

Litter Index Methods Port Phillip Bay

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We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

DEECA is committed to genuinely partnering with Victorian Traditional Owners and Victoria's Aboriginal community to progress their aspirations.



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List of acronyms

BACI	Before-After-Control-Impact
CCAT	Clean Communities Assessment Tool
DEECA	Department of Energy, Environment and Climate Action (Victoria)
EMP	Port Phillip Bay Environmental Management Plan 2017–2027
GES	Good Environmental Status
HELCOM	Helsinki Commission
EPA	Environment Protection Authority (Victoria)
EPBC	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
MACA	<i>The Marine and Coastal Act 2018</i>
MACKF	Marine and Coastal Knowledge Framework
MERI	Monitoring, Evaluation, Reporting, and Improvement (plan)
MSFD D10	Marine Strategy Framework Directive Descriptor 10
PPB	Port Phillip Bay
RMIT	Royal Melbourne Institute of Technology
UN	United Nations

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1. Purpose

This document has been created for the Port Phillip Bay Environmental Management Plan 2017-2027 (EMP). It identifies and describes an evaluation methodology for the litter priority area that can be used for reporting and to drive continuous improvement. That said, the approach described is relevant for other geographical locations.

The Litter Index aims to synthesis available data and provide a framework to assess the state of litter and its impact on Port Phillip Bay (PPB). Reducing litter loads in PPB is a key strategy of the EMP's overarching goal of improving water quality to ensure environmental health and community enjoyment of the Bay. Supporting this goal aligns with the targets outlined in Protecting Victoria's Environment – Biodiversity 2037 (Biodiversity 2037) and the Victorian Marine and Coastal Knowledge Framework (MACKF). The Litter Index aligns with the MACKF's Good Environmental Status (GES) methodology, with the key descriptor that 'marine litter does not cause harm'.

2. Introduction

2.1 Policy context

Marine litter is a significant environmental challenge that requires sector collaboration and strong legislation to manage. To minimise its threat to the environment, thorough data collection and monitoring of marine litter is required. This is reflected in the EMP and Protecting Victoria's Environment – Biodiversity 2037, which includes a key state priority of improving data collection and subsequent evidence-based decision-making in marine environments. In response to Biodiversity 2037, the MACKF was established to provide strategic direction for decision-making for Victoria's coastal and marine environments. This Litter Index will act as a tool to support the GES targets outlined in MACKF, particularly for the key descriptor that 'marine litter does not cause harm'.

The EMP is authorised under the *Marine and Coastal Act 2018* (MACA) section 55 (1) specifies environmental management plans must be reviewed within five years of making the plan. The EMP's Monitoring, Evaluation, Reporting and Improvement plan (MERI) will guide the five-yearly evaluation through an assessment of the effectiveness and efficiency of the EMP's strategies (Figure 1). The EMP MERI will assess the effectiveness of the EMP in delivering on its overarching vision of 'a healthy Port Phillip Bay that is valued and cared for by all Victorians'.

For the marine environment, MACA provides an integrated approach to planning and managing the marine and coastal environment. MACA's Marine and Coastal Policy 2020, states water quality in the marine and coastal environment must be maintained where it is in good condition, and rehabilitated where it has degraded (for example, as a result of nutrients, plastics, litter, sediment, pathogens and chemical pollutants impacting on water quality or accumulating in soil/sediment).

In Victoria, the *Environment Protection Act 2017* provides legislation for minimising harm to the environment from pollution and waste, including litter. The Environment Reference Standards (2021) and its predecessor, the State Environment Protection Policy (Waters) (2018), are tools produced under the Act to assess environmental values by identifying objectives and indicators for waterway health. Extending from the Act, the Statewide Waste and Resource Recovery Infrastructure Plan was produced, and the related Victorian Waste Education Strategy, which provides direction for waste management and reducing litter for the state.

Impacts on marine life from marine debris, including plastic pollution, has been federally recognised as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC). Monitoring marine debris is a key objective of the Commonwealth's Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018), produced under the EPBC Act.

VISION	A healthy Port Phillip Bay that is valued and cared for by all Victorians						
GOALS	Stewardship of the Bay is fostered across community, industry and government		Water quality is improved to ensure environmental health and community enjoyment of the Bay			The Bay's habitats and marine life are thriving	
PRIORITY AREAS	Connect and inspire	Empower action (work together)	Nutrients and pollutants	Litter	Pathogens (human health)	Habitat and marine life	Marine biosecurity
STRATEGIES	Improve appreciation and understanding of Bay values and connections to catchment	Improve collaboration and partnerships across community, industry and government	Ensure nutrient and sediment loads do not exceed current levels and pollutant loads are reduced where practicable	Reduce litter loads to the Bay	Minimise risks to human health from pathogens	Conserve and restore habitats and marine life	Manage risks from marine pests
PRIORITY ACTIONS	 1.1 Work with Aboriginal groups to improve understanding of Aboriginal cultural values and interests in the Bay and support connections to Country 1.2 Develop and deliver programs to inspire greater appreciation of the Bay's values 1.3 Build understanding of management responsibilities and programs for the Bay and its catchments	 2.1 Build capacity and knowledge within community and industry networks 2.2 Empower the broader community to get more actively involved in caring for the Bay 2.3 Support stronger partnerships across community, industry and government to ensure aims and outcomes are aligned	 3.1 Effectively maintain existing stormwater infrastructure and programs to mitigate loads to the Bay, or secure via equivalent means 3.2 Prevent increases in nutrient loads from wastewater systems and where practicable reduce loads of other pollutants 3.3 Ensure all urban and rural land use effectively controls impacts from stormwater and runoff, and that controls are in place to manage increases in loads	 4.1 Establish a baseline estimate of the volume of litter entering the Bay and support clean up activities 4.2 Support capability and capacity building programs that target litter prevention, including reduction of microplastics 4.3 Identify and prioritise litter sources and pathways, and take actions to prevent litter entering the Bay	 5.1 Improve understanding of links between pathogen concentrations and human health for swimming and consumption of shellfish 5.2 Adopt a risk-based approach to mitigate sources of pathogens found in the Bay 5.3 Improve monitoring and reporting to better detect and communicate human health risks from pathogens	 6.1 Monitor indicator species and key habitats at priority locations 6.2 Improve understanding of ecological processes, threats and pressures 6.3 Improve overall extent and condition of the Bay's natural ecosystems	 7.1 Prevent introduction and dispersal of marine pests 7.2 Monitor priority locations for early detection of marine pest introductions 7.3 Respond rapidly to new introductions of marine pests

Figure 1: The litter goal within the broader EMP framework.

2.2 Litter background

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (UN Environment Program, 2009). The *Environment Protection Act 2017* defines litter as a quantity of waste that does not exceed 50 litres. The top identified litter issue for Victoria is litter in coastal areas and waterways (Sustainability Victoria, 2016a). The largest source of coastal litter is plastic, with plastic pollution predicted to grow globally (DELWP, 2017c).

Litter accumulation in waterways and oceans leads to detrimental outcomes for wildlife. Marine mammals are particularly at risk when interacting with marine debris. Nationally, over 30% of records involving cetacean interactions with fishing gear and marine debris involved threatened, vulnerable or endangered species (Tulloch et al. 2019). Most entanglement items harming marine mammals such as seals are made of plastic twine and rope (Lawson et al. 2015). Management initiatives such as 'Seal the Loop', led by Zoos Victoria, actively target removing the source of entanglement debris, including discarded fishing line.

