TEER
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2022 Tamar Estuary Report Card

Technical Report

May 2022

Summary and Key Messages

This report has been developed to assist with the interpretation of the 2022 Tamar Estuary Report Card, to provide insight into the drivers of changes in ecosystem condition over time. This report shows that there has been a minor decline in grades in Zones 2, 4 and 5, with Zones 1 and 3 remaining the same when compared to the 2020 Report Card monitoring period. The reporting period coincides with high rainfall throughout the catchment relative to the 2020 and 2018 Report Card monitoring periods. Zone 1 (Launceston to Legana) remains in 'poor ecosystem health', with ecosystem health index and grade values consistent with most other reporting periods. The change in grade from B- to C+ in Zone 2 sees a shift from 'good' to 'fair' ecosystem health in this Zone. Zones 3 to 5 are in 'good' and 'excellent' ecosystem health, consistent with previous years. The main factors that have contributed to the ecosystem health grades in the reporting period are:

- Continued high levels of nutrients in the upper and mid estuary.
- Maintained improvements in nutrient levels in the lower estuary first observed in the 2020 Report card monitoring period.
- Maintained improvement in dissolved metal concentrations in all zones following high levels experienced during years when the sediment raking program was operating.
- Low dissolved oxygen during two months of the year at many monitoring locations and water being generally more acidic than in previous years.

Elevated chlorophyll-a and total phosphorus are consistent pressures on the ecosystem throughout the estuary.

The analysis of longer-term trends in the ecosystem health index for each zone and the components that contribute to this show:

- Key drivers of poor ecosystem health in Zone 1 are high concentrations of total phosphorus and high turbidity which have exceeded all condition thresholds at all monitoring locations in all years. Chlorophyll-a has also been a driver of poor condition in some years but compliance with thresholds for this parameter has fluctuated over time.
- There has been a shift in the assessed ecosystem health due to pH in Zones 1, 4 and 5 from 2009/10 to the current reporting period with monitoring data showing increases in acidification in these zones which are outside guideline limits. Reasons for this trend are unclear but may include impacts of climate change, point source inputs or acidification due to land use practices which disturb potential acid sulfate soils. Continued monitoring of pH as part of the Ecosystem Health Assessment Program over time is expected to provide a data set that will help determine the degree to which changes are affected by localised factors as opposed to longer term changes associated with climate change.
- In general, heavy metals fall within guideline levels, exceeding them by smaller magnitudes on fewer occasions than other pollutants. There is evidence of increased dissolved metals affecting ecosystem health during years where sediment raking campaigns were being conducted. Since raking ceased, levels of dissolved metals have improved back to pre-raking conditions. Zinc is the main metal of concern with other heavy metals generally within guidelines.

Contents

1 Background

This report has been developed as a supplement to the 2022 Tamar Estuary Report Card, providing a comparison of 2022 grades with those from previous years, exploring trends in grades and ecosystem health over time. The aim of this report is to allow for changes in ecosystem health in the kanamaluka/Tamar estuary, as defined by estuary report card grades and ecosystem health index values, to be better understood. Background on the estuary and its catchment as well as the sources of pollutants to the estuary and their relative impacts on water quality are provided for context.

1.1 kanamaluka/Tamar estuary and its catchment

The kanamaluka / Tamar estuary is strongly influenced by the tide along its 70 km length, with the tidal range in Launceston exceeding four metres at times, between high and low tide. The combination of the tidal exchange and inflows from the North and South Esk rivers results in seasonal variability in salinity throughout the estuary. In addition, due to the shape of the estuary and other bathymetric features that influence friction, such as estuary bed materials, the tide is asymmetric, with the incoming tide faster and stronger than the outgoing tide. This means that pollutants in the upper estuary can be retained for an extended period of time. As shown in Figure 1, six catchments drain into the kanamaluka/Tamar estuary, a total catchment of over 10,000 km^2, which is approximately 15 percent of Tasmania's land mass. Run-off contributes pollutants from a range of diffuse sources, which can be associated with land uses such as forestry, grazing, dairy, intensive cropping and rural and urban settlements. The largest urban footprint in the catchment is the city of Launceston, situated at the head of the estuary. Over 120,000 people live around the estuary in the Greater Launceston Area and Tamar Valley. Stormwater from urban areas contributes pollutants such as pathogens, nutrients and sediment to the estuary and is known to be impacted by sewage intrusion in some urban areas. Point sources of pollutant inputs to the estuary include discharges from industry, 26 wastewater treatment plants discharging either to rivers and streams in the freshwater sections of the catchment or directly to the estuary, Launceston's combined sewage and stormwater network and fish farms and hatcheries including the salmon farm at Rowella.

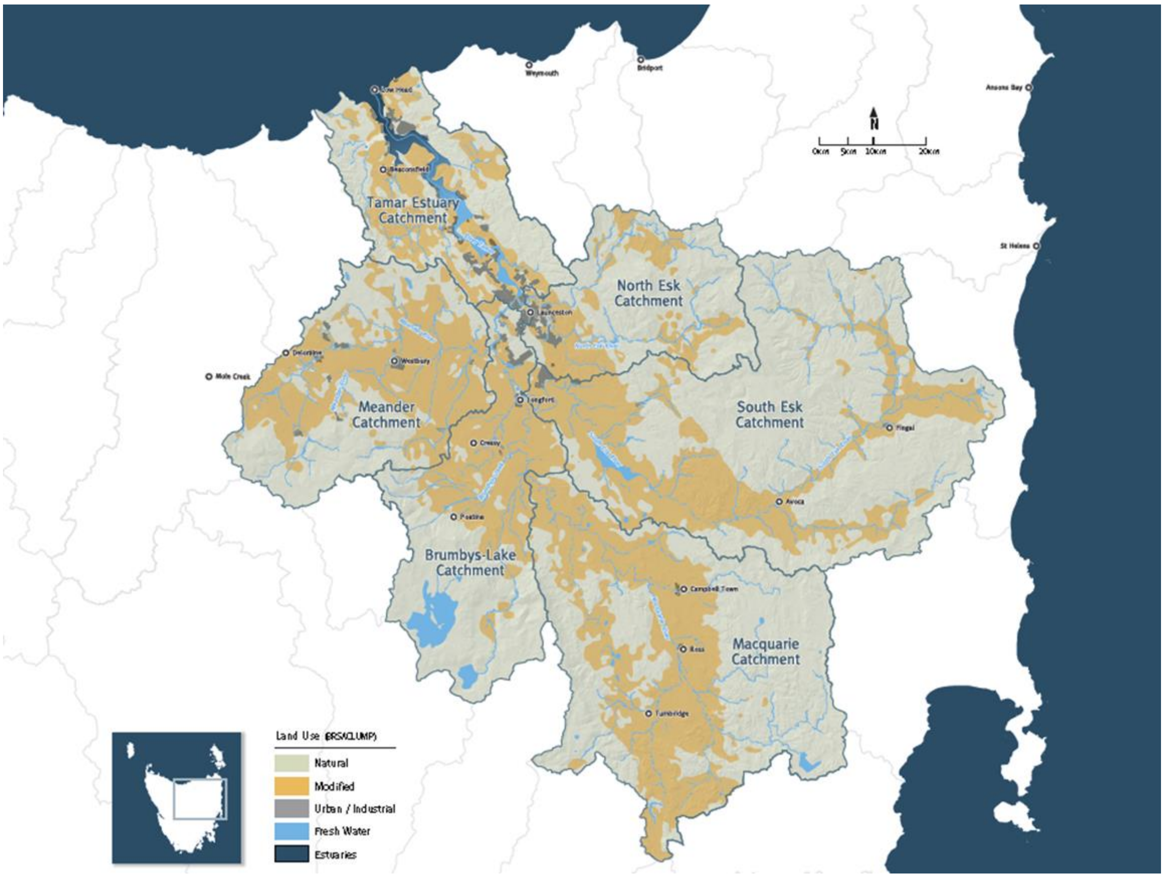


Figure 1. Catchments (CFEV) draining to the kanamaluka/Tamar estuary. Note catchments other than the North Esk and Tamar Foreshore drain through Lake Trevallyn either through flows down Cataract Gorge or as releases from the Tailrace. Wastewater treatment plants are also shown.

The estuary is 70 km long, stretching from the North Esk at St Leonards, 13 km upstream of where it joins with the main kanamaluka / Tamar estuary to Low Head on Bass Strait. Salinity varies from close to freshwater in the upper estuary during much of the year to marine at the estuary mouth.

As shown in Figure 2, the kanamaluka / Tamar estuary has been divided into five Functional Zones for the purpose of reporting on ecosystem health. These reflect the differences in critical habitats, key processes and anthropogenic impacts of the estuary. The zones also provide a focus for management actions and future research. Each Functional Zone is defined by a unique set of characteristics which determines the extent (or length) of each functional zone and where the boundaries should lie. These characteristics include:

- Key processes defined by chlorophyll-a concentrations and behaviour.
- Anthropogenic impacts defined by concentrations of heavy metals and nutrients.
- Critical habitats defined by mapping of subtidal substrates and known habitats.
- Salinity.
- Key values such as recreation, conservation areas and high diversity areas.
- Key issues including the presence of heavy industry, sewage treatment plants, weeds and pests, and sedimentation.

The characteristics of the five functional zones of the kanamaluka / Tamar estuary are summarised in Table 1.

