A3P Project: Stony Creek whole of system litter investigation & management prioritisation

Targeted Litter Surveys Summary Report

Jackie Myers, Gina Mondschein, Michael Clark and Vincent Pettigrove

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Aquatic Pollution Prevention Partnership

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Acknowledgment of Country

RMIT University and Melbourne Water respectfully acknowledges Aboriginal and Torres Strait Islander peoples as the Traditional Owners and custodians of the land and water on which all Australians rely. This research was conducted on Boonwurrung Country, and we pay our respects to their Elders past, present and future as Traditional Owners and the custodians of the land and water on which we rely and operate.

We acknowledge and respect the continued cultural, social and spiritual connections of all Aboriginal Victorians, and the broader Aboriginal and Torres Strait Islander community have with lands and waters and recognise and value their inherent responsibility to care for and protect them for thousands of generations.

Melbourne Water is committed to working in partnership with Traditional Owners to ensure meaningful ongoing contribution to the future of land and water management.

Report produced by: Aquatic Environmental Stress Research Group under the
Aquatic Pollution Prevention Partnership with Melbourne Water
RMIT University
+61 9925 9587
rmit.edu.au/aquest rmit.edu.au/a3p
Contact: Jackie Myers
Contact email: jackie.myers@rmit.edu.au
Contact phone: 9925 4841

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Executive Summary

In 2018, Stony Creek, an urban waterway that runs through Melbourne's western suburbs and flows into the Yarra River beneath the West Gate Bridge, was subjected to a contamination event following firewater runoff entering the creek during a warehouse fire in Tottenham. This decimated plant and animal life in the creek and required substantial remediation to make the area safe for users. To address the environmental damage caused by the fire, Melbourne Water partnered with the Environmental Protection Authority Victoria, Maribyrnong City Council and the local community to develop the Stony Creek Rehabilitation Plan 2019 – 2029. The Plan contains restoration goals and actions for the Stony Creek catchment. Action WQ9 is to improve litter management, specifically to 'Place litter traps in appropriate places throughout the Stony Creek catchment'. This project was commissioned to improve litter management under Action WQ9 of the Rehabilitation Plan.

The project investigates litter across the entire Stony Creek catchment with the aim to understand the litter problem in the catchment and identify how to effectively tackle it across different stakeholder needs. The first step in the project was to describe the current state of litter in the catchment, which was outlined in a background report (see Trestrail *et al,* 2020). The next steps were to characterise litter and determine its primary sources through targeted surveys across the catchment and then assess risks litter pose to values of Stony Creek and identify potential actions to manage and/or reduce threat from litter across the catchment. This report outlines the targeted litter monitoring program outcomes, risk prioritisation and recommendations around management options.

Targeted litter surveys were conducted to assess the contribution of litter from urban runoff through the stormwater system and from more localised catchment activities through bank surveys. Eight sites were surveyed weekly assessing litter along creek banks over four weeks from 16th November 2020 to 9th December 2020, while six stormwater drains were surveyed weekly to assess litter entering the creek from the stormwater network over 6 weeks between 11th February 2021 and 24th March 2021.

From 68 site visits, a total of 3019 litter items were collected, 1988 from along creek banks and 1031 from the stormwater network in Stony creek. Litter captured during the study period is considered to generally represent that delivered to Stony Creek during dry weather, with only 3 visits considered representative of wet weather events. Further, results are possibly an underestimation of the amount of litter entering Stony Creek, as surveys were conducted during COVID-19 restrictions which may have resulted in fewer visitations to the creek and less activity in commercial and industrial areas that produce litter. That said, key litter types contributing to litter in and along the creek included soft plastics, food related packaging, expanded polystyrene and cigarette related items.

Two main mechanisms were identified as being responsible for litter delivery to Stony Creek: direct and indirect littering or dumping, and downstream transport and accumulation. Littering and dumping was mostly associated with dry weather conditions, while downstream transport and accumulation was associated with rainfall, occurring extensively at the bottom of the catchment and via the stormwater network. The dominant litter types delivered via littering or dumping, which included soft and hard plastics and food related packaging, differed to that entering Stony Creek via downstream transport and accumulation which was most distinctly related to the occurrence of cigarettes, polystyrene, and organic matter.

While litter occurred across all sampling sites, there were several locations where greater accumulation occurred. Most littered sites included Thomas Street and Yarraville MD and Mathews Hill Reserve, followed by Paramount Road, Sara Grove and Tottenham MD, and Benbow St and the Francis St MD.

To understand which litter items are of higher priority to target in management actions, an examination of the risk litter poses to Stony Creek was undertaken by assessing how different litter types are expected to

impact on the social and environmental values and assets of Stony Creek. Items posing greatest risk to values and assets of Stony Creek included soft plastics, expanded polystyrene, organic matter, and food wrappers. These items significantly reduce amenity, pose higher risk of physical or habitat impacts for vegetation, birds and fish, and are more likely to block assets.

Seven key recommendations and twenty-eight actions were identified for further consideration and feasibility assessments to improve the litter situation in Stony Creek. The recommendations and actions are founded on six main mechanisms of delivery being education and awareness, infrastructure and services, enforcement and regulation, improved knowledge, partnerships and capacity building, clean-up activities and focused on achieving six objectives, including to:

1. Reduce soft plastics in Stony Creek
2. Reduce cigarette butts in the catchment and Stony Creek
3. Reduce food related litter in the catchment and Stony creek
4. Improve management of EPS at source to reduce inputs to Stony Creek
5. Reduce organic matter inputs to Stony Creek
6. Reduce illegal dumping in the catchment, especially along Stony Creek

Further they are focused on managing litter at hot spot sites and targeting those items posing greatest risk to values and assets of Stony Creek. The specific recommendations and actions include:

Recommendation 1:* *Increase education and awareness of the litter issues in the catchment

1.1 Review current awareness materials in the catchment and revise and implement most appropriate and effective
1.2 Understand current behaviour of businesses and traders regarding litter management and the reporting of litter management issues and identify areas to improve.
1.3 Develop targeted education and behaviour change programs that provide positive and consistent messaging focused on reducing key litter types in Stony Creek
1.4 Develop campaigns that raise awareness of the penalties of illegal dumping and littering
1.5 Educate local schools about litter programs they can get involved in

Recommendation 2:* *Review and expand infrastructure and services within the catchment

2.1 Review and audit current bin infrastructure to ensure it meets community needs, including general waste and recycling bins.
2.2 Provide cigarette bins in hot spot areas
2.3 Review and improve the street sweeping schedules.
2.4 Audit the coverage of grated side entry pits
2.5 Investigate the provision of ‘waste disposal passes’ to residents
2.6 Assess options and feasibility for a litter trap at Thomas St and/or Matthews Hill Reserve.

Recommendation 3:* *Assess current litter management by businesses and effectively enforce and regulate litter and illegal dumping law

3.1 Encourage the reporting of litterers to the EPA
3.2 Provide surveillance at illegal dumping hot spots.
3.3 Audit and enforce commercial area litter management
3.4 Identify and audit litter management by businesses that deal with soft plastics and EPS packaging
3.5 Audit cigarette management at commercial and industrial businesses
3.6 Publicise littering and illegal dumping enforcement activities and outcomes.

Recommendation 4:* *Continue to improve knowledge through co-ordinated research and monitoring

4.1 Agree on a consistent methodology for the recording of litter type and volume across agencies and community groups
4.2 Provide training and support to groups undertaking litter clean-ups

4.3 Undertake litter audits at set sites to develop baseline data and to identify litter generation areas within the catchment.
4.4 Record data on illegal dumping in DumpIn data or a centralised database

Recommendation 5: ***Foster effective partnerships to build capacity within the community, government, and industry***

5.1 Partner with education sector (primary, secondary and tertiary) and others
5.2 Partner with local organisations and industry to raise awareness of EPS and soft plastics issues
5.3 Partner with local business such as fast-food outlets to raise awareness about litter
5.4 Recognise efforts through awards and promotion of activities

Recommendation 6: ***Support coordinated clean-up activities to remove litter and illegally dumped items through on ground actions, including collection of data***

6.1 Increase engagement, support and coordination with community groups to undertake litter removal activities.
6.2 Remove illegally dumped items, following investigation, to discourage further illegal dumping.
6.3 Maintain current clean-up activities for protection of assets

Recommendation 7: ***Establish a MERI plan to monitor and evaluate progress towards reducing litter across stony creek***

1. Introduction

The Aquatic Environmental Stress Research Group (AQUEST) were engaged by Melbourne Water to conduct a strategic litter investigation across the entire Stony Creek catchment. The project aimed to identify the types and sources of litter in the catchment and identify and prioritise recommendations for the management of litter across the catchment.

1.1. Project drivers

In 2018, a Tottenham warehouse storing unregistered containers of toxic chemical waste caught fire. Firewater runoff containing chemical waste was washed into Stony Creek, decimating plant and animal life. Substantial remediation efforts were required to remove contaminated sediment and water from the catchment and make the area safe for users. To address the lasting environmental damage caused by the warehouse fire, Melbourne Water partnered with the Environment Protection Authority Victoria, Maribyrnong City Council and the local community to develop the Stony Creek Rehabilitation Plan 2019 – 2029. The Plan contains stakeholder-identified restoration goals for the Stony Creek catchment and the actions to be implemented to achieve these goals. Action WQ9 of the Plan is to improve litter management, specifically to 'Place litter traps in appropriate places throughout the Stony Creek catchment'. This project has been commissioned to improve litter management under Action WQ9 of the Rehabilitation Plan.

1.2. Scope of the study

This project investigates litter across the entire Stony Creek catchment. The project aimed to understand the litter problem in the catchment and identify how to effectively tackle it across different stakeholder needs.

The specific objectives of the project were to:

1. Describe the current state of litter in the catchment, by:
    - Identifying the existing stormwater network assets
    - Identifying current litter management measures
    - Assessing how litter affects the catchment values, and
    - Locating litter hotspots.
2. Characterise litter and determine its primary sources via litter counts and observations using methods developed under the Aquatic Pollution Prevention Partnership (A3P) (a research partnership between Melbourne Water and AQUEST @ RMIT) Project F5.1 *Understanding the impact of litter, including microplastics, on the social and ecological values of waterways and bays*.
3. Create a high-level decision framework to prioritise risks and propose management options.

Objective 1 was outlined in the Catchment Background report, see Trestrail *et al.* (2020). This report focuses on objectives 2 and 3 and outlines the targeted litter monitoring program outcomes, risk prioritisation and recommendations around management options.

Definitions

For this project litter is defined as per the Environmental Protection Authority (Victoria) definition:
litter *includes any solid or liquid domestic or commercial waste, refuse, debris or rubbish and, without limiting the generality of the above, includes any waste glass, metal, plastic, paper, fabric, wood, food, soil, sand, concrete or rocks, abandoned vehicles, abandoned vehicle parts and garden remnants and clippings, but does not include any gases, dust or smoke or any waste that is produced or emitted during, or as a result of, any of the normal operations of the mining, building or manufacturing industry or of any primary industry.*

Note, while waste produced during building is not included as litter under the definition above, for this project any building debris that escapes from a construction site and is mobile in the landscape was considered a form of litter.

2. Background

The Stony Creek catchment is one of ten sub-catchments in the Maribyrnong Catchment of Melbourne. The creek originates in St Albans and flows in a south-easterly direction through Sunshine, Tottenham, West Footscray, Kingsville and Yarraville before emptying into the Yarra River estuary at Spotswood, under the West Gate Bridge (Figure 1). At its confluence with the Yarra River, the creek forms a backwash and estuary.

The catchment has been extensively urbanised. Several areas were used as (now defunct) bluestone quarries, and significant portions of the catchment are now used for residential and industrial purposes. The Stony Creek estuary has been stabilised with silt and sand to limit erosion and prevent flooding of the nearby industrial areas (Melbourne Water, 2018, p.4). The creek itself has also been significantly altered over time, and now flows mostly in either a modified natural channel or a concrete-lined channel (Melbourne Water, 2018). The creek has been diverted underground for most of its length through Sunshine, starting at Duke Street and emerging above ground at Matthew's Hill Reserve.

Stony Creek catchment has a long history of chemical and litter pollution. One of the largest pollution events, and perhaps the most publicised, occurred in 2018 with the Tottenham warehouse fire. This incident contaminated the catchment land and waters with chemical waste and decimated the plant and animal life. In contrast to chemical pollution, litter receives less media attention but is nevertheless a significant concern for users of the catchment.

Despite urbanisation and continued pollution problems, Stony Creek catchment is prized by the local community as a unique place to experience nature and connect with others. The community-driven, long-term vision for rehabilitation of the catchment seeks to address the ongoing litter problem (Action WQ9; Melbourne Water, 2019b).

A desktop investigation into the current state of litter in the Stony Creek catchment (see Trestrial *et al.* 2020) detailed what we know about litter in the Stony Creek catchment, including litter sources, "hot spots", current management and possible access points to enable management. This work was also presented in two public webinars.

To fully understand the state of the litter problem in Stony Creek, characterise the litter occurring, determine its primary source/s, and prioritise management actions, in field assessments of litter on creek banks and from storm drains were needed. This report outlines the findings of targeted litter surveys of creek banks and storm drains and provides a high-level decision framework to prioritise risks and management options.

The data collected from targeted monitoring will allow determination of:

- Litter sources to Stony Creek
- Any hot spots for litter in Stony Creek
- The major types of litter occurring in Stony Creek
- Whether litter poses threats to values and services

3. Methods

Targeted litter surveys were conducted to assess the contribution of litter from urban runoff through the stormwater system and from more localised catchment activities through bank surveys. Details of the monitoring methods for both approaches are outlined further below.

Rainfall data for the periods of each of the monitoring programs was obtained from Melbourne Waters rainfall and river levels website: https://www.melbournewater.com.au/water-data-and-education/rainfall-and-river-levels#/reader/230112A.

3.1. Stormwater Drain Surveys

A spatial and temporal assessment of litter entering Stony Creek from the stormwater network was undertaken. There are six larger stormwater outlets, managed by Melbourne Water, entering Stony Creek and over 55 council managed stormwater drain outlets. Sampling focused on 5 main drain outlets managed by Melbourne Water and a council drain (Cala St; See Figure 1 and Table 1). Nets (0.5x 0.5m opening, 1.2m length, 0.2cm mesh) were deployed at the opening of each drain and set to capture any litter that would wash out to the creek. Nets were deployed at the drains on week 1 and then cleared on a weekly basis for a period of 6 weeks between 11th February 2021 and 24th March 2021.

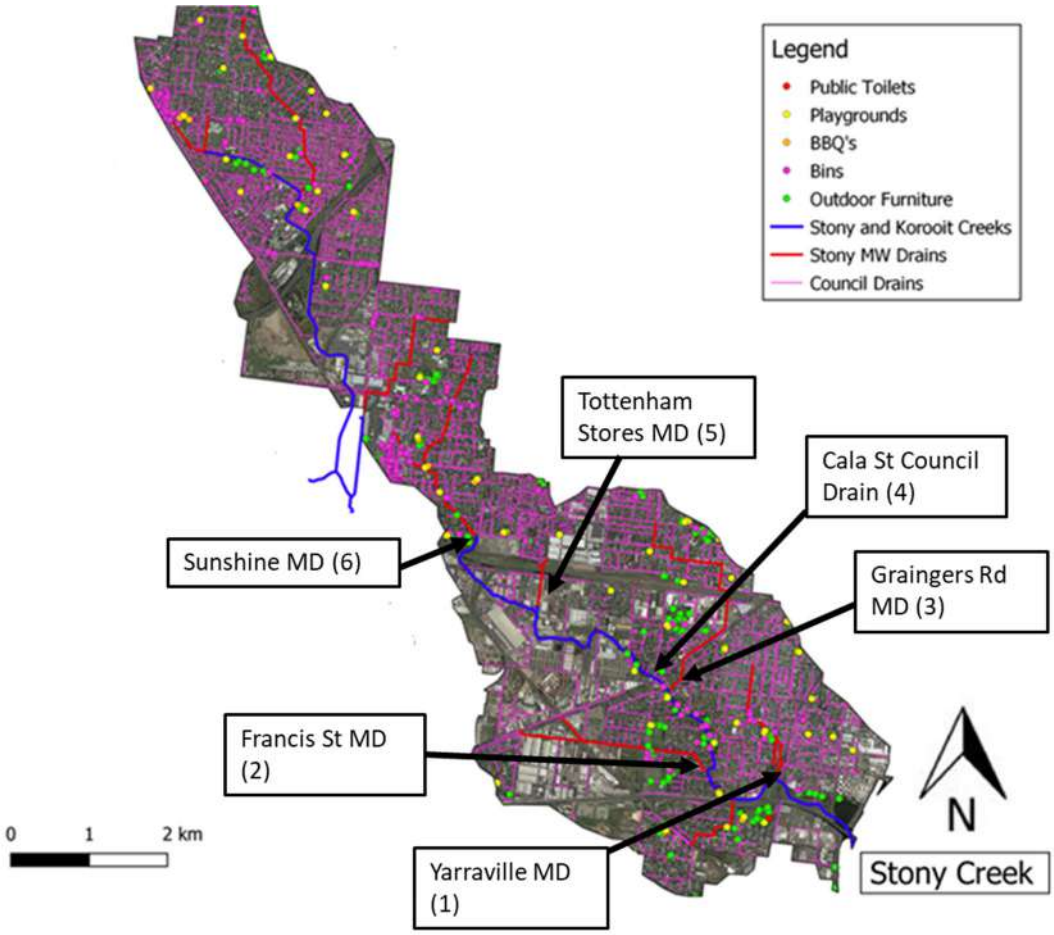

Figure 1: Stormwater Drains surveyed during the study.

Table 1: Site locations for drain surveys

Drain Number	Drain Name	Catchment area (km²*)
1	Yarraville MD	2.35
2	Francis St MD	4.28
3	Graingers Rd MD	2.49
4	Cala St Council Drain	0.96
5	Tottenham Stores MD	1.49
6	Sunshine MD	1.34

*Data supplied by Jesse Barrett Melbourne Water

3.2. Bank Surveys

A spatial and temporal assessment was conducted to assess litter accumulation and types along the banks of Stony Creek. Eight sites situated along the creek from Matthews Hill Reserve in the upper catchment (Brimbank City Council municipality), down to Yarraville Golf course at Thomas Street in the lower catchment (Hobsons Bay Council municipality) were surveyed weekly for a period of 4 weeks from 16th November 2020 to 9th December 2020. It's important to note that week 1 results are a culmination of litter accumulated at the site prior to the four-week sampling regime, while weeks 2-4 represent litter accumulated over the week between sampling. Sampling sites are shown in Figure 2 and Table 2. Surveys were conducted by Work for Victoria Crews following a training session with A3P researchers in the survey methods.