Beyond its deleterious effects to the environment, marine litter also causes major social, health, and financial concerns (DELWP, 2019). Plastic is known to be an eco-toxicant, and macro litter has the potential to act as a vector for invasive species. Research highlights that marine litter actively impacts the aesthetic enjoyment of an environment, with less direct impacts including effects on regional tourism. In 2015, an estimated US\$10.8 billion of damage per annum was caused to Asia-Pacific marine industries from marine debris (McIlgorm et al. 2020). Litter services cost Victoria \$78 million per year (Victorian Litter Action Alliance, 2014). An estimated breakdown of resources

reveals 95% of resources are allocated to litter management and 5% to litter prevention throughout Victoria (Sustainability Victoria, 2013).

Beaches and waterways are hotspots for littering in the metropolitan Melbourne area (Metropolitan Waste and Resource Recovery Group, 2020), and a citizen science study found microplastics and microfibrils throughout PPB beaches (Sustainability Victoria, 2019). Litter in PPB comes from a range of sources, but most flows in from the surrounding drains and waterways (DELWP, 2017a).

To combat the harmful effects of marine litter, collaborative and dynamic management is required. Marine litter is challenging to monitor effectively without spatially explicit, long-term datasets. However, it is vital to capture this information to accurately evaluate the health of marine environments and inform management decisions (Victorian Litter Action Alliance, 2014; DELWP, 2017a). Currently, beach litter monitoring data is gathered and stored via the LitterWatch Victoria portal.

Indices, or composite indicators, enable simplified reporting on complex information for broad audiences (McIntosh et al 2019), and are used worldwide for reporting on environmental condition and management actions (Logan 2020). By representing complex environmental processes and describing states, trends and potential management hotspots, indicators can support decision-making and preventative management approaches. Research calls for outcome-based indicators (Hastings et al. 2013) to be incorporated into reporting for governments.

2.3 Existing litter indices

A variety of litter-focused indices exist, both internationally and locally (Table 1). These indices provide insight into the prevalence of litter in marine environments by using a variety of quantitative and qualitative indicators across environmental, ecotoxicology and enforcement focus areas.

Existing indicators rely on a variety of methods. O'Day (2013) and Vu et al. (2017) both used qualitative ranking systems to index litter condition in the environment. Both indices used items per 100 feet as a metric to produce four categories ranging from optimal to poor (O'Day, 2013) or very light to high litter (Vu et al. 2017). Moore et al. (2007) produced a rapid trash assessment methodology to quickly evaluate the impact of litter on a selected site. The rapid trash assessment considers parameters that span across environmental, aesthetic and health-related indicators. Melbourne Water's Healthy Waterways Litter Index report cards for catchments across Victoria waterways sub-catchment litter ratings using land use assumptions based on the Clean Communities Assessment Tool (CCAT) (Melbourne Water, 2021). A review of litter monitoring methods was recently completed by the Royal Melbourne Institute of Technology's (RMIT) Aquatic Environmental Stress Research Group highlighting several of the above litter indices and discusses their methodologies in greater detail (Richardson et al. 2021).

Another prominent example comes from the Baltic Marine Environment Protection Commission's (or the Helsinki Commission's) HELCOM, an intergovernmental organisation that aims to protect marine environments and uphold EU directives and regulations. HELCOM's State of the Baltic Sea Report (2018) outlined their desire to produce an integrated index tool for marine litter, which as of 2022 is in development for their next reporting cycle. In preparation for its release, HELCOM produced a pre-core indicator report, a preliminary look at available marine debris monitoring data, reporting on litter trends across various time intervals. Following this report, marine litter thresholds and baselines papers have been published, which will be used to inform their final index.

Under the EMP, a litter index is needed that incorporates relevant baselines and thresholds for coastal and marine environments. A temporally and spatially explicit index which harnesses meaningful categories that can trigger management intervention would allow identification of priority areas for litter management using a graded status system. This information could subsequently inform future data collection, improving survey design coverage (Hardesty et al. 2016). The litter index developed for the EMP MERI is described below.

Table 1: Summary of key existing Litter Indices

Litter Index	Indicators included	Location
HELCOM pre-core indicator paper	Litter trends across seasons/years.	European Union
Ranking system – O’Day (2013)	Visual ranking system of number of items per 100ft (optimal, suboptimal, marginal, poor).	Philadelphia, USA
Rapid Trash Assessment – Moore et al. (2007)	Litter Assessment Parameters (level of litter, number of litter items, count of persistent litter items, count of biohazard items, site accessibility, illegal littering, accumulation of litter).	San Francisco, USA
Anacostia Stream Trash Indexing System – Vu et al. (2017)	Verbal Condition Ranking of number of items per 100ft (very light litter, light, moderate, high).	US EPA
National Litter Index – Keep Australia Beautiful	Litter averages and changes through time.	Australia
Stony Creek Risk Assessment – Myers et al. (2022)	Consequence matrix to assess risks of litter to assets, social and environmental values.	Victoria, Australia
Healthy Waterways – Melbourne Water (2021)	Waterways sub-catchment litter ratings use landuse assumptions based on the Clean Communities Assessment Tool (CCAT) due to lack of data.	Victoria, Australia

HELCOM’s litter indicators align with their outcome-based reporting approach, the GES, achieved under their Marine Strategy Framework Directive (MSFD). HELCOM’s GES methodology is adopted by Victoria in the Marine and Coastal Policy 2020 and the MACKF. HELCOM Biodiversity, Litter, Underwater noise, and Effective regional measures for the Baltic Sea leads the MSFD Directive 10 MSDF D10) for marine litter (Figure 2), including calculating baseline and threshold values for marine litter for the region to produce their own index-style tool for reporting.

HELCOM MSFD D10 (marine litter):

Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

Criteria:

D10C1 – Primary: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment. Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities

D10C2 – Primary: The composition, amount, and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.

D10C3 – Secondary: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned. Member States shall establish threshold values for these levels through regional or subregional cooperation.

Figure 2: HELCOM's MSFD D10 (marine litter) criteria.

3. Litter Index structure

3.1 Overview

The Litter Index developed for the EMP MERI draws on HELCOM's litter indices as well as the structure used for DEECA's Marine Biodiversity Index (Mazor et al. 2021). The Litter Index is designed to evaluate the impact of marine litter on the environment and inform management decisions. The Litter Index is a spatially and temporally explicit, hierarchical metric where component indicators are weighted by relevance determined through expert elicitation. The index amalgamates four unique indicators calculated from long-term monitoring data (litter density, litter composition, litter-related ingestion, and litter-related entanglements/injuries) into an overall status of litter in PPB (Figure 3). These four indicators have been synthesised from the HELCOM litter standards and fall within two assessment areas. The first area is Litter Profile, represented by litter density and litter composition indicators, and the second area is Marine life, represented by litter-related ingestion and litter-related entanglements/injuries indicators.

This Litter Index has been inspired by the integrated Marine Biodiversity Index (Mazor et al. 2021), which can be broken down into component parts in terms of habitats and ecosystem components. The Litter Index is first broken up spatially into zones: coastal, water surface and waterbed. Litter data is then categorised by size into micro and macro litter and evaluated by defined litter assessment categories: litter profile, and the litter impact on marine life. Litter profile is composed of two indicators: litter area density and litter material composition, which are measured per year. Litter impact on marine life is composed of two indicators which are measured per year: litter amount ingested by marine life, and the number of individual of a species entangled/injured by litter.

