A little litter goes a long way: Innovation in litter assessments

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Key Points

- Hydrodynamic particle track modelling and time lapse camera monitoring are novel approaches that enable data-driven insights for performance investigations of litter traps in waterways.
- The planning and positioning of litter traps in waterways should follow an integrated program approach, considering appropriate and complementary devices that optimise the capture of the specific target litter types under the river conditions of that reach, as well as how these integrate to the whole of river system or catchment.
- The approach taken for this project plays an important part in the planning and operation stages of an asset management framework to ensure the asset base to be managed by Parks Victoria addresses its service delivery objectives.

Abstract

Parks Victoria has actively managed litter in the lower Yarra and Maribyrnong Rivers for 20+ years. To review the performance of existing Bandalong litter traps, Streamology undertook an innovative data-driven study for Parks Victoria, that focused on assessing the typical operational hydrodynamic conditions, the performance of currently used and alternative litter trap designs and locations to optimise the management of litter in both waterways.

The study was conducted in three stages. Stage 1 consisted of hydrodynamic and particle track modelling, together with time lapse camera monitoring, to assess litter particle pathways through both waterways and the effectiveness of existing Bandalong traps to capture and contain floating litter. Stage 2 expanded on the findings from Stage 1 to identify improvements, including alternative locations for existing Bandalong traps and the application of alternative litter interceptor technologies. In Stage 3, knowledge from the previous stages was built on to develop an integrated program that includes combinations of different suitable interceptors to target a wider range of litter types and optimise capture efficiency within Parks Victoria's known operational constraints.

The study shows that trap location is a key determinant of success and relocating existing Bandalong traps can significantly increase performance. The effectiveness and feasibility of different litter interceptors was related to the type of litter the device targets (e.g. small, medium or large) and its location within the waterway (hydrodynamic conditions).

A scenario comparison shows how litter management within urban waterways requires an integrated approach, combined with knowledge of the targeted litter types, sources and pathways.

Keywords

asset management, hydrodynamic particle tracing modelling, integrated program, litter pathways, litter traps, time lapse monitoring, multi-criteria assessment,

Introduction

Parks Victoria is the Waterway Manager of the lower reaches of the Yarra and Maribyrnong Rivers. They have actively worked on litter management in these waterways for over 20 years. The litter traps in these waterways were significantly impacted by the October 2022 flood events, including those within the

Maribyrnong River which all required repair or replacement following the floods. The existing litter traps are Bandalong[1] devices that consist of two outspread floating polyethylene boom arms attached to a central litter collection trap. The booms funnel floating litter and debris through a one-way gate into the trap from where the captured litter is removed. Due to constraints such as water depths and river traffic, there are limited opportunities to alter the location of the current Bandalong traps or add additional litter traps to the system.

The aims of this study were to: a) assess the performance of the litter traps in the Yarra and Maribyrnong Rivers and identify opportunities for improvement, including alterations to the current Bandalong trap system or the development of the next generation of litter traps and devices, and b) assess whether the hydrodynamic conditions, litter types and quantities, and litter movement patterns in the project area are suited to the existing Bandalong traps.