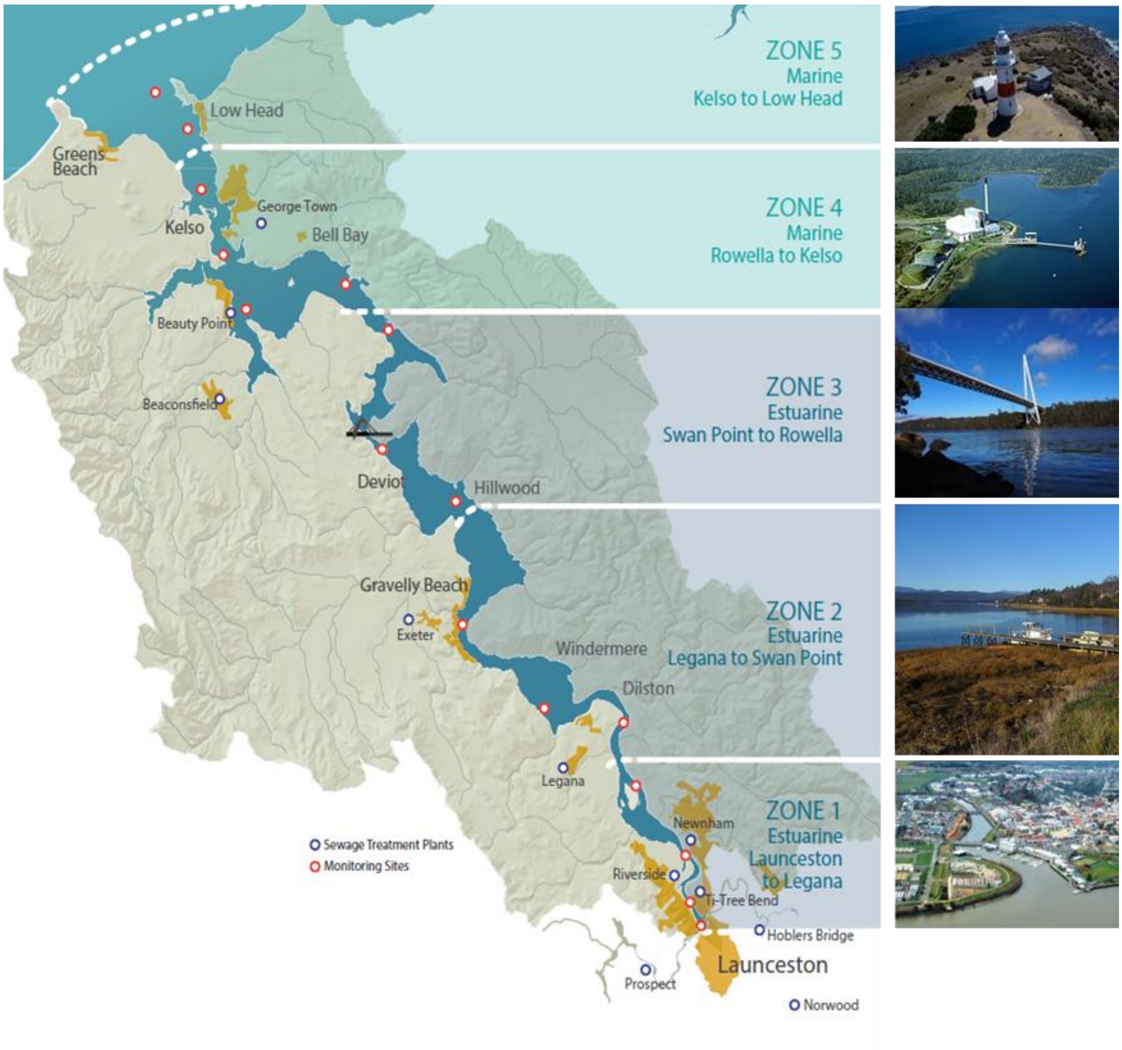


Figure 2. Functional zones of the kanamaluka/Tamar estuary used for reporting. The location wastewater treatment plants discharge to the estuary are shown.

Table 1. Characteristics of functional zones of the estuary

Zone	Location	Type	Natural habitats	Key processes	Environmental values	Social and economic values	Issues and threats
1	Launceston to Legana	Estuarine	• Dominated by silt, including extensive mudflats; • Wetlands	• Wide range of primary productivity; • Nutrient cycling between sediment and overlying water; • Sedimentation	• Diversity of aquatic flora and fauna including wetland flora species, Australian Grayling and green and gold frog	• Launceston (2nd largest city in Tasmania); • Residential, tourism including ferries, marinas and yacht clubs; • Recreational (rowing); • Industrial and commercial including restaurants and slipway	• Diffuse and point inflows from North and South Esk catchments; • Launceston combined sewer overflows; • Stormwater; • Six WWTPs including the Ti Tree Bend (largest WWTP which processes sewage and combined flows); • Changes in freshwater flow including irrigation extraction and hydro-electric dams
2	Legana to Swan Point	Estuarine	• Dominated by silt, including extensive mudflats; • Saltmarsh vegetation on shoreline including rice grass	• Wide range of primary productivity; • Nutrient cycling between sediment and overlying water; • Sedimentation; • Erosion	• Wetland communities	• Primarily rural (some farming/orchards); • Several small communities; • Recreational activities such as boating, sailing, fishing and rowing	• Foreshore catchment diffuse loads (mostly forestry and agriculture with some rural communities using onsite sewage treatment); • Two WWTPs with recycled water schemes
3	Swan Point to Rowella	Estuarine	• Dominated by silt and saltmarsh; • Some reef and cobble towards the lower reaches of the estuary	• Seasonal primary productivity; • Nutrient cycling between sediment and overlying water; • Catchment runoff	• Wetland communities	• Primarily rural (some farming/orchards; • Several small communities; • Recreational activities (boating, sailing, fishing, rowing); • Commercial activities (salmon farm)	• Foreshore catchment diffuse loads (mostly forestry and agriculture with some rural communities using onsite sewage treatment) • Salmon farm

Zone	Location	Type	Habitats	Key processes	Environmental values	Social and economic values	Issues and threats
4	Rowella to Kelso	Marine	• High areal extent of silt; • Extensive reef and sand habitats; • Soft coral and sponge gardens are found in main channel; • Seagrass meadows in Middle Point and the entrance to West Arm; • Foreshore predominantly rock with tidal/sand flats in the bays of West and Middle Arm	• Seasonal primary productivity; • Nutrient cycling between sediment and overlying water; • Stormwater and sewage discharge	• Deeper areas of reef and cobble are considered to be biologically diverse with sponge-dominated invertebrate communities containing temperate soft corals; • Conservation area at mouth of West Arm and Middle Point	• Industrial estate of Bell Bay; • Beaconsfield gold mine; • Several small communities; • Recreational activities (boating, sailing, fishing, rowing, scuba diving); • Commercial activities (abalone farm, berry farm)	• Foreshore catchment diffuse loads (mostly forestry and agriculture with some urban areas with onsite or reticulated sewage) • Three WWTPs, two with recycled water schemes • Elevated metals in water column, sediments and biota due to industrial activities; • Shipping activities and risk of introduction of aquatic pest species
5	Kelso to Low Head	Marine	• High areal extent of reef habitat (low, median and high profile); • Extensive seagrass on subtidal banks at Kelso and sand habitats; • Soft corals and sponge gardens found in main channel; • Foreshore predominantly rock with sand flats	• Seasonal primary productivity; • Nutrient cycling between sediment and overlying water; • Catchment runoff and stormwater discharge	• Deeper areas of reef and cobble are considered to be biologically diverse with sponge-dominated invertebrate communities containing temperate soft corals; • The eastern foreshore is a designated conservation area	• Several small communities; • Recreational activities (boating, sailing, fishing, scuba diving)	• Foreshore catchment diffuse loads with some urban runoff from small settlements • Shipping activities and risk of introduction of exotic aquatic pest species and oil spills

1.2 Sources of pollutants and their impacts on the estuary

The kanamaluka / Tamar estuary and Esk rivers catchment has a wide range of sources of pollutants that contribute to both the freshwater system and in some cases discharge directly to the estuary. These pollutants include nutrients, such as total nitrogen (TN) and total phosphorous (TP), sediments, heavy metals and other contaminants. Sources of these pollutants include diffuse loads from land uses such as grazing, dairy, cropping, native and plantation forestry areas and urban areas. There are also 24 wastewater treatment plants in the catchment, 11 of which are in close proximity to the estuary. Other point sources of pollutants include combined sewer overflows in Launceston and the salmon farm at Rowella. Figure 3 shows the relative contribution to average annual total catchment loads of TN, TP and total suspected sediments (TSS) estimated using the CAPER DSS that was originally developed to support the TEER Water Quality Improvement Plan (version May 2022). This figure shows that over 80% of nutrient loads and almost all sediment loads are derived from diffuse sources.

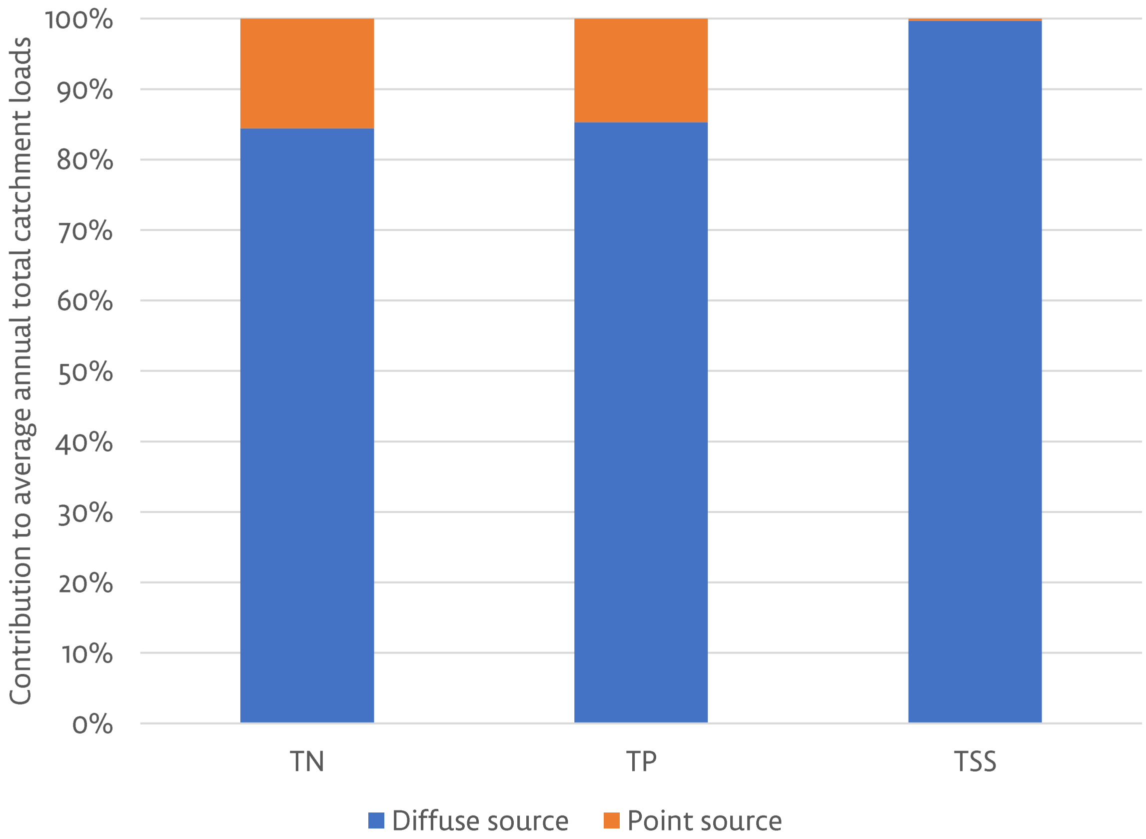
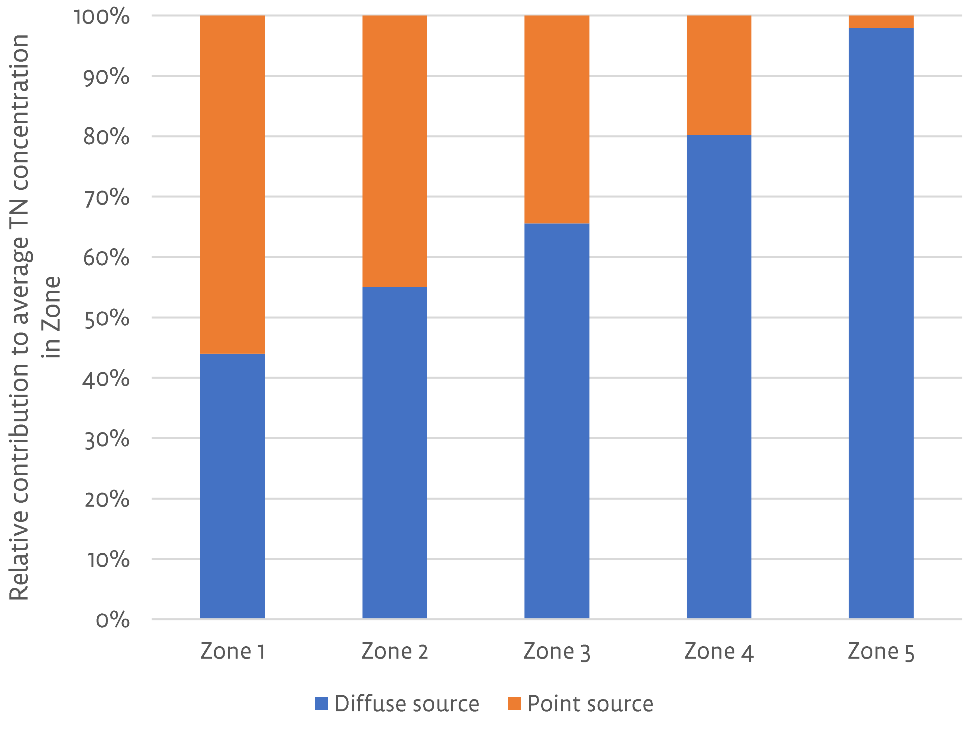


Figure 3. Relative contribution of point and diffuse sources to average annual catchment loads. Point sources include WWTPs, combined sewer overflows and salmon farm at Rowella. Values based on CAPER DSS version May 2022.