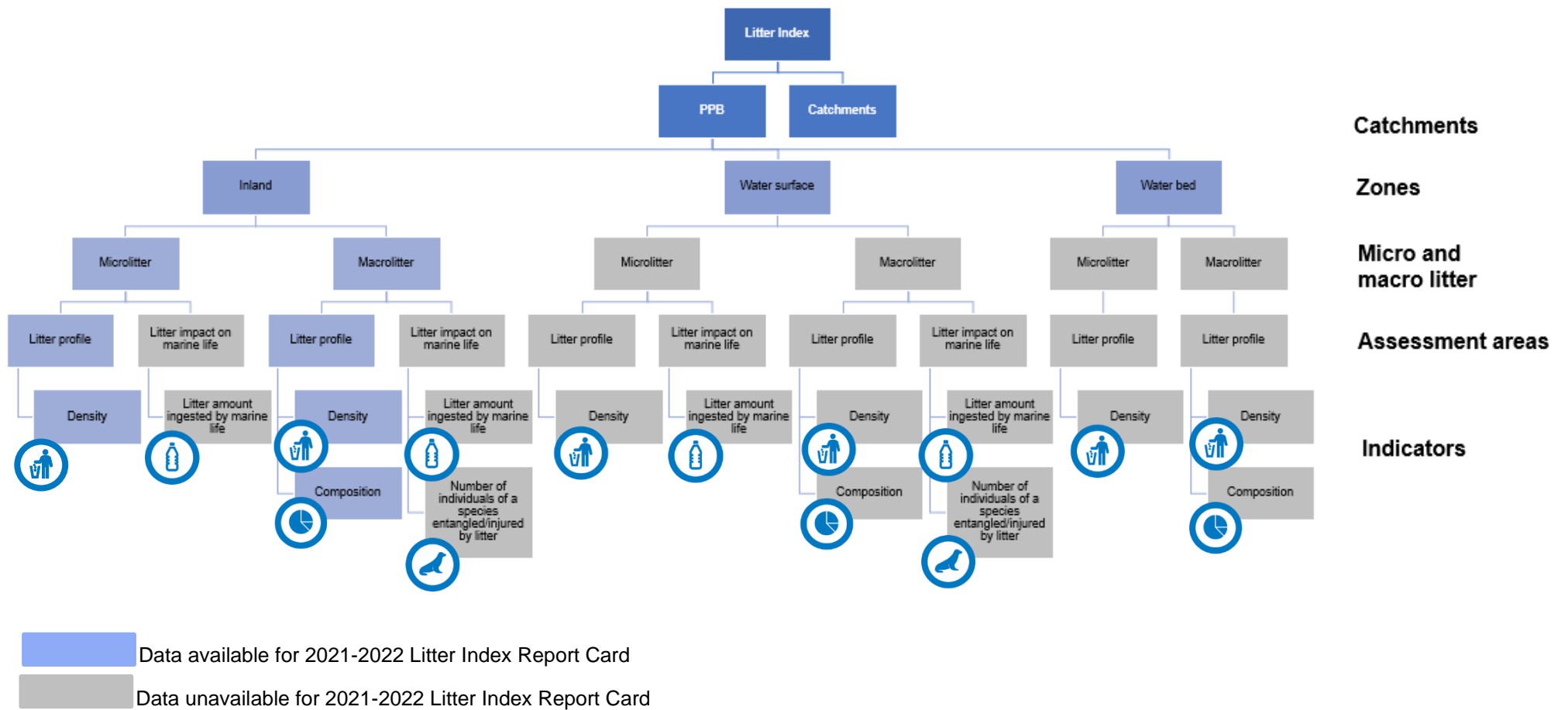


Figure 3: Litter Index structure.

3.2 Catchments

PPB is a large embayment located in Victoria, Australia. The EMP applies to Port Phillip Bay and its feed in catchments as shown in Figure 4. In managing the health of the Bay, the EMP also seeks to influence the management of surrounding and connecting rivers and catchments, and all inputs they bring to the Bay.

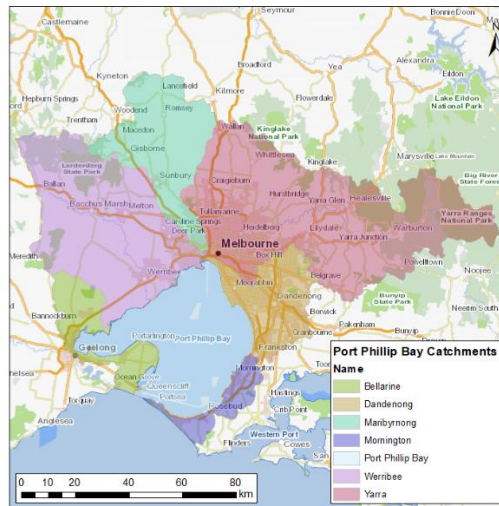


Figure 4: Port Phillip Bay catchment area

Due to the limited data available, the 2021-2022 Litter Index analysis for the EMP MERI will only use the PPB coastal zone litter profile data, however in future when data becomes available, catchment data will be incorporated and some measure of litter impact on marine life. Additional information on litter using the Clean Communities Assessment Tool (CCAT) is displayed in the Healthy Waterways Strategy report cards (Melbourne Water, 2021).

3.3 Port Phillip Bay Zones

The PPB coastal zone is defined as the area between the high tide mark and 5km inland from the high tide mark (in accordance with MACA) (Figure 5). This zone can include riparian zone, beach, and coastal dune areas. Litter data in the coastal zone will be sourced via hand-collection surveys.

The water surface zone is defined as the top layer of the water surface, or the interface between water and air. It can include floating and some suspended debris. Litter identification data may be collected through visual surveys, drone surveys, collections nets, and collection booms/floats (Richardson et al. 2021).

The waterbed zone is defined as the ocean, waterway or waterbody floor and its associated sediment. Litter identification data may be collected via trawl surveys and sediment samples.

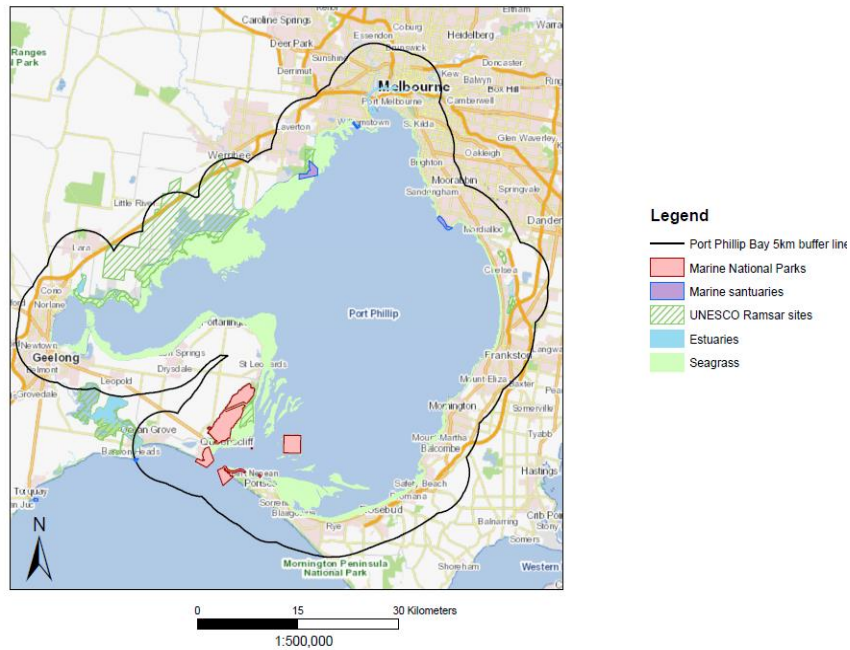


Figure 5: Map outlining the PPB coastal zone with inland 5km radius

3.4 Macro and micro litter

Expert elicitation, research, and a review of literature has shown that the impacts to PPB and its associated waterways (Blake et al. 2014) as well as related effects on the marine environment are different depending on the size of litter, therefore macro and micro litter types have been separated in the index. For the Litter Index, micro litter is defined as any item of litter less than 5mm in size, for example a plastic fragment. Macro litter is 5mm or greater in size, and more easily visible, for example a water bottle.