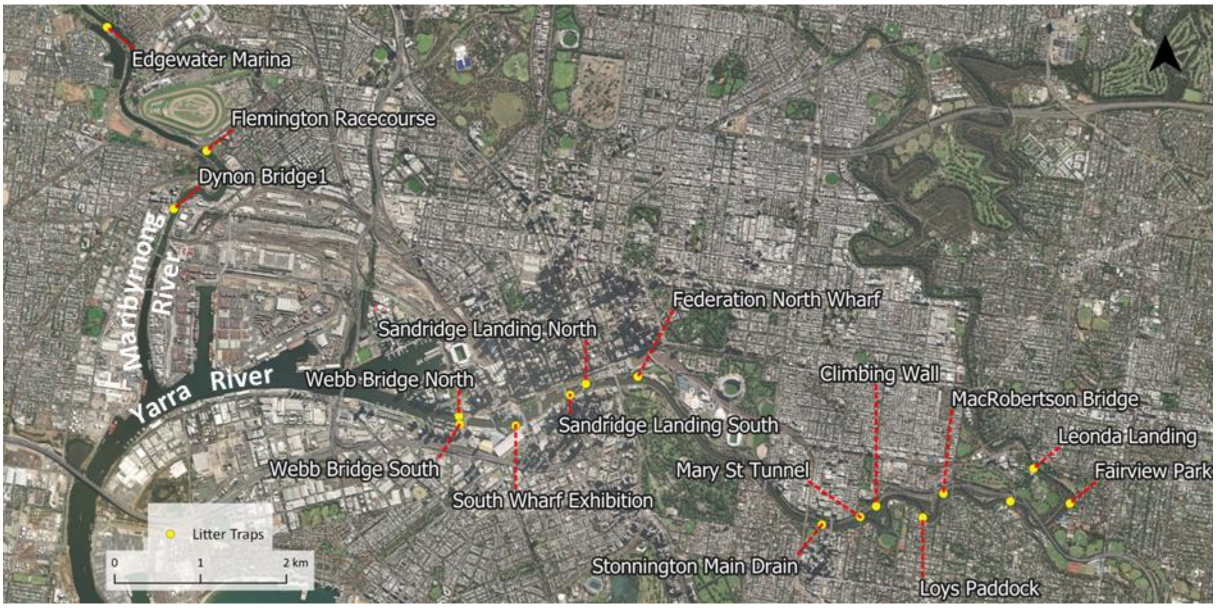

Figure 1. Melbourne area map showing the study area and locations of existing Bandalong traps

[1] https://www.bandalong.com.au/

Project approach

Figure 2 provides an overview of the three-stage project approach.

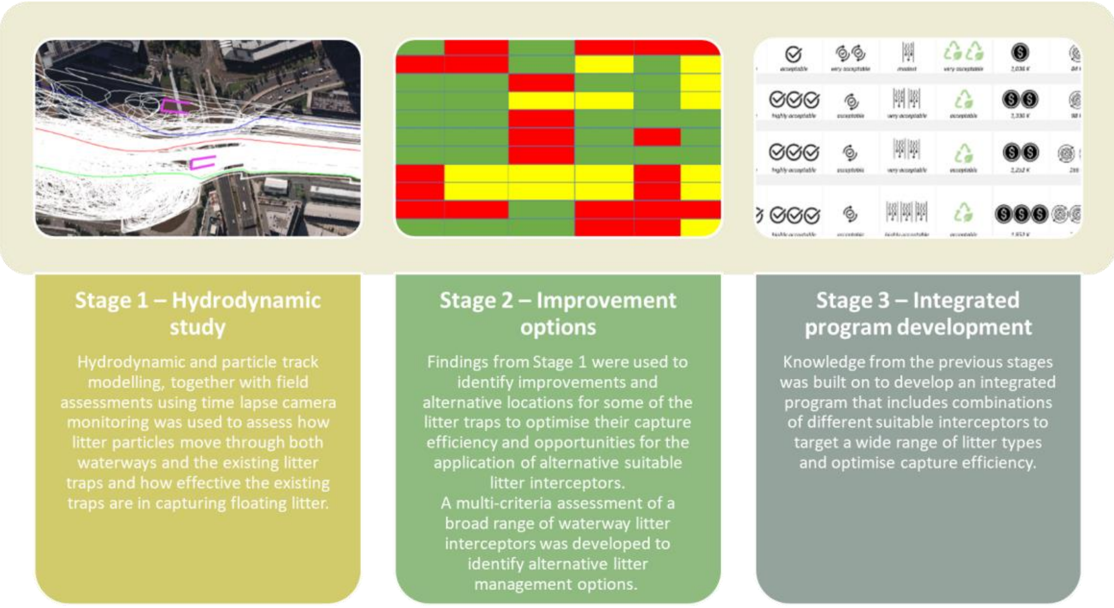

Figure 2. Overview of project approach

Stage 1 – Hydrodynamic study

Objectives

The objectives of Stage 1 were:

1. Illustrate the inflows and movements of litter and river surface water in the two rivers.
2. Assess the suitability and effectiveness of the current Bandalong trap design and locations.
3. Identify the main reasons for litter loss from existing Bandalong traps on the Maribyrnong River.

