

Water

1 Water Quality

Indicator Overview

A water quality index (WQI) is a numerical expression that summarises multiple water quality parameters to provide an assessment of the overall condition of a water body. This indicator was used in the 2021 Darwin Harbour Integrated Report Card (DHIRC) and is calculated by the Flora and Fauna Division of the Department of Environment, Parks and Water Security within the Northern Territory Government.

Methodology

The WQI is calculated using the Darwin Harbour Water Quality Objectives, which specify four key health indicators: algae, water clarity, dissolved oxygen and nutrients. Testing is completed at over 100 sites across nine reporting zones (Figure 1-1). Measurements of ammonia, chlorophyll-a, dissolved oxygen, filterable reactive phosphorous, nitrous oxide and water clarity are recorded and reported for each station. These results are published annually in a water quality report ([DEPWS, 2022](#)).

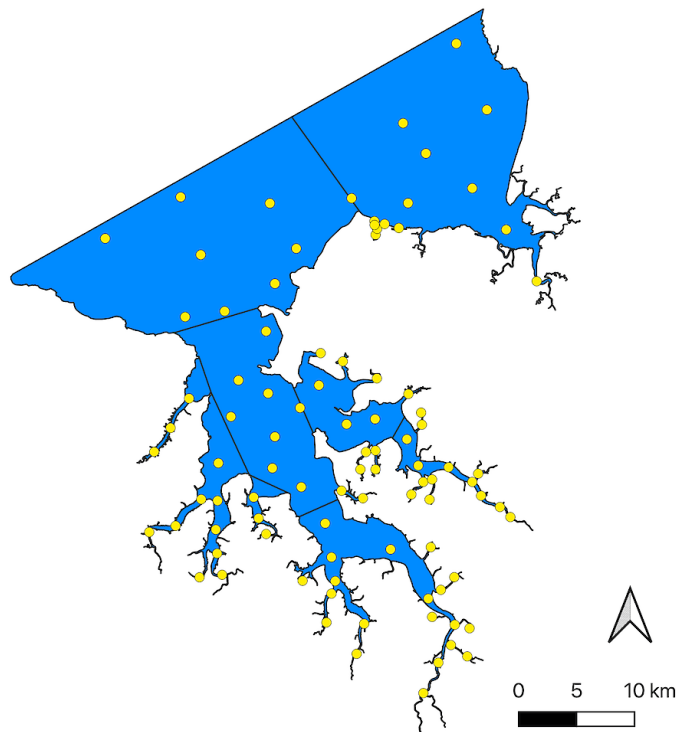
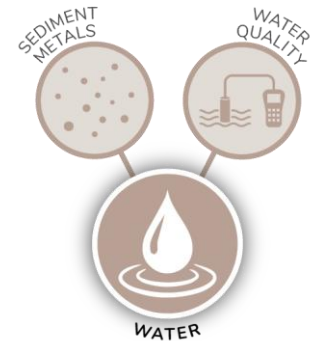


Figure 1-1. Water quality sampling sites in Darwin Harbour.

Collected water quality data are compared to guidelines to yield an index value on a scale between 0-1, with an index value of 0 reflecting no data met guidelines, and an index value of 1 indicating that all values have met their respective guideline. As with all indicators, the WQI is converted to the standardised report card scoring scale of 0-100% as shown in Figure 1-2 and outlined in Equation 1.