3.5 Assessment themes

The Litter Index includes two assessment themes: Litter Profile and Litter Impacts on Marine Life. The Litter Profile assessment theme evaluates the quantity and types of litter where relevant. Once developed the Litter Impacts on Marine Life assessment theme will evaluate the impacts of litter on marine species, including litter-related ingestion, and entanglements/injuries.

3.6 Litter Profile indicators

3.6.1 Density

Litter density indicates the quantity of litter items over a spatial extent. This indicator standardises the assessment procedure to account for differences in survey effort and produce results that are explicit and cross-comparable across PPB sites. The metric selected is items counted per 200 metres squared, and this density metric is a standard measurement used in other indices to quantify litter density (Palialexis et al. 2014). The EMP also addresses litter volume (EMP Action 4.2), however this has not been incorporated into the Litter Index as data is currently collected as counts. Using a set conversion factor to convert counts to volume would not add value to the current measure.



Metric: litter items counted/200m² per year (number of litter items counted/size of area surveyed)

Data source: LitterWatch Victoria

Updated: Annually

Experts consulted: Federation Uni, Yarra Riverkeeper Association, Phillip Island Nature Parks, Beach Patrol

Supporting literature:

- Healthy Waterways Strategy: metrics based on The Clean Communities Assessment Tool (CCAT) methodology.
- National Litter Index, 2019: tracked litter density for each state over time.
- Werner et al. 2020: identifying thresholds for litter.
- Ibrahim et al. 2020: measured clean beach average litter densities.
- Alkalay et al. 2007: Clean Coast Index values.

3.6.2 Composition

Litter composition provides the percentage of plastic or polystyrene litter items in an area compared to all other material types (wood, glass, other) by classifying data into litter categories (see Appendix 1). Measuring the proportion of plastic is important due to its persistence and pervasiveness in the marine environment; along the coast of Australia, approximately 75% of rubbish is plastic (Hardesty et al. 2014). Plastic marine debris is amongst the most harmful type of litter for marine wildlife (Wilcox et al. 2016) and is also related to health issues for people (Engler et al. 2012). Polystyrene, or EPS, pollution is a major concern in waterways flowing into PPB, being one of the highest littered microplastic in the Yarra River (Despotellis et al. 2021).



Metric: Percentage Plastic/Polystyrene items counted per year

Data source: LitterWatch Victoria

Updated: Annually

Experts consulted: Federation Uni, Yarra Riverkeeper Association, Phillip Island Nature Parks, Beach Patrol

Supporting literature:

- Yarra Riverkeeper Association, 2020: litter composition in the Yarra.
- Werner et al. 2020: identifying thresholds for litter.
- Ibrahim et al. 2020: plastic composition percentages on clean beaches.

3.6.3 Litter amount ingested by marine life

Ingestion of litter is a concern for wildlife (Kühn et al. 2015), and rate of faunal ingestion of litter has been identified as an indicator required in PPB (Kowalczyk et al. 2017). This indicator must account for different sized stomachs of the different taxa that are known to ingest litter, including fish, marine mammals, and birds. There is minimal data available for this indicator around PPB. Litter amount ingested by marine life will be incorporated as an indicator once data becomes available.



Metric: number of items/individuals per year

Data source: No monitoring programs currently exist. Including this indicator, would require funding for monitoring.

Updated: TBC

Experts consulted: Melbourne Zoo Marine Response Unit, Yarra Riverkeeper Association, Phillip Island Nature Parks

Supporting literature:

- Maillard et al. 2013: microplastic nurdle surveys in water column and shoreline of PPB.
- Norman et al. 1995: litter in gannet nests in PPB.

3.6.4 Number of individuals of a species entangled/injured by litter

Litter-related entanglements and injuries are common due to marine debris (Wilcox et al. 2016). A global study found individuals from 22 of 33 extant mammals with front and rear flippers were recorded with entanglements in live gear or marine debris (Jepsen and de Bruyn, 2019). Marine mammals are vulnerable to entanglements, though often the larger species such as seals have more data and focused studies. Due to the high biodiversity around PPB (Mazor et al. 2021), entanglements are a conservation and animal welfare issue. It is vital to monitor the number of entanglements around PPB as a proxy for litter harm to wildlife. Number of individuals of a species entangled/injured by litter will be incorporated as an indicator once data becomes available.



Metric: number of individuals of a species entangled/injured by litter per year

Data source: No monitoring programs currently exist. Including this indicator, would require funding for monitoring

Updated: TBC

Experts consulted: Melbourne Zoo's Marine Response Unit

Supporting literature:

- Tulloch et al. 2019: seals make excellent indicators for marine plastic pollution and entanglement of marine life as they are easier to monitor.
- McIntosh et al. 2015: entanglement rates of seals dismissing effort (number of entangled seals/(total number of population). As a percentage of the estimated seal population but dismissing effort, entanglement rates from 1997 to 2013 ranged from 0.02 to 0.19% of individuals per year.

4. Litter Index methodology

4.1 Status categories

The Litter Index is based on five categories of status as defined in Figure 6. The progression of Litter Index status from Very Poor through to Very Good broadly represents a decrease in litter in the assessment area. The Litter Index combines weighted component indicators to produce a score based on a scale of five gradient categories to evaluate the status of litter in PPB. The Litter Index will be calculated on a financial year basis for zones with sufficient data.

First, data from various litter-related survey initiatives and projects are used to calculate the four component Litter Index indicators: density, composition, amount ingested and entanglements. Data are standardised for survey effort and represent information for indicators for a single survey location per year. Each indicator is then allocated to a category based on that indicator's unique threshold values (Figure 6). Thresholds were determined through expert elicitation via online survey and feedback and supporting peer-reviewed literature.

As each indicator is measured in different units, Equation 1 is used to standardise each of the four indicators by calculating an individual Indicator Score for each survey site based on the assigned

category and associated score (Figure 6). Indicator scores are therefore comparable on a resulting 0-1 scale. To calculate individual Indicator Scores for each survey site per year:

Equation 1

$$\text{Individual Indicator Score} = (\text{maximum Indicator Score} - \text{minimum Indicator Score}) \frac{\text{Observed value} - \text{minimum Threshold}}{\text{maximum Threshold} - \text{minimum Threshold}} + \text{minimum Indicator Score}$$

To calculate the overall Litter Index Score, all four Individual Indicator Scores are processed using Equation 2. This calculation weights the litter profile assessment area more strongly (0.6 weighting) than the impact on wildlife assessment area (0.4 weighting), based on expert feedback and the lack of robust data in the impact on wildlife assessment area. For each indicator, the median of all Indicator Score values across all survey sites are calculated to represent the overall current state of that indicator in PPB. The Litter Index Score can also be calculated if data for a particular Indicator is absent (zero values would be applied). Equation 2 works by comparing the current state of PPB's litter/litter-related impacts against the best-case scenario of minimal litter and litter-related impacts around PPB (i.e. a Very Good status of 1). The equation combines all four Indicator Scores (median values) across all survey sites per year to provide the overall Litter Index Score:

Equation 2

$$\text{Litter Index Score} = \frac{0.6 * (\text{median (Density Indicator Score)} + \text{median (Composition Indicator Score)}) + 0.4 * (\text{median (Amount Ingested Score)} + \text{median (Entanglement Score)})}{0.6 * (\text{Very Good Density Indicator Score} + \text{Very Good Composition Indicator Score}) + 0.4 * (\text{Very Good Amount Ingested Indicator Score} + \text{Very Good Entanglement Indicator Score})}$$

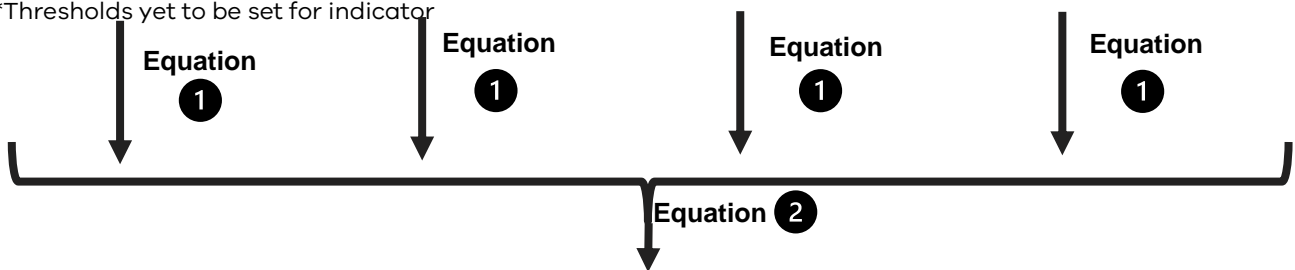
This final Litter Index score is then assigned a Litter Index category (Figure 5). An example of the litter index calculations is presented in Appendix 2.

Note that the Very Good status threshold values do not reflect a pristine system: threshold values for all indicators are quantitative, and these values have been assigned to relate to realistic litter levels. It could be assumed that the ideal environmental state regarding litter would be pristine, meaning no litter or litter-related impacts are occurring in PPB. However, achieving a pristine state is challenging for two reasons: firstly, litter, particularly plastic, is very pervasive and significant work is needed to remove litter already in the environment; and secondly, it would require design of a perfect system where no accidental losses occur as well as sufficient engagement for no intentional litter to occur. As this is not feasible, Very Good status relates to ambitious goals of avoiding polluted environments, rather than a pristine state.

Table 2: Litter threshold values in rated categories for litter profile and marine species impact

Threshold values			
Litter Profile		Marine Species Impact	
Density	Composition	Amount Ingested	Entanglements /Injury
< 1 items/200m2	< 10% Plastic	*	*
1 items/200m2 – 2 items/200m2	10% – 20% Plastic/Polystyrene	*	*
2 items/200m2 – 100 items/200m2	20% – 40% Plastic/Polystyrene	*	*
100 items/200m2 – 200 items/200m2	40% – 60% Plastic/Polystyrene	*	*
> 200 items/200m2	> 60% Plastic/Polystyrene	*	*

*Thresholds yet to be set for indicator



Density	
Indicator Status	Indicator Score
Very Good	0.8 – 1
Good	0.6 – 0.79
Fair	0.4 – 0.59
Poor	0.2 – 0.39
Very Poor	0 – 0.19

Composition	
Indicator Status	Indicator Score
Very Good	0.8 – 1
Good	0.6 – 0.79
Fair	0.4 – 0.59
Poor	0.2 – 0.39
Very Poor	0 – 0.19

Amount ingested	
Indicator Status	Indicator Score
Very Good	0.8 – 1
Good	0.6 – 0.79
Fair	0.4 – 0.59
Poor	0.2 – 0.39
Very Poor	0 – 0.19

Entanglements	
Indicator Status	Indicator Score
Very Good	0.8 – 1
Good	0.6 – 0.79
Fair	0.4 – 0.59
Poor	0.2 – 0.39
Very Poor	0 – 0.19

Overall Litter Index	
Litter Index Status	Litter Index Score
Very Good	0.8 – 1
Good	0.6 – 0.79
Fair	0.4 – 0.59
Poor	0.2 – 0.39
Very Poor	0 – 0.19

Figure 6: Litter Index indicator status categories

4.2 Confidence Assessment

The inclusion of multiple datasets and unique indicators into the Litter Index requires a confidence assessment that quantitatively evaluates the reliability of the data. There is also currently no single, cohesive method for litter surveying in Victoria (Richardson et al. 2021), so the Litter Index needs to account for different surveying techniques. Confidence categories for litter datasets for the current indicators outlined in Figure 2 were determined through a combination of research

and expert elicitation. Confidence categories consider data categorisation, temporal and spatial spread of data, and survey design (Table 3). Each dataset is scored annually for each category with a confidence score of either high (1.5), medium (1) or low (0.5). Confidence scores are then combined with equal weighting to produce a final Confidence Metric assigned to the dataset (Table 4):

$$\text{Confidence Metric (CM)} = (0.25 * \text{ConfC}) + (0.25 * \text{ConfT}) + (0.25\text{ConfS}) + (0.25\text{ConfSd})$$

Table 1: Confidence Metric (CM) components and their classification within the high, intermediate, and low categories

Confidence category	Confidence score		
	High (value = 1.5)	Intermediate (value = 1)	Low (value = 0.5)
ConfC: Data categorisation and granularity	LitterWatch level 3 categories (2022) are used to identify litter from surveys	Most litter from surveys is identified to at least a LitterWatch level 2 category (2019)	Litter from surveys not classified beyond LitterWatch level 1 categories (2019) or classified using a non-standard categorisation
ConfT: Temporal spread of data	More than one survey each month per site	One survey each month per site	Less than monthly repeated surveys for sites
ConfS: Spatial spread of data	10 or more surveys per catchment area	Between 5 and 10 surveys per catchment area	Less than 5 surveys per catchment area
ConfSd: Survey design	Most relevant survey method applied (observation/nets/trawl etc.) (Richardson et al. 2021) and best practice survey design implemented (McDonough, 2019)	Relevant survey method applied (observation/nets/trawl etc.) (Richardson et al. 2021) and no best practice design applied	No standardised survey method used, and no best practice design applied

Table 2: Confidence Status as determine by the Confidence Metric (CM) value

Confidence Status	CM Value
High	> 1.25
Intermediate	0.75 – 1.25
Low	< 0.75

5. Applications

5.1 Reporting

The Litter Index will be used to assess the priority area of litter under the water quality goal for the EMP for the five-yearly evaluation. The Litter Index results will be shared publicly utilising online dashboards.

As a spatially explicit index, this tool can be used to identify litter hotspots in PPB by using the litter status. This will enable priority locations to be targeted for management efforts, including data collection and clean-ups. The index will assign sites in PPB a status which is tied to meaningful threshold values enabling the status to inform and trigger relevant follow-up management. It is also the first index aiming to integrate litter presence with the flow-on impacts on coastal and marine wildlife (Figure 7).

The inclusion of long-term monitoring data allows the Litter Index to track litter trends in PPB across years.

The index relies on the Victorian LitterWatch dataset to inform its status assignment. The Litter Index, by proxy, is a useful tool for visualising and reporting local citizen science data and provides a framework to guide the development and improvement of survey efforts for LitterWatch.