Survey methodology followed that outlined in Melbourne Water litter standard operating procedure Bank Surveys Rapid Method (Mondschein, 2020). In short, all litter is collected from within 5 transects situated at 10m intervals along the creek bank. Transects run from the waters' edge to 2m beyond the dominant debris line, the line marking the landward limit of debris deposits resulting from the upper reaches of water during flooding and are 4m wide (See Figure 3 for a representation of the method laid on a bank).

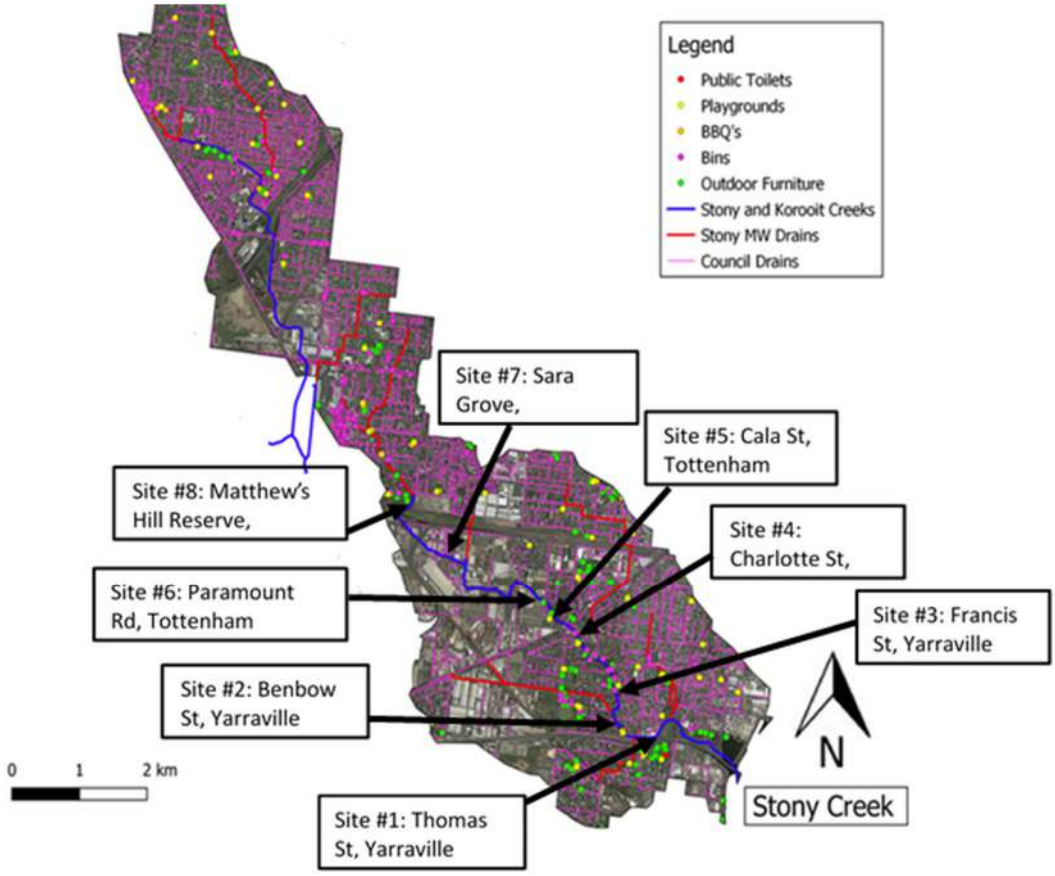

Figure 2 : Site locations for bank surveys

Table 2: Site locations for bank surveys

Site Number	Location	General Catchment Description
1	Thomas St, Yarraville	Sampling undertaken at the end of the concrete channel, where channel is naturalised.
2	Benbow St, Yarraville	Sampling undertaken directly downstream of the Benbow St bridge within the concrete channel.
3	Francis St, Yarraville	Sampling undertaken at the bottom of Cruikshank Park just before the start of the concrete channel.
4	Charlotte St, Yarraville	Sampling undertaken at the top of Cruikshank Park just upstream of Graingers Rd MD outlet, but below Somerville Rd.
5	Cala St, Tottenham	Sampling undertaken directly downstream of Cala St drain outlet.
6	Paramount Rd, Tottenham	Sampling undertaken directly downstream of the bridge over Somerville Rd.
7	Sara Grove, Tottenham	Sampling was conducted at the end of Sara Grove.
8	Matthews Hill Reserve, Sunshine	Top of catchment site, with sampling conducted directly below Sunshine MD outlet.

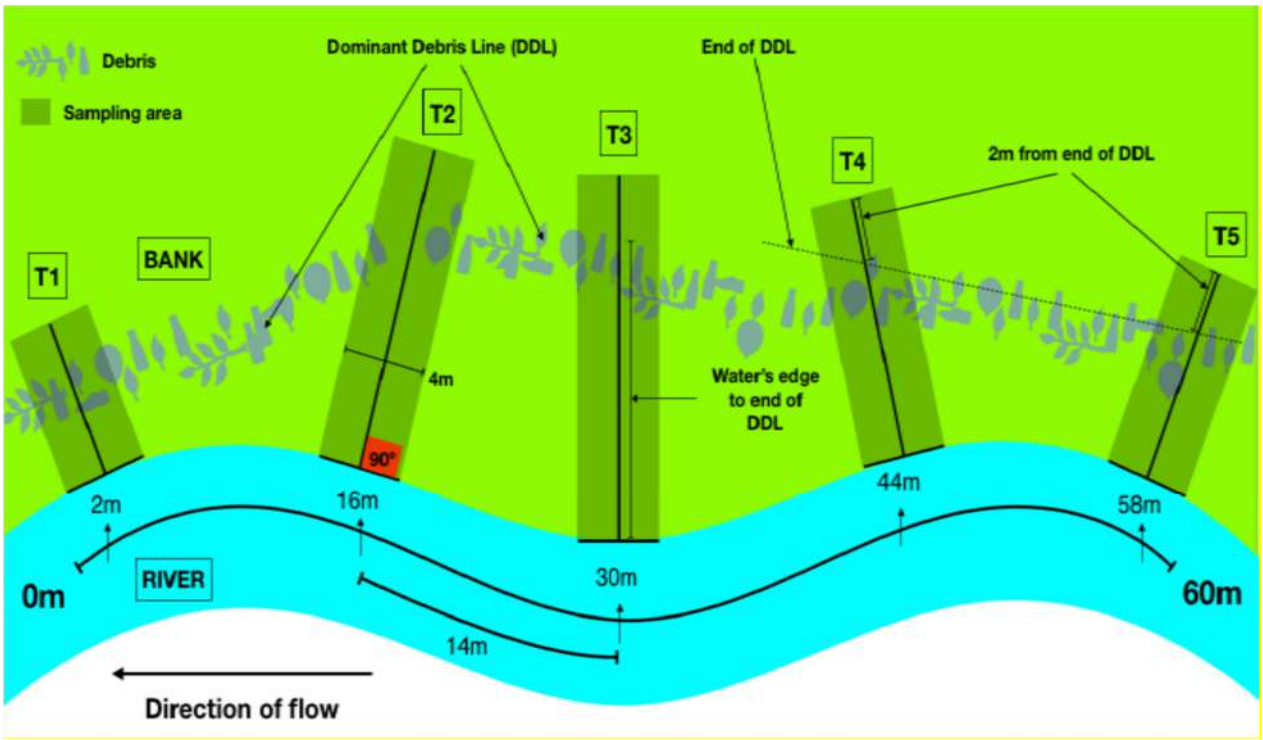

Figure 3: Schematic of the rapid bank survey method.

3.3. Litter classification

Litter was classified on site using the DEWLP (2019) classification system. This classification system comprises a two-level hierarchy that identifies firstly by material composition, (e.g. plastics, glass, metal etc) and then by form (e.g. bottle >2L, bags). There are 5 overarching litter categories: plastics, expanded polystyrene, glass, metal and other (e.g. mixed materials, ceramics, cloth, paper/cardboard, rubber, wood, organics); followed by 236 discrete types of litter. Litter was sorted first by material composition, then items counted, weighed, and recorded by form in the discrete categories.

3.4. Limitations

The survey method captures data on litter collected from within the transects or nets. Litter that does not reside within the transects for bank surveys or nets for drain surveys is noted if it is excessive or appears to be dumped, however is not counted in tallies. This may underestimate condition of sites such as Quarry Rd where illegal dumping of rubbish occurs at the end of the street but is not within the survey areas close to banks. There are also various activities occurring across the catchment involving the picking up of litter which could influence monitoring results. For the bank surveys, litter collected on week 1 represents that accumulated over an unknown time, while weeks 2-3 represent litter accumulated weekly. Week 1 results are not used in determination of litter deposition rates.

4. Results

4.1. Stormwater Drain Surveys

4.1.1. Rainfall during survey period

Rainfall during the stormwater drain survey period is shown in Figure 4. During weeks 1 -4 small rainfall events occurred with total rainfall ranging 1.4-4.8 mm. During weeks 5 and 6 two significant storm events occurred resulting in total rainfall of 12 and 17 mm in each week respectively (Figure 4). This indicates that flow in Stony Creek during the first 4 weeks of sampling is representative of dry weather flows, while weeks 5 and 6 are representative of storm event flows (Figure 4).

Figure 4: Cumulative (blue line) and total rainfall at Spotswood during storm drain surveys.

4.1.2. Survey results

4.1.2.1. Litter captured

Thirty-six samples were collected from the six stormwater drains (6 samples per drain). Litter captured weekly from the six drains is shown in Figure 5, while total litter captured from each drain is shown in Figure 6 and Table 3. Litter loads over the sampling period varied for each drain (Figure 5). Highest litter loads were documented during Week 1 at Yarraville MD (214 items), whilst lowest litter loads were observed in Weeks 2-4 at the Cala St council drain (1 and 0 items respectively) and Week 5 in the Tottenham MD (0 items) (Figure 5). There was no relationship between litter loads and rainfall in the catchment (Pearson correlation $P>0.05$; Figure 5).

Assessing overall litter captured during the study period, the highest litter loads (by number of items) were documented in Yarraville MD with 301 items, which was predominantly due to the large number of litter

items captured in Week 1 (Figure 6), with Week's 2-6 only contributing a total of 87 litter items. Francis St MD and Tottenham MD recorded the next highest litter loads with 263 and 189 litter items documented respectively, whilst lowest litter loads were observed in Sunshine with a total of 56 items documented (Figure 6, Table 3). The catchment area for each drain ranged from 0.96 km^2 (Cala St Council Drain) to 4.28 km^2 (Francis St MD), however there was no relationship between catchment size and the litter loads based on weight or number of litter items (Pearson Correlation P>0.05; Table 3).

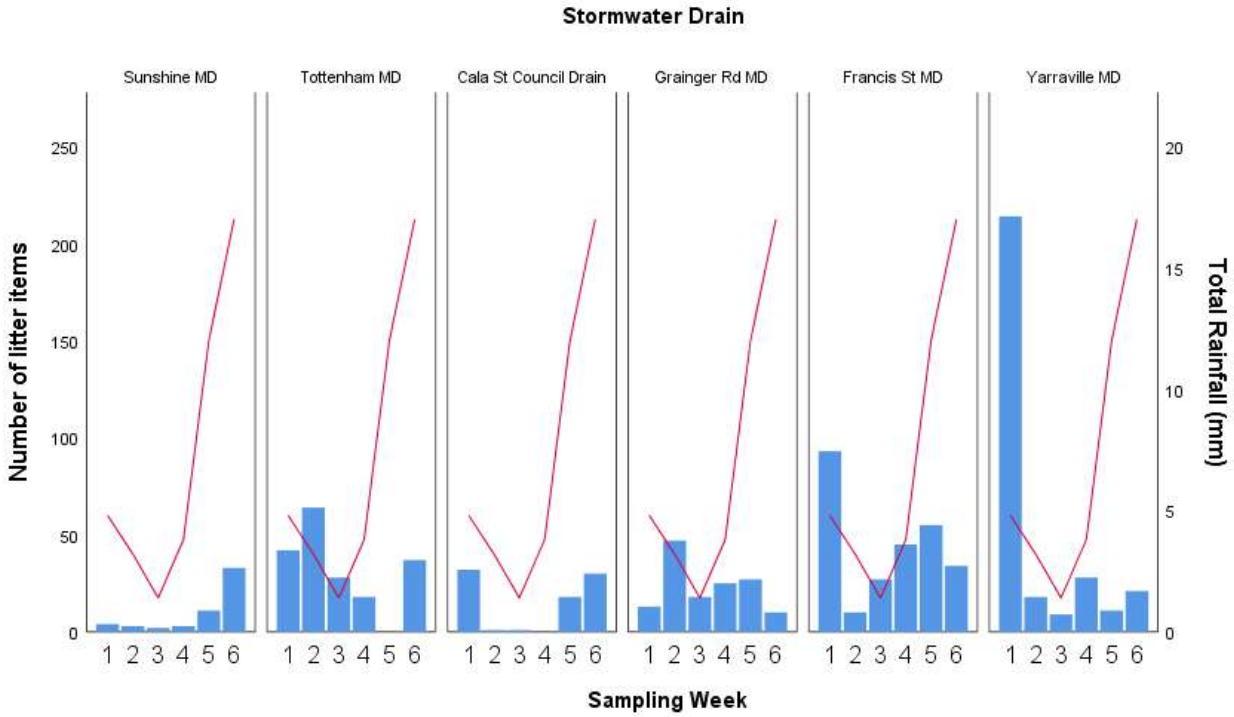

Figure 5: Weekly counts of litter items captured in nets deployed in stormwater drains discharging to Stony Creek (Blue bars) and weekly total rainfall measured at Spotswood (red line).

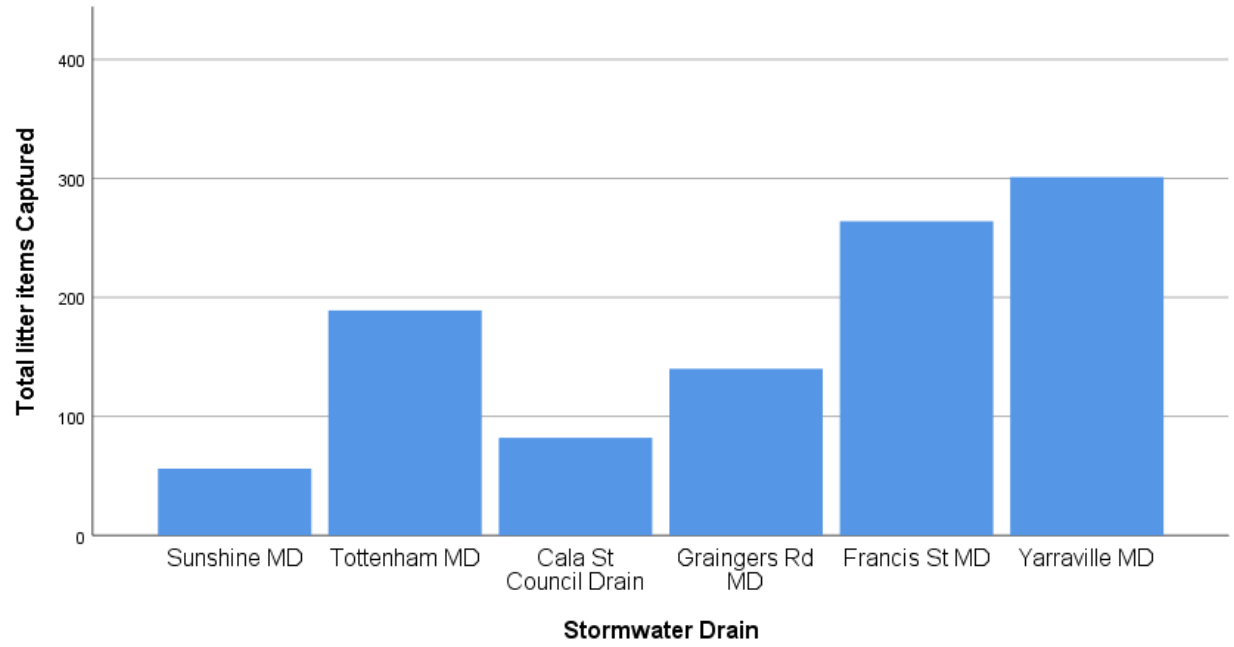

Figure 6: Total number of litter items captured in nets deployed over 6 weeks in stormwater drains discharging to Stony Creek.

Table 3: Total litter items captured by weight and number of items and drain catchment area.

Stormwater Drain	Catchment size (Km^2)	Total litter captured	
		Items	Weight (Kg)*
Cala St Council Drain	0.96	82	0.37
Sunshine MD	1.34	56	0.44
Tottenham MD	1.49	189	0.39
Yarraville MD	2.35	301	0.34
Graingers Rd MD	2.49	140	2.18
Francis St MD	4.28	263	1.50

*Weight may exclude very light items that are below the limit of detection for the scales.

4.1.2.2. Litter deposition rates

The monitoring design provided the opportunity to estimate litter deposition rates as litter was removed from nets during each site visit. Average rates of deposition (litter pieces per drain per day) were calculated for each site and are shown in Figure 7. Overall, the average litter deposition rate was 4.1 pieces of litter per drain per day. Deposition rates were lowest in drains discharging to Stony Creek in the most upstream reaches of the study area, generally below an average of 2 pieces of litter per day, except for Tottenham MD which averaged 4.5 litter items per day (Figure 7). Highest measured deposition rates were observed for the two drains that discharge in the most downstream reaches of the study area, Francis St MD and Yarraville MD with average rates of 6.3 and 7.2 items per day respectively (Figure 7). Of note is the high variability in deposition rates for the Yarraville MD, which is due to the large number of items captured during Week 1 sampling. With Week 1 rates removed the average deposition rate at this site is 2.5 items per day.

