (2008) and EPA (2005) recommend a 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 three summers (2023-24 and 2024-25) were pooled to yield 128 samples.

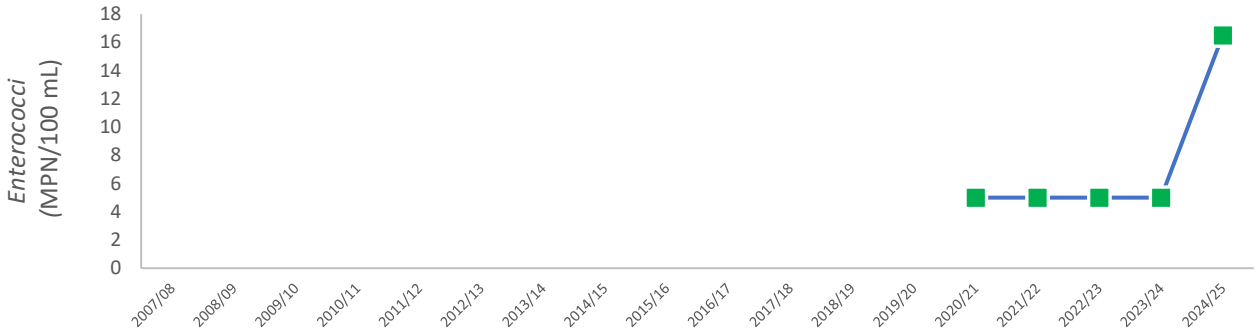
Though not formally assessed against the EQC, the 95th percentile *Enterococci* spp. concentration derived from the 128 samples was 16.5 CFU/100 mL, meeting the EQC (Table 29).

Table 29 The 95th percentile of *Enterococci* spp. concentrations at the shoreline monitoring sites for the Sepia Depression outlet for 2023-25 and comparison to the EQG

Sampling period	95th percentile[1,2]	Environmental Quality Criteria[1,2,4]		Compliance[3]
Dec 2023 – Mar 2024 Dec 2024 – Mar 2025	16.5 MPN/100 mL	EQG (primary contact)	95th percentile <200 MPN/100 mL	
		EQG (secondary contact)	95th percentile <500 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. MN/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.
2. Shoreline Monitoring commenced in the 2020-21 sampling season. Shoreline sites are not formally assessed against the EQC.

Figure 31 95th percentile shoreline *Enterococci* spp. concentration (with assessment against the primary contact EQG; 2020/21 – 2024/25)

6 Aesthetics

Aesthetic quality was assessed on each field sampling event via a questionnaire completed by field personnel on eight 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 outlet. Water clarity around the outlet (mean LAC at 350 m from the diffuser, pooled from all days) was compared against water clarity at a greater distance from the outlet (mean LAC at 1500 m from the diffuser from all days pooled) to assess whether aesthetic differences exist. Water Corporation also maintains a complaints register for the SDOOL program.

Results against the EQS are provided in Table 31. The field surveys observed algae/plant material visible on the surface on 50% of occasions. No dead marine organisms were visible on any occasion. There was no noticeable colour variation on any occasion. There were no films, oil or floating debris on the water surface on any sampling occasion. There was no noticeable odour associated on any occasion. There was no overall decrease in the aesthetic water quality values of Cockburn Sound.

Mean LAC at 350m from the ocean outlet (0.075 m^{-1}) was the same as the 1500 m distance from the outlet (0.075 m^{-1}) suggesting that light was equally attenuated at both distances (Table 32). Overall, water clarity was not reduced at all (0%), and therefore the EQG that the natural visual clarity of the water should not be reduced by more than 20% was met.

Table 30 Environmental Quality Criteria for Aesthetic Quality

Indicator	Environmental Quality Criteria	
	EQG[1]	EQS[1]
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.
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 Sepia Depression ocean outlet from December 2024 to March 2025

Date	Site	Algae/plant material?	Dead marine organisms?	Secchi depth (m)	Colour variation?	Oil or other films?	Floating debris?	Odour?	Cotton buds?
13/12/2024	SD14	Yes (macroalgae)	No	9.0	No	No	No	No	No
20/12/2024	SD16	No	No	6.0	No	No	No	No	No
02/01/2025	SD05	Yes (algae/plant material)	No	12.0	No	No	No	No	No
16/01/2025	SD15	No	No	9.5	No	No	No	No	No
10/02/2025	SD1	No	No	9.0	No	No	No	No	No
17/02/2025	SD7	No	No	14.0	No	No	No	No	No
12/03/2025	SD9	Yes	No	11.0	No	No	No	No	No
26/03/2025	SD5	Yes (*Trichodesmium* algae)	No	16.0	No	No	No	No	No

Notes:

1. Macroalgae or other plant materials are not always considered a nuisance organism, and may be present following storms or other metocean events. However they are recorded in the Field Sheet under this category.