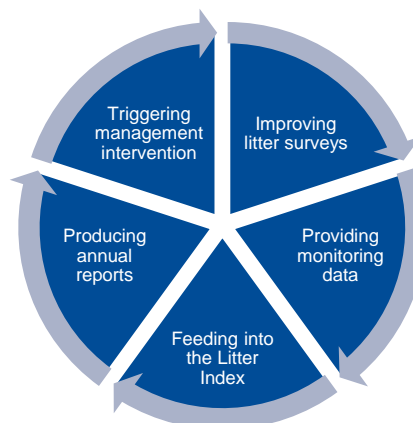


Figure 7: How the Litter Index utilises citizen science data and informs reporting

5.2 Limitations and improvement

5.2.1 Limitations

The Litter Index is limited by the lack of comprehensive marine litter data in PPB. Specifically, available data on entanglement and ingestion rates for wildlife is poor, due to the lack of standardised monitoring efforts. Citizen science survey efforts across PPB can be spatially and temporally sporadic, resulting in missing information for various locations and time intervals. These gaps mean inferences on the status of litter in the area can lack confidence. That said, the need for improved marine debris data is not only a local concern, but an international one (Campbell et al. 2019).

Litter Index can be used for site prioritisation; any location returning Poor or Very Poor status or a declining trend can alert when management intervention may be required. However, reliability will be limited by the confidence rating for the data. It must also be noted that the index can only identify the status of a site and cannot identify specific management actions required to increase the status of a site. The Litter Index allows for site prioritisation via spatially represented statuses, but the contributing data cannot identify the source of the litter. Currently the index represents litter count monitoring data and does not have the ability to isolate what may be causing major littering events or the influence of weather or other natural events on the results. It is noted that there may be limitations with collecting data on Marine Species Impact however cannot be addressed until the data collection commences. Further refinement of the Litter Index and greater data availability is required to be able the Litter Index to recommend targeted actions for site improvement.

5.2.2 Improvements

One of the Litter Index's core strengths is its flexible structure which allows for the inclusion of updated or new datasets. This will enable adoption of the Litter Index in other geographic locations, such as elsewhere in Victoria, or expansion of the analysis to a state-wide context. For the EMP's purposes when data becomes available, this will enable reporting of Litter Index results for PPB's catchments.

To successfully expand on the Litter Index, threshold values must be set for marine entanglement and ingestion indicators. Additionally, data would be required for both water surface and waterbed zones, and for the Marine Life assessment area. There is also a need for litter monitoring at 'pristine' and 'polluted' sites across PPB. Using a before-after-control-impact (BACI) survey method design, baselines and thresholds could be refined to become site-specific, not simply Bay-wide. The findings from such a study could also indicate changing baselines over time.

If the data were available, the Litter Index could also be applied to the feed-in catchments of Port Phillip Bay, such as the Bellarine. This would enable site prioritisation of terrestrial sites.

6. Conclusion

This index is novel in its inclusion of wildlife-related indicators of litter harm, and the inclusion of indicator thresholds that can guide future management of PPB. The Litter Index has the potential to incorporate a vast array of monitoring datasets including state-wide data.

The Litter Index will enable efficient reporting and evaluation of the progress of the EMP's priority area 'Litter'. The Litter Index method and its outputs will contribute to the formation of the evidence base for assessing management interventions and environmental outcomes. As a spatially explicit, integrated reporting tool that can quantify the status of litter and its impacts the Litter Index will support informed decision making to ensure a purposeful and systematic approach is taken to litter management.

It is recommended that the Litter Index be adopted for ongoing use in evaluation of the EMP.

7. References

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Appendix 1

LitterWatch categories (2023)

Level 1 Name	Level 2 Name	Level 3 Name
	PLASTIC	
PLASTIC	Microplastics < 5mm	
PLASTIC	Microplastics < 5mm	Nurdles/ resin pellets
PLASTIC	Microplastics < 5mm	Soft plastic pieces < 5mm
PLASTIC	Microplastics < 5mm	Hard plastic pieces < 5mm
PLASTIC	Cigarette butts	
PLASTIC	Other cigarette related litter	
PLASTIC	Other cigarette related litter	Lighter
PLASTIC	Other cigarette related litter	Cardboard type packets and cartons
PLASTIC	Other cigarette related litter	Tobacco pouches, e-cigarette packages, outer wrapper, foil inners etc.
PLASTIC	Food wrappers (soft includes metallic type) chips, confectionary etc.	
PLASTIC	Cutlery, stirrers and plates	
PLASTIC	Cutlery, stirrers and plates	Forks, knives and spoons
PLASTIC	Cutlery, stirrers and plates	Stirrers
PLASTIC	Cutlery, stirrers and plates	Picnic type plates and bowls
PLASTIC	Straws	
PLASTIC	Coffee cups and lids	
PLASTIC	Coffee cups and lids	Coffee cup and lid
PLASTIC	Coffee cups and lids	Coffee cup only
PLASTIC	Coffee cups and lids	Coffee lid only
PLASTIC	Other cups and lids	
PLASTIC	Other cups and lids	Slushie type cups only
PLASTIC	Other cups and lids	Slushie lid only (domed plastic)
PLASTIC	Other cups and lids	Cardboard mix drink dispenser cup
PLASTIC	Other cups and lids	Flat plastic cup lids (not coffee)
PLASTIC	Other cups and lids	Plastic picnic type cups
PLASTIC	Beverage bottles (includes caps and labels)	
PLASTIC	Beverage bottles (includes caps and labels)	Bottles 1L or less only
PLASTIC	Beverage bottles (includes caps and labels)	Bottles >1L only
PLASTIC	Beverage bottles (includes caps and labels)	Lid and lid rings only

PLASTIC	Beverage bottles (includes caps and labels)	Labels only
PLASTIC	Food and beverage other packaging (hard and soft)	
PLASTIC	Food and beverage other packaging (hard and soft)	Lollipop sticks
PLASTIC	Food and beverage other packaging (hard and soft)	Soy sauce fish and caps
PLASTIC	Food and beverage other packaging (hard and soft)	Other sauce sachets
PLASTIC	Food and beverage other packaging (hard and soft)	Mesh bags (vegetable, oyster, mussel etc.)
PLASTIC	Food and beverage other packaging (hard and soft)	Ring carriers (six-pack can holders etc.)
PLASTIC	Food and beverage other packaging (hard and soft)	Hard takeaway food tubs and lids
PLASTIC	Food and beverage other packaging (hard and soft)	Cling wrap/ film
PLASTIC	Food and beverage other packaging (hard and soft)	Wine and beverage bladders (with box if present)
PLASTIC	Food and beverage other packaging (hard and soft)	Other food containers (ice cream, food jars etc.)
PLASTIC	Food and beverage other packaging (hard and soft)	Bread bag tags
PLASTIC	Food and beverage other packaging (hard and soft)	Longlife milk carton 1L+
PLASTIC	Food and beverage other packaging (hard and soft)	Longlife milk carton >1L
PLASTIC	Food and beverage other packaging (hard and soft)	Longlife (not milk) 1L+
PLASTIC	Food and beverage other packaging (hard and soft)	Longlife (not milk) >1L
PLASTIC	Food and beverage other packaging (hard and soft)	Drink pouches/ squeeze tubes
PLASTIC	Food and beverage other packaging (hard and soft)	Food pouches/ squeeze tubes (yoghurt etc.)
PLASTIC	Food and beverage other packaging (hard and soft)	Bread bag, pasta bag and similar
PLASTIC	Bags	
PLASTIC	Bags	Light weight bag
PLASTIC	Bags	Heavy weight/ retail bag
PLASTIC	Bags	Ice bag
PLASTIC	Bags	Zip lock type bags
PLASTIC	Bags	Small produce/ barrier bags (from grocery store etc.)