Methodology

The methodology developed for Stage 1 (Figure 3) involved the collection of field data (bank information such as morphology and vegetation, river bathymetry, flow velocity), Bandalong trap performance (time lapse cameras) to inform the modelling of the hydrodynamic conditions in both rivers. Once the data was collected, the models were setup and used to simulate flow and litter conditions in the rivers using a novel particle tracking approach.

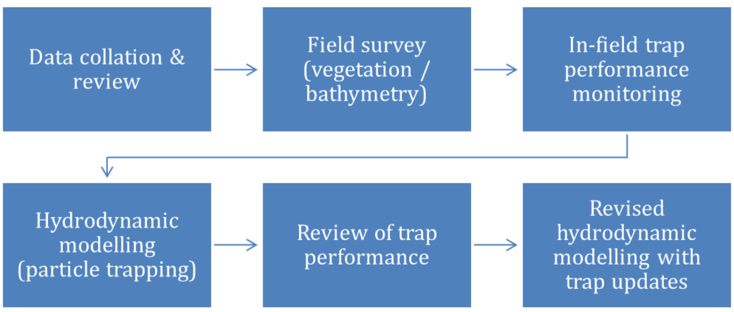

Figure 3. Stage 1 methodology

Hydrodynamic modelling approach

Hydrodynamic models were developed for the lower Yarra and Maribyrnong Rivers using the industry standard Delft3D software. The model grids included 25 and 16 grid cells, respectively, across each river channel to enable a detailed representation of the flow velocity and how is varies across the channel. Features in the river such as bridge piers were explicitly included as they can alter the flow pattern and influence litter movements. The Bandalong traps were included in the model based on their general dimensions and by blocking surface flows to enable them to "capture" litter.

The movement of litter was simulated by the release of model particles at the upstream boundary of each model. These floating particles then move with the currents and their paths were tracked for the duration of the simulation. The results were analysed to assess how many litter particles were "captured" in each Bandalong trap and to help understand the overall pattern of litter movements to inform potential new locations or improvements for Stage 2.

Findings

Findings of Stage 1 are summarised in Figure 4. The main factors influencing the performance of the Bandalong traps were:

- Trap location relative to the surface currents, with better performance when the currents were more uniform across the channel.
- Shorter duration of slack water or upstream tidal currents which limits the potential for litter to exit the trap through the entrance.
- Large debris can get jammed in the traps, affecting the opening mechanism.