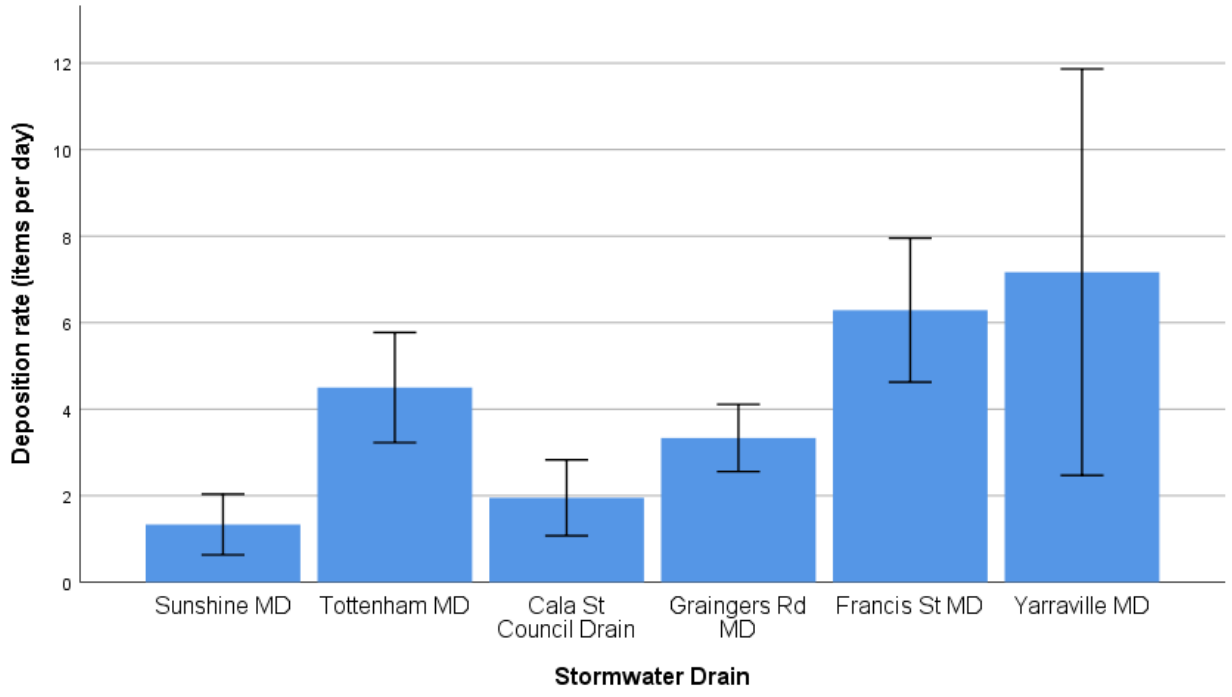

Figure 7: Mean deposition rates (items per day) for litter entering Stony Creek from stormwater drains. N=6

4.1.2.3. Litter composition

Figure 8 shows the breakdown of litter (by number of items) captured during the six sampling events in each stormwater drain. Litter composition varied between drains, with soft plastics contributing greatest to loads (28% to 39.3%) for all drains except for Yarraville MD, where Expanded Polystyrene (EPS) contributed 78.1% of total litter load (Figure 8). The second highest categories contributing to total litter loads were either EPS, food related packaging or cigarettes (Figure 8). For instance, in Graingers Rd MD and Francis St MD, EPS contributed 22% and 24% respectively, followed by food related packing and cigarettes (11% each in Graingers Rd MD and 13% and 5% in Francis St MD, respectively). While for Cala St Council drain and Tottenham MD cigarettes were the second highest contributors to litter loads (23% and 27% respectively), followed by food related packaging (18% and 10% respectively) and EPS (13% and 14% respectively) (Figure 8). In Sunshine MD food related packaging was the second biggest contributor to litter loads (18%) followed by EPS (11%) (Figure 8).

The remaining litter categories contributed <10% to total litter loads. For instance, plastic bags were captured in all drains, but only comprised of 0.7-7% total loads. The "Other Plastics" category included plastic items such as hard plastics, non-food wraps and packaging, gloves and other plastic items that did not fit in the other categories and contributed between 3% and 9% total litter load. Paper items including paper cups, paper food related packaging and paper sheets contributed 9% in Tottenham MD, and <4% in Graingers Rd MD, Francis St MD, and Yarraville MD. Heavier items such as glass and metal made up a small amount of the total litter loads (<6%) in all drains, except Sunshine MD where they were not present at all. Similarly, the "Other" category included items such as building rubble, clothing, rubber balls, wooden material and items not classified elsewhere contributed <4% in all drains, other than Sunshine MD where again they contributed zero to litter loads (Figure 8). Additional characterization data is available in Appendix A.

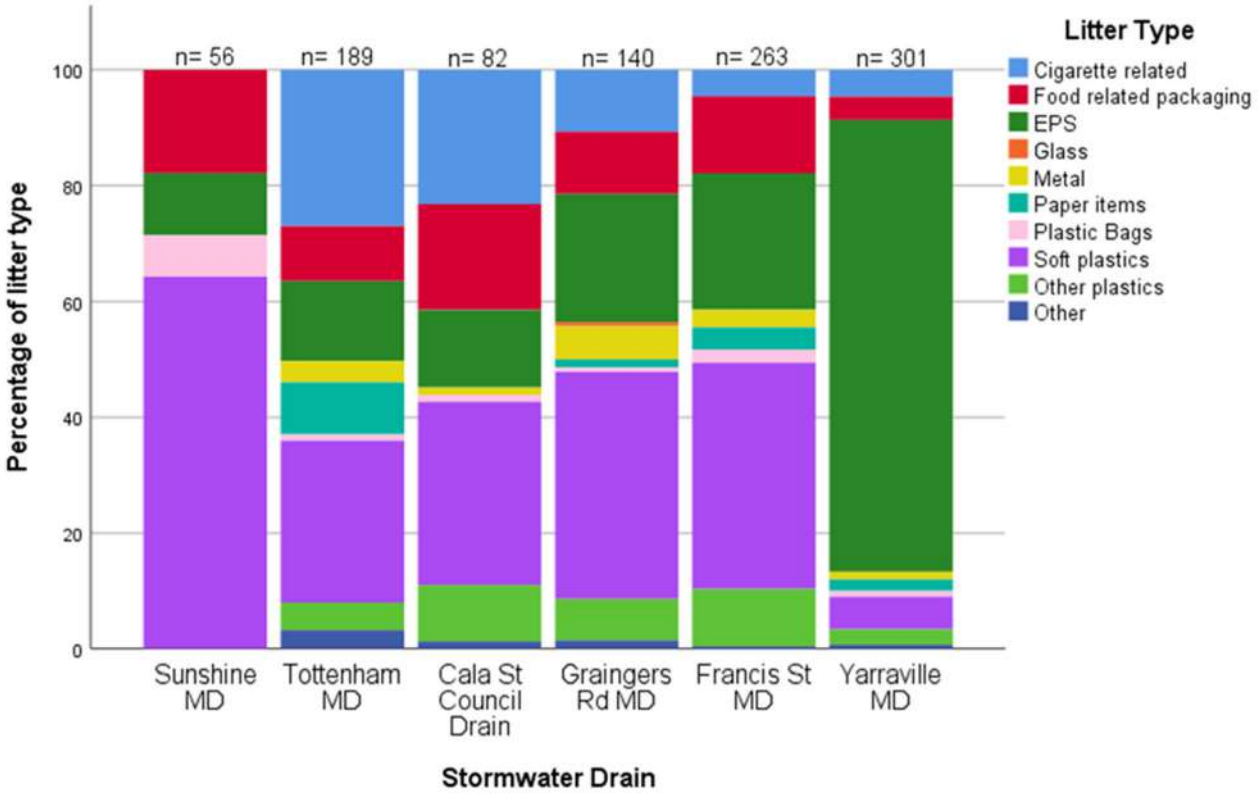

Figure 8: Mean composition of litter captured in stormwater drains discharging to Stony Creek.

4.1.2.4. Organic debris versus litter

The breakdown of material (by weight) collected during the six sampling events in each stormwater drain is shown in Figure 9. Total organic debris captured varied across drains, ranging from 0.6 Kg at Sunshine MD to 14.4 Kg at Francis St MD, while the litter component captured weighed between 0.3 and 2.2 kg (Figure 9a). The bottom graph in Figure 9 shows the percent composition of organic debris and litter in the stormwater drains. This breakdown of the data shows that in most drains <9.5% (by weight) of all the material that was collected was litter, with the remaining material being organic debris (mostly leaves garden clippings and sticks). The exceptions were Graingers Rd MD and Sunshine MD were litter made up 22% and 42% of captured material and 78% and 58% was organic debris, respectively (Figure 9 bottom graph).

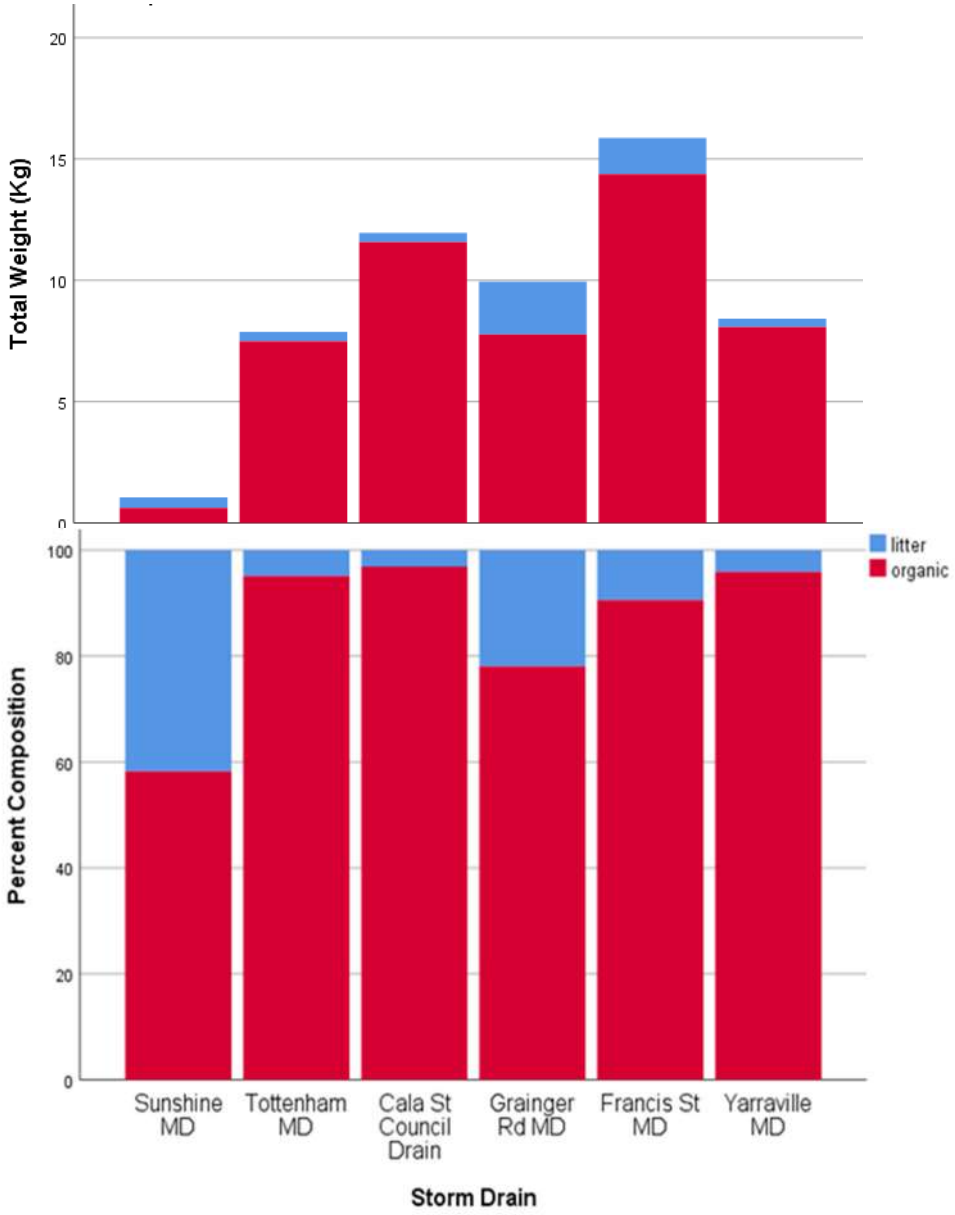

Figure 9: Total weight (Kg) (top graph) and composition (bottom graph) of organic debris and litter captured in stormwater drains discharging to Stony Creek.

4.2. Bank Surveys

4.2.1. Rainfall

Rainfall occurring during the bank survey period is shown in Figure 10. Generally, rainfall over the survey period was low (<6mm) except for week 2 where a significant rain event occurred late in the week (38.8 mm; Figure 10). This indicates that sampling during weeks 1, 3 and 4 is representative of dry weather flows, while sampling during week 2 is representative of storm event flows (Figure 10).

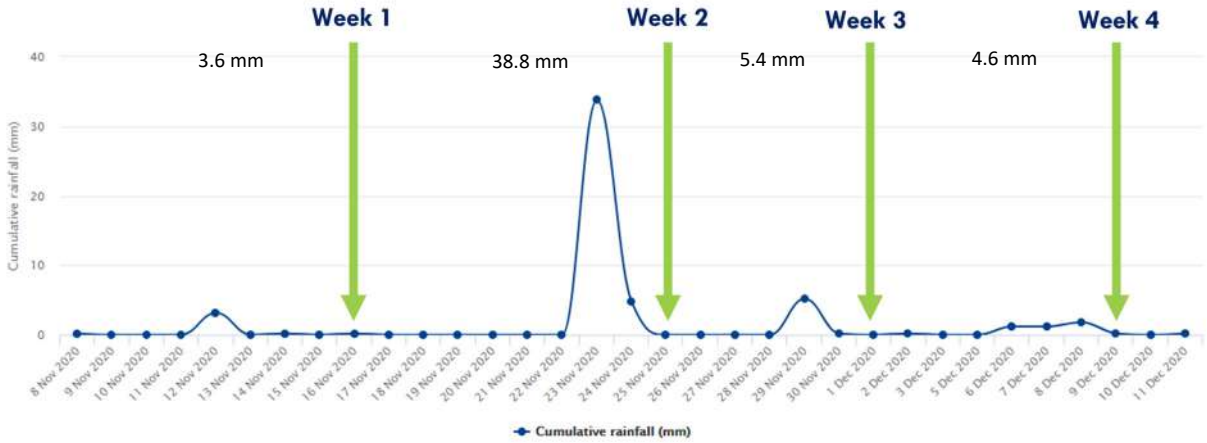

Figure 10: Cumulative and total rainfall at Spotswood during Bank Surveys.

4.2.2. Survey results

4.2.2.1. Litter captured

Litter captured weekly from the eight banks sites is shown in Figure 11, while total litter captured from each site is shown in Figure 12.

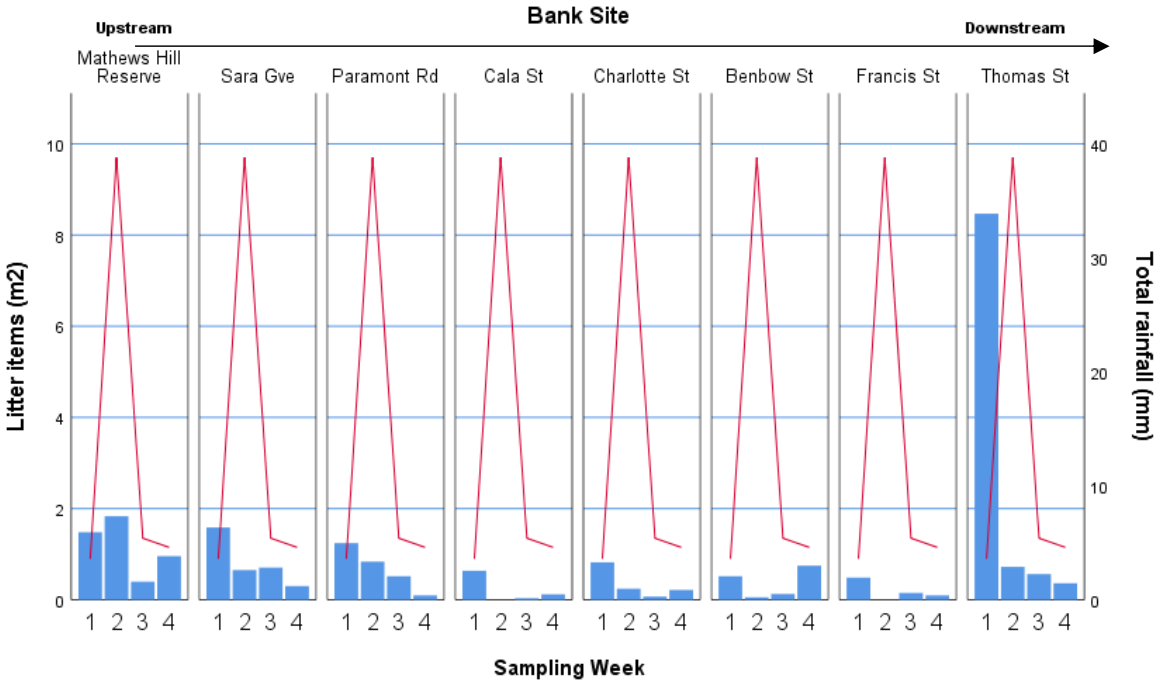

Figure 11: Weekly counts of litter items (m^2) collected from bank sites along Stony Creek (blue bars) and weekly total rainfall measured at Spotswood (red line). Note: Weeks 2-4 represent litter accumulated weekly, while week 1 represents litter present prior to the commencement of the surveys.

The amount of litter items collected showed no relationship with rainfall in the catchment (Pearson correlation P>0.05). Rather, the highest amounts of litter were generally collected in Week 1 sampling across all sites, thereafter the number of litter items collected tended to decrease across the following sampling weeks (Figure 11). The exceptions were Mathews Hill Reserve and Benbow St, where highest amounts of litter were collected in Weeks 2 and 4 respectively (Figure 11).

The most downstream bank site, Thomas St, had the highest litter levels (>10 items/m^2), followed by the most upstream site, Mathews Hill Reserve (>4 items/m^2), then Sara Grove and Paramount Road with just over 2.5 items/m^2. Lowest litter levels were observed at sites in the middle of the studied area (Cala St to Benbow St) with <1.5 items/m^2 (Figure 12).