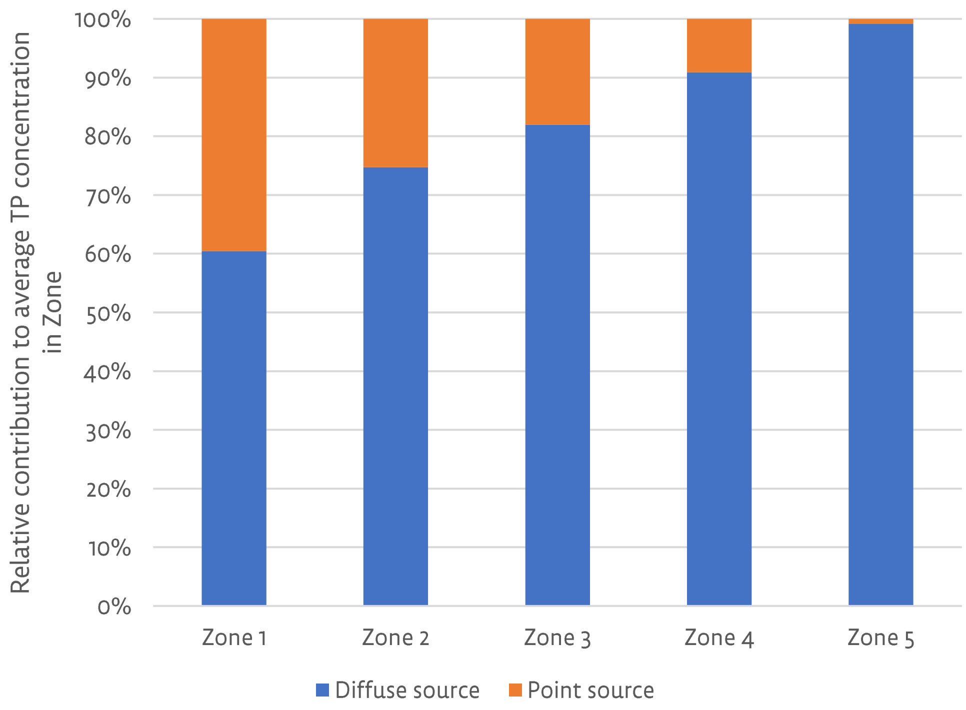
How pollutant sources affect the estuary depends on their proximity to the estuary, in particular whether they are above Lake Trevallyn, and where they discharge into the estuary. Pollutants discharged into the lower estuary tend to be subject to greater exchange with the marine system and are diluted to a greater extent than those discharged into the upper estuary. The tidal nature of the estuary means that pollutants can travel 'upstream' (i.e. towards Launceston) once they reach the estuary. Some pollutants, such as sediment, settle out where the estuary transitions from freshwater to saltwater due to processes such as flocculation and deposition, whereas other pollutants remain in suspension; therefore, able to travel further on the outgoing tide.

Figure 4 shows the relative contribution of total catchment diffuse and point sources to average annual concentrations of TN, TP and TSS in each Zone, again estimated using the CAPER DSS. Note that absolute concentrations are much higher in Zone 1 than Zone 5. Figure 4 shows the proportional contribution of each source to estuary concentrations and does not reflect the relative differences between concentrations in each zone that are described in the report card.

TN



TP



TSS

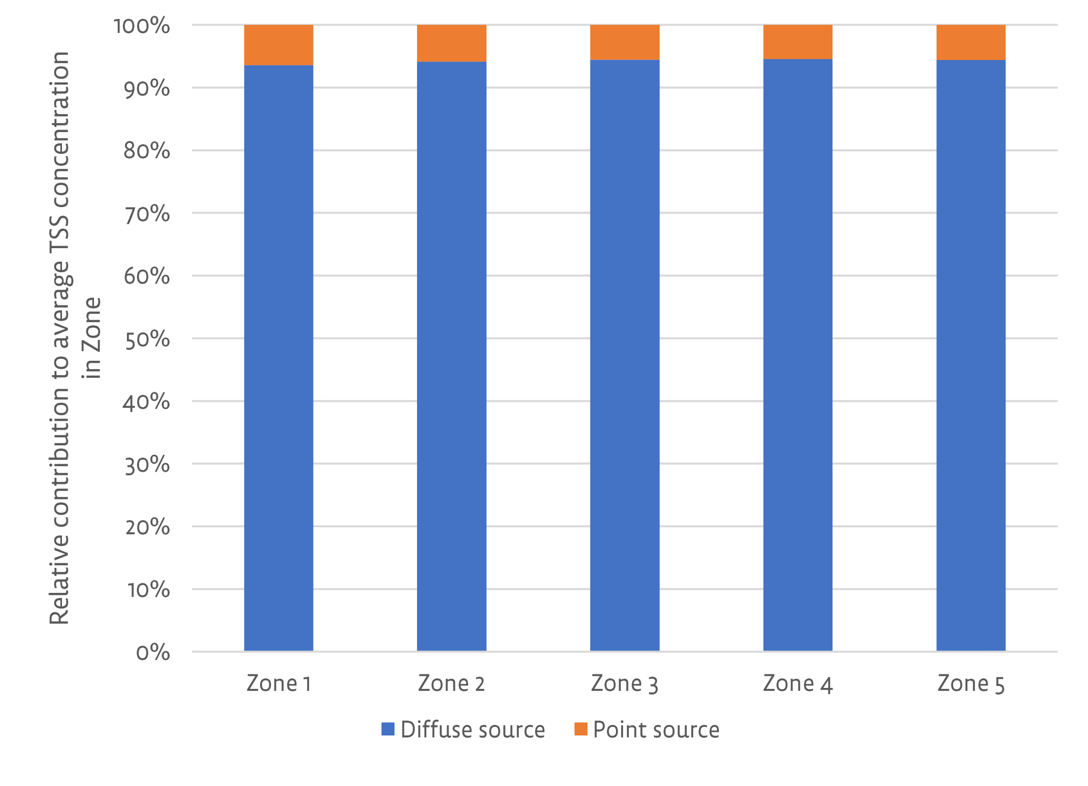


Figure 4. Relative contribution of total catchment point and diffuse sources to average concentration in kanamaluka/Tamar Estuary by zone. Point sources include WWTPs, combined sewer overflows and salmon farm at Rowella. Values based on CAPER DSS version May 2022.

1.3 Other potential influences on water quality in 2022

Climate is a key driver of catchment and estuary processes with rainfall and associated runoff affecting inputs such as diffuse runoff from agricultural and forestry areas, stormwater quality and quantity and overflows from Launceston's combined-sewer stormwater system. Table 2 compares annual and monthly rainfall at Ti Tree Bend experienced during the 2022 reporting year (December 2020 to November 2021) with percentiles from data over the period 2002 to 2022.

Table 2. Comparison of annual and monthly rainfall (total mm) at Ti Tree Bend in 2022 Report Card period (Dec 2020 to Nov 2021) with percentiles from 2002-2022 data.

Statistic 2002-2022 rainfall data (mm)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Annual
2022 Report Card period	14	49	51	24	25	55	68	115	81	37	116	41	661
10th percentile	15	14	12	14	19	21	22	40	34	31	10	14	518
25th percentile	25	18	20	20	25	37	40	58	46	44	19	27	595
Median	50	34	35	41	38	53	65	81	72	66	41	48	676
75th percentile	73	55	49	64	75	83	92	104	109	80	64	62	778
90th percentile	91	82	58	88	82	98	125	124	174	91	96	81	860

This table shows that annual rainfall was below the median for this period (~40th percentile) with December rainfall below the 10th percentile but October rainfall above the 90th percentile showing a high degree of variability within the year. Figure 5 compares annual rainfall over the 2022 report card period (2020/21) with annual rainfall data coinciding with monitoring programs used for previous reporting years. This figure shows that while annual rainfall for the 2022 reporting period is below the 20-year median, this year is the second wettest for which report cards have been produced and sees a significant increase in rainfall compared to the 2018/19 reporting period.

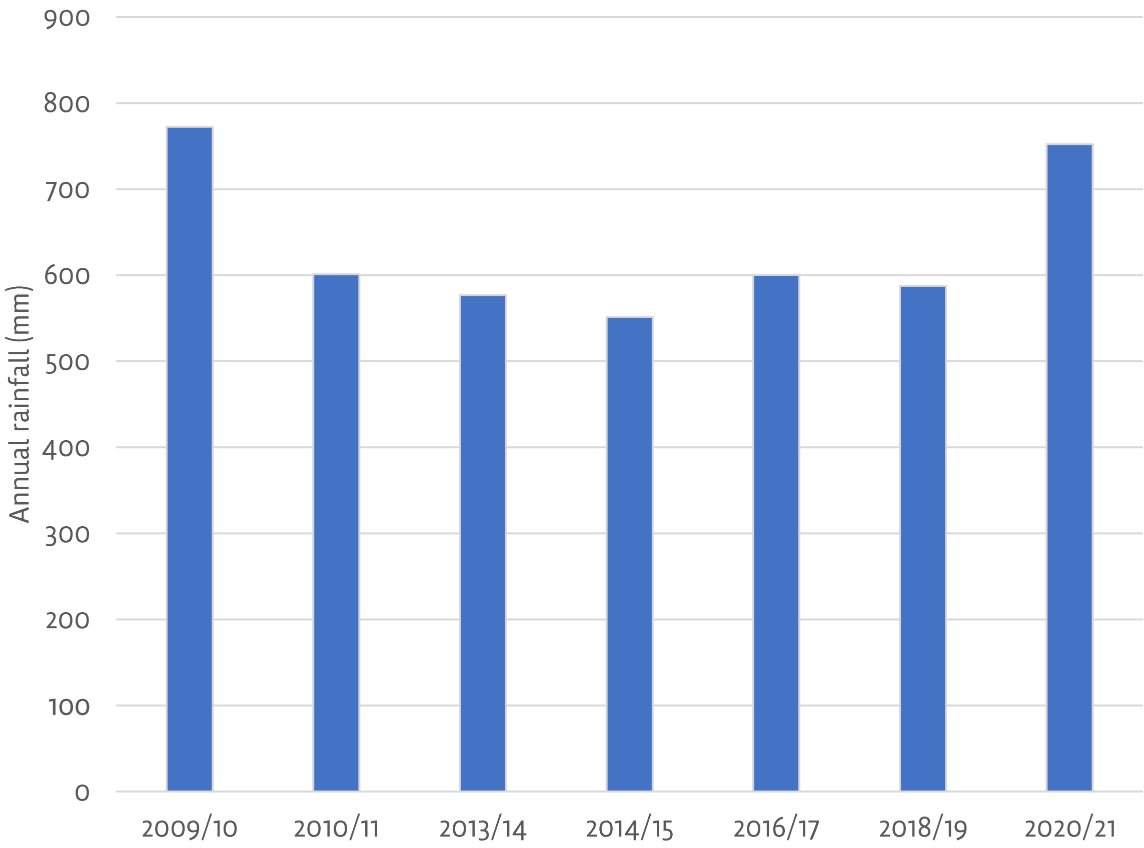


Figure 5. Comparison of annual rainfall at Ti Tree Bend for 2022 reporting year (2020/21) with rainfall during previous report card monitoring years.