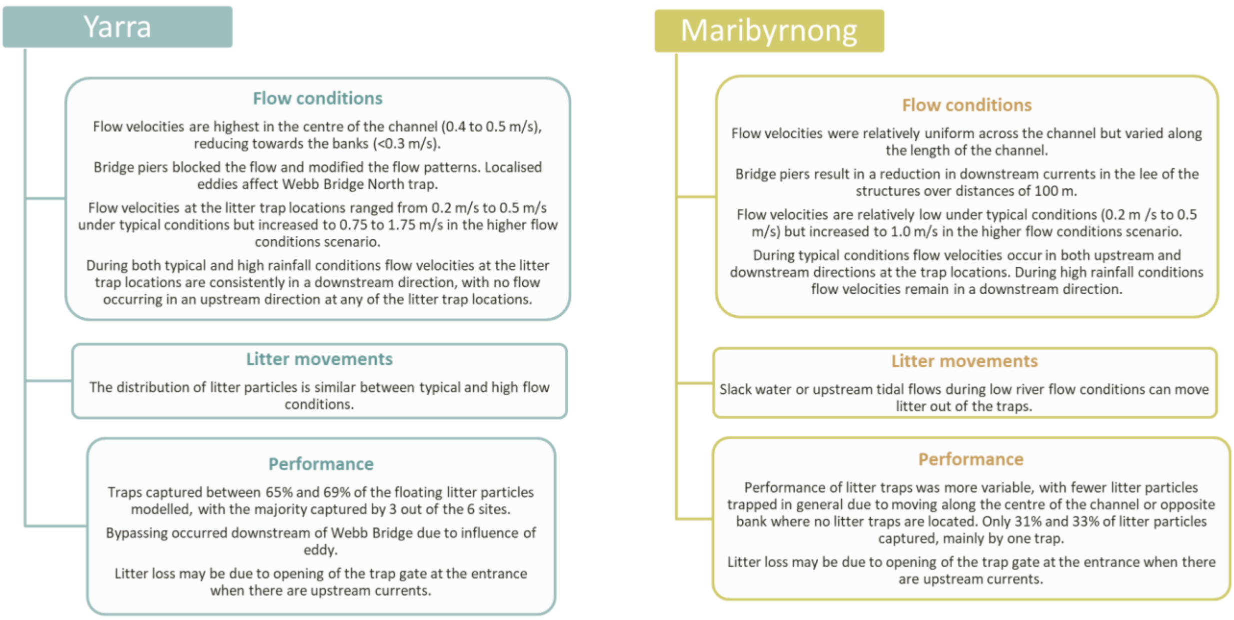

Figure 4. Summary of Stage 1 findings

The hydrodynamic modelling and time lapse camera monitoring outputs were particularly useful for visualising key aspects affecting Bandalong trap performance. They showed:

- Many of the traps are positioned in suitable locations, intercepting the modelled particles well (Figure 5 top left).
- Eddys near bridge piers can interrupt litter tracks, causing traps in these locations being bypassed (Figure 5 bottom).

- In some instances, litter tracks moved along the side of the channel that is opposite to the trap, subsequently bypassing it (Figure 5 top right).
- Variable currents are likely the cause of trap entrances opening at times, causing litter to escape.
- Large woody debris blocking the trap entrance or submerging the trap prevent the entrance gate from functioning.

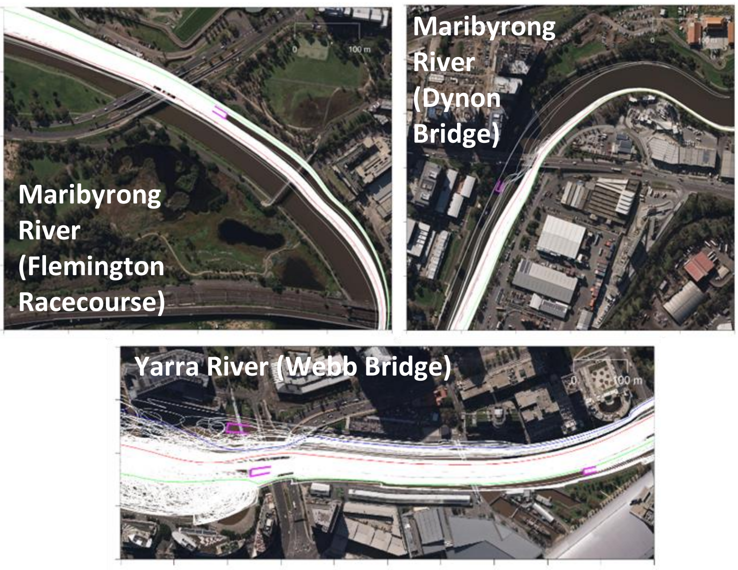

Figure 5. Particle track modelling outputs showing litter pathways (white) in relation to the positioning of the Bandalong traps (magenta rectangles)

Stage 2 – Improvement options

Objectives

The objectives of Stage 2 were:

1. Evaluate improvements to the existing Bandalong trap based on the outcomes from Stage 1.
2. Review and assess alternative litter interceptor design collaboratively with Parks Victoria to determine the most feasible options.
3. Review and assess alternative conveyor belt systems.