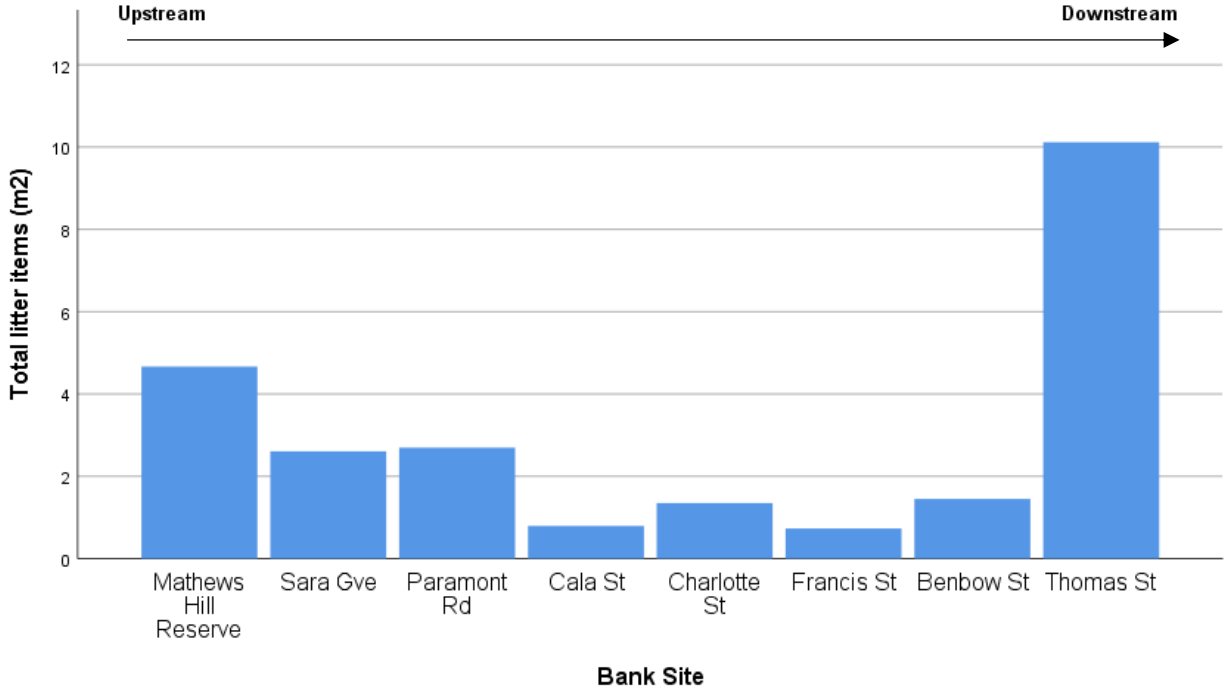

Figure 12: Total number of litter items (m^2) collected from bank sites along Stony Creek.

4.2.2.2. Litter deposition rates

The monitoring design provided the opportunity to estimate litter deposition rates as litter was removed from banks during each site visit. There was a total of 24 site visits (3 per site) that could be used to calculate deposition rates. A rate of deposition (pieces per day) was calculated for all sites and are shown in Figure 13. Overall, the average litter deposition rate was 0.06 pieces of litter per m^2/day.

Deposition rates were lowest at bank sites in the middle of the study area, from Cala St to Francis St, where <0.03 litter items were deposited per day / m^2 (Figure 13). Highest measured deposition rates were observed at Mathews Hill Reserve, followed by Thomas St and Paramount Rd, with average rates of 0.15, 0.08 and 0.07 items per day / m^2 respectively (Figure 13). At Sara Grove and Benbow St, average litter deposition rates were 0.04 items per day / m^2 (Figure 13).

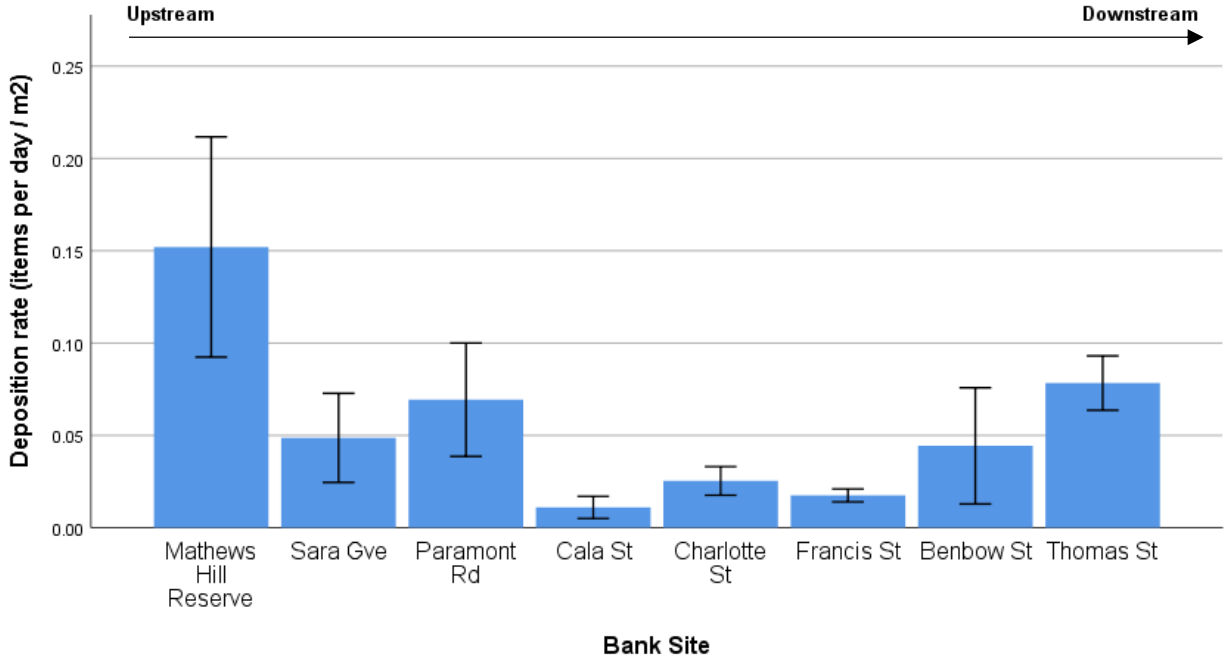

Figure 13: Mean deposition rates (items per day/m^2) for litter on banks. N=3

4.2.2.3. Litter composition

Figure 14 shows the breakdown of litter (by number of items) captured during the four sampling events at bank sites. Litter composition varied, with dominant litter types differing depending on site (Figure 14). Soft plastics contributed greatest to loads at Thomas St (60%), Charlotte St (42%), and Mathews Hill Reserve (27%) and this was generally followed by food related packaging, mostly plastic food wrappers and bottles, which contributed between 14 and 32% to loads at these sites (Figure 14). At Sara Grove soft plastics and food related packaging each contributed 41% of total litter load. While at Benbow St, Frances St, Cala St Council drain and Paramount Rd litter loads were dominated by other plastics (37%, mostly hard plastic pieces and bubble wrap), other litter (34%, pencils), and EPS (29%) respectively, with soft plastics contributing second most to litter loads at these sites (26-31%, Figure 14). Other plastics, which was mostly made up of hard plastic pieces, was generally the third greatest contributor to litter loads across sites, or paper items, which was mostly due to paper sheets and strips (Figure 14). Heavier items such as glass and metal made up a small amount of the total litter loads (<1%) at sites where they were collected. Similarly, plastic bags and cigarettes contributed <6% to total litter loads at sites where they were collected (Figure 14). Additional characterization data is available in Appendix A.

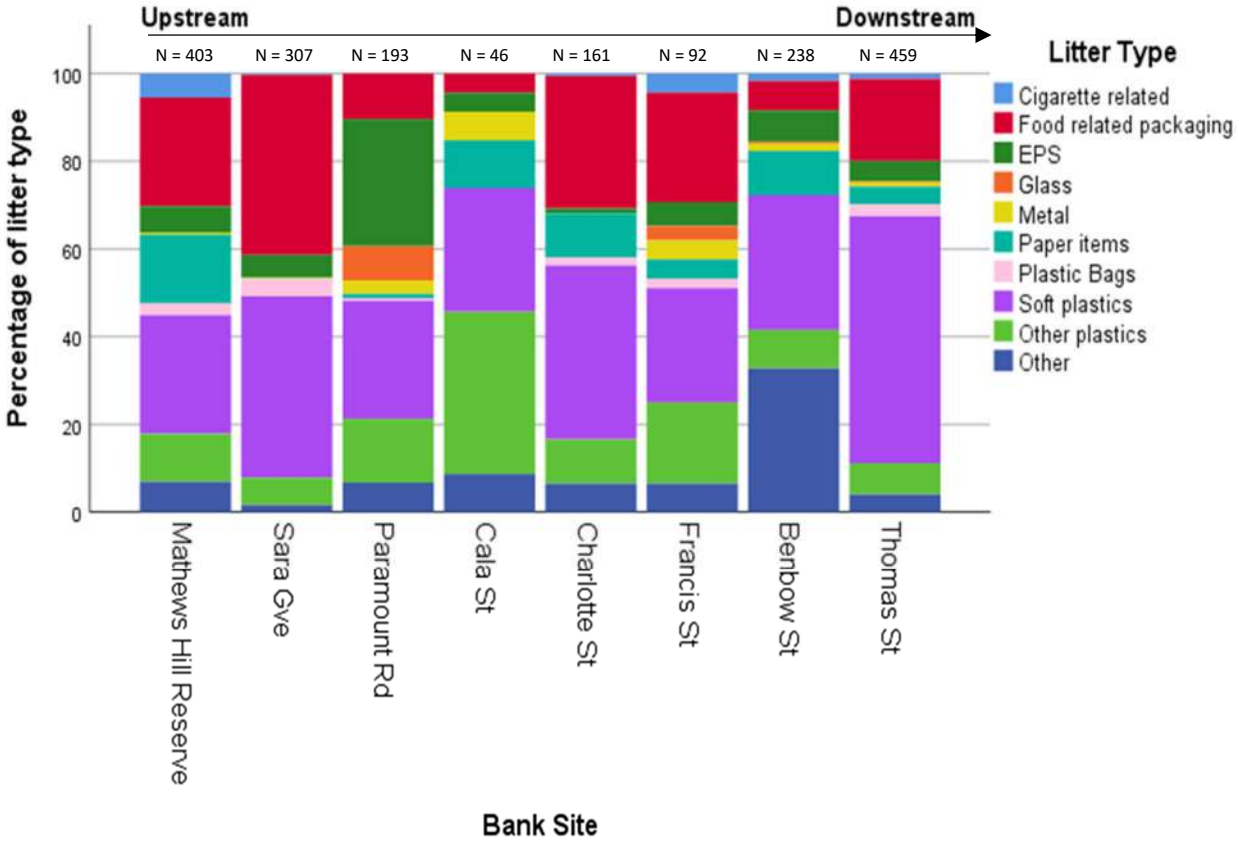

Figure 14: Mean composition of litter captured in stormwater drains discharging to Stony Creek.

4.3. Comparison of drains versus banks surveys

The breakdown of litter (by number of items) collected during the bank surveys and stormwater drain sampling events is shown in Figure 15. Soft plastics, followed by food related packaging and other plastics, which was mostly hard plastic pieces, were the dominant litter types contributing to loads on Stony Creek banks, while EPS, soft plastics, cigarette related items and food related packaging dominated the litter loads from stormwater drains (Figure 15). Heavier items such as glass and metal contributed the lowest to litter loads for both banks and stormwater drains. Remaining litter categories, which includes paper items, plastic bags and other mixed materials contributed between 2 to 9% and 1-3% for bank and stormwater drains, respectively (Figure 15).

Generally, a greater number of litter items were collected from creek banks, compared to through the stormwater drains, for each of the litter categories, with total litter collected from banks being nearly double that collected from the stormwater drains (1899 items for banks, 1031 items in storm drains; Figure 16). The exceptions were the categories of EPS and cigarette related material which were collected in much greater quantities from stormwater drains. Additional characterization data is available in Appendix A.

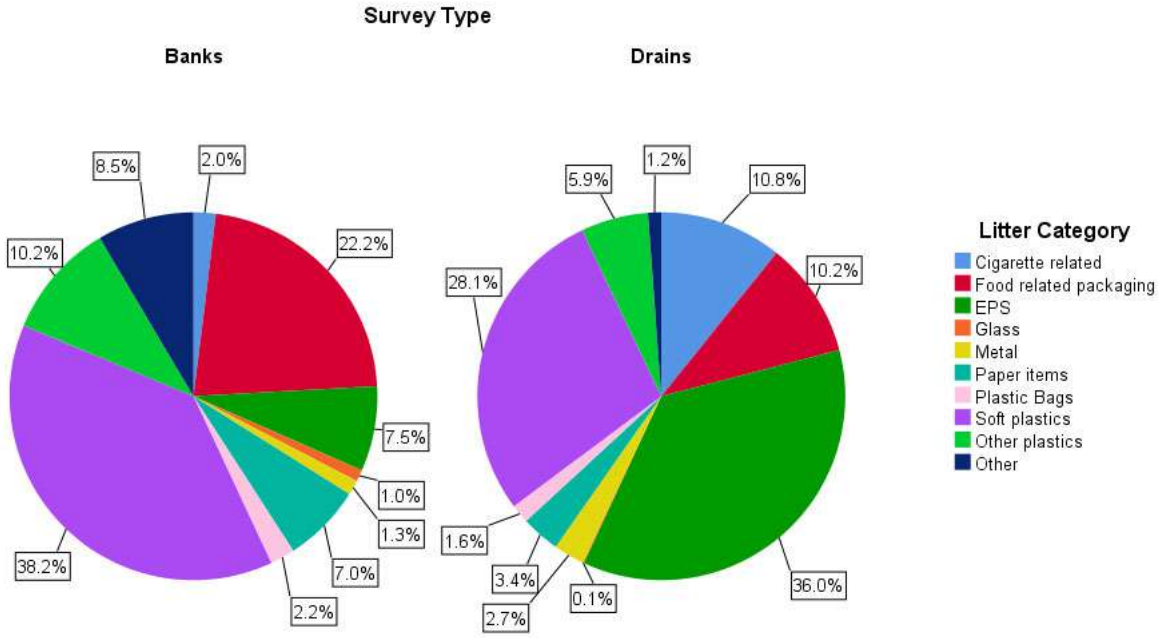

Figure 15: Contributions of different litter types in bank and stormwater drain surveys. Drains N = 1031; Banks N = 1899.

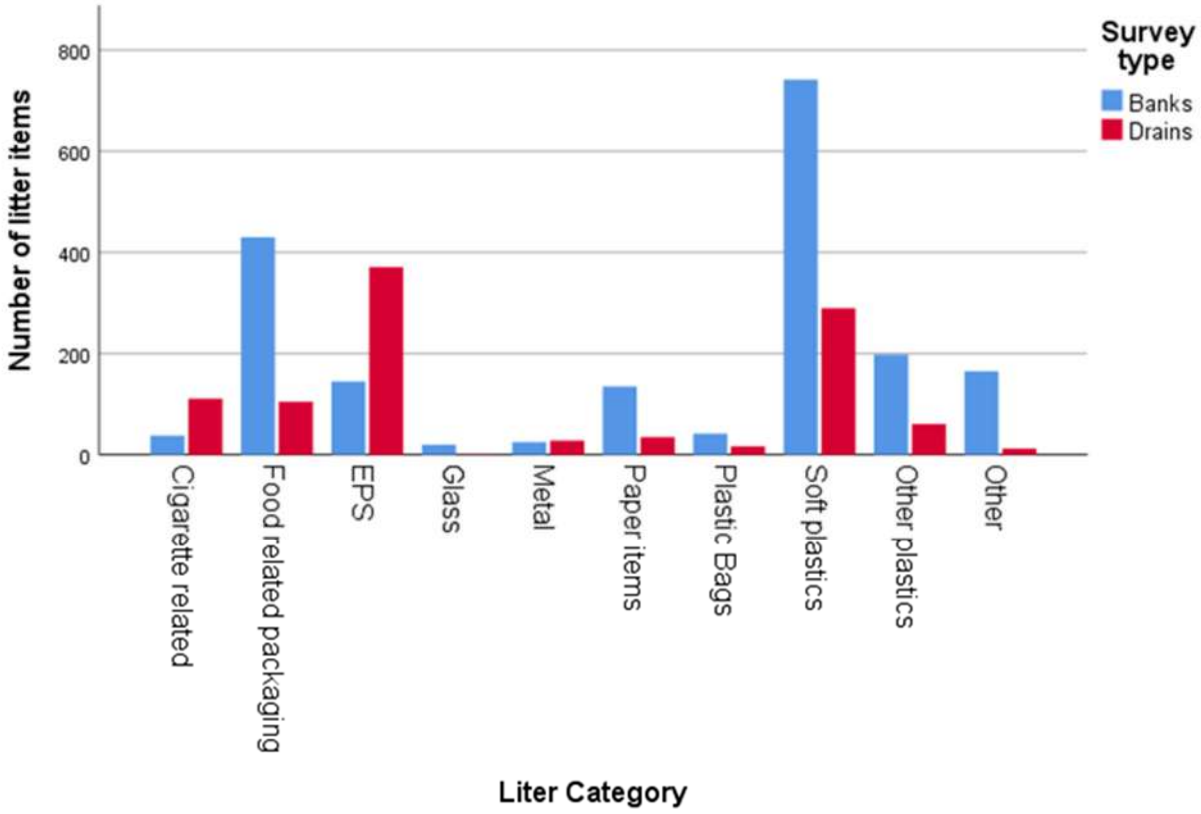

Figure 16: Number of litter items collected from banks and storm drains in the different litter categories. Drains N = 1031; Banks N = 1899.

5. Litter Types, Sources, and Hot Spots

5.1. Litter composition and sources

From the 68 site visits, a total of 3019 litter items were collected, 1988 of these were collected from along creek banks and 1031 litter items captured from the stormwater network. The litter captured during the study period is considered to generally represent that delivered to Stony Creek during dry weather, with only 3 visits considered representative of wet weather events. A second point for consideration is that the results are possibly an underestimation of the amount of litter entering Stony Creek, as surveys were conducted during COVID-19 restrictions which may have resulted in fewer visitations to the creek and less activity in commercial and industrial areas that produce litter. That said, key litter types contributing to litter in, and along the creek included soft plastics, food related packaging, expanded polystyrene and cigarette related items. These results are not dissimilar to those reported in studies on waterways within Melbourne, such as the Hoffmans Main Drain, Yarra and Maribyrnong Rivers where soft and hard plastics, food packaging, polystyrene and/or cigarettes have made up most of the litter captured (Charko *et al.*, 2020; Alluvium, 2018).

A total of 3019 litter items were collected from the banks and via the stormwater system in Stony Creek, predominantly consisting of soft plastics, food related packaging, expanded polystyrene and cigarettes.

Two main mechanisms were identified as being responsible for litter delivery to Stony Creek: ***direct and indirect littering or dumping***, and ***downstream transport and accumulation***. Littering and dumping was mostly associated with dry weather conditions, while downstream transport and accumulation was associated with rainfall, occurring extensively at the bottom of the catchment and via the stormwater network. The dominant litter types delivered via littering or dumping differed to that which enter Stony Creek through downstream transport and accumulation.

Direct and indirect littering was evident across all sites and is likely to account for most of the litter captured during bank surveys due to the limited storm events that occurred during the monitoring period. It appears to be a **major mechanism for the occurrence of soft and hard plastics** and **food related packaging** in Stony Creek. ***Downstream transport and accumulation*** was most evident at Thomas St, at the bottom of the catchment, and accounted for all litter items captured from stormwater drain outlets. It was **most distinctly related to the occurrence of cigarettes and polystyrene**; however soft plastics and food related packaging were also significant from this delivery method. However, the **largest component of litter delivered by downstream transport and accumulation was consistently organic debris**.