While climate variability is a natural part of the variation estuaries are adapted to, longer term climate change is having broad impacts on entire ecosystems at a global scale. In recent decades, long-term monitoring programs have been able to establish clear evidence of the impact's climate change is having on Australian estuaries. Recent studies have identified that climate change impacts are highly dependent on the morphology of the estuary, showing variability in the severity, rate and trajectory of change for different water quality parameters, including physical changes such as sea level rise. Water bodies such as rivers and lagoons with shallow average depths are suggested to be most at risk of increasing water temperatures and increasing levels of acidity. In the kanamaluka / Tamar estuary, long term measurements of pH in the upper estuary have been observed to consistently decline, becoming more acidic most notably in the upper estuary. While it is acknowledged that several environmental factors can influence changes in pH (and other water quality parameters), such as freshwater inflows and acid sulfate soils, it is important to recognise that climate change is a major factor that influences water quality and acidity, and which will continue to play a significant role in water quality and ecosystem health into the future. Further investigations into the long-term changes to water quality in the kanamaluka/Tamar estuary driven by climate change are required, and it should be recognised that climate change is likely to substantially influence ecosystem health into the future.

2 TEER Estuary Report Card Methodology

The 2022 Tamar Estuary Report Card has been produced using 12 months of kanamaluka / Tamar estuary ambient monitoring data, from December 2020 to November 2021, at 16 sites along the length of the estuary. In 2020, a new methodology was employed to calculate the grades. Key changes to the report card methodology include the adoption of biologically relevant trigger values, which are generally more stringent than previous methods. Note that ecosystem health assessment is based on water quality only and does not include biological indicators.

Grades are allocated based on an ecosystem health index (EHI) for each zone. The overall EHI is the average of composite EHI from three categories – dissolved heavy metals, nutrients and 'other' consisting of pH, dissolved oxygen, turbidity and chlorophyll-a. Each pollutant is assigned a score between one and four for each monitoring site (described further below). The way in which scores are assigned varies between pollutants:

- For heavy metals the score compares the maximum pollutant concentration over the 12 month period to ANZECC 99th, 95th and 80th level of protection guideline values.
- For chlorophyll-a, nutrients and turbidity the score compares the median concentration over the 12 month period to a series of thresholds developed for Tasmanian estuaries (which are similar to 20th, 80th and 50th percentile EPA's Default Guideline Values (DGV's)).
- For pH and dissolved oxygen, values are compared with a series of upper and lower thresholds developed using the EPA's DGV's and advice in the ANZECC explanatory notes on variation from these that is ecologically significant. The score is then the 10th percentile of category scores attributed using these thresholds to the 12 month data series.

The EHI for each pollutant is the average score for that pollutant across all monitoring sites within the zone divided by four to give a value between zero and one. Component EHI are then the average across pollutant EHIs within that category. The overall EHI is the average of these three category component EHIs, as demonstrated in Figure 6.

$$Overall\ EHI = \frac{Nutrient\ EHI + Metals\ EHI + Other\ EHI}{3}$$

Figure 6. Pollutants contributing to component EHIs. Overall EHI for the zone is the average across these three components

The final letter grades assigned to each zone are allocated based on ranges of EHI values as shown in Table 3.

Table 3. Thresholds for EHI values assigned to letter grades

EHI	Letter Grade
0.950-1.000	A+
0.900-0.949	A
0.850-0.899	A-
0.800-0.849	B+
0.750-0.799	B
0.700-0.749	B-
0.675-0.699	C+
0.625-0.674	C
0.600-0.624	C-
0.575-0.599	D+
0.525-0.574	D
0.500-0.524	D-
<0.500	F

The method by which scores and grades are calculated means that EHIs and grades are subject to significant threshold effects, and that changes in EHI and grades are not necessarily reflective of overall trends in individual observations but do capture ecologically significant changes in water quality within each zone.

3 2022 Report Card Grades relative to the 2020 Report Card

Grades and associated conditions for the five zones of the estuary for the 2022 report card are summarised in Table 4. This table also includes 2020 grades for comparison as well as a brief summary of key drivers of the grade for each zone.

Table 4. Comparison of 2022 with 2020 report card grades and ecosystem health.

Zone	2022 Grade & health	2020 Grade	Comment
1	D: Poor ecosystem health	D	Zone 1 has consistently received 'poor' grades in past reporting years. As with previous years, a 'poor' ecosystem health score in Zone 1 is mostly driven by high levels of nutrients and elevated turbidity. Chlorophyll-a has significantly improved following a long period of elevated levels. There has been continued improvement in heavy metal concentrations in this zone.
2	C+: Fair ecosystem health	B-	Ecosystem health in Zone 2 decreased from a rating of good to fair due to a small shift in grade from B- to C+. This zone experiences consistent pressures from elevated nutrients, turbidity and chlorophyll-a. The decline in grade from 2020 was driven by an increase in median concentrations of nutrients, more acidic pH, as well as reduced dissolved oxygen concentrations in two months over the monitoring period.
3	B: Good ecosystem health	B	Zone 3 remains stable with 'good' ecosystem health. Total phosphorus and chlorophyll-a continue to be the main pressures on ecosystem health in this zone. Ecosystem health index values for nutrients, heavy metals and dissolved oxygen experienced small decreases relative to the 2020 Report Card. These changes were offset by improvements in turbidity and chlorophyll-a.
4	B+: Good ecosystem health	A-	Zone 4 experienced 'good' ecosystem health for this monitoring period, representing a change in classification from 'excellent' due to a small shift in grade. Elevated chlorophyll-a and total phosphorus have been persistent pressures on ecosystem health in this zone. The shift in grade was primarily driven by increased total phosphorus concentrations, acidic pH and low dissolved oxygen. These pressures were partially offset by a small improvement in heavy metals and relatively large improvement in turbidity.
5	A-: Excellent ecosystem health	A	Zone 5 experienced 'excellent' ecosystem health, driven by continued low dissolved metals, turbidity, total nitrogen and good dissolved oxygen levels. Total phosphorus, chlorophyll-a and pH are consistent pressures observed within this zone. A small shift in grade from A to A- is due to increased median concentrations of total phosphorus and chlorophyll-a and high variability in pH in the lower estuary.

4 Trends in report card grades and EHI over time

Report card grades by zone for each of the monitoring periods from previous report cards is shown in Figure 7 (note the report card is released the year after the monitoring period finishes so for example 2020/21 corresponds to the 2022 report card). This figure shows:

- Ecosystem health generally improves towards the coast and is poorest in Zone 1 at the head of the estuary, however, for some reporting periods (e.g. 2014/15) grades are lower in the marine zones 4 and 5 than the middle estuary zone 3.
- Grades tend to have been more stable in Zones 1, 2 and 3 with more significant fluctuations in grade having been experienced in Zones 4 and 5.
- While grades have declined in Zone 4 and 5 from 2018/19 to 2020/21, both these years represent better ecosystem health than previous reporting years except 2009/10 when grades in zone 5 were the same as for 2020/21.

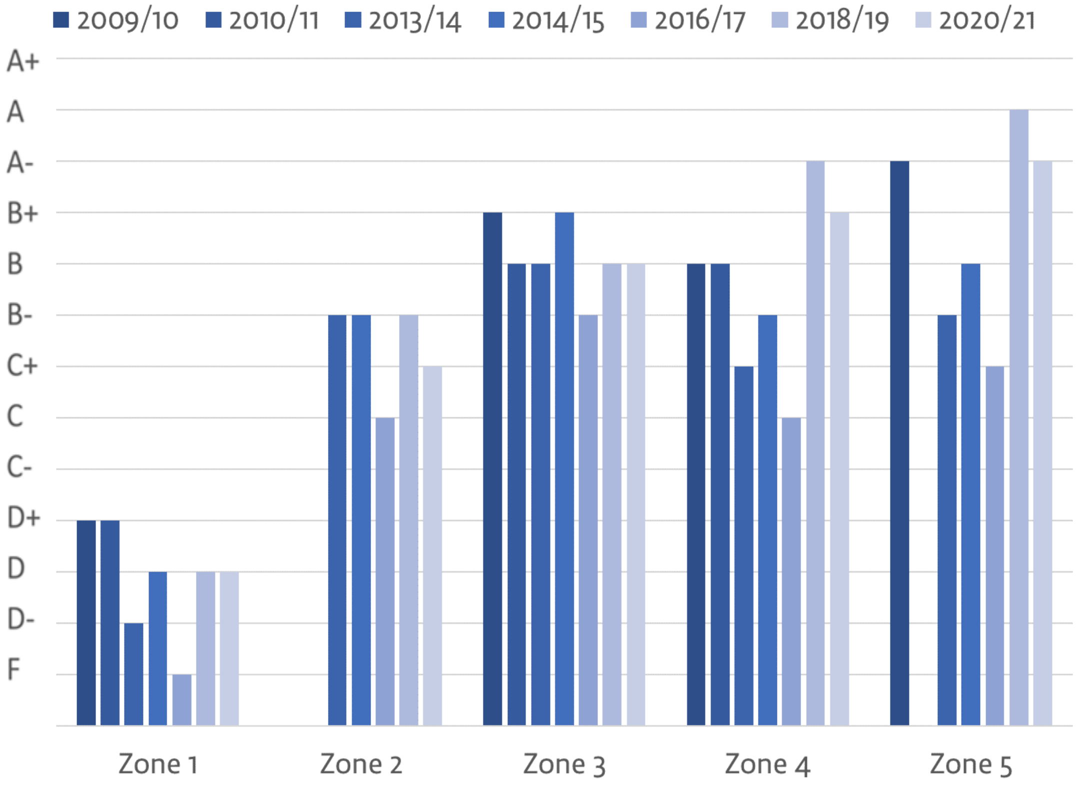


Figure 7. Trends in grades in each zone over time.

These grades represent changes in EHI and are subject to significant threshold effects, with a small change in EHI (1/1000) able to shift a grade in a way that shifts assessed ecosystem health, for example a change from a B- to a C+ which shifts assessed condition from 'good' to 'fair' was caused by a change in EHI of 0.045 in 2022. Figure 8 shows the trends in overall EHI for all zones which are used to determined grades.