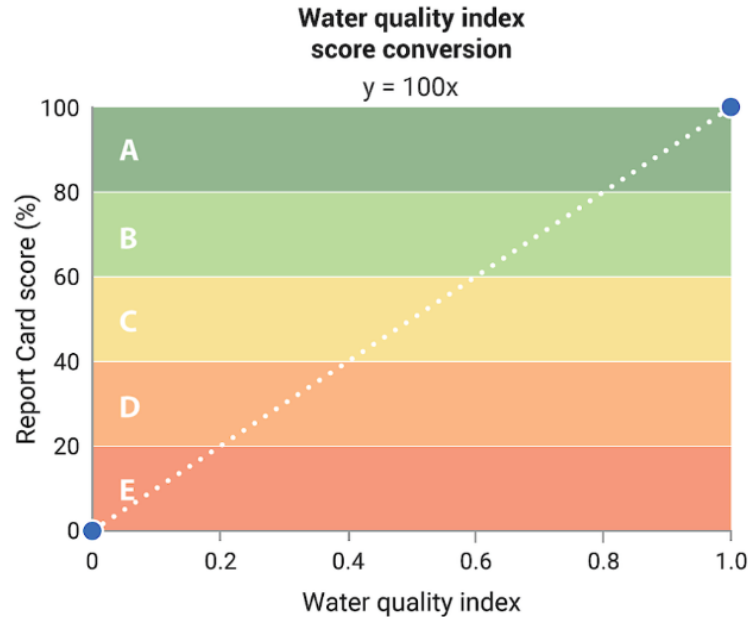


Figure 1-2. Linear relationship between the water quality index (WQI) and the standardised 0-100% report card scale. Report card indicator results are standardised to a common scale of 0-100% and categorised into five categories ranging from 'Very Poor' to 'Very Good'. A score of 100% indicates that all indicator measures have met their threshold (objective), whilst a score of 0% indicates none of the indicator measures have met their threshold. If a score is within 5% of a grade boundary, a '+' or '-' is added to the grade (e.g. a score of 58% = C+, whereas a score of 62% = B-).

Equation 1. Method for converting water quality index (WQI) results into a standardised 0-100% report card scale.

$$\text{Report card score} = 100 \times \text{WQI}$$

Report card score and grade

The WQI scores and corresponding report card grades for the current and previous reporting periods are shown (Table 1-1). The WQI scores for Central Harbour, East Arm, Outer Harbour and West Arm show an improvement, whilst water quality in Middle Arm and Shoal Bay has decreased between reporting periods. Overall, there has been an increase in water quality conditions since 2021.

The changes in water quality (and grades) across the harbour are often attributed to changes in wind conditions during the dry season. These conditions with macrotides influence the resuspension and movement of suspended sediment impacting water clarity. Elevated turbidity (a measure of water clarity) are typically intermittent and not induced by human activities such as dredging. The exceptions are for Buffalo and Myrmidon Creeks which are subject to a combination of limited flushing and wastewater inputs resulting in localised episodes of eutrophication.

Table 1-1. Summary of water quality index (WQI) scores in 2021 and 2024.

Region	2021			2024		
	WQI Score	Report Card Score	Grade	WQI Score	Report Card Score	Grade
Buffalo Creek	0.34	34	D	0.36	36	D
Central Harbour	0.67	67	B	0.88	88	A
East Arm	0.84	84	A-	0.94	94	A
Elizabeth Creek	0.96	96	A+	0.90	90	A
Middle Arm	0.86	86	A	0.76	76	B+
Myrmidon Creek	0.59	59	C+	0.54	54	C
Outer Harbour	0.76	76	B+	0.82	82	A
Shoal Bay	0.87	87	A	0.76	76	B+
West Arm	0.70	70	B	0.94	94	A
Area Weighted Grade		67	B		82	A-

The WQI indicator receives a 'A-' grade for the 2024 DHIRC. This is an improvement from 2021 in which WQI received a 'B' grade (Table 1-2).

Table 1-2. Overall results for water quality index (WQI)

	DHIRC 2021	DHIRC 2024
Report Card Score	67	81.9
Report Card Grade	B	A-

2 Sediment Metals

Indicator Overview

Sediment metals are reported using a sediment metal index (SMI) that assesses copper, lead, and zinc in the sediments of Darwin Harbour. This indicator, formerly referred to as the sediment quality index (SQI), was used in the 2021 Darwin Harbour Integrated Report Card (DHIRC) and is calculated by the Department of Environment, Parks and Water Security within the Northern Territory Government.