PLASTIC	Bags	Dog poo and nappy bags (empty)
PLASTIC	Bags	Dog poo and nappy bags (full)
PLASTIC	Bags	Garbage, rubbish bags, bin liners (empty)
PLASTIC	Bags	Garbage, rubbish bags, bin liners (full)
PLASTIC	Bags	Reusable material carry bags (synthetic not cloth)
PLASTIC	Balloons and balloon accessories (strings and sticks)	
PLASTIC	Balloons and balloon accessories (strings and sticks)	Foil balloons only
PLASTIC	Balloons and balloon accessories (strings and sticks)	Rubber type balloons only
PLASTIC	Balloons and balloon accessories (strings and sticks)	Balloon ribbons/ strings
PLASTIC	Balloons and balloon accessories (strings and sticks)	Balloon sticks and clips
PLASTIC	Industrial litter	
PLASTIC	Industrial litter	Cable ties and fasteners
PLASTIC	Industrial litter	Tile spacers
PLASTIC	Industrial litter	Commercial type tags
PLASTIC	Industrial litter	Strapping band (whole)
PLASTIC	Industrial litter	Strapping band scraps
PLASTIC	Industrial litter	Packaging accessories (seals, reels, spools, handles etc.)
PLASTIC	Industrial litter	Duct tape, masking tape etc.
PLASTIC	Industrial litter	Pipe, PVC, irrigation and articulation
PLASTIC	Industrial litter	Farming implements, devices and fittings
PLASTIC	Industrial litter	Blasting items
PLASTIC	Industrial litter	Tubes and hoses
PLASTIC	Industrial litter	Caulking tubes and guns (silicone etc.)
PLASTIC	Industrial litter	Sheeting (tarpaulin, woven bags, pallet wrap)
PLASTIC	Industrial litter	Foam ear buds
PLASTIC	Industrial litter	Other OH&S items (gloves etc.)
PLASTIC	Industrial litter	Tie downs and octopus straps
PLASTIC	Industrial litter	Trimmer line
PLASTIC	Industrial litter	Plastic coated wires
PLASTIC	Unidentifiable fragments (hard and soft)	
PLASTIC	Unidentifiable fragments (hard and soft)	Hard plastic pieces 5mm and greater

PLASTIC	Unidentifiable fragments (hard and soft)	Soft plastic pieces 5mm and greater
PLASTIC	Unidentifiable fragments (hard and soft)	Fibre glass fragments
PLASTIC	Fishing items	
PLASTIC	Fishing items	Bait bag
PLASTIC	Fishing items	Tackle bags and fishing item packaging
PLASTIC	Fishing items	Bait containers, lids and bait savers
PLASTIC	Fishing items	Plastic buoys and floats
PLASTIC	Fishing items	Commercial fishing traps, pots, aquaculture items etc.
PLASTIC	Fishing items	Recreational fishing items (lures, floats, rods, reels etc.)
PLASTIC	Fishing items	Fishing line pieces (<1m)
PLASTIC	Fishing items	Fishing line (1m and greater)
PLASTIC	Fishing items	Fishing net scraps (<1m)
PLASTIC	Fishing items	Fishing net (1m and greater)
PLASTIC	Fishing items	Fishing glow sticks
PLASTIC	Syringes	
PLASTIC	Medical waste and sanitary items	
PLASTIC	Medical waste and sanitary items	First aid materials and equipment (band aids, thin gloves etc.)
PLASTIC	Medical waste and sanitary items	Sanitary pads and tampons
PLASTIC	Medical waste and sanitary items	Other drug paraphernalia including syringe caps
PLASTIC	Medical waste and sanitary items	Other sharps
PLASTIC	Medical waste and sanitary items	Cotton buds (plastic stick)
PLASTIC	Medical waste and sanitary items	Condoms and foil/ plastic wrappers
PLASTIC	Medical waste and sanitary items	Single use nappies
PLASTIC	Medical waste and sanitary items	Dental floss and toothbrushes
PLASTIC	Medical waste and sanitary items	Wet wipes/ baby wipes
PLASTIC	Medical waste and sanitary items	Face masks (single use)
PLASTIC	Other plastics (not EPS)	
PLASTIC	Other plastics (not EPS)	Synthetic rope (>1cm diameter)
PLASTIC	Other plastics (not EPS)	Plastic string and cord (<1cm diameter)
PLASTIC	Other plastics (not EPS)	Pens, markers and other stationary
PLASTIC	Other plastics (not EPS)	Clothing tags and fasteners
PLASTIC	Other plastics (not EPS)	Personal care and pharmaceutical packaging

PLASTIC	Other plastics (not EPS)	Hair ties
PLASTIC	Other plastics (not EPS)	Hair accessories (not ties), shower caps, comb, hairbrush, toothbrush
PLASTIC	Other plastics (not EPS)	Synthetic cleaning sponges, wipes, brushes etc.
PLASTIC	Other plastics (not EPS)	Toys, party poppers etc.
PLASTIC	Other plastics (not EPS)	Glow sticks, bangles (not for fishing) etc.
PLASTIC	Other plastics (not EPS)	Ceremonial and festive (wreaths, flowers etc.)
PLASTIC	Other plastics (not EPS)	Childcare items
PLASTIC	Other plastics (not EPS)	Recreation and sporting equipment
PLASTIC	Other plastics (not EPS)	Gardening items
PLASTIC	Other plastics (not EPS)	Housewares, tableware, house fittings
PLASTIC	Other plastics (not EPS)	Outdoor furniture and camping items (chairs, tables, eskies etc.)
PLASTIC	Other plastics (not EPS)	Lids, pump spray, bottle tops etc. (Not from beverages)
PLASTIC	Other plastics (not EPS)	Bleach and cleaner bottles
PLASTIC	Other plastics (not EPS)	Non-food containers including tubes (oil, sealant, chemical, glue) <4L
PLASTIC	Other plastics (not EPS)	Non-food containers (oil, sealant, chemical, glue) 4L+
PLASTIC	Other plastics (not EPS)	Signs (corflute etc.)
PLASTIC	Other plastics (not EPS)	Non-food wrap (bubble wrap etc.)
PLASTIC	Other plastics (not EPS)	Lino, plastic type decking, boat decking
PLASTIC	Other plastics (not EPS)	Maritime safety and survival equipment
PLASTIC	Other plastics (not EPS)	Municipal activities (tree guards, barrier fence etc.)
PLASTIC	Other plastics (not EPS)	Bullet cartridge and wadding, pellets
PLASTIC	Other plastics (not EPS)	Vehicle parts
PLASTIC	Other plastics (not EPS)	Oceanic research items
PLASTIC	Other plastics (not EPS)	Plastic-type material shopping docket, receipts, tickets
PLASTIC	Other plastics (not EPS)	Synthetic turf/grass
EPS (Expanded Polystyrene)		
EPS (Expanded Polystyrene)	Microplastics	
EPS (Expanded Polystyrene)	Microplastics	Packaging beads (<5mm)
EPS (Expanded Polystyrene)	Microplastics	Unidentifiable polystyrene pieces <5mm
EPS (Expanded Polystyrene)	Fishing Items (buoys and floats)	
EPS (Expanded Polystyrene)	Food and beverage packaging	
EPS (Expanded Polystyrene)	Food and beverage packaging	Cups