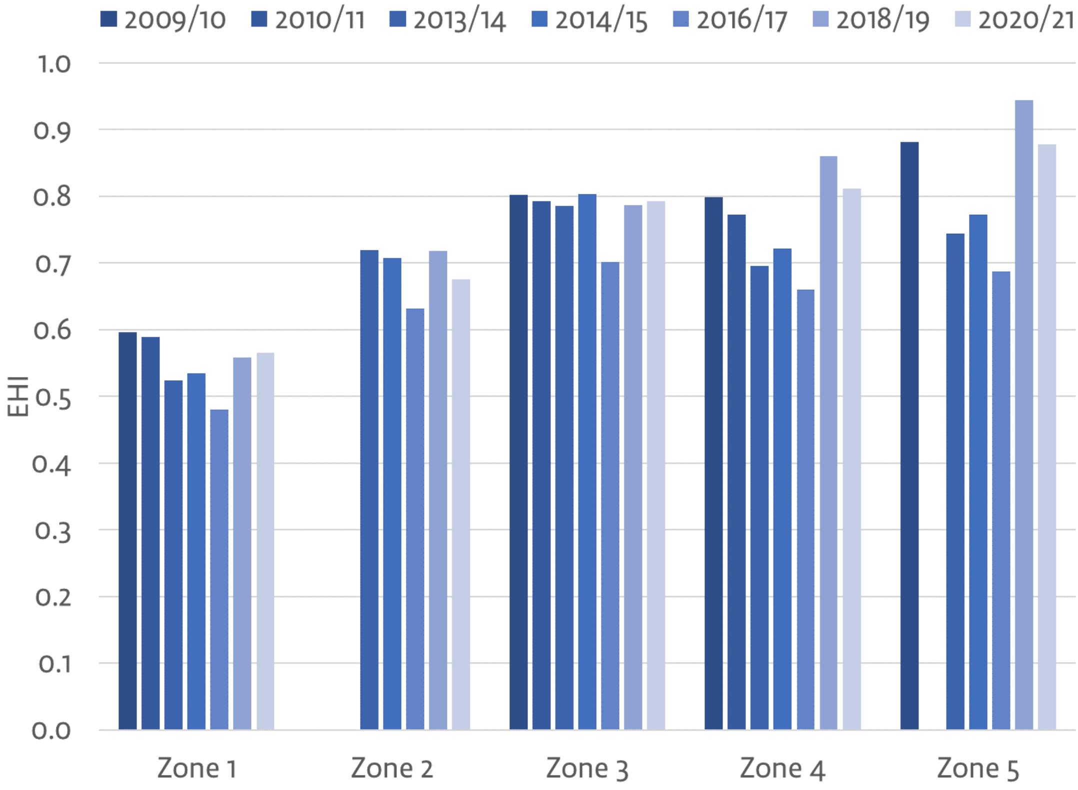


Figure 8. Trends in overall EHI by zone.

This figure shows that EHI tends to be more stable than grades as grades are influenced by these threshold effects. For example, grade changes from B+ in 2020/21 to B in 2009/20 in Zone 4 are due to a very small change in EHI that occurs at the threshold for these grades. Annual EHI in Zone 3 are also more stable than allocated grades though the general pattern of differences between years (i.e. better/worse condition) is the same.

5 Trends in component and pollutant EHIs over time

Differences in EHI between years reflect differences in the three component EHIs – nutrients, metals and 'other'. This section looks at trends in EHI for each component and explores EHI values for pollutants which make up these component EHIs.

5.1 Nutrients

Nutrients are compounds that provide energy, promote growth and are essential to life. Nitrogen and phosphorus are examples of nutrients that are particulalry important to plant life and are commonly found in waterways from runoff and point source discharges. Monitoring the concentrations of both nitrogen and phosphorus in the kanamaluka / Tamar estuary is important because elevated concentrations can cause water quality problems and affect the health of the ecosystem, including aquatic life. Elevated nutrient concentrations enable excessive algae and plant growth, which can cause dissolved oxygen levels to decline. Low concentrations of dissolved oxygen can have severe negative health impacts on the respiratory ability and subsequent survival of aquatic organisms.

Nutrient EHI values are based on the degree to which the median nutrient observation over the 12-month monitoring period exceeds guideline values. Figure 9 shows the trend in nutrient EHI values for all zones.

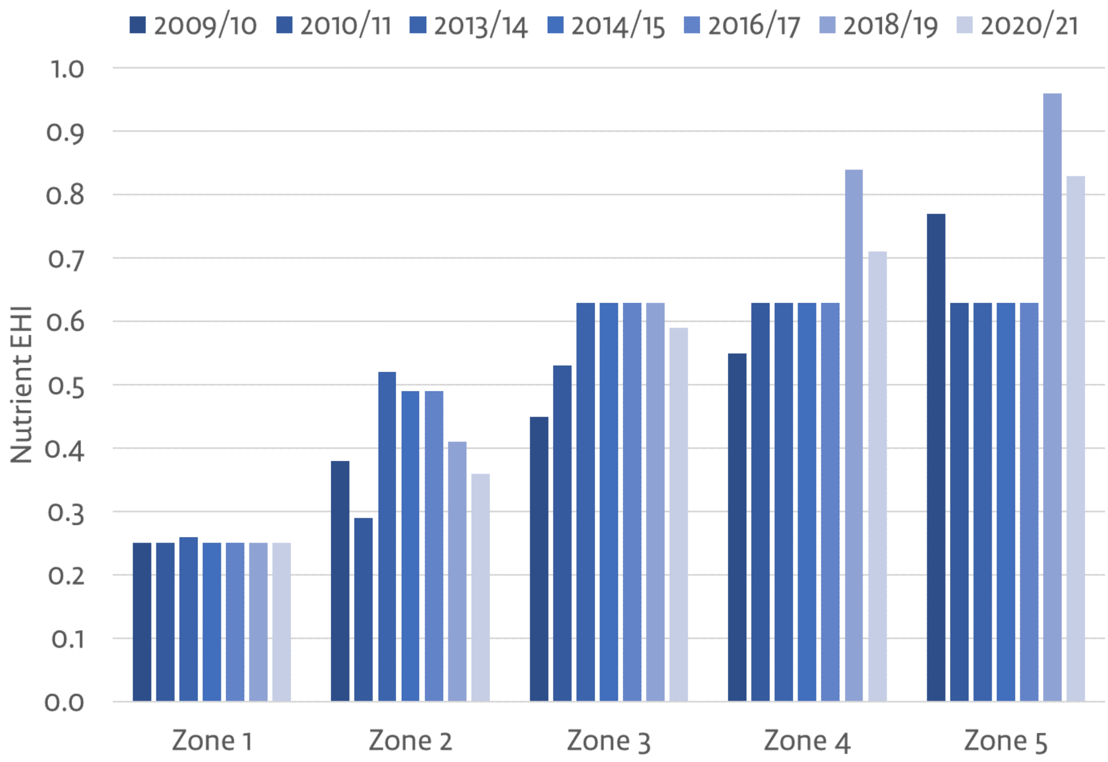


Figure 9. Trends over time in nutrients EHI in each zone.

This figure shows that the nutrient EHI is consistently very low, indicating very poor ecosystem health, in Zone 1. While nutrient EHI is higher in other zones, it has generally been relatively low compared to the overall EHI. This indicates elevated nutrients are a consistent pressure on ecosystem health in all zones, particularly in the upper and middle estuary. Zones 4 and 5 have experienced a significant improvement in nutrient EHI in the last two report card periods.

Figures 10 and 11 show the trends in EHI for TP and TN that contribute to these nutrient EHI values.

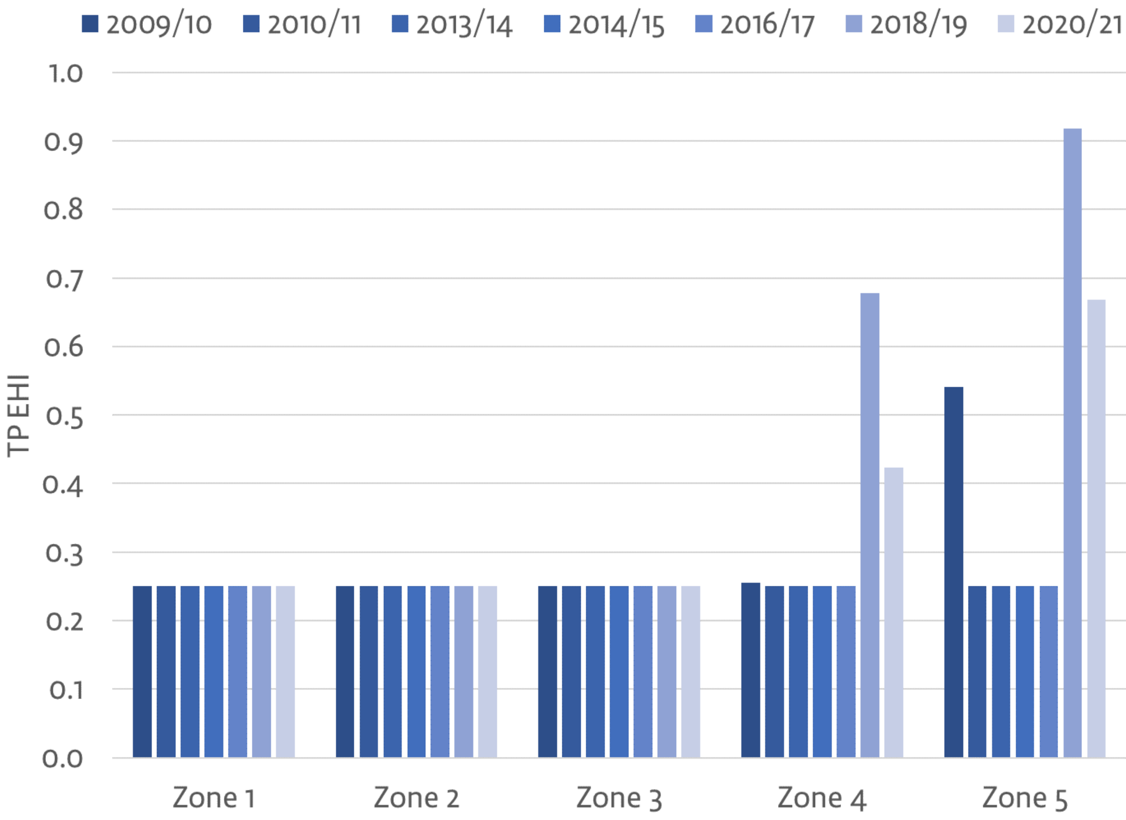


Figure 10. Trends over time in TP EHI in each zone.

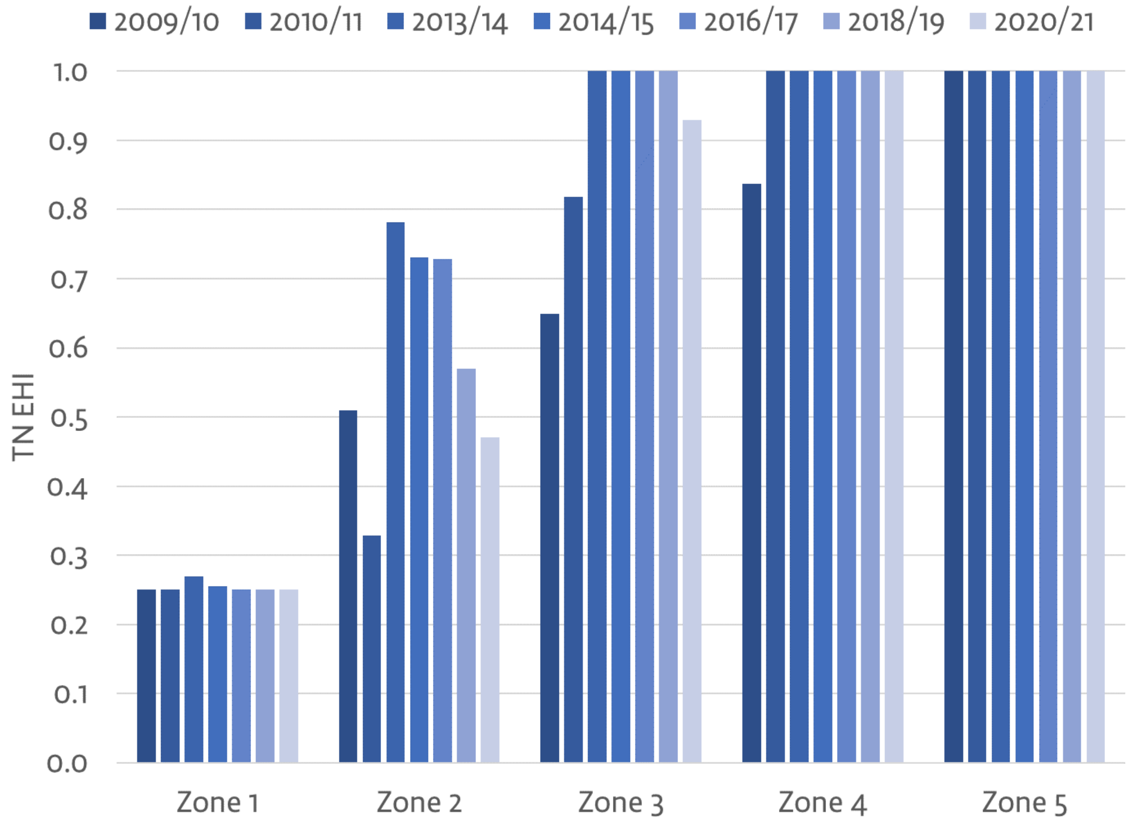


Figure 11. Trends over time in TN EHI in each zone.