Soft plastics were a major contributor to litter loads in bank surveys, while being the second highest contributor to litter captured from the stormwater system. This result is supported by similar studies in Hoffmans MD where soft plastics dominated litter surveyed within the channel (Alluvium, 2018). Soft plastics are difficult to trace back to a single source, due to them most often being pieces of larger items broken down by rapid flows, snagging and weathering. Due to their light-weight nature, they can be transported via wind large distances depending on prevailing wind strength and direction in relation to the source of use. They most likely originate from direct littering and dumping on the streets, indirect littering from overflowing industrial, commercial, household, and public bins, are blown off trucks during transport, or from construction and/or demolition sites. The determination of specific sources would require further investigation within the catchment.

Food related packaging includes items such as beverage bottles, cups, lids and lid rings, straws, paper, polystyrene, metal and plastic food wrappers, pouches, containers, and packaging. Of these items, **food wrappers e.g. chip and confectionary wrappers and bottles comprised the greatest component**. One of the principal litter sources for food related packaging is likely to be people visiting the creek as a recreational area. Visitors as a principal litter source has been identified in several studies of litter in river systems (e.g. Kiessling *et al.,* 2019; Gasperi *et al.*, 2014; Rech *et al.,* 2015; McCormick and Hoellein, 2016; Carpenter and Wolverton, 2017), and some of those studies have further assessed individual litter characteristics (e.g. their weight and purpose of use) to identify which type of visitors cause most litter. For example, Kiessling *et al*., (2019) identified that visitors consuming or preparing food was the principal activity resulting in food related litter reaching the river environment. In addition, other likely sources are the discarding of food wrappers from vehicles in carparks, at public transport stops and within the industrial zones and indirect littering from overflowing skips at the back of commercial service areas, and public and residential bins in the local area. The Hoffmans MD study identified the rear of commercial premises (e.g. back alleys of shopping strips) as a significant source of litter to stormwater due to overfilling of bins and spillage from commercial litter collections (Alluvium, 2018).

Direct and indirect littering or dumping, and downstream transport and accumulation are the main mechanisms responsible for litter in Stony Creek.

Expanded polystyrene (EPS) consistently ranks as one the most common litter items collected in litter assessments and is recognised as a major waterway pollutant in metro Melbourne (Charko *et al*., 2020). EPS was a dominant litter type detected in the stormwater drain surveys and includes items such as packing beads/balls, foam sheeting, and other packaging related products, but also unidentifiable EPS remnants of polystyrene boxes and packaging from boxed goods, which are broken down by prevalent weather conditions. It was the **polystyrene remnants** that were the main contributor to this litter type. This result is consistent with litter monitoring results for Moonee Ponds Creek, Hoffmans MD, and the Yarra and Maribyrnong Rivers (Kowalczyk and Kelly, 2020; Barmand *et al.*, 2020; Alluvium 2018, Charko *et al.*, 2020; Alluvium, 2020). Sources of EPS include manufacturing and distribution facilities, commercial areas, and waste transfer and recycling facilities where it can be lost during transport or in loading bays or as it is processed (Barmand *et al.*, 2020). Tracing investigations undertaken by the Cleanwater Group and Yarra Riverkeeper Association that involved surveying 64 manufacturing and distribution facilities found that over 80% of surveyed sites had some level of polystyrene pollution somewhere around their site or in close enough proximity to be able to be attributed to their activities (Barmand *et al.*, 2020). In addition, building sites are a potential source of polystyrene pollution when using insulation waffle pods, which is a potential source of the EPS captured in Week 1 sampling of the Yarraville Main Drain.

Cigarette related items includes butts, packaging, and lighters, with cigarette butts being by far the most littered item in Victoria when measured by count, and one of the top ten most littered items in Australia (DELWP, 2017). Of the 149 cigarette related items captured in the current study, 144 were cigarette butts. Although not commonly thought of as being plastic, cigarette butts mostly consist of a type of plastic called cellulose acetate, with a thin paper coating (DELWP 2017). The primary source of cigarette related litter, especially butts, is direct littering by smokers in industrial and commercial areas, at building sites, public transport stations, and from residential areas. Industrial and commercial areas around Cala St Council Drain and in the catchment of Tottenham Main Drain appear to be significant sources, where they are likely directly littered and then washed via the stormwater network into Stony Creek. This is supported by results of the Hoffmans MD study, where cigarettes dominated litter collected in catchment and street surveys (Alluvium, 2018).

Organic debris includes twigs, leaves, sticks, food scraps, and lawn clippings which represented the largest component of loads in drain surveys. Organic debris enters predominantly via catchment runoff during storm events and is the result of direct dumping within the catchment or at the end of streets which back on to the creek (e.g. Sara Grove, Thomas St) or natural shedding of leaves and twigs from trees lining urban streets and in green spaces. Although not assessed as part of the bank and drain surveys, it was noted that at several locations across the study area significant amounts of organic material built up following high flow events at bridges (e.g. Waratah St) and in creekside vegetation such as around Charlotte St, downstream of Cala St council drain and at end of the concrete channel.

5.2. Litter Hot spots

While litter occurred across all sampling sites, there were several locations where greater accumulation occurred. Most adversely effected sites and stormwater outlets, in terms of highest number of total litter pieces and highest deposition rates, were Thomas Street and Yarraville MD at the bottom of the catchment and Mathews Hill Reserve at the top of the catchment. This was followed by Paramount Road and Sara Grove, including Tottenham MD in the mid reach of the catchment, and Benbow St and the Francis St MD in the concrete lined channel (Figure 17). The issues at key hot spot sites and at low litter sites is further discussed below.

Most littered sites include Thomas Street and Yarraville MD and Mathews Hill Reserve, followed by Paramount Road, Sara Grove and Tottenham MD, and Benbow St and the Francis St MD.

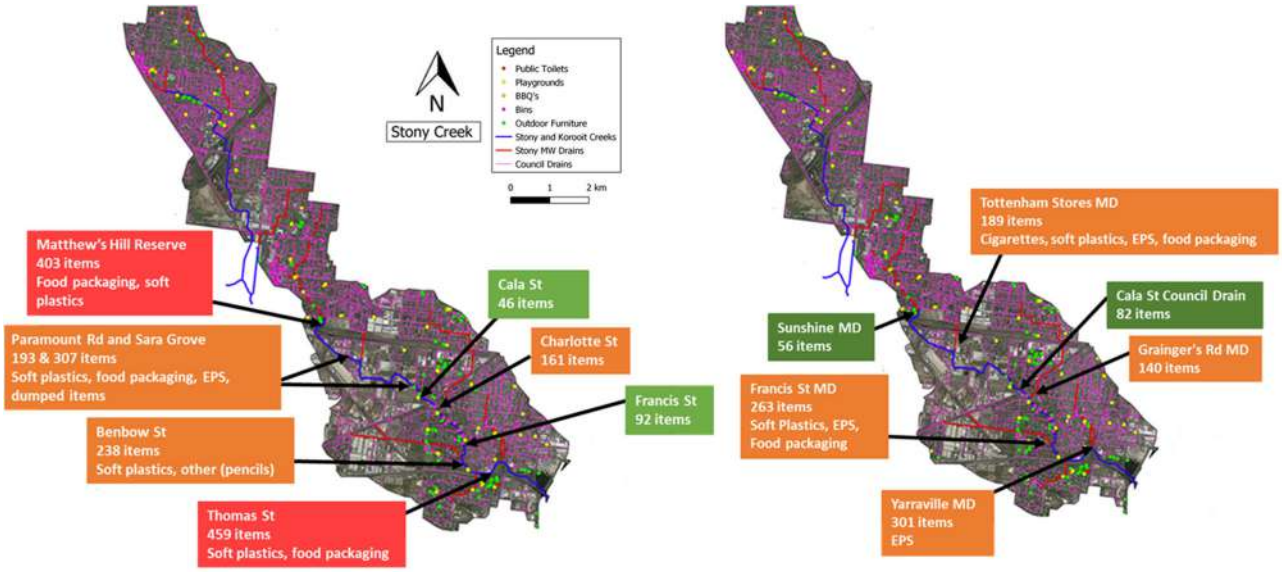

Figure 17: Litter hot spots within the Stony Creek catchment

Thomas St and Yarraville MD

Thomas St and Yarraville MD are at the bottom of the Stony Creek catchment where the creek leads into the estuary. There is significant amenity value in this area, as it is surrounded by the Westgate Golf course and due to its close association with the estuary and bay. Any litter at this point in the system has potential to be transported to Port Phillip Bay.

Thomas St, which had the highest total number of litter items and 2nd highest deposition rate, absorbs the impact of litter delivered from the concrete lined channel directly upstream during storm events, but there

is much evidence of local littering and dumping as well, which combined, results in the high rates of litter deposition at this site. Highest litter levels were observed in Week 1, with 293 items, much of which is likely due to old litter which has accumulated at the site from downstream transport. It is a very visible accumulation point for downstream transport as the concrete channel finishes and the creek resumes a more natural channel, water flow slows as it hits the vegetation, and large amounts of litter are deposited and entangled. However, litter is clearly deposited at this site weekly due to localised littering, with 44 or more items consistently collected from each bank survey. Key litter types included soft plastics and food related packaging.

The site is surrounded by commercial, residential and open parkland areas. The east bank is bound by the West Gate Golf Course, where the survey area was situated, as well as the M1 Freeway and tunnel works. While the west bank is dominated by commercial activities situated around Thomas St, and residential housing. Thomas St, a court, is lined with commercial skip bins which are a likely source of litter items such as soft plastics, while direct littering by visitors using the creek area as a throughfare or undertaking illegal activities in the concrete channel (based on observations and collection of spray cans and graffiti) is likely a primary source of the weekly counts of food related packaging. There was evidence of illegal dumping of green waste on the creek banks during surveys.

Yarraville MD enters Stony Creek at the top of the estuary, approximately 270 metres downstream from the Thomas St site. The drain outlet is within the golf course and drains a catchment of 2.35 km^2 that is predominantly residential with some commercial precincts. It is considered a hot spot due to the delivery of high levels of EPS to the creek, which occurred as a large event in Week 1 of sampling. Sources of the EPS are likely to be a single incident in the catchment, such as the unloading of waffle pods to a construction site, or loss from a residential or commercial bins as it was all small unidentifiable pieces. In addition, there was a significant amount of organic debris (8kg) delivered from this drain.

This is one of two sites where structural alternatives could be evaluated for implementation due to the amount of litter that appears to come from downstream transport, however education and awareness, enforcement and regulation-based approaches as well as assessments of infrastructure and services are likely to be good options or required in combination (See recommendations in Table 6).

Matthews Hill Reserve and Sunshine MD

Matthews Hill Reserve and Sunshine MD are situated in the upper Stony Creek catchment where Stony Creek emerges from underground via the Sunshine MD. Matthews Hill reserve is a valued amenity site, being a high traffic area with a shared bike and walking trail, open parklands, picnic and BBQ facilities, a playground, and an off-leash dog area. The surrounding land use is predominately residential and industrial. Directly south of the site is the Sunshine railway line, a caravan park and industrial area. While directly east is a new residential building site. The remainder of the site is surrounded by established residential areas and parklands. Sunshine MD drains a catchment area of 1.34 km^2, which is dominated by the commercial shopping precinct of Sunshine, Sunshine train station and residential land uses.

Matthews Hill Reserve had the highest litter deposition rate of all sites (average 0.15 items/m^2/day). It absorbs the impact of litter delivered via Sunshine MD and a large council drain and via local littering in the nearby catchment. Downstream transport and accumulation appear to be a significant source of litter at this site, with higher litter counts observed following rainfall in both bank and drain surveys. Litter is quite visible where the drain enters the creek as it is captured and retained in the creekside vegetation or in the shallow pool at the end of the drain. There is evidence of sustained local littering at the site, with between 38 to 92 pieces captured in bank surveys during dry deposition periods. Dominant litter types included soft plastics and food related packaging, which were mostly food wrappers such as confectionary and chip packets. However, there was also a significant contribution from paper items and EPS.

Structural alternatives could be considered for evaluation at this site, due to the contribution of downstream transport and accumulation. However, maintenance of current clean-up activities, together with assessments of infrastructure and services, enforcement and regulation, education and knowledge improving initiatives are likely to be good options to reduce litter impacts at this site (See recommendations in Table 6).

Paramount Rd, Sara Grove, and Tottenham MD

Paramount Rd and Sara Grove are situated in the most industrialised section of Stony Creek in the mid-upper area of the catchment and had the 3rd and 4th highest litter loads and deposition rates across sites, respectively. Both sites are directly surrounded by industrial activities. Sara Grove is a heavy vehicle traffic area to the surrounding distribution and import industry sites, with limited public access to the creek. The Paramount Road site is directly downstream of the Paramount Rd bridge across Stony Creek, thus is influenced by vehicle traffic and the creek is accessible to the public via a walkway along the creek which terminates at Paramount Rd.

The dominant litter types across these two locations were food related packaging, soft plastics and EPS. Local littering and dumping are likely a significant contributor to litter at these sites, with consistently high number of items collected in weekly surveys. Surrounding industries are predominantly import and distribution companies which could be a source of soft plastics and EPS. While food related packaging is likely associated with littering by workers, recreational walkers and road users. There is evidence of downstream transport continuing to add to litter loads at these sites, with an increased number of items found following the rain event in Week 2 compared to dry deposition sampling in Weeks 3 and 4. Illegal dumping was also evident at Sara Grove.

Tottenham MD discharges to Stony Creek at the end of Quarry Rd, which is situated approximately 400 m downstream of Sara Grove, and 1.4 km upstream of Paramount Rd. A total of 189 litter items were captured during the surveys, with a deposition rate of 4.5 items per day, being the third highest contributor of litter from the drain network to Stony Creek. The drain services a catchment of 1.49 km^2 which is dominated by industrial, a commercial shopping precinct, railway infrastructure and residential land uses. Key litter types captured at the drain outlet included soft plastics, EPS and cigarettes. Soft plastic and EPS items are likely from unintentional littering at industrial and commercial sites within the catchment, while cigarettes are likely from direct littering across the catchment. There was a significant amount of illegal dumping observed at Quarry Rd, above the Tottenham drain outlet, and evidence of people spending time recreating under the trees by the creek which is likely contributing to litter loads in this area and downstream.

To improve the condition of the creek in this area investment in education and awareness, enforcement and regulation initiatives are likely to be the best options (see recommendations in Table 6).

Benbow St and Francis St MD

The Benbow St site is situated within the concrete lined channel of Stony Creek, just downstream of the Benbow St bridge, and approximately 110 m downstream of the Francis St MD outlet. This area of the creek is fenced off to public access, although there is a gravel track used by walkers, commuters, and bike riders that runs along the fence line. The directly surrounding land use is residential and includes a primary school. There is also consistent vehicle traffic along Benbow St. Francis St MD captures a catchment area of 4.28 km^2, which is made up of predominately residential land use, but also includes a school and various sporting and recreational fields.

Litter is very visible in this section due to the openness of the concrete channel and vegetation growing along the edges of the middle channel which capture and retain it. Dominant litter types captured in bank surveys included soft plastics, and other litter items which included pencils, while from the drain outlet there were soft plastics, EPS, and food related packaging. There was also a significant amount of organic

material delivered via the Francis St MD and cigarettes. Highest number of items were in Week 4, which suggests that local littering is a considerable contributor to litter at this site. This could be from residential bins or recreational users of the area. There was evidence of food related packaging left by users siting under the bridge in the concrete channel. There were observations of illegal dumping within the concrete channel at this site and in the grass areas along Benbow St near the bridge.

Results from Frances St MD suggest there was a constant source of litter from the stormwater system at this site, with the second highest number of items captured from this outlet (approximately 30 or more items captured in weekly samples). This section of the creek is thus likely to be a net source of litter to downstream areas.

This area could be a focus for efforts such as education and awareness programs, reviews of infrastructure and services, and knowledge building actions to reduce litter impacts (See recommendations in Table 6).

Charlotte St and Graingers Rd MD

Charlotte St is located directly downstream of a busy intersection, car wash, commercial shopping precinct and take-away outlets. The area has a high amenity value, situated at the top of Cruikshank Park, which is used for recreational activities such as walking, jogging, picnicking, dog walking. There is also a playground and sport facilities in close vicinity. The more widely surrounding land use for the site is residential.

Litter levels were fairly high at the initial site visit (105 pieces) due to accumulation of old litter at the site. Most litter collected was food related packaging, predominately food wrappers and soft drink bottles, and soft plastics, with smaller contributions of paper items and hard plastic pieces. Litter levels were lower during subsequent visits (6 to 31 pieces), suggesting that the litter collected during the first visit was old, relict litter. Based on the types of litter collected, it is likely litter is transported to the site via local littering and dumping. The adjacent parking lot behind the shops on Somerville Rd and commercial bins which are placed on the bridge over the creek could be a significant source of food related packaging and soft plastics, as well as vehicle traffic on Somerville Rd and recreational users of the area. There are indications that downstream transport, most likely during high flow events, contributes to litter at the site, with litter in the first week found in the vegetation along the creek and based on the slightly higher levels collected in Week 2 surveys which preceded a rainfall event.

Graingers Rd MD is approximate 100 m downstream of the Charlotte St site. The drain captures from a catchment of 2.49 km^2, which is dominated by residential land uses, but also includes recreational and sporting fields, schools and light commercial areas. Dominant litter captured included soft plastics and EPS, followed by food related packaging and cigarettes. These items are likely contributed from direct and indirect littering in the catchment. For instance, EPS could be from indirect littering during delivery to a building site or via road transport. Whereas cigarettes are most likely due to direct littering by smokers in the catchment. Food related packaging, which was mostly wrappers such as confectionary and chip packets, is likely contributed from both direct and indirect littering, which then is captured during storm events and transported to the storm drain system.

Focus of actions in this area could include assessments of infrastructure and services including bins and cigarette ballot boxes in recreational areas, enforcement and regulation activities that assess waste management at commercial and industrial or building sites, education and awareness programs (See recommendations in Table 6).

Low litter areas –Francis St, Cala St and Cala St Council Drain

Low litter areas included Francis St, Cala St and Cala St Council Drain, where less than 100 litter items per site were collected in total over the sampling periods.

The Francis St assessment site is situated at the bottom of Cruickshank Park just before Stony Creek becomes a concrete lined channel. The surrounding land use is predominantly residential and parklands. The site is of high amenity value, being adjacent to the Yarraville Community Garden, Dinosaur Park, Clare Court Children Service, and the Cruikshank Park BMX track. Highest litter levels occurred in the first week of sampling, which is likely due to accumulation of older items present, with subsequent sampling weeks having <14 items collected. Litter was mostly soft plastics, food related packaging (including food wrappers, aluminium foil and paper plates/cups) and hard plastics. There was also a significant contribution of cigarettes. These items most likely come from local littering by visitors to the area. There are rubbish bins located near the Dinosaur Park and parking lot in front of Clare Court Children Service. The Friends of Cruickshank Park and Clare Court Children's Service are active groups that pick-up litter around this site. The presence of bin infrastructure and combined efforts of the community and council management activities possibly contribute to the lower litter levels here compared to other sites in the catchment.