Methodology

The SMI is calculated as the mean enrichment quotient (MEQ) for copper, lead, and zinc in sediments. MEQ is a measure of the average amount of enrichment of copper, lead and zinc over pre-development 'backgrounds'. For example an MEQ of 1.5 is considered the threshold between unimpacted sediment and sediment affected by human influence (Birch et al, 2020; Munksgaard et al. 2020).

Since the 2021 DHIRC, where data from 286 sites were used to calculate report card scores, a statistical optimisation procedure was undertaken on the baseline dataset (2019-20) for gains in cost efficiency. As a result, sampling in 2023 included approximately half of the original sites (140). Moreover, a weighting was applied in the optimisation to include more sites in built-up areas compared to undeveloped areas. The change in methodology does account for some variability between reporting. As such, updated 2021 results have been included below.

The SMI reports on a scale between < 1 to > 4, with an index value of < 1 being very good and an index value of 4+ being very poor. In order to standardise the reporting scale across all indicators, the average sediment metal index for sites within each reporting region was converted to a 0-100% report card scale using the relationship shown in Figure 2-1 and detailed in Equation 2.

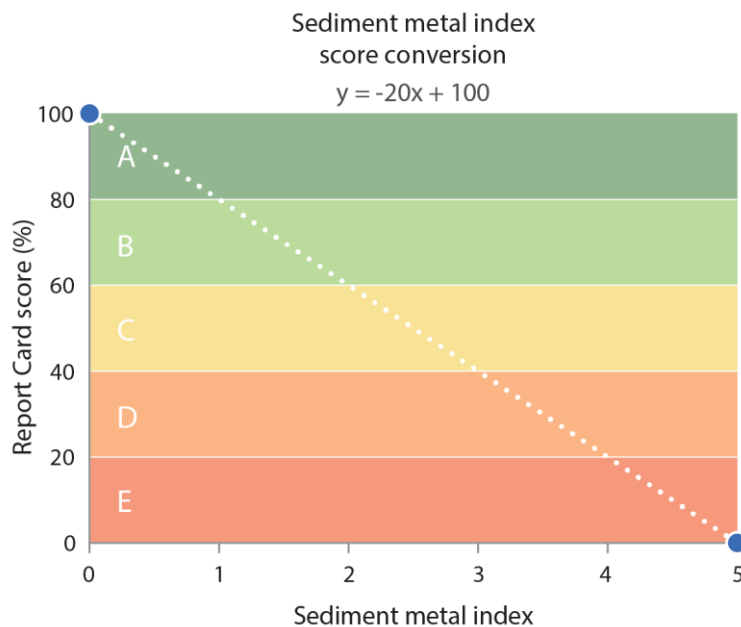


Figure 2-1. Linear relationship between the sediment metal index (SMI) and the standardised 0-100% report card scale. Report card indicator results are standardised to a common scale of 0-100% and categorised into five categories ranging from 'Very Poor' to 'Very Good'. If a score is within 5% of a grade boundary, a '+' or '-' is added to the grade (e.g. a score of 58% = C+, whereas a score of 62% = B-).

Equation 2. Formula for converting sediment metal index (SMI) results into a standardised 0-100% report card scale.

$$Report\ card\ score = -20(SMI) + 100$$

Report card score and grade

The SMI scores for the 2024 DHIRC are shown in Table 2-1. The SMI ranged from a B- to B+ for sediment metals in all regions assessed in Darwin Harbour with an area-weighted average score across all regions of 66% (B).

Several sites adjacent to developed Harbour regions were more impacted, especially in the vicinity of Darwin City and northern suburbs (Figure 2-2). High SMIs do not necessarily imply that metal concentrations exceed National guideline values because the index is calculated from aluminium or iron normalised data. While, there was a National Guideline exceedance for copper in one of three samples taken from a site in Sadgroves Creek (Figure 2-2), the bioavailable amount of copper in the sediment was found to be below the guideline value in a separate test.

It should also be noted that, despite SMI scores in the typical Harbour range, Buffalo Creek, and to a lesser extent Myrmidon Creek, have poor sediment quality due to organic enrichment.

Table 2-1. Summary of sediment metal index sampling sites, MEQ's, and corresponding report card scores and grades.