These figures show that the key contributor to low EHI is TP in all zones except Zone 1 where EHI for both TN and TP indicate very poor ecosystem health. TP EHI was consistently low for most reporting periods in all other zones until the last two reporting periods when a significant improvement occurred in Zones 4 and 5. By contrast, TN EHI indicates adherence to guideline levels in recent years for Zones 3, 4 and 5. A small decrease below one in Zone 3 for this reporting period indicates one monitoring site where median values are outside the 'best condition' range. TN EHI is more variable in Zone 2 and indicative of median concentrations consistently outside the 'excellent' condition range but still significantly better than for TP.

Investments in improved wastewater treatment through the Launceston Sewage Intrusion Program (LSIP), reduced combined system overflows (CSOs) and sewage intrusion to stormwater as well as improvements in agricultural practice through the River Health Action Plan (RHAP) investments will all contribute to significantly lower nutrient loads to the estuary and should improve this important component of ecosystem health over time.

5.2 Dissolved metals

Dissolved metals can come from natural sources, but their concentrations can be increased by human activities such as mining and industrial activities. Monitoring dissolved metals in the kanamaluka / Tamar estuary provides an important measure of ecosystem health due to the impact they can have on aquatic flora and fauna. Dissolved metals are toxic to aquatic organisms, even in low concentrations, which impacts the survival and reproduction of aquatic organisms and have the potential to bioaccumulate in the food chain.

The dissolved metals EHI represents the highest concentration over the period and any exceedance of ecosystem health thresholds for dissolved aluminium, arsenic, lead, cadmium, copper and zinc. Higher index values represent better water quality associated with lower maximum concentrations of dissolved metals. Figure 12 shows the trend in dissolved metal EHI in all zones.

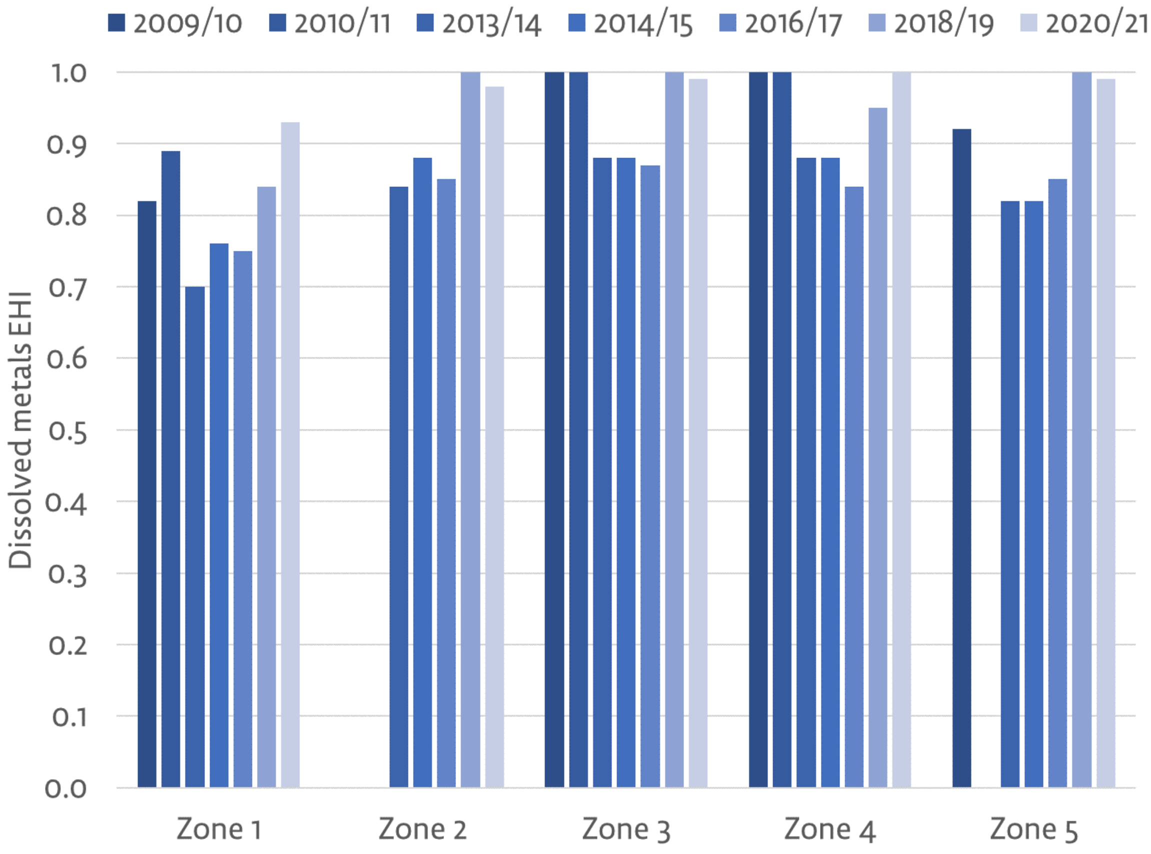


Figure 12. Trends in dissolved metals EHI by zone (includes arsenic, cadmium, lead, zinc, aluminium, manganese and copper). Note not all metals were collected in all zones in every year.

Dissolved metal EHI is consistently higher than the nutrient EHI in all zones. The poorest ecosystem health is experienced in Zone 1 but differences in this zone for dissolved metals are significantly less than those seen for nutrients. Dissolved metal EHI was very high (at or close to one) in Zones 3, 4 and 5 in the two years before sediment raking occurred, then declined during the years when sediment raking was occurring. Similar trends were seen in Zone 1 (note Zone 2 does not have a dissolved metals EHI in 2009/10 due to insufficient data). The improvement in dissolved metals EHI seen in 2018/19 that occurred with the end of sediment raking has been maintained in this reporting period indicating a return to previous ecosystem health for dissolved metals. Aluminium and zinc are the only metals that exceed low risk guideline values in 2020/21 with cadmium, arsenic, copper and lead all being below this threshold for all monitoring sites in every zone. Aluminium only exceeds guideline levels in Zone 1. Zinc exceeds low risk guideline levels in all zones except Zone 4, with EHI values indicative of concentrations below the poorest condition threshold. This exceedance was due to a spike in a single month (July 2021) in all zones except Zone 4.

5.3 Other parameters

The EHI equivalent measure for 'other' water quality parameters averages EHI for dissolved oxygen, pH, turbidity and chlorophyll-a. For dissolved oxygen and pH this EHI represents the 10th percentile deviation from guideline values over the reporting period, noting that thresholds for these parameters have maximum and minimum limits. EHI for chlorophyll-a and turbidity are calculated in the same way as for nutrients, reflecting the degree to which the median value over 12 months exceeds the guideline levels.

Figure 13 shows the trend in Other EHI in all zones.

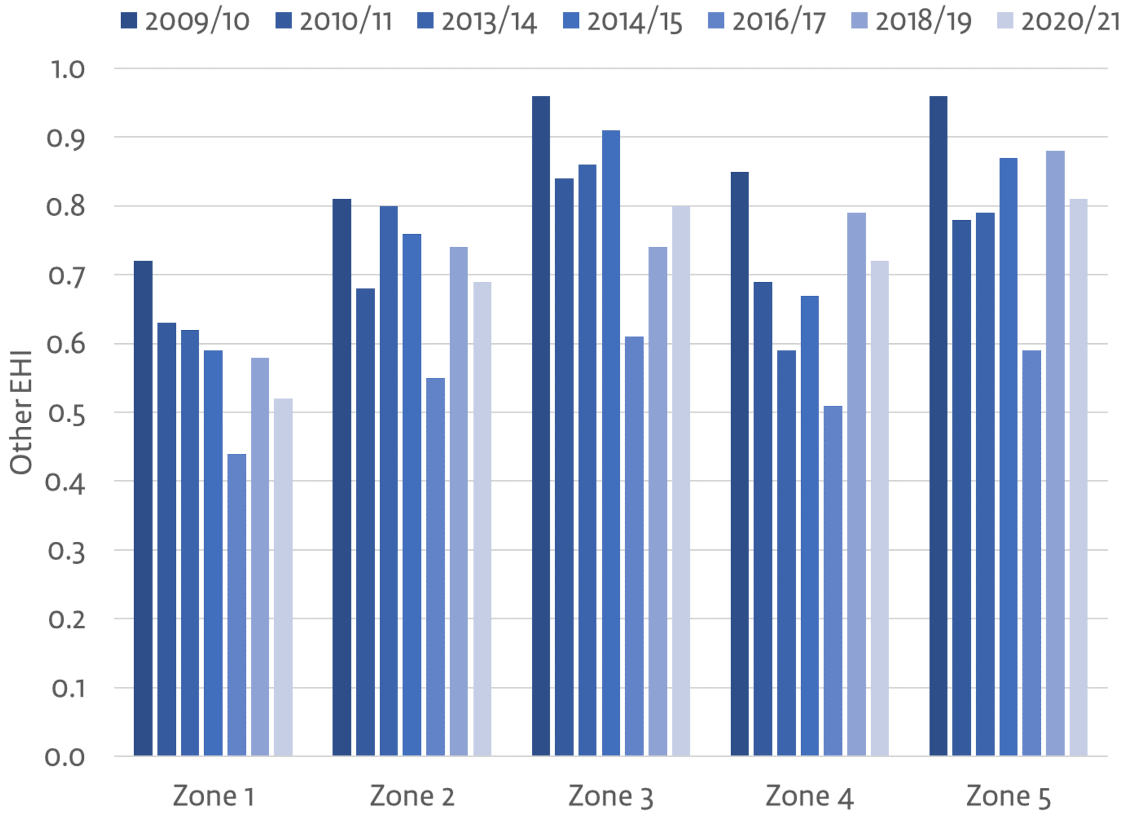


Figure 13. Trends over time in 'other' parameter EHI (chlorophyll-a, turbidity, pH and dissolved oxygen % saturation) by zone

This figure shows that this component EHI experiences the greatest degree of variability between years in all zones as well as the smallest degree of difference between Zones 1 and 5. The diverse nature of parameters used to calculate this component EHI drives these differences. Trends in parameter EHIs that are averaged to create the Other EHI are described in the sections below.

5.3.1 Dissolved oxygen

Dissolved oxygen refers to the amount of oxygen dissolved in water and is an important parameter in assessing water quality and ecosystem health because aquatic life relies on it for survival. Fish, invertebrates, bacteria, and plants all need dissolved oxygen for respiration. Therefore, low dissolved oxygen impacts the respiratory ability of organisms and their survival. Just as low dissolved oxygen concentrations can cause problems, so too can high concentrations. Supersaturated water can cause gas bubble disease in fish and invertebrates, leading to significant mortalities.