EPS (Expanded Polystyrene)	Food and beverage packaging	Plates
EPS (Expanded Polystyrene)	Food and beverage packaging	Takeaway containers (lidded)
EPS (Expanded Polystyrene)	Food and beverage packaging	Meat trays and similar
EPS (Expanded Polystyrene)	Other polystyrene	
EPS (Expanded Polystyrene)	Other polystyrene	Packaging peanuts and beads (5mm and greater)
EPS (Expanded Polystyrene)	Other polystyrene	Other packaging
EPS (Expanded Polystyrene)	Other polystyrene	Eskies, fish boxes and similar
EPS (Expanded Polystyrene)	Other polystyrene	Unidentifiable pieces 5mm and greater
EPS (Expanded Polystyrene)	Other polystyrene	Weather balloon parts
EPS (Expanded Polystyrene)	Other polystyrene	Foam sponge sheeting
EPS (Expanded Polystyrene)	Other polystyrene	Recreational items (balls, body boards, sports items)
EPS (Expanded Polystyrene)	Other polystyrene	Polystyrene bead filled item (any outer material)
GLASS		
GLASS	Beverage bottles	
GLASS	Beverage bottles	Wine and spirit bottles
GLASS	Beverage bottles	Other alcoholic beverages (Beer, cider, ready mixed etc.)
GLASS	Beverage bottles	Soft drink, juice, milk and water bottles
GLASS	Other glass and unidentifiable pieces	
GLASS	Other glass and unidentifiable pieces	Buoys
GLASS	Other glass and unidentifiable pieces	Unidentifiable broken pieces
GLASS	Other glass and unidentifiable pieces	Tableware (plates and cups etc.)
GLASS	Other glass and unidentifiable pieces	Fluorescent light tubes
GLASS	Other glass and unidentifiable pieces	Light globes/ bulbs
GLASS	Other glass and unidentifiable pieces	Jars and sauce bottles
GLASS	Other glass and unidentifiable pieces	Knick knacks/ ornaments
METAL		
METAL	Aluminium beverage cans	
METAL	Aluminium beverage cans	Soft drink, water, juices
METAL	Aluminium beverage cans	Alcoholic (beer, spirits, ready mixed etc.)
METAL	Industrial waste/litter	
METAL	Industrial waste/litter	Tools, building and trades materials (not E Waste)
METAL	Fishing Items	

METAL	Fishing Items	Buoys and floats
METAL	Fishing Items	Traps and pots
METAL	Fishing Items	Fish hooks and lures, traces etc.
METAL	Fishing Items	Lead sinkers
METAL	Fishing Items	Fishing knives, scissors, pliers etc.
METAL	Large items	
METAL	Large items	Large items (bicycle frames, trolleys, outdoor equipment etc.)
METAL	Other food and beverage	
METAL	Other food and beverage	Aluminium foil sheet
METAL	Other food and beverage	Foil tubs/ trays
METAL	Other food and beverage	Bottle lids and pull rings
METAL	Other food and beverage	Food cans (includes pet food)
METAL	Other food and beverage	Kegs
METAL	Other metal	
METAL	Other metal	Aerosol / spray cans
METAL	Other metal	Small gas and volatile liquid cans
METAL	Other metal	Large gas and volatile liquid cans
METAL	Other metal	Tins <4L (non-food)
METAL	Other metal	Tins 4L+ (non-food)
METAL	Other metal	Vehicle parts and engines
METAL	Other metal	Signs and sheeting
METAL	Other metal	Wire, stakes and pipes
METAL	Other metal	Fragments and remnants
METAL	Other metal	Metal cutlery, plates, cups, straws
METAL	Other metal	Bullets, cartridges etc.
METAL	Other metal	Nangs (N20 canisters)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)		
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Large items	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Large items	Wooden furniture
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Large items	Boat parts, wreckage and remnants (not metal)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Large items	Mattresses
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Large items	Other large items

OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Large appliances (fridge, air conditioner etc.)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Small appliances (toaster, watch, camera etc.)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Mobile phones and pieces
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	IT, other telephone and TV equipment
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Electrical cords and charging equipment
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Lighting equipment (not torches)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Electrical and electronic tools (drills, lawn mowers, sewing machines)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Toys and hobby equipment (electric train, hand-held video game, console, radio etc.)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Headphones
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Head torches and other torches
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	Batteries (not in device) – all sizes
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	E-cigarettes – rechargeable
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	E Waste	E-cigarettes – single use
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Industrial litter/waste	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Industrial litter/waste	Wooden material (processed timber, pallets, crates and similar pieces)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Industrial litter/waste	Other materials (bricks, cement, ceramic/ concrete pipes, tiles and similar)

OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Fishing litter	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Fishing litter	Wooden fishing items
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Medical waste and sanitary items (no plastic components)	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Medical waste and sanitary items (no plastic components)	Paper tissues
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Medical waste and sanitary items (no plastic components)	Cotton buds (paper/cardboard/wood stick)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Medical waste and sanitary items (no plastic components)	Cotton balls
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Paper napkins
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Fast food packaging (incl. paper bags)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Paper/cardboard ice cream wrappers, sugar sachet etc.
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Paper/cardboard, natural material plates, cups and bowls
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Wooden ice cream sticks, cutlery, toothpicks, stirrers
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Egg cartons, pizza boxes, cake boxes and similar
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Cardboard cup sleeves
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Wine and other beverage casks (box only)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	Food and beverage packaging	Straws
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Ceramic pieces (unidentifiable)

OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Ceramic tableware (plates and cups etc.)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Ceramic knick knacks and decorations
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Binding, thread, string and cord (not plastic/ synthetic)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rope natural pieces (<1m)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rope natural (1m+)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Clothing, shoes, hats and towels
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Backpacks and bags
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Canvas, sailcloth and sacking (hessian) – not plastic
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Carpet and furnishings
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Other textiles (pieces of cloth, rags etc.)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Personal effects (wallets, money, keys, jewellery)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Pet handling and care items – mixed materials
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Paper bags (not fast food)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Newspapers and magazines
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Junk mail and free circulars
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Cardboard packages, boxes, sheets and tubes
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Paper shopping docketts, receipts, tickets

OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Fireworks incl. tubes and pieces
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Paper sheets, strips etc.
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rubber type balls and toys
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rubber bands
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rubber type sheeting and mats
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Rubber pieces (not tyres)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Tyres
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Tyre fragments
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Inner tubes, seals and similar
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Wooden brooms, brushes, paint brushes and similar
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Matches and pencils etc.
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Corks
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Oil globules and tar
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Organic materials and food scraps, including dog poo (not bagged)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Medical tablets/capsules
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Wax (surf wax, candles, paraffin and similar)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Soap, dry lubricant, glue (not in plastic tubes)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Asbestos

OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Dangerous items such as military, weapons (incl. knives)
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Natural material cleaning sponges, cloths, wipes and brushes
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Clean fill piles
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	'Fatballs' / sewage grease
OTHER (mixed materials, ceramics, cloth, paper and cardboard, rubber, wood, organics)	All other	Reusable face masks

Appendix 2

Example Litter Index Score:

Apply Equation 1:

- *Observed data value = Density of 5 items*
- *minimum Indicator Score = 0.4*
- *maximum Indicator Score = 0.59*
- *minimum Threshold = 2 items*
- *maximum Threshold = 100 items*

$$(0.59 - 0.49) \left(\frac{(5 - 2)}{(100 - 2)} \right) + 0.49$$

Individual Indicator Score = 0.493 (Status = Fair)

Apply Equation 2:

- *median Density Indicator Score = 0.493*
- *median Composition Indicator Score = 0.845*
- *Very Good Indicator Score = 1*

$$\frac{0.6 * (0.493 + 0.845) + 0.4 * (0)}{0.6*(1+1) + 0.4 (0+0)}$$

0.8028

1.2

Litter Index Score = 0.669 (Status = Good)