Methodology

The methodology developed for Stage 2 (Figure 6) involved the re-evaluation of the existing Bandalong traps within **the** lower Yarra and Maribyrnong Rivers using the hydrodynamic model. The suggested improvements from Stage 1 were incorporated in the models and changes to the performance of the Bandalong traps were assessed. In parallel, a detailed review was undertaken of a range of alternative litter trapping devices.

Based on the updated modelling and the review, the most feasible options for implementation were identified and a multicriteria analysis (MCA) approach was used to compare these different systems.

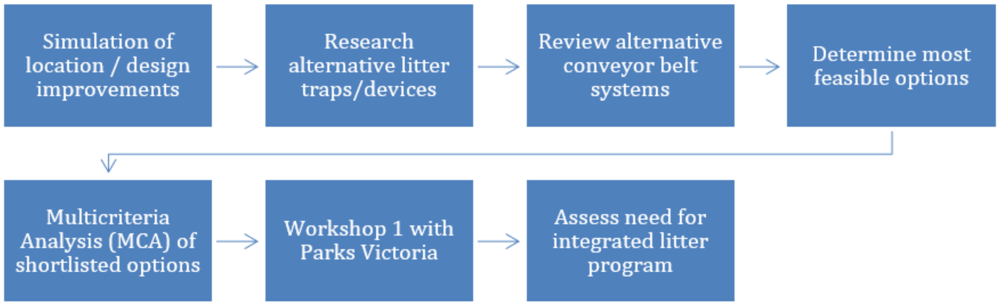

Figure 6. Stage 2 methodology

MCA approach

The MCA was based on a comprehensive review of 24 alternative waterway litter interceptors. Of these, 11 alternatives were shortlisted and rated against the following four criteria that were identified to be crucial for the ongoing management and performance of these assets:

- effectiveness – litter types/quantity
- technical feasibility
- impacts on values – environmental and social, and
- cost – implementation, maintenance.

Categories were analysed according to the criteria and the different were ranked in a finer scale. This provided further insights into which would perform best for different purposes and environments (Figure 7).

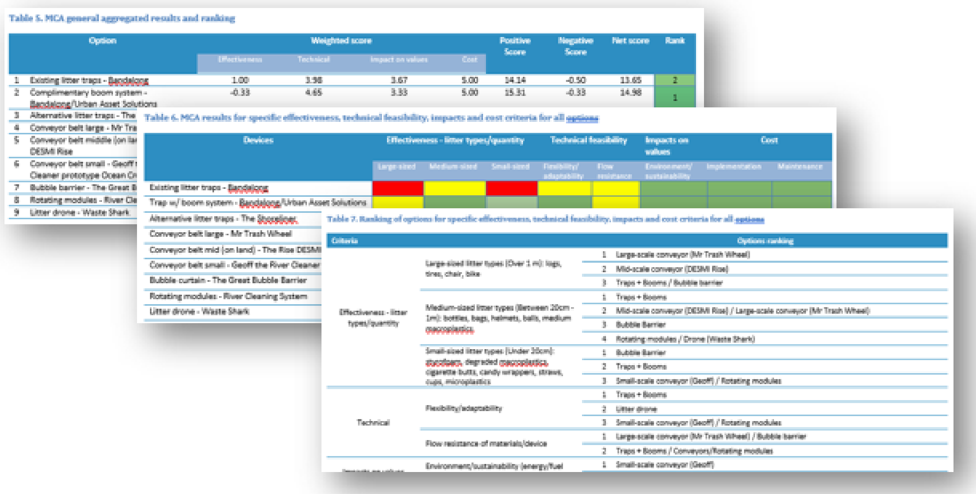

Figure 7. Ranking of options using the developed MCA framework

Recommendations

The improvements identified from the Stage 2 analysis are summarised in Figure 8. These encompass recommendations for enhancing trapping efficiency, including more suitable litter trap locations and positioning, Bandalong trap design modifications and complementary alternative interceptors.