The Cala St site is located where the heavy industrialised section of the catchment transitions back to residential land use. The site has high public access and is used by walkers, riders, runners, commuters, and dog walkers which frequent the walkway along the creekside. Highest litter levels were observed during first sampling week, with a total of 37 litter items, thereafter subsequent sampling events had <7 litter items collected. It is likely this site receives litter from upstream during high flow events, which then accumulate on the banks, however litter observed during the survey period is most likely due to local littering. Dominant items included hard and soft plastics.

Cala St Council drain enters Stony Creek at the end of Cala St. The drain services a catchment of 0.96 km^2 which is dominated by predominantly residential with small sections of industrial land uses. Litter contributions from this drain are rainfall dependant, with litter loads increasing with increased rainfall and little to no litter present when there is no rainfall. Soft plastics and cigarettes were the main litter types contributing to litter load, followed by food wrappers and EPS. Sources of these items are likely a mix of direct littering by people in the catchment, and indirect littering from residential and commercial bins in the catchment. A significant contribution of organic matter is provided to Stony Creek from Cala St Council drain, with approximately 12Kg captured over the 6 weeks of sampling. This is possibly in part due to shedding of trees in the small catchment area.

These sites could be a focus for continued litter clean-ups but could also benefit from education and awareness programs and infrastructure and serving assessments to review convenience of bin locations for area users and review presence of cigarette bins. Further investigation of the source of organic litter would be beneficial in this area as well (See recommendation Table 6).

5.3. Risks litter poses to the values of Stony Creek

To understand which litter items are of higher priority to target in management actions, an examination of the risk litter poses to Stony Creek was undertaken by assessing how different litter types are expected to impact on the social and environmental values and assets of Stony Creek (Table 4). The values of Stony Creek were identified in the background report (Trestrail *et al.,* 2020) and were determined based on review of the Stony Creek Rehabilitation Plan 2019-2029 and the Healthy Waterways Strategy plan for the Maribyrnong Catchment (Melbourne Water, 2019). Three environmental and three social values were identified, based on those which litter in Stony Creek could affect the improvement trajectory of. Only those values which can improve (Melbourne Water, 2019, p.18) have been assessed, as litter is not going to affect the improvement trajectory of values which the Rehabilitation Plan identified as unimprovable (frogs, macroinvertebrates, platypus).

The environmental values identified included fish, birds and vegetation. Litter can affect all these values, by exacerbating the pressures already present and by creating new pressures. For instance, litter can contribute to habitat degradation and degraded water quality. It can be a physical hazard to fish, birds and

vegetation by creating barriers for migration, through entanglement or ingestion, and through smothering. Lastly the leaching of chemicals, e.g. from batteries and the breakdown of macro plastics to microplastics which are then ingested, are a toxicological hazard to fish and birds.

Three social values were identified, with amenity being the key value, which underpins the other two social values of community connection and recreation. Amenity is likely to be the driving value for investment in Stony Creek, with a strong relationship between litter and the social values of amenity, community connection and recreation. As outlined in the background document (Trestrail *et al*., 2020) litter diminishes community perceptions of naturalness and that visitors to the creek are unlikely to perceive the catchment as a "healthy and clean natural community asset" (Melbourne Water, 2019, p.3) if litter is abundant. Litter types such as broken glass and metal objects can pose a health hazard, hindering recreational use along the waterway. During public consultation phases of the Rehabilitation Plan, litter pollution was identified by the community as a prominent issue, indicating users are acutely aware of litter in the catchment. It is likely that, if not addressed, litter will interfere with the improvement of social and recreational rehabilitation values. Improving and or providing more facilities and activities along Stony Creek was identified in the Rehabilitation Plan as an action that would enhance users' passive enjoyment of the catchment and improve the amenity, community connection and recreational values. However, if the creek is not perceived as an attractive place to gather due to litter pollution, this will undermine the effectiveness of improving facilities.

The litter survey data provides information on the various types of litter that occur across the Stony Creek catchment. Key litter types observed included soft and hard plastics, food related packaging (notably confectionary wrappers and beverage containers), EPS and cigarettes. Organic matter was also a significant component of litter delivered via the stormwater network. These formed the main categories assessed for risk of impact to values and assets. While lower amounts of glass, metal and paper were found these categories were also included in the assessment.

Table 4: Consequence matrix to assess risks of litter to assets, social and environmental values of Stony Creek.

Consequence Matrix					
Severity Score	Assets	Social Values	Environmental values		
		Amenity, community connection and recreation	Fish, Birds and Vegetation		
			Physical hazard	Toxicological hazard	Habitat hazard
0	No measurable impact on services or assets provided	No lasting impact to community amenity	No toxicological or physical impacts to species or changes to habitat		
1	Short term degradation of services to a local area or slight damage to assets	Minor impact on community amenity	Minor toxicological or physical impact on species or changes in habitat		
2	Minor damage or extended degradation of services to a local area; short term degradation of services to a widespread area	Short term impact to community amenity	Moderate or short-term toxicological or physical impact to species or changes to habitat		
3	Moderate damage or extended degradation of services to a widespread area; short term total loss of services to a local area	Major impact on community amenity	Major reversible (>5 years) toxicological or physical impacts to species or changes to habitat		
4	Major damage or extended total loss of services to a local area; short term total loss of services to a widespread area	Permanent loss of community amenity	Permanent toxicological or physical impacts which could or have resulted in loss of species. Permanent change in habitat		

*Physical hazard is something that impact physically on the value, toxicological hazard is something that results in a toxic effect to the value and habitat hazard is something that alters the habitat for a value.

The risks posed by different litter types to values and assets of Stony Creek are assessed and summarised in Table 5. The litter categories identified as posing greatest risk to assets and values of Stony Creek were soft plastics and plastic bags, followed by EPS, food wrappers and organic matter (Table 5). These items significantly reduce amenity, pose higher risk of physical or habitat impacts for vegetation, birds and fish and are more likely to block assets.

The greatest risks from litter are observed for social values of Stony Creek (Table 5). All litter impacts amenity when its visible in the creek or caught up in vegetation. However, items which are more easily seen and likely to be more annoying for people along waterways are the types of litter that float and get trapped in vegetation, e.g. plastic drink bottles, aluminium cans, large pieces of polystyrene, food wrappers, soft plastics, and plastic bags. The presence of large quantities of organic litter can also disrupt visual amenity. Litter items such as broken glass, metal objects and cigarette butts while not as visually obtrusive at sites, are a threat to recreational values, as they pose a risk to safety of creek users and are more likely to lead to perceptions of an unsafe area.

Items posing greatest risk to values and assets of Stony Creek include soft plastics, expanded polystyrene, organic matter, and food wrappers. These items significantly reduce amenity, pose higher risk of physical or habitat impacts for vegetation, birds and fish and are more likely to block assets.

In terms of the environmental values, litter poses the greatest threat to vegetation, both instream and terrestrial, with litter items such as soft plastics, plastic bags and organic matter identified as posing a risk of permanent physical impacts to vegetation (Table 5). These items become entangled in vegetation during storm events or from being wind-blown and trapped. Once entangled they can remain for long periods of time where they reduce light and oxygen exchange and can result in smothering and dieback of natural vegetation cover.

Birds and fish are vulnerable to litter as it may lead to entanglement and/or ingestion. Once litter is ingested or entangles an animal, that animal can have great difficulty ridding themselves of this debris and it can lead to reduced mobility, disrupted feeding, lowered fitness, lacerations and infection, suffocation, or cause death. Litter may also impact habitat structure and availability (Green *et al*., 2021). For instance, by smothering benthic areas used for feeding or depositing of eggs and reducing gas exchange between water and sediments creating anoxic or hypoxic conditions, or through reducing available canopy for birds, or by creating barriers for migration. Items of greatest concern were identified as being soft plastics, plastic bags and organic matter, followed by cigarette butts, EPS, glass and metal objects (Table 5). Plastic litter items are of concern also for their risk to breakdown into microplastics, which if ingested have potential to expose animals to additives and toxic substances adhered to litter items.

The greatest risk for assets along Stony Creek is organic matter (Table 5). Organic matter collected consisted mostly of green waste such as grass clippings, leaves and tree branches which can lead to the blocking of the drainage systems and creek channel, directly through the build-up of debris and decomposed sediments, and indirectly through the spread of invasive plant species that colonise wet areas. This can result in increased flooding and facilitate higher rates of erosion by smothering natural vegetation cover. Litter items including soft and hard plastics, EPS, metal, if large pieces, and beverage containers also have a potential to cause short term degradation to services if allowed to build up and clog stormwater drains or the creek channel.

Table 5: Risk assessment of different litter types to the social and environmental values and assets of Stony Creek.

Value/asset	Observed Litter Categories										
				Food related packaging							
	Soft Plastics	Hard Plastics	Plastic Bags	Wrappers	Beverage containers	Cigarettes	EPS	Glass	Metal	Paper	Organic Matter
Assets											
Asset damage or blockage	2	2	2	1	2	0	2	1	2	2	3
Social Values											
Amenity	3	2	3	3	3	2	3	2	2	3	2
Community connection	3	2	3	3	3	2	3	2	2	3	2
Recreation	3	2	3	3	3	2	3	4	4	3	2
Environmental values											
Birds											
Physical hazard	3	2	3	2	0	3	3	1	1	0	0
Toxicological hazard	1	1	1	1	0	2	1	0	0	0	0
Habitat Hazard	2	0	2	0	0	0	0	0	0	1	1
Fish											
Physical hazard	3	2	3	1	1	3	1	3	3	0	0
Toxicological hazard	1	1	1	1	0	2	1	0	0	0	0
Habitat hazard	3	0	3	0	1	0	1	0	1	0	3
Vegetation											
Physical hazard	4	1	4	1	1	0	1	0	1	2	4
Toxicological hazard	0	0	0	0	0	0	0	0	0	0	0
Overall Score	**28**	**15**	**28**	**16**	**14**	**16**	**19**	**13**	**16**	**14**	**17**

*Physical hazard is something that impact physically on the value, toxicological hazard is something that results in a toxic effect to the value and habitat hazard is something that alters the habitat for a value.

6. Management Options

A significant part of the project is to propose litter actions that will reduce the impact of litter on the aesthetics and environmental values of Stony Creek and reduce the impact of litter on Port Phillip Bay.

There are a broad range of options for managing litter which fall into six main mechanisms of delivery, ranging from prevention-based options, such as education and awareness programs, knowledge building, partnerships and capacity building, and enforcement and regulation to infrastructure-based solutions such as installation of litter traps or bins and clean-up activities. Preferably higher priority would be given to actions to reduce and manage litter at the source, as this minimises environmental impact, with lesser priority given to actions that have lower environmental benefit such as treatment or litter disposal as outlined in the waste hierarchy (Figure 18). However, often an integrated approach is necessary as currently litter cannot be effectively managed by prevention-based actions alone.

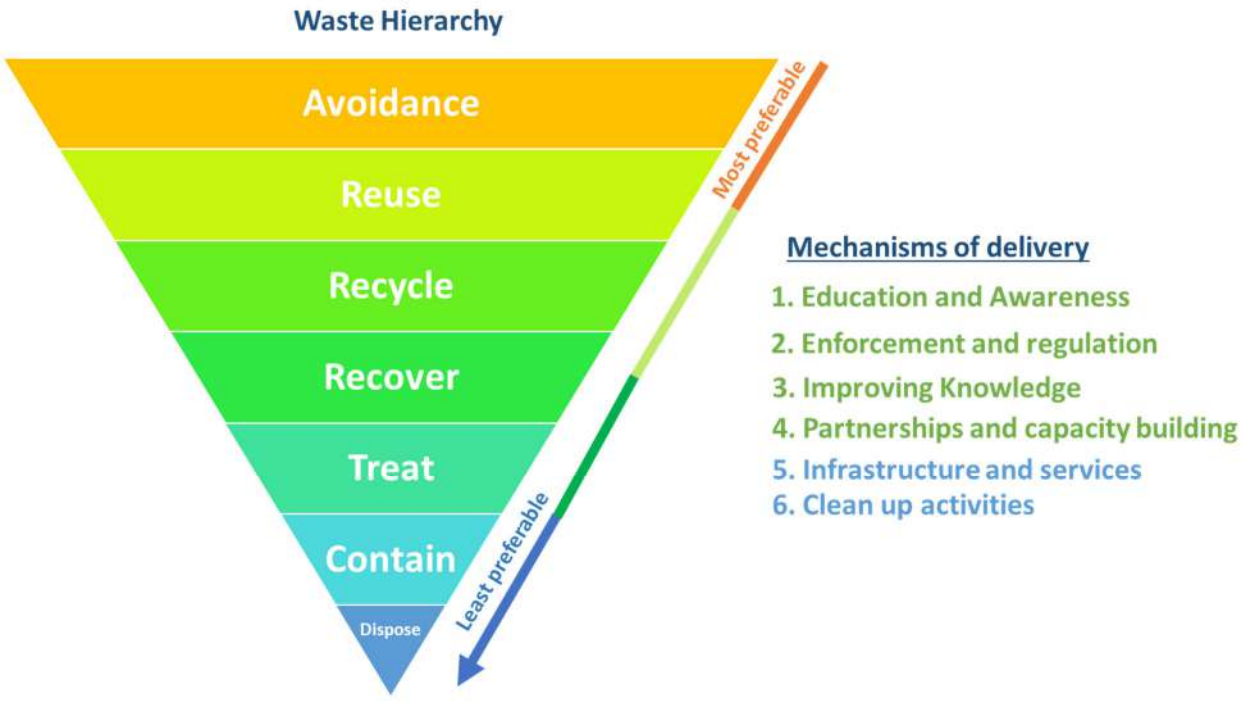

Figure 18: Mechanisms of delivery for litter management and the waste management hierarchy. Mechanisms of delivery in green are focused on prevention and reuse, while those in blue are treatment and disposal-based options.

Seven key recommendations and twenty-eight actions were identified for further consideration and feasibility assessments to improve the litter situation in Stony Creek. The recommendations and actions are founded on the six main mechanisms of delivery and focused on achieving six objectives. The objectives were established based on the outcomes of the targeted litter surveys and background report which outlined the key litter items found in Stony Creek and their potential sources. They are to:

1. Reduce soft plastics in Stony Creek
2. Reduce cigarette butts in the catchment and Stony Creek
3. Reduce food related litter in the catchment and Stony creek
4. Improve management of EPS at source to reduce inputs to Stony Creek
5. Reduce organic matter inputs to Stony Creek
6. Reduce illegal dumping in the catchment, especially along Stony Creek

Further they are focused on managing litter at hot spot sites and targeting those items posing greatest risk to values and assets of Stony Creek. Some guidance on the priority of actions is provided based on the waste management hierarchy, the number of objectives targeted by the action and based on the expected level of impact on reducing litter, thus providing best outcomes for Stony Creek and the bay.

Details of the seven recommendations and associated actions are outlined below.

Recommendation 1:

Increase education and awareness of the litter issues in the catchment

As part of cultivating a shared responsibility for the management of litter in the Stony Creek catchment, education and awareness is essential. Several actions are proposed that focus on increasing education and awareness of litter issues within the catchment. These actions rely on the principles of behaviour change in the community, and those working in the commercial, industrial and building/construction sectors to reduce or manage litter at the source, however it's important to have the right messaging in various formats tailored for different user groups. Education and awareness approaches are considered lower cost options that can have wide reaching benefit and have been shown to be successful in other catchments, for instance in the Yarra catchment there has been reductions in the occurrence of plastic straws attributed to education efforts and community behaviour change (Charko et al 2020). It is recommended that education and awareness focus on actions that understand current behaviour and materials applied in the catchment, followed by implementing programs to target users and producers of key litter types found in Stony Creek. Educating schools on programs they can participate in to raise awareness of litter issues and reduce waste are also suggested. Specific recommended actions include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green):

Education and awareness actions		***Litter objectives addressed***
1.1	***Review current awareness materials*** *in the catchment and revise and implement most appropriate and effective.*	*1, 2, 3, 4, 5*
	Rationale Awareness materials educate individuals, the community and businesses on the issues and impacts of litter. It is proposed to review the use of awareness materials within the catchment e.g. spray on decal signage on stormwater pits, messaging on bin infrastructure, retailer litter education material through surveying types, locations, condition, and design of awareness materials and through assessing community and/or trader behaviour towards these materials. This will allow an understanding of the most effective messaging materials which can then be used as part of targeted education and behaviour change in key areas of the catchment such as shopping strips, public transport sites, recreational areas.	
1.2	***Understand current behaviour*** *of businesses and traders regarding litter management and the reporting of litter management issues and identify areas to improve.*	*1, 2, 3, 4*
	Rationale Indirect littering from commercial and industrial waste management is possibly a significant contributor to food related packaging, soft plastics, and EPS in Stony Creek. Cigarettes were also higher in catchment areas dominated by commercial and industrial land uses. Litter management at the back of shops and spillage from commercial litter collection was identified as one of the most significant issues in the Hoffman's MD project. There is a need to understand how well-educated business operators around shopping precincts and commercial areas that they are	

	in a hot spot for litter generation and how well they manage litter and report litter management issues. Once current behaviour is understood auditing and enforcement actions, or education and awareness campaigns can be targeted to problematic areas or businesses. It may be that there is a need to encourage business to develop waste management plans – e.g adequate cigarette bins for staff in industrial areas, waste management for retailer and takeaway stores. Particular focus needs to be on businesses that deal with goods in polystyrene packaging and soft plastic wrapping (e.g. white goods suppliers, freight companies) and food packaging (e.g. fast food outlets).	
1.3	***Develop targeted education and behaviour change programs*** *that provide positive and consistent messaging focused on reducing key litter types in Stony Creek* *Rationale* The key litter types occurring in stony creek were identified as being food related litter, soft plastics, polystyrene and cigarette butts. Education and behaviour change programs should focus on informing producers and users of the issues these items pose in the catchment and supporting/informing them how to change their behaviour to manage them at the source through means of reduce, re-use, recycle or dispose. The education and awareness materials should be tailored to the key users/producers of each item. Suggested target groups are outlined for each key litter type below. ***Expanded Polystyrene*** Expanded polystyrene breaks up into small balls making its capture problematic once it reaches waterways. The management of polystyrene at source is therefore a priority. Targeting large scale users such as businesses that deal with goods in polystyrene packaging, including white goods retailers, insulation suppliers, seafood and vegetable retailers is likely most effective for managing this litter type. ***Food related litter*** Food related litter is likely to enter Stony Creek from both recreational users and direct and indirect littering around commercial areas, carparks, public transport stops and from overflowing bins (commercial, residential, and public). Targeting areas considered high generation for this street litter is likely to provide for most effective improvement. Areas include commercial areas, shopping precincts, food outlets, but also around recreational areas with playgrounds, seating or BBQs. ***Soft plastics*** Soft plastics are difficult to trace, as they are mostly pieces of larger items broken down by rapid flows, snagging and weathering. Further, their light-weight nature allows transport vast distances via wind. Like EPS, targeting large scale users such as businesses and activities that use soft plastics such as pallet wrap, plastic bags, sleeves and bubble wrap in transport and packaging is likely most effective for managing this litter type.	*1, 2, 3, 4, 5, 6*

	Cigarette butts Direct littering by smokers is the source of cigarette butts to Stony Creek. While education campaigns can be catchment wide, it is recommended that particular attention be made in the industrial and commercial areas around Cala St Council Drain and in the catchment of Tottenham Main Drain as they appear to be significant sources in Stony Creek. Note: this action overlaps with the infrastructure and services actions 2.1 and 2.2 and enforcement and regulatory actions 3.3 and 3.4 around the review and auditing of commercial/industrial/public litter management and cigarette infrastructure.	
1.4	***Develop campaigns that raise awareness of the penalties of illegal dumping and littering***	*5, 6*
	Rationale Illegal dumping is a key issue in the Stony Creek catchment, especially around Increasing awareness of the issue and providing information about disposal options, particularly free disposal options, could help reduce this incidence. Target audience would be residents across the catchment as most dumped items are of residential nature and workers in the industrial areas around Tottenham where there appears to be lots of direct littering along the roadside e.g.: along Quarry Rd. Note: this action overlaps with the enforcement and regulatory action 3.2 to provide surveillance at illegal dumping hot spots	
1.5	***Educate local schools about litter programs*** *they can get involved in,*	*1, 2, 3*
	Rationale There are education programs that schools can get involved in to learn about litter impacts and what they can do to manage litter or be more sustainable at their school or in their local catchment such as Resource Smart Schools a free program offered by Sustainability Victoria. Schools can also get involved in litter reduction activities (i.e. clean-ups, data collection) through programs such as Clean up Australia Day, Tidy Towns, Beach Patrol. They can enter data collected in Litterwatch which collates all litter data collected across Victoria. Waterwatch, Litter Trackers, and the Port Phillip Bay Ecocentre also provide school education around litter. However, many schools do not know about these programs or where and how to access them. Promotion of these across the education sector could increase uptake and works towards building effective partnerships across the catchment to tackle litter.	