Region	Number of sites	Mean MEQ (Cu+Pb+Zn)	Report Card Score	Report Card Grade
Buffalo Creek*	2	1.33	Insufficient number of sites to score	
Central Harbour	16	1.97	60.6	B-
East Arm	39	1.81	63.9	B-
Elizabeth Creek	11	1.52	69.6	B
Middle Arm	14	1.24	75.1	B+
Myrmidon Creek*	1	1.46	Insufficient number of sites to score	
Outer Harbour	20	2.00	60.0	B-
Shoal Bay	26	1.40	72.0	B
West Arm	11	1.18	76.5	B+
Area Weighted Grade			66.0	B

*Note: As Buffalo Creek (2) and Myrmidon Creek (1) include a small number of testing sites there is an increased risk of bias in the results. As such the DHIRC has decided to not include a report card score and grade for Buffalo and Myrmidon Creek.

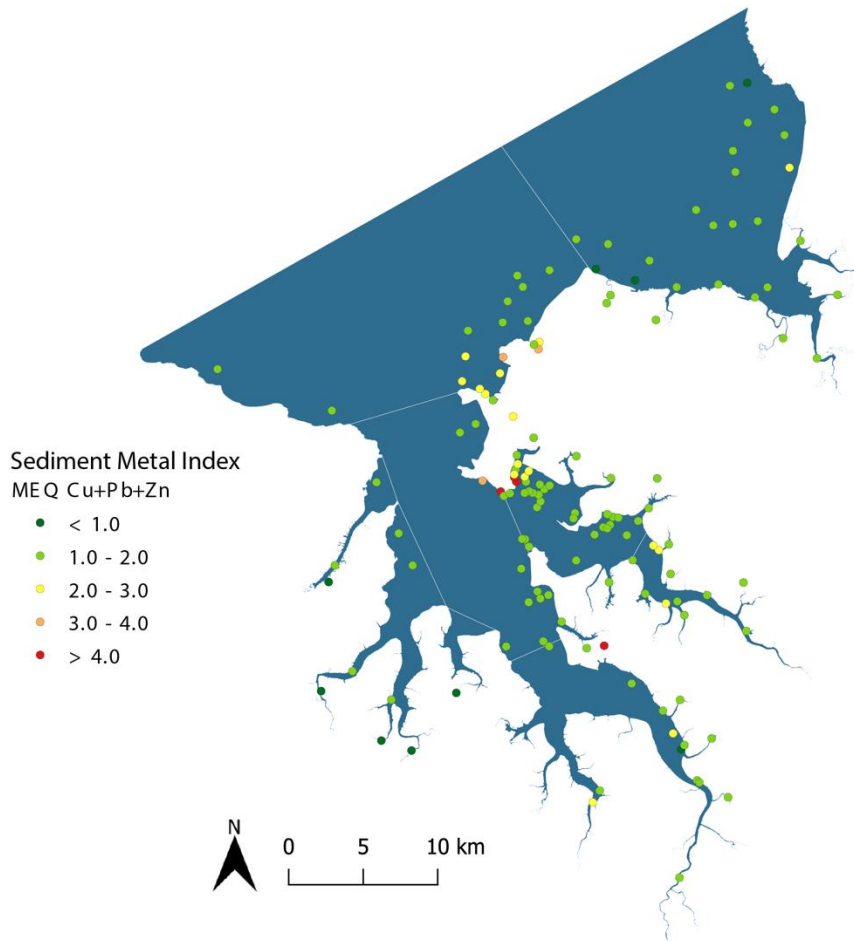


Figure 2-2. Location of sampling sites and site specific results for sediment metal index.

Darwin Harbour has attained an overall 'B' grade for sediment metals in the 2024 Report Card. This is the same grade as obtained in the 2021 DHIRC although the score has decreased. Lower scores are evident at some sites in some developed Harbour regions.

Table 2-2. Overall results for sediment metals

	DHIRC 2021 (Updated)	DHIRC 2024
Report Card Score	70.0	66.1
Report Card Grade	B	B