The EHI for dissolved oxygen is based on a minimum and maximum range such that either high or low dissolved oxygen can lead to a reduction in EHI. Dissolved oxygen is a parameter that has both an upper and lower threshold, with both very high and very low dissolved oxygen having the potential to negatively impact on ecosystem health. Therefore, a low EHI may be due to either increased or decreased dissolved oxygen percent saturation.

Trends in dissolved oxygen over time are shown in Figure 14. This figure shows that unlike other parameters which have an obvious increasing trend from the upper to lower estuary, the EHI for dissolved oxygen is similar across all zones. The 2020/21 period has a lower EHI than the previous reporting period in all zones except Zone 5 where the highest threshold was met for all monitoring sites in the zone. The decrease in EHI in other zones was based on a low measured dissolved oxygen in April 2021. This lower dissolved oxygen EHI was a significant cause of the decrease in the Other EHI component for Zones 1 and 2 and of the overall EHI and grade in most zones.

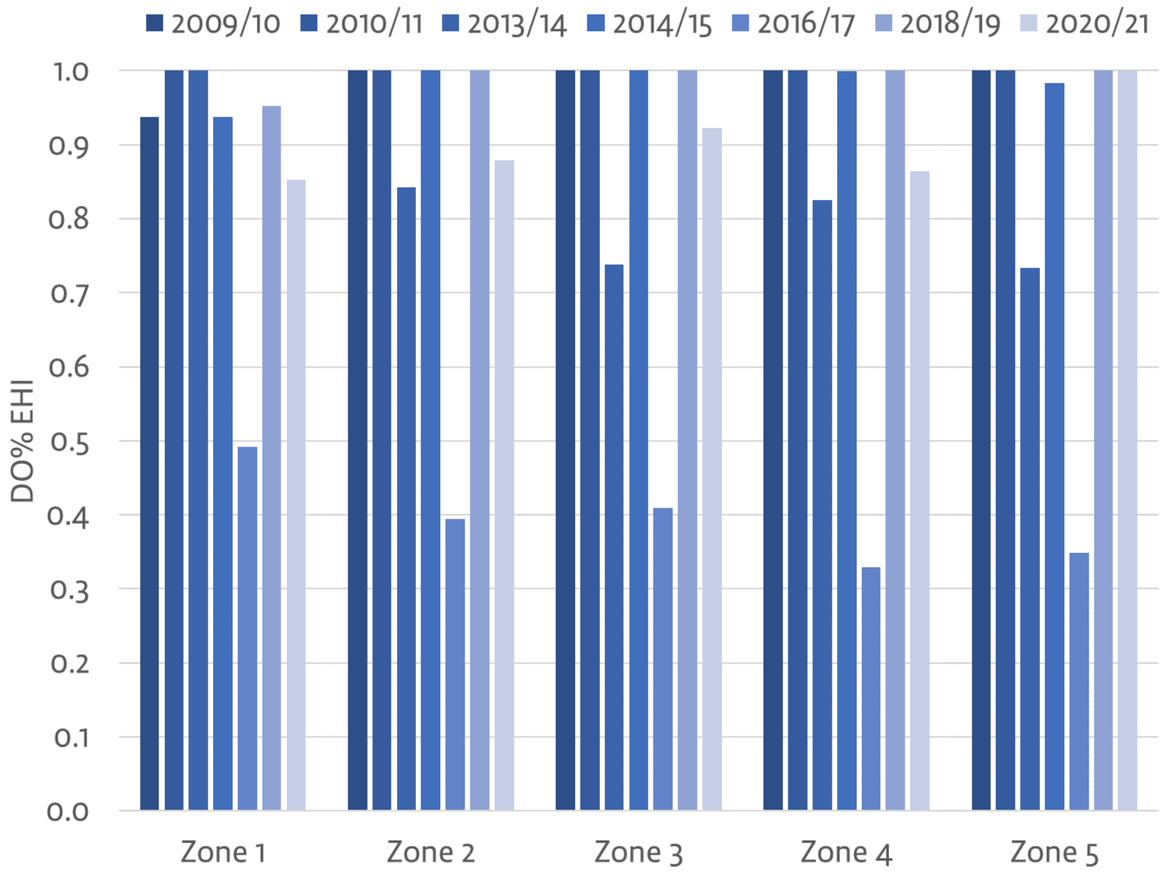


Figure 14. Trends over time in dissolved oxygen (% saturation) EHI by zone.

5.3.2 pH

The pH of water represents hydrogen ion concentration, expressed in equivalents per litre, and provides a quantitative measure of the acidity or alkalinity of water. pH is an important measure of water quality and ecosystem health, with an upper and lower threshold representing poor water quality at both ends of the spectrum. High pH indicates increasing alkalinity, while low pH indicates increasing acidity. Increasing acidity can change the chemical properties of some toxic compounds such as metals, making them more bioavailable and easier to assimilate into the food web. Highly acidic or highly alkaline pH can affect the physiological functions of aquatic organisms and can lead to changes in the diversity of flora and fauna, and consequently ecosystem health.

High or low measurements of pH have the potential to negatively impact on ecosystem health so EHI for pH is based on bands with upper and lower guideline values. This means that a decrease in EHI may be due to either increased acidity or alkalinity associated with changes in pH.

Figure 15 shows the trend in pH EHI in each zone. This figure shows that for zones 1, 4 and 5 there has been a downward shift in pH EHI since the first two report card periods (2009/10 and 2010/11) with some variations in trend between years. In these zones, pH EHI is significantly lower in 2020/21 than was the case for the early reports (EHI of 1 indicated 100 percent adherence to 'excellent' condition thresholds with recent values around 0.5). The EHI for pH is most consistent in Zone 3 and has been stable in Zone 2 with the exception of this reporting period (2020/21) where it has experienced a significant decrease. This may be due to the transition from estuarine to marine conditions within this zone. Marine condition thresholds have a smaller range than estuarine with a shift from the use of estuarine to marine thresholds from Zone 3 to 4. In reality a more gradual shift from estuarine to marine conditions within the estuary would occur but is difficult to account for in the reporting methodology. In all cases the decrease in pH EHI in 2020/21 is due to more acidic conditions outside acceptable ranges for optimal condition.

Reasons for this trend are unclear, but may include a combination of impacts from climate change, point source inputs or acidification due to land use practices which disturb potential acid sulfate soils. Within this monitoring period, substantially higher rainfall (relative to other monitoring periods) may have contributed to more acidic pH observed across all zones (except Zone 3), as freshwater is more acidic relative to saline water. The long-term data set provided by the Ecosystem Health Assessment Program will aid in understanding changes in acidification in the estuary over time, and may potentially be used to detect the changes that are expected from climate change.

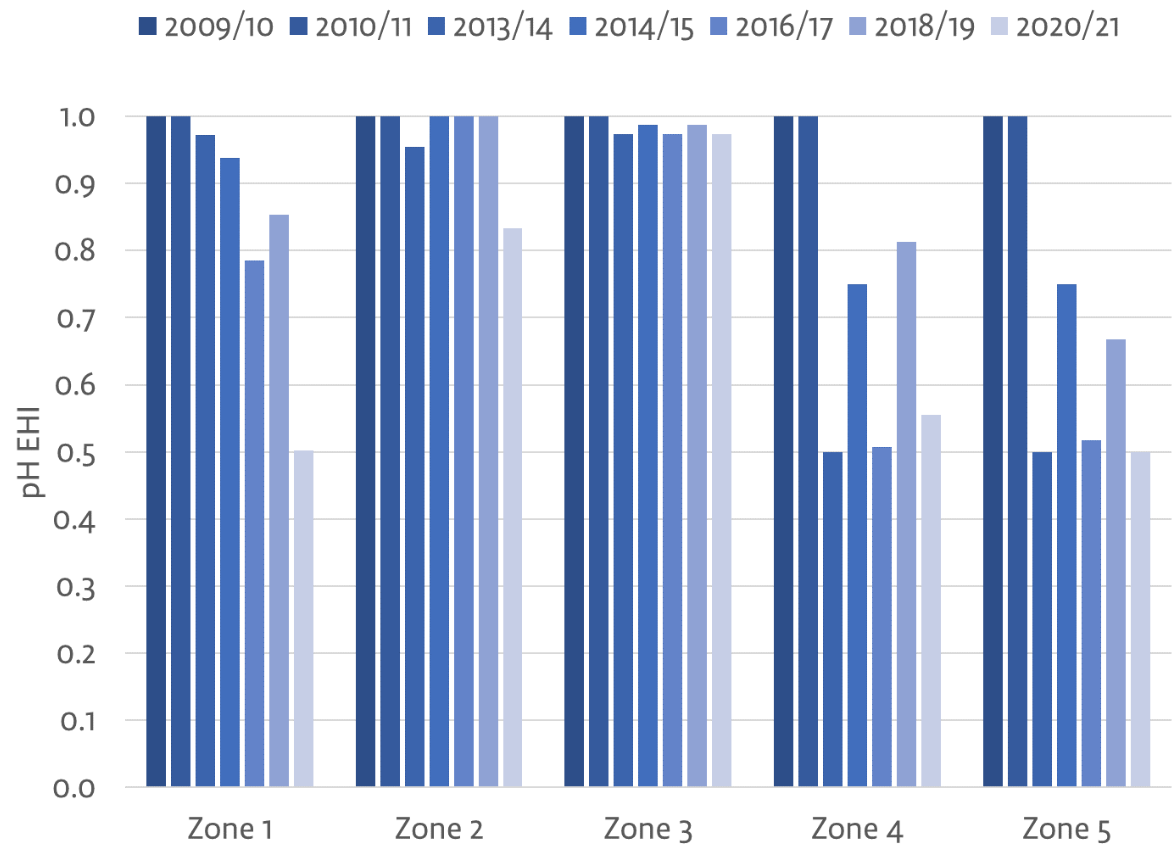


Figure 15. Trends over time in pH EHI by zone.

5.3.3 Chlorophyll-a

Chlorophyll-a is a pigment present in all green plants and cyanobacteria, the concentration of which is an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. High levels of chlorophyll-a can indicate excessive water column productivity which can increase the daily fluctuations in pH and dissolved oxygen, and in some cases may lead to low concentrations of dissolved oxygen which negatively impacts aquatic species.

The EHI for chlorophyll-a reflects the degree to which median chlorophyll-a concentrations exceed condition thresholds, with lower concentrations indicative of better ecosystem health. Figure 16 shows the trend in chlorophyll-a EHI in all zones of the estuary.