Recommendation 2:

Review and expand infrastructure and services within the catchment

While avoiding waste generation is most preferable, there is always going to be some form of litter generated by catchment activity. Therefore end-of-line responsibilities for litter need to be adequate. Highest priority actions around infrastructure and services are focused on reviewing and revising current general waste, recycling and cigarette bin infrastructure and street sweeping services to ensure they are appropriate to meet both the needs of the community and facilitate responsible disposal practices. While lower priority actions, due mostly to their higher costs, include reviews of side entry grate infrastructure to stormwater system, provision of waste disposal passes to residents and an assessment of the feasibility of litter traps at Mathews Hill reserve and Thomas Street. Specific recommended actions include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green):

Infrastructure and Services Actions		*Litter objectives addressed*
2.1	***Review and audit current bin infrastructure*** *to ensure it meets community needs, including general waste and recycling bins.* *Rationale* There is a need to understand if current bin infrastructure and the service frequency is adequate, especially in high traffic areas such as through Cruickshank Park, Mathews Hill Reserve, Cala St and Benbow St. At entrances along pathways e.g. Cala St bridge area and at sites where food is likely to be consumed e.g. public transport stops, carparks, takeaway shops, areas where recreational tables/seats are provided and playgrounds. It is recommended to review current bin infrastructure to ensure it meets the community needs. This should consider, bin: • Number • Type • Location • Condition • Design, and • Service frequency, especially during peak periods This could also include an investigation of smart bin technology (i.e. sensors and compacting bins) to monitor bin capacity and servicing adequacy.	1, 3
2.2	***Provide cigarette bins in hot spot areas*** *Rationale* Audit existing litter management measures for cigarettes and then provide appropriate butt bin infrastructure in hot spot areas such as public transport stops, commercial shopping areas, recreational areas where people are likely to consume food or spend a period of time. This audit should consider: • presence and number of cigarette bins/ballot boxes • Frequency of service • Locations of bins Note: this action overlaps with enforcement and regulatory action 3.4 to Audit cigarette management at businesses and encourage business owners to install cigarette bins for staff and customers.	2
2.3	***Review and improve the street sweeping schedules.*** *Rationale* There is a need to review the frequency of street sweeping to determine if its adequate around areas where there is high commercial activity and commercial waste is stored (shopping strips, laneways, carparks). Further to understand if there are issues such as parked parks impacting the effectiveness of this service. Highly trafficked commercial areas such as along Sommerville Road bridge, which is directly upstream of Charlotte St, but also in other areas that would be considered potential generation hot spots across the catchment would be the key areas of focus.	1, 2, 3, 4, 5
2.4	***Audit the coverage of grated side entry pits*** *Rationale* Grated side entry pits capture litter and prevent it from entering the stormwater system. There is a need to audit the coverage of grated side entry pits or other infrastructure that holds litter in place and prevents it from entering the stormwater system, especially in commercial areas and high traffic roads across	1, 2, 3, 4, 5

	the catchment. As well as auditing for the presence, sizing and coverage of physical infrastructure for the hotspots, a review of the effectiveness of design and operation may be warranted.	
2.5	***Investigate the provision of 'waste disposal passes' to residents*** *Rationale* Illegal dumping of household and organic waste occurs across the catchment. Waste disposal passes, if not already provided across the catchment, is an action to work to reduce the occurrence of illegal dumping. Thus, its suggested to investigate the provision of a limited number of free disposals at resource recovery centres or hard waste collection services for household items, furniture and organic waste, if feasible and if it aligns with council's strategic priorities.	5, 6
2.6	***Assess options and feasibility for a litter trap at Thomas St and/or Matthews Hill Reserve.*** *Rationale* Litter traps provide a means to capture and trap litter entering the creek from the stormwater system and are an important mechanism to manage litter in many systems. Within Stony Creek there are two sites proposed where litter traps could potentially provide effective management of litter, Mathews Hill Reserve and Thomas Street at the end of the concrete channel. At Mathews Hill reserve this would capture litter coming from the Sunshine commercial precinct and surrounding catchment, while at Thomas Street this could lead to reduced litter loads to PPB. However, litter traps at these sites are likely to be visible traps which can often look ugly, even when empty, which generates complaints. Litter traps are also a significant investment, which may not be as beneficial as investing in several other solutions which are more likely to contribute to effective management of amenity throughout the Catchment.	1, 2, 3, 4, 5

Recommendation 3:

Assess current litter management by businesses and effectively enforce and regulate litter and illegal dumping law

Enforcement and regulation play an important role in ensuring producers and users appropriately manage and dispose of litter generated. It can also play a pivotal role in communicating about the impacts of litter, requirements of businesses and the community regarding waste management and encourage good practice. Highest priority recommendations are focused on encouraging report of litters to the EPA, surveillance of illegal dumping hot spots and auditing and enforcement of appropriate waste and cigarette management at commercial businesses and businesses that deal with soft plastics and EPS packaging. It is also recommended to publicise enforcement activities and outcomes to inform the community of work being undertaken and to promote a change in culture in the way littering is seen as a 'social norm'. Specific recommended actions include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green):

Enforcement and regulatory Actions		***Litter objectives addressed***
3.1	***Encourage the reporting of litterers to the EPA*** *Rationale* This encourages the community to take action for managing illegal littering and dumping issues in the catchment. Contact details to be promoted and shared include: email contact@epa.vic.gov.au or call the EPA pollution hotline on 1300 372 842.	1, 2, 3, 4, 5, 6

	https://www.epa.vic.gov.au/report-pollution/reporting-pollution	
3.2	***Provide surveillance at illegal dumping hot spots.*** *Rationale* Illegal dumping appears to occur prevalently at certain hot spots such as Sara Grove. Provision of surveillance at hot spots such as surveillance cameras and patrolling, would help identify illegal dumpers and support enforcement actions and may also lead to reduced occurrence of dumping.	5, 6
3.3	***Audit and enforce commercial area litter management*** *Rationale* In the Hoffmans MD study litter management at the back of shops and spillage from commercial litter collection was identified as one of the most significant issues (Alluvium, 2018). These areas are likely a source of food related packaging, but also soft plastics and EPS were used, to the creek. This action proposes an audit of waste management for commercial businesses. The audit can then direct enforcement where appropriate or education actions around waste management plans – e.g. for retailer and takeaway stores, or infrastructure actions such as the addition of bin latches on kerbside bins in areas with identified issues, such as windy conditions, or where wildlife is interfering with bins. The state government is also introducing a ban on single-use plastic drinking straws, cutlery, plates, drink-stirrers, expanded polystyrene food and drink containers, and cotton bud sticks from sale or supply in Victoria from 1 February 2023. The ban will apply to items made from conventional plastic, and also those made from degradable, biodegradable and compostable plastic. As part of audits, it would be good to ensure they understand impacts of the ban on their business and educate them about different items they could transition too such as materials made from paper, wood and bamboo. Note: this action overlaps with education and awareness action 1.2 to assess the understanding of trader's education about litter	1, 3, 4
3.4	***Identify and audit litter management by businesses that deal with soft plastics and EPS packaging*** *Rationale* EPS and Soft plastics were two of the key litter types found across the Stony Creek catchment. Targeting large scale users and producers of these products are likely to provide most effective management. Need to identify users and producers of EPS and soft plastics used in packaging in the catchment then target them for assessment of practices and create programs to work with them to reduce waste from this source. Once users and producers are identified, actions could include auditing sites and communication about impacts, the requirements for onsite management and encouragement or enforcement (where necessary), to undertake good waste management practice. Positive impacts on construction practices were observed after a combined education and enforcement program, the Building Site Controls Pilot Project (2002) which ran across Hume, Moreland, Moonee Valley, Melbourne, Casey and Kingston Councils (Alluvium, 2020), showing education and enforcement are important actions that work effectively when combined.	1, 4
3.5	***Audit cigarette management at commercial and industrial businesses*** *Rationale*	2

	While cigarettes butts come from direct littering by smokers anywhere in the catchment, in Stony Creek storm drain outlets draining the Tottenham industrial areas e.g.: Sara Grove to Cala Street and around Thomas Street appeared to be a specific hot spot for cigarette butts. Targeting cigarette butt management at businesses within these sub-catchments is likely to lead to effective reductions in cigarette butts in stormwater and thus Stony Creek. There is a need to assess current butt-bin infrastructure provided by businesses and encourage business owners to install butt bins in hot spot areas where they are currently inadequate. Note: This action overlaps with infrastructure and services action 2.2 general audit of cigarette infrastructure.	
3.6	***Publicise littering and illegal dumping enforcement*** *activities and outcomes.* *Rationale* Publishing littering and illegal dumping enforcement activities and outcomes informs the community about work EPA and local government, e.g.: councils, are undertaking to manage this issue. It also instils to the community that individuals or businesses that litter or dump items will be penalised. Lastly, it promotes a change in culture in the way littering is seen as a 'social norm'.	1, 4, 5, 6

Recommendation 4:

Continue to improve knowledge through co-ordinated research and monitoring

Research and monitoring provide the knowledge to make informed decisions regarding litter management. It is an important means to track condition over time, identify emerging litter issues and litter sources and track and monitor management actions. However co-ordinated and standardised approaches to data collection are paramount. Thus, there is a need for agreement on improved and co-ordinated data collection processes to build and share knowledge and to then provide training to groups undertaking litter clean-ups so that data can inform management**.** Further additional research is needed to adequately assess contributions of litter from the stormwater network during large storm events and to understand the litter generation hot spots within the catchment. Recommendations for improving knowledge through research and data collection include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green):

Improve knowledge actions		***Litter objectives addressed***
4.1	***Agree on a consistent methodology for the recording of litter type and volume*** *across agencies and community groups* *Rationale* There is a clear need to agree on a consistent methodology for the sampling and recording of litter type and volume across agencies and community groups. The litter audit methods described in this report demonstrate a scientifically valid means of data collection for assessing litter within Stony Creek, while the street litter audit method applied by Scouts Victoria in the Street2Bay project has also proven to be an effective and replicable means of monitoring litter pollution on streets in Port Phillip Bay catchments. Continued data collection using standardised methods can provide a means to understand litter generation sites, to continue to understand the key litter items occurring in Stony Creek and a way of evaluating strategies implemented to reduce litter pollution over time.	1, 2, 3, 4, 5
4.2	***Provide training and support*** *to groups undertaking litter clean-ups* *Rationale*	1, 2, 3, 4, 5

	Training in standard methods is integral to collecting data that will be usable by local government to make informed management decisions. It is a form of quality control so that data is collected and recorded in a consistent manner and uploaded to DELWPs Litterwatch database.	
4.3	***Undertake litter audits at set sites to develop baseline data and to identify litter generation areas*** *within the catchment.* *Rationale* To understand if the actions implemented are leading to reductions in litter within Stony Creek there needs to be continued monitoring at a select number of sites. This could be undertaken as part of catchment monitoring programs such as the MERI for litter program by Melbourne Water. There is also a need to identify generation areas for litter across the catchment and undertake targeted surveys of these to determine those of highest concern for litter generation. This will allow for more focused actions to work with retailers, commercial and industrial businesses that will lead to greater impacts on litter reduction. This could be done with tertiary institutions or volunteer groups but needs to be a co-ordinated program so scientifically sound data is collected. The WfV scheme applied for bank surveys in this program was a good example of how this could work can be run or the Street2Bay program, which is a collaboration between Scouts Victoria, The Port Phillip Ecocentre and DELWP to audit litter in catchments.	1, 2, 3, 4, 5, 6
4.4	***Record data on illegal dumping in a centralised database*** *Rationale* Centralising data collected on illegal dumping will assist in identification of hotspots and common dumped items. This data can then guide development of targeted campaigns to reduce dumping incidence or areas to target enforcement and regulatory actions such as surveillance campaigns.	5, 6

Recommendation 5:

Foster effective partnerships to build capacity within the community, government, and industry

It is important to build and maintain collaborative working partnerships to create capacity that will lead to positive outcomes and ensure effective change around litter management. All stakeholders need to be engaged in dialogue about roles and responsibilities and agree on the who is responsible for different actions to achieve overall success. This might be achieved through things like workshops, forums, collaborative education campaigns in the community and training days. These actions are likely to be more long-term and this may take longer before benefits are observed. Specific capacity building actions include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green):

Capacity building Actions		***Litter objectives addressed***
5.1	***Partner with education sector (primary, secondary and tertiary) and others*** *Rationale* There are primary, secondary and tertiary schools who are keen to learn about and help in the management of waterways and the bay. It is suggested to work with them to identify safe and effective ways for them to assist in litter prevention and collection at the hot spot or high amenity areas. This could include conducting clean-ups and audits at litter hotspots, with data then informing local actions to reduce key litter items.	1, 2, 3, 4
5.2	***Partner with local organisations and industry to raise awareness of EPS and soft plastics issues***	1, 4

	Rationale EPS and soft plastics are key issues in Stony Creek, but also across the wider Melbourne area. As outlined in the Moonee Ponds litter assessment, there is a need to work more widely across local government agencies, fellow organisations, peak bodies (e.g. Expanded Polystyrene Australia) and industry to educate about the impacts of EPS and soft plastics and improve onsite management.	
5.3	***Partner with local business such as fast-food outlets to raise awareness about litter***	1, 2, 3
	Rationale Local businesses can play an important role in raising the awareness of their customers and other business owners about litter, assisting to reduce litter at the source. To begin there is a need to identify fast-food outlets that may be willing to work collaboratively. Once partnerships are established actions could involve running litter prevention and education programs in the community, litter clean ups or advocating for reduced use and improved product stewardship.	
5.4	***Recognise efforts through awards and promotion of activities***	1, 2, 3, 4, 5, 6
	Rationale Recognising efforts of individuals, community groups, schools and others through awards shows awareness of their efforts, and highlights that the work they are undertaking is worthwhile and appreciated. It also promotes a positive culture around litter management activities. Promotion of activities supports efforts around litter management and will help in gaining greater attention to the activity which can encourage greater participation.	

Recommendation 6:

Support coordinated clean-up activities to remove litter and illegally dumped items through on ground actions, including collection of data

Even with a strong focus on reducing litter at the source, there is still going to be litter making its way down stream, so there will still be a need to manage the litter within the creek. Clean up activities will continue to be important means to manage litter that reaches Stony Creek. Further these activities can contribute to improving knowledge by assisting in tracking condition over time, identify emerging litter issues and litter sources and tracking and monitoring effectiveness of management actions. Engaging and supporting the local community in clean-up activities provides a means to include this stakeholder group in the management of litter issues in the catchment. Specific recommended actions include, with suggested priority coloured coded in left margin (high = orange, medium = yellow, low = green, grey = ongoing):

Clean-up activity Actions		***Litter objectives addressed***
6.1	***Increase engagement, support and coordination with community groups to undertake litter removal activities.***	1, 2, 3, 4
	Rationale There are community groups within the Stony Creek catchment who currently undertake litter audits or are willing to help in the management of litter in the creek. There is a need to increase engagement and coordination with these groups where they are willing to assist. This could include identifying safe and effective ways for them to assist in identifying and monitoring litter generation areas, routine monitoring at defined sites or in litter clean-ups. These groups could be trained to collect data following the standardised methods.	

6.2	***Remove illegally dumped items,*** *following investigation, to discourage further illegal dumping.*	5, 6
	Rationale The presence of illegally dumped items is likely to lead to further dumping at the same site. Once investigated it remove items as soon as possible to discourage further dumping.	
6.3	***Maintain current clean-up activities*** for protection of assets	1, 3, 4, 5, 6
	Rationale It is important to maintain current clean-up activities for asset protection, however it would be good if they could contribute data that could be used to assess changes in condition, litter type or amount.	

Recommendation 7:

Establish a MERI plan to monitor and evaluate progress towards reducing litter across Stony Creek

To ensure actions that are undertaken are effective at meeting the objectives of reducing litter in Stony Creek it is recommended to develop a monitoring and evaluation plan. This would provide guidance on the assessment of actions during and after implementation. This allows amendments to be made during implementation if needed to improve effectiveness.

7. References

Alluvium (2018). Hoffmans Road Main Drain – Litter Management Investigation, project report for Melbourne Water, Cremorne, Victoria.