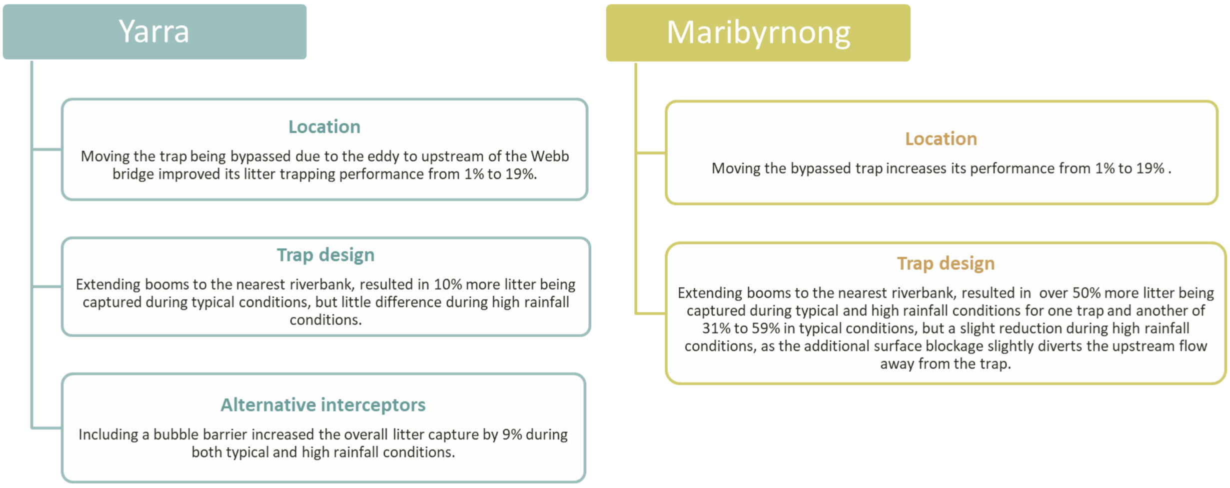

Figure 8. Summary of the identified alternative litter interceptor design improvement options for the lower Yarra and Maribyrnong Rivers

Stage 3 – Integrated program development

Objectives

The objectives of Stage 3 were to develop an integrated program of different litter trap devices and locations to maximises the type and amount of litter that can be collected across both rivers, considering:

1. The best functional designs and design requirements including existing infrastructure and litter interceptors and the shortlisted alternative designs.
2. A hierarchy of options that includes a range of litter trap devices using a whole of river approach for both rivers.

Methodology

The methodology developed for Stage 3 (Figure 9) involved setting up a base case (existing conditions) for the lower Yarra and Maribyrnong Rivers and a series of scenarios that were focused on maximising litter collection. These scenarios were compared against the base case to identify constraints and opportunities for Parks Victoria's litter program.

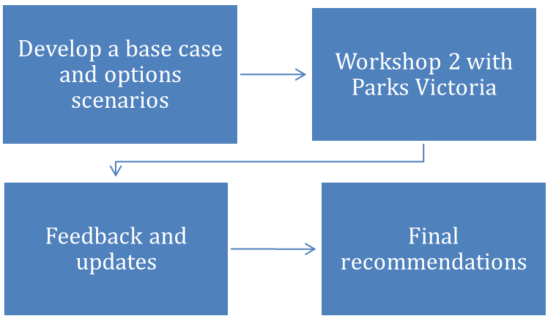

Figure 9. Stage 3 methodology

Integrated program development approach

Scenarios (Figure 10) focused on maximising litter collection in both rivers were identified and investigated against a base case.