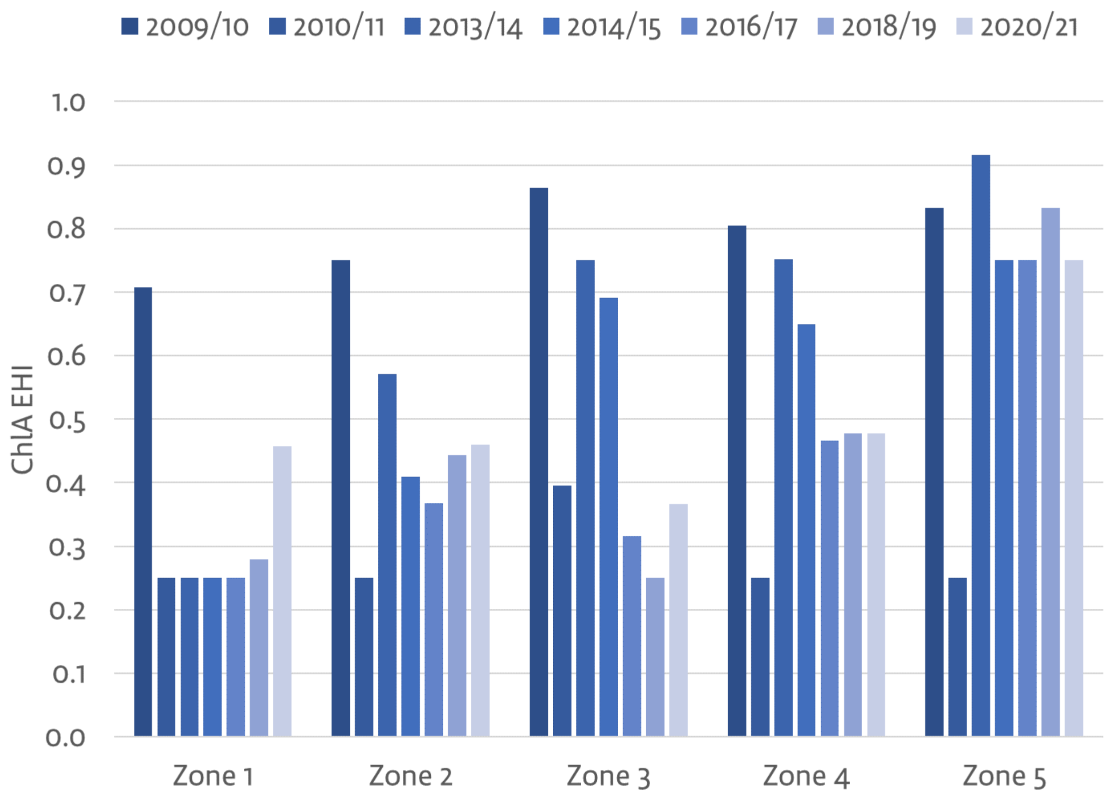


Figure 16. Trends over time in chlorophyll-a EHI by zone.

After 2010, an increase in median chlorophyll-a concentrations across all zones resulted in a significant reduction in chlorophyll-a EHI from the 2009/10 period to 2010/11. For most zones the EHI then increased in subsequent periods with EHI remaining lower than the 2009/10 value but significantly improved from the low experienced in 2010/11. The exception to this is Zone 1 where chlorophyll-a EHI remained at the lowest level possible (0.25) until 2018/19 when it experienced a small improvement. A further, more significant increase in chlorophyll-a EHI was seen in 2020/21 in this zone. Unlike other parameters there is not a clear and consistent trend to increased EHI moving from the upper estuary to the estuary mouth in all years. In particular trends between Zone 2 and 3 are subject to significant year-on-year variability. Chlorophyll-a EHI in Zone 3 in 2020/21 is quite low in comparison to other years whereas for Zone 1 it sees a marked improvement.

5.3.4 Turbidity

Turbidity measures the clarity of water and indicates the concentration of suspended organic matter and particulates within the water column which may include silt, detritus and organisms such as zooplankton and algae. Monitoring turbidity within the kanamaluka / Tamar estuary is important, as high concentrations of particulate matter affects light penetration and ecological productivity in the water column which can impact processes such as photosynthesis, as well as potentially smothering sessile and/or benthic organisms. Particles also provide attachment places for other pollutants such as metals.

Turbidity EHI reflects the degree to which median turbidity exceed thresholds during the monitoring period. Figure 17 shows the trend in turbidity EHI in all zones in the estuary.

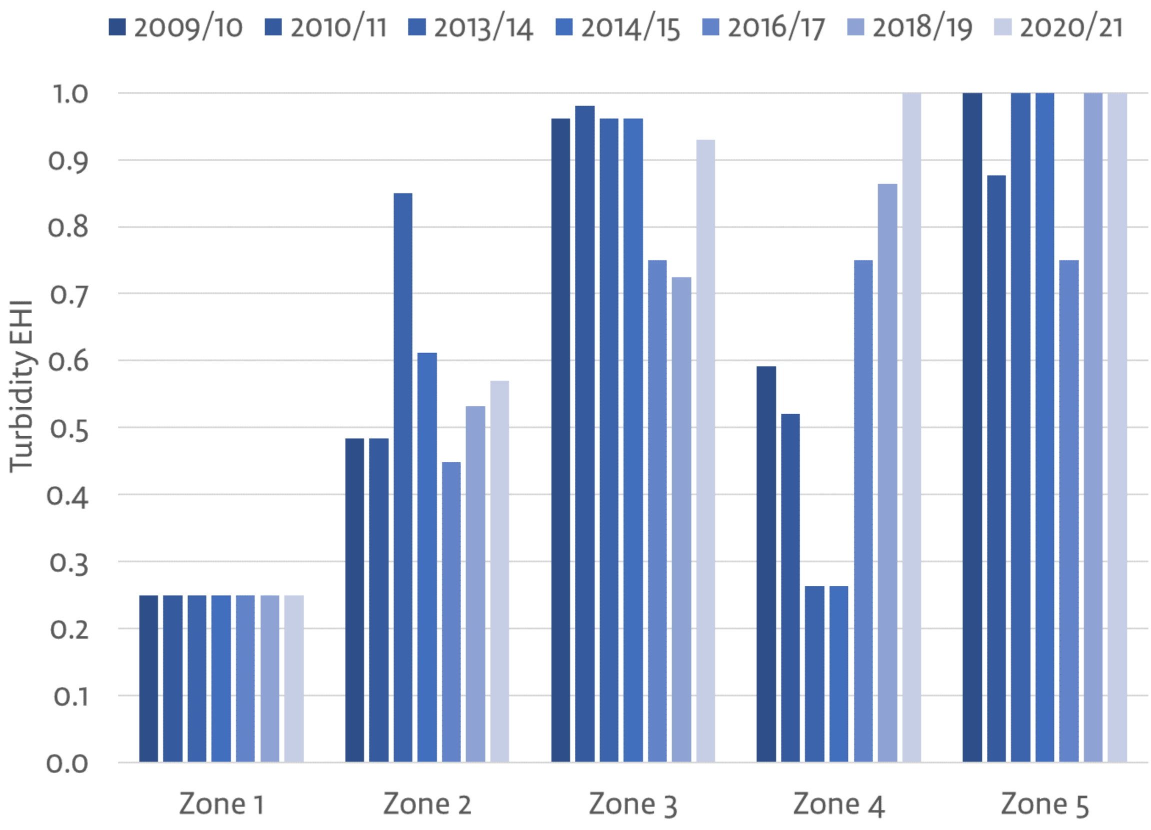


Figure 17. Trends over time in turbidity EHI by zone

This figure shows that turbidity EHI in Zone 1 is consistently the lowest possible value (0.25), indicating that this parameter is a driver for poor condition in this zone. Turbidity EHI in other zones is more variable between years. There is a general increase in turbidity EHI between Zones 2 and 3 and between Zones 4 and 5 but turbidity EHI has generally been lower in Zone 4 than Zone 3. This is likely due to the more stringent guideline levels for turbidity in marine waters, with this 'threshold' affecting EHI values for turbidity between these two zones (Zone 3 is estuarine and Zone 4 is marine). Turbidity EHI in Zone 2 has been relatively stable between years with the exception of 2013/14 when it was much higher than other years. 2020/21 sees higher turbidity EHI in Zones 3, 4 and 5 than was the case for the previous reporting period.

6 Current investments in improving water quality

There are currently significant investments being made to improve water quality in the estuary by reducing point and diffuse source inputs. This section summarises key investments currently or recently undertaken.

6.1 Wastewater treatment plants

There are 11 wastewater treatment plants (WWTPs) located in close proximity to the kanamaluka / Tamar estuary that treat domestic sewage and trade waste from surrounding townships, with a total of 24 WWTPs in the catchment. Once treated, effluent is discharged directly to the kanamaluka / Tamar estuary, or to other connected waterways in close proximity. Treated wastewater discharged from these WWTPs contributes contaminants including organic compounds, nutrients and suspended solids to the estuary. Ti Tree Bend is the largest of these WWTPs and is designed to treat a proportion of combined stormwater and sewage from the Launceston area. Five of the 11 WWTPs have reuse schemes for disposal of treated wastewater. TasWater has a dedicated process optimisation team that targets process improvements at each of the WWTPs in the greater Launceston area. Most WWTPs are being operated beyond their design capacities to achieve the best possible effluent quality.

Longford WWTP has historically been a major contributor of nitrogen and phosphorus within the kanamaluka / Tamar estuary and Esk rivers catchment. This WWTP has undergone a major upgrade which will reduce the nutrient output significantly and improve the sustainability of the discharge. The upgrade will be completed by 2022.

The Launceston Sewerage Improvement Plan strategic business case is in development which will provide a series of recommendations to improve the sustainability of the WWTPs within the greater Launceston area. An early decision has been made with regard to Hoblers Bridge and Norwood WWTPs, to remove the discharge and associated impact on the North Esk River.

6.2 Catchment works

The Tamar Estuary River Health Action Plan (RHAP) was prepared by the Tamar Estuary Management Taskforce (the Taskforce) in 2017 under the Launceston City Deal with an aim to identify investments to improve the health of the kanamaluka / Tamar estuary. It focused on investing in a select group of recommended actions from the Water Quality Improvement Plan which would lead to the greatest decrease in pathogens in Zone 1 of the upper estuary. The catchment actions funded in the RHAP, to the value of $11.5 million, are being implemented across dairy and grazing areas and are prioritised based on cost-benefit and capacity to deliver. This program is being managed by NRM North with the assistance of City of Launceston, West Tamar and Meander Valley Councils, Dairy Tasmania and the Tasmanian Farmers and Graziers Association (TFGA). Funded actions seek to exclude stock from streams, protect and/or rehabilitate streamside vegetation on grazing properties, ensure better effluent management on dairy farms and remove sewage intrusion into the separated stormwater system across the greater urban Launceston area. These actions are expected to reduce pathogen concentrations in the Launceston to Legana zone of the estuary by more than four percent, with the added benefit of reducing riverbank erosion, sediment and nutrients loads from the catchment that enter the estuary. For more information see Catchment Management on the Taskforce website.

6.3 Stormwater

Urban stormwater is generated primarily by rain falling on impervious surfaces such as roofs, roads, footpaths and car parks, after which it enters the drainage network before being transported to waterways. In some areas of Launceston sewage has been entering the urban stormwater system through old or damaged infrastructure, or through cross connected infrastructure. A sewage intrusion program which investigated 13 catchments across the greater Launceston urban area as part of the River Health Action Plan Catchment Works Program has recently been completed.

As of October 2021, these investigations found 44 confirmed sewage intrusions, two broken sewage mains and a collapsed stormwater main within the thirteen catchments; all of which have now been rectified. These improvements to stormwater management have resulted in 13.2 megalitres of raw sewage being redirected from entering the kanamaluka / Tamar estuary each year.

7 Tamar Estuary and Esk Rivers (TEER) Program

The TEER Program is a partnership between agencies responsible for the management of the kanamaluka / Tamar estuary and Esk rivers waterways. The TEER Program aims to improve our scientific understanding of the issues impacting these waterways, and take a coordinated approach to manage and guide investment. This is achieved through scientific reporting such as the 2022 Tamar Estuary Report Card and this technical report, which has been developed to assist with the interpretation of the report card and to provide insight into the drivers of changes in ecosystem health over time. The long term monitoring program continues to improve our understanding of the variations in water quality throughout the estuary and consistent and emerging pressures that impact ecosystem health.