Table 32 Light attenuation coefficient at sites 350 m and 1500 m from the Sepia Depression ocean outlet from December 2024 to March 2025

Date	Light attenuation coefficient (m^{-1})	
	350 m (site SDT - 350 m)	1500 m (site SDT – 1500 m)
13/12/2024	0.088	0.077
20/12/2024	0.075	0.075
02/01/2025	0.067	0.086
16/01/2025	0.078	0.075
10/02/2025	0.076	0.076
17/02/2025	0.066	0.067
12/03/2025	0.075	0.070
26/03/2025	0.072	0.074
Mean	**0.075**	**0.075**

6.1 Fish tainting substances

The EQG for fish tainting substances states that the concentrations of contaminants in a 24-hour composite sample are not to exceed the guidelines described by the EPA (2017).

No exceedances were detected for fish tainting substances in the Sepia Depression composite TWW sample, meeting the EQG (Figure 32).Note that the fish tainting substances 2,4-Dichlorophenol, 2,4,6-Trichlorophenol and Hexachlorocyclopentadiene could not be assessed due to the lack of sensitivity of the laboratory test. These have been assessed as 'indeterminate'.

All units have been converted to ug/L for consistency and a dilution factor of 1:357 (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

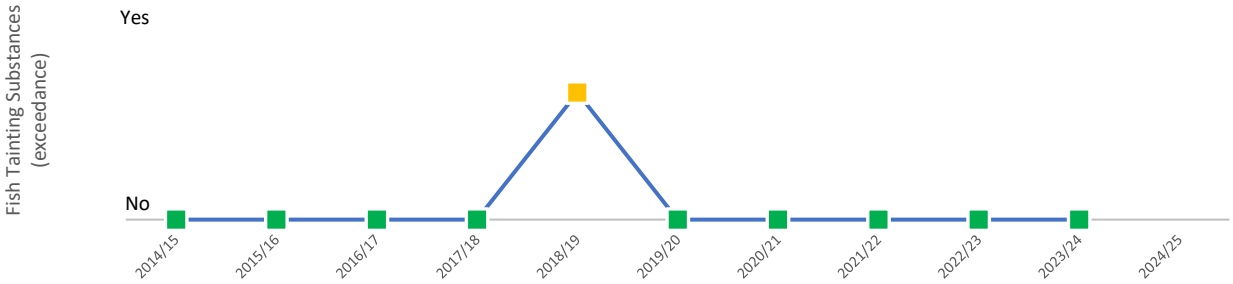
EQG[1]	Concentrations of contaminants will not exceed the aesthetics guidelines for fish tainting substances at the Recreational Contact Exclusion Zone boundary during normal plant operating conditions.

Notes:
1. EQG = Environmental Quality Guideline.

Table 34 Assessment of fish tainting substances

Parameter (µg/L)	Value (µg/L)	99% EPL[1] (µg/L)	Aesthetic Guidelines[2] (µg/L)	Exceedance
Metals and Metalloids				
Copper	20	0.3	1,000	No
Zinc	49	7	5,000	No
Phenols				
Phenol	< 10	270	300	No
2,4-Dichlorophenol	< 10	-	0.3	Indeterminate
2,4,6-Trichlorophenol	< 20	-	2	Indeterminate
Pentachlorophenol (PCP)	< 10	11	30	No
Chlorinated hydrocarbons				
Hexachlorocyclopentadiene	< 20	-	1	Indeterminate
Ethers				
Nitrobenzene	< 20	-	30	No
BTEX				
Toluene	< 1	-	250	No
Ethylbenzene	< 1	-	250	No
PAHS				
Naphthalene	< 0.01	50	1,000	No
Acenaphthene	< 0.01	-	20	No

Notes:
1. EPL = Ecological Protection Level.
2. The aesthetic guidelines are described in the Environmental Quality Criteria Reference Document for Cockburn Sound (EPA, 2017).



Notes:

1. EQG = Environmental Quality Guideline
2. Assessment is based on the EPA (2017) Fish tainting substance guidelines
3. Exceedances for Fish Tainting Substances 2,4-Dichlorophenol, 2,4,6-Trichlorophenol and Hexachlorocyclopentadiene were indeterminate due to laboratory reporting limits being greater than the guideline values.

Figure 32 Environmental Quality Guideline assessment for Fish Tainting Substances

7 References

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