The base case was based on:

- using existing infrastructure and Bandalong traps and booms available
- existing river conditions and recommendations provided in Stage 1 are in place: all Bandalong traps have boom systems extended from the trap to the riverbank and are located following the recommendations, and
- effectiveness, technical feasibility and impacts of devices obtained from MCA scores.

Scenarios were based on the following considerations:

- stormwater outlet locations to position the litter traps
- space and access requirements and landownership to determine the level of agreements/approvals
- sections of the river without litter traps
- effectiveness of devices derived from MCA scores, and
- cost.

Scenario	Effectiveness - litter types/quantity			Technical		Impacts on values	Cost		Agreements
	Large-sized	Medium-sized	Small-sized	Flexibility/ adaptability	Flow resistance	Environment/ sustainability	Implementation	Maintenance (per year)	Agreements/ approvals
Base case									
14 Bandalong litter traps and booms	*acceptable*	*very acceptable*	*acceptable*	*very acceptable*	*modest*	*very acceptable*	*1,036 K*	*84 K*	*Not needed*
Scenario 1									
10 Bandalong litter traps and booms 1 Bubble Barrier	*acceptable*	*very acceptable*	*highly acceptable*	*acceptable*	*very acceptable*	*acceptable*	*1,330 K*	*98 K*	*Council / MW*
Scenario 2									
8 Bandalong litter trap and boom 1 mid-scale conveyor* 1 Bubble Barrier	*very acceptable*	*very acceptable*	*highly acceptable*	*acceptable*	*very acceptable*	*acceptable*	*1,252 K*	*166 K*	*2 Councils / MW*
Scenario 3									
8 Bandalong litter trap and boom 1 mid-scale conveyor 1 large-scale conveyor 1 Bubble Barrier	*highly acceptable*	*highly acceptable*	*highly acceptable*	*acceptable*	*highly acceptable*	*acceptable*	*1,852 K*	*341 K*	*2 Councils / MW / Port*

Figure 10 Example of visual output produced for the scenario comparison

Results

Based on the objective to maximise the type and amount of litter that can be collected across both rivers, the following most effective options to complement the existing network of Bandalong traps would be:

- Move Bandalong traps and extend booms as per recommendations provided in Stage 2.

- Install a complementary alternative device (bubble barrier for the lower Yarra River or mid-scale conveyor belt system or bubble barrier for the Maribyrnong River) to improve capture of medium to small sized litter and microplastics and reduce number of existing Bandalong traps in the Central Business District to improve capture of medium to small litter types and microplastics without extensively increasing costs.

- Redeploy reduced CBD Bandalong traps further upstream where there are currently no other devices and position them downstream of main drain outlets.

Conclusions

Hydrodynamic particle track modelling and time lapse camera monitoring are novel approaches that enable data-driven insights for performance investigations of litter traps in waterways.

The effectiveness of litter interceptor devices to trap litter increases when a range of devices, targeting different litter types are combined; however, costs and approvals could also increase.

The planning and positioning of alternative designs should consider the targeted litter types and the river conditions of that reach, as well as how these integrate to the whole of river system or catchment.

As the litter interceptors cover more extensive sections of the river, the need for approvals to implement alternative designs grows. This is due to the increased demand for space to accommodate the interceptors, as well as the necessity for access roads to facilitate litter collection and transportation, along with energy connections.

The approach taken for this project plays an important part in the planning and operational stages of an asset management framework to ensure the asset base to be managed by Parks Victoria addresses its service delivery objectives. The planning stage includes a determination of asset requirements, based on an assessment of both service delivery needs and the capability of the existing asset base to meet these needs. The operational and maintenance stage considers the management and use of the assets to deliver services, including maintenance.

Acknowledgements

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