Alluvium (2020) Moonee Ponds Litter assessment for the Chain of Ponds Collaborative Committee

Barmand, S., Goodsell, K., Yardley, D., Kowalczyk, N. (2020). Polystyrene Pollution in the Yarra River: Sources and Solutions. Yarra Riverkeeper Association

Carpenter, E., Wolverton, S. (2017). Plastic litter in streams: the behavioural archaeology of a pervasive environmental problem. Applied Geography, 84: 93-101.

Charko, F., Blake, N., Seymore, A., Johnstone, C., Barnett, E., Kowalczyk, N., and Pattison, M. (2020) Clean Bay Blueprint: Microplastics in Melbourne, October 2020. Port Phillip Ecocentre.

DELWP (2017). Reducing the impacts of Plastics on the Victorian Environment. The State of Victoria Department of Environment, Land, Water and Planning, available at: https://www.environment.vic.gov.au/__data/assets/pdf_file/0030/395418/Reducing-the-impacts-of-plastics-on-the-Victorian-environment.pdf

Gasperi, J., Dris, R., Bonin, T., Rocher, V., Tassin, B. (2014). Assessment of floating plastic debris in surface water along the Seine River. Environmental Pollution, 195: 163-166.

Green, D.S., Jefferson, M., Boots, B., and Stone, L. (2021). All that glitters is litter? Ecological impacts of conventional versus biodegradable glitter in a freshwater habitat. Journal of Hazardous Materials, 402: 124070.

Kiessling,T., Knickmeier, K., Kruse, K., Brennecke, D., Nauendorf, A., and Theil, M. (2019) Plastic Pirates sample litter at rivers in Germany – Riverside litter and litter sources estimated by schoolchildren. Environmental Pollution, 245: 545-557.

Kowalczyk N., Kelly A. (2020) Litter and Flows: Connecting the Yarra and Bay. Yarra Riverkeeper Association

McCormick, A. R., Hoellein, T. J. (2016). Anthropogenic litter is abundant, diverse, and mobile in urban rivers: insights from cross ecosystem analyses using ecosystem and community ecology tools. Limnology and Oceanography, 61: 1718-1734

Melbourne Water (2019). Stony Creek Rehabilitation Plan 2019-2029.

Melbourne Water (2018). Co-Designed Catchment Program for the Maribyrnong Catchment Region (including Moonee Ponds Creek). Melbourne Water, Docklands.

Rech, S., Macaya-Caquilpan, V., Pantoja, J., Rivadeneira, M. M., Kroeger Campodonico, C., Thiel, M. (2015). Sampling of riverine litter with citizen scientists findings and recommendations. Environmental Monitoring and Assessment, 187: 335.

Trestrail, C, Myers, J, MacMahon, D & Pettigrove, V (2020), Aquatic Pollution Prevention Partnership Project: Stony Creek whole of system litter investigation & management prioritisation Catchment background report, Aquatic Environmental Stress Research Group, Technical Report No. 31, RMIT University, Victoria, Australia.

Appendix A: Litter composition Figures and Data

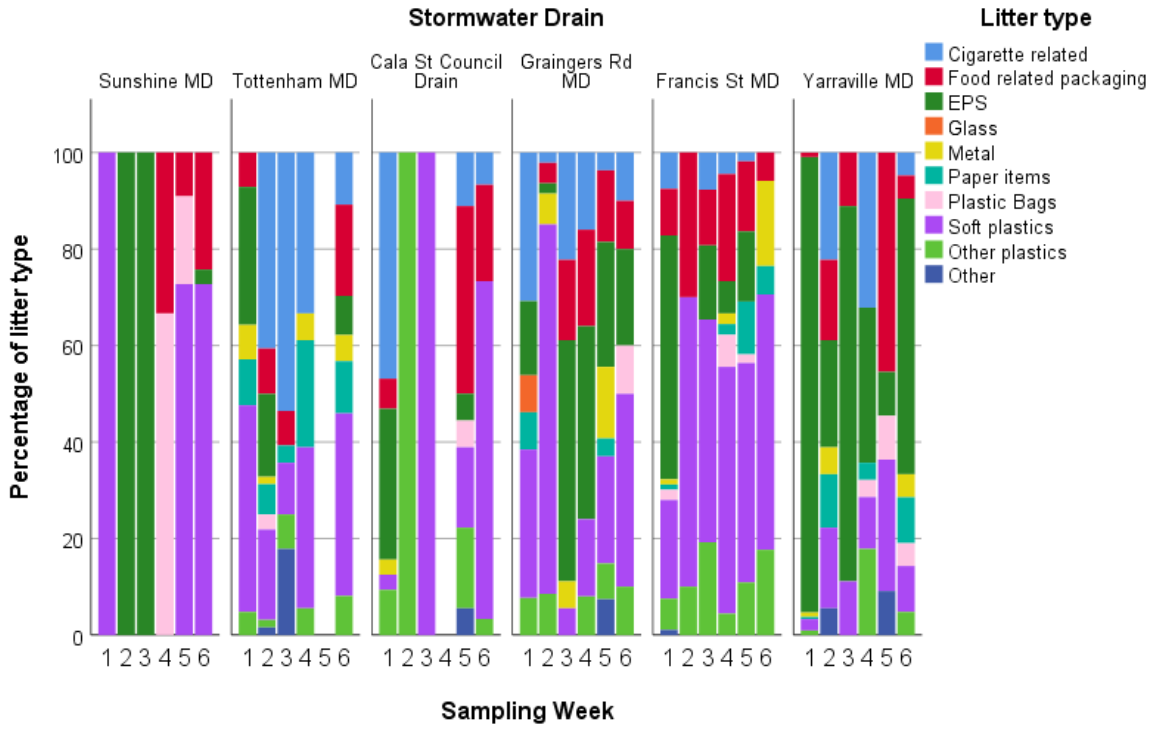

Figure 19: Composition of litter captured from stormwater drains according to sampling week.

Table 6: Summary of litter items captured from stormwater drains (Bold are most captured items).

Litter category	Site	Yarraville MD		Francis St MD		Cala St Council Drain		Graingers Rd MD		Tottenham MD		Sunshine MD	
	Litter Type	#	% total	#	% total	#	% total	#	% total	#	% total	#	% total
Metal	Aluminium beverage cans	1	0.33	1	0.38	0	0	3	2.14	0	0	0	0
	Aluminium foil pieces	2	0.66	1	0.38	0	0	1	0.71	2	1.06	0	0
	Fragments and remnants	1	0.33	1	0.38	0	0	1	0.71	1	0.53	0	0
	Aluminium packaging	1	0.33	6	2.28	1	1.22	4	2.86	4	2.12	0	0
	Coin	0	0	0	0	0	0	1	0.71	0	0	0	0
	Aerosol/ spray cans: Deodorant	0	0	0	0	0	0	1	0.71	0	0	0	0
Cigarette related	**Cigarette butt**	**14**	**4.65**	**12**	**4.56**	**19**	**23.17**	**15**	**10.71**	**50**	**26.46**	0	0
	Cardboard type packets & cartons	0	0	0	0	0	0	0	0	1	0.53	0	0
Plastic food related packaging	Bottles 1L or less only	2	0.66	0	0	0	0	2	1.43	0	0	0	0
	Lid and lid rings only	2	0.66	5	1.90	2	2.44	0	0	0	0	0	0
	Lollipop sticks	1	0.33	0	0	0	0	0	0	0	0	0	0
	Food wrappers (soft includes metallic type) chips, confectionary etc	**5**	**1.66**	**26**	**9.89**	**10**	**12.20**	**9**	**6.43**	**15**	**7.94**	**10**	**17.86**
	Straws	0	0	1	0.38	0	0	1	0.71	2	1.06	0	0
	Coffee cup only	0	0	0	0	2	2.44	0	0	0	0	0	0
	Coffee lid only	1	0.33	0	0	1	1.22	0	0	1	0.53	0	0
	Soy sauce fish & caps	0	0	2	0.76	0	0	0	0	0	0	0	0
Plastic bags	Dog poo & nappy bags (empty)	1	0.33	1	0.38	1	1.22	1	0.71	0	0	0	0
	Light weight bag	2	0.66	5	1.90	0	0	0	0	2	1.06	**4**	**7.14**
Soft Plastics	**Soft Plastic >5mm**	**17**	**5.65**	**103**	**39.16**	**26**	**31.71**	**55**	**39.29**	**53**	**28.04**	**36**	**64.29**
Other plastics	Hard plastic pieces >5mm	2	0.66	13	4.94	1	1.22	9	6.43	4	2.12	0	0
	Hard plastic packaging	0	0	1	0.38	1	1.22	0	0	0	0	0	0
	Packaging accessories (seals, reels, spools, handles etc.)	0	0	1	0.38	0	0	0	0	0	0	0	0
	Pens, markers & other stationary	0	0	1	0.38	0	0	0	0	0	0	0	0
	Rubber type balloons only	0	0	0	0	0	0	0	0	1	0.53	0	0
	Wrap non-food & bubble wrap	2	0.66	0	0	0	0	0	0	0	0	0	0
	Contact lens packaging	0	0	0	0	0	0	0	0	1	0.53	0	0
	Plastic Glove	1	0.33	0	0	0	0	0	0	1	0.53	0	0
	Non-food containers including tubes (oil, sealant, chemical, glue) >4L	0	0	1	0.38	0	0	0	0	0	0	0	0
	Mask	0	0	0	0	0	0	1	0.71	0	0	0	0
	Mesh	0	0	1	0.38	0	0	0	0	0	0	0	0
	Other OH&S items (safety markers, gloves etc.)	1	0.33	0	0	0	0	0	0	0	0	0	0
	Plastic coated wire	0	0	1	0.38	0	0	0	0	0	0	0	0
	Plastic label	0	0	1	0.38	3	3.66	0	0	0	0	0	0
	Plastic string & cord (<1cm diameter)	0	0	1	0.38	0	0	0	0	0	0	0	0
	Synthetic cleaning sponges, wipes, brushes etc.	0	0	0	0	1	1.22	0	0	0	0	0	0
	Syringes	0	0	0	0	1	1.22	0	0	0	0	0	0
	Duct tape, masking tape etc.	2	0.66	3	1.14	0	0	0	0	0	0	0	0
EPS	**Unidentifiable polystyrene pieces <5mm**	**200**	**66.45**	0	0	**1**	**1.22**	0	0	0	0	0	0
	Unidentifiable pieces >5mm	**33**	**10.96**	**58**	**22.05**	**5**	**6.10**	**24**	**17.14**	**18**	**9.52**	**5**	**8.93**
	Packaging bead <5mm	1	0.33	2	0.76	**5**	**6.10**	2	1.43	0	0	1	1.79
	Foam sponge sheet	0	0	1	0.38	0	0	0	0	0	0	0	0
	Other packaging	1	0.33	2	0.76	0	0	**5**	**3.57**	**8**	**4.23**	0	0
Glass	broken glass	0	0	0	0	0	0	1	0.71	0	0	0	0
Paper items	Paper >5mm unid	6	1.99	9	3.42	0	0	1	0.71	14	7.41	0	0
	paper cup	0	0	1	0.38	0	0	0	0	1	0.53	0	0
	paper food packaging/related	0	0	0	0	0	0	1	0.71	2	1.06	0	0
Other	Bird corpse	0	0	0	0	0	0	1	0.71	0	0	0	0
	Other materials (bricks, cement, ceramic/ concrete pipes, tiles & similar)	0	0	0	0	0	0	0	0	5	2.65	0	0
	Floristry foam	0	0	1	0.38	0	0	0	0	0	0	0	0
	Hardened paint/laminate	0	0	0	0	1	1.22	0	0	0	0	0	0
	Clothing, shoes, hats & towels	0	0	0	0	0	0	1	0.71	0	0	0	0
	Binding, thread, string & cord (not plastic/ synthetic)	0	0	0	0	0	0	0	0	1	0.53	0	0
	Other textiles (pieces of cloth, rags etc.)	1	0.33	0	0	0	0	0	0	0	0	0	0
	Rubber type balls & toys: Tennis balls	0	0	1	0.38	1	1.22	0	0	0	0	0	0
	Rubber band	0	0	0	0	0	0	0	0	2	1.06	0	0
	Wooden material (processed timber, pallets, crates & similar pieces)	1	0.33	0	0	0	0	0	0	0	0	0	0
TOTAL LITTER ITEMS		**301**		**263**		**82**		**140**		**189**		**56**	

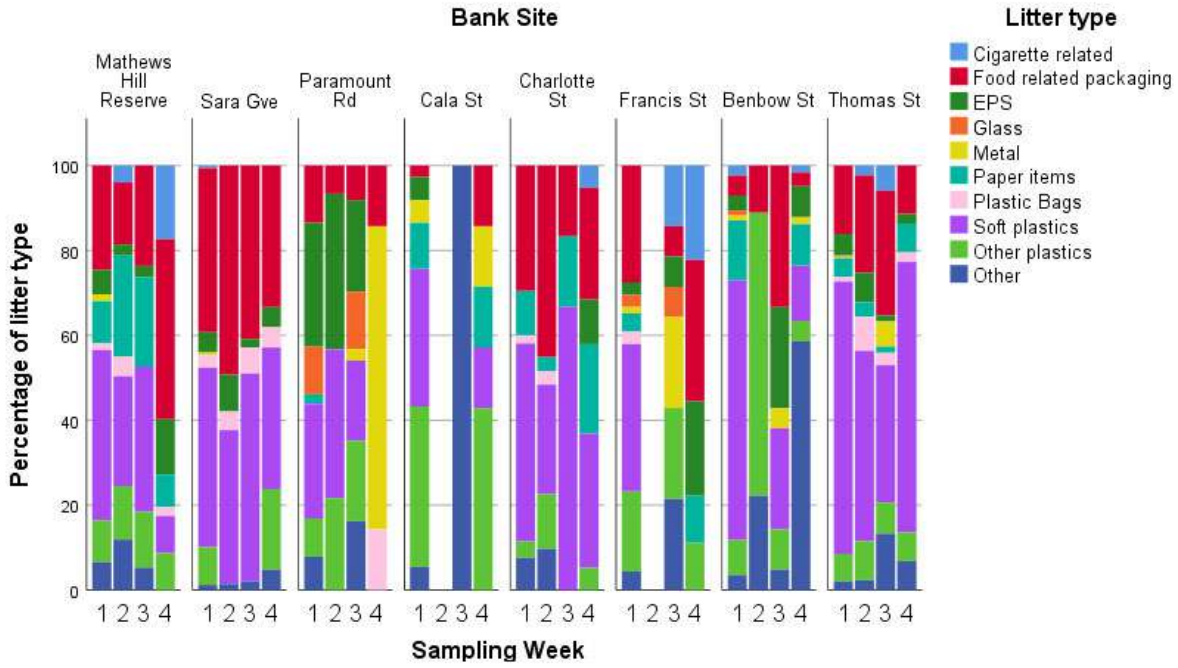

Figure 20: Composition of litter captured during bank surveys according to sampling week.

Table 7: Summary of litter items captured from banks (Bold are most captured items).

Litter Category	Site	Thomas St		Benbow St		Francis st		Charlotte st		Cala St		Paramount rd		Sara Grove		Mathews Hill Reserve	
	Litter Type	#	% total	#	% total	#	% total	#	% total	#	% total	#	% total	#	% total	#	% total
Metal	Tools, building and trades material (not E waste)			1	0.42												
	Aerosol/ spray cans	1	0.22														
Cigarette related	**Cigarette butts**	4	0.87	4	1.69	**4**	**4.35**									**22**	**5.46**
	Lighter													1	0.33		
	Cardboard type packets & cartons	1	0.22														
	Outer wrapper, foil inners, tobacco pouches	1	0.22					1	0.62								
Food Related Packaging - EPS	Cups											1	0.52	1	0.33	2	0.50
Food Related Packaging - Paper	Paper napkins					1	1.09										
	Fast food packaging (incl. paper bags)	2	0.44	7	2.95			1	0.62							2	0.50
	Paper/cardboard ice cream wrappers, sugar sachet etc.			1	0.42	1	1.09										
	Paper/cardboard, natural material plates, cups and bowls					**3**	**3.26**										
Food Related Packaging - Plastic	**Food wrappers (soft includes metallic type) chips, confectionary etc**	**16**	**3.49**	**1**	**0.42**	**6**	**6.52**	**26**	**16.15**	**1**	**2.17**	**6**	**3.11**	**93**	**30.29**	**68**	**16.87**
	Forks, knives & spoons					1	1.09	1	0.62								
	Straws	7	1.53			3	3.26	1	0.62			2	1.04	6	1.95	4	0.99
	Coffee cup & lid													2	0.65		
	Coffee cup only	1	0.22			1	1.09					1	0.52			3	0.74
	Coffee lid only							1	0.62					1	0.33		
	Smoothie type cups only (transparent plastic)	1	0.22					1	0.62							1	0.25
	Smoothie lid only (transparent domed plastic)					1	1.09	1	0.62							1	0.25
	Flat plastic cup lids (not coffee)															5	1.24
	Plastic picnic type cups	2	0.44											8	2.61		
	Bottles 1L or less only	5	1.09	1	0.42			8	4.97			1	0.52	2	0.65	1	0.25
	Bottles >1L only	1	0.22									1	0.52	1	0.33	3	0.74
	Lid and lid rings only	1	0.22			1	1.09							3	0.98	1	0.25
	Labels only	2	0.44			1	1.09	1	0.62							1	0.25
	Lollipop sticks															2	0.50
	Soy sauce fish & caps											1	0.52				
	Other sauce sachets	2	0.44					1	0.62								
	Mesh bags (vegetable, oyster, mussel etc.)	1	0.22														
	Hard takeaway food tubs & lids			1	0.42											2	0.50
	Other food containers (ice cream, food jars etc.)					1	1.09										
	Beverage pouches / squeeze tubes			1	0.42												
	Food pouches/ squeeze tubes (yoghurt etc.)	12	2.62	1	0.42							2	1.04				
	Bread bag, pasta bag & similar			1	0.42							1	0.52				
Food related Packaging - Glass	Other alcoholic beverages (beer, ready mix, etc)					1	1.09					2	1.04				
Food Related Packaging - Metal	**Soft drink, water, juices**	4	0.87	2	0.84	1	1.09	**6**	**3.73**			1	0.52	7	2.28	2	0.50
	Alcoholic beer, spirits, ready mixes, etc	2	0.44			1	1.09	1	0.62	1	2.17			1	0.33	1	0.25
	Aluminium foil pieces	4	0.87	3	1.27	4	4.35	1	0.62	**3**	**6.52**	**6**	**3.11**	2	0.65	2	0.50
	Foil tubs and trays							1	0.62								
	Food cans, includes pet food											1	0.52			1	0.25
Plastic bags	Light weight bag	6	1.31			1	1.09					1	0.52	4	1.30	2	0.50
	Heavy weight / retail bag															1	0.25
	Snap lock type bags	3	0.66											2	0.65		
	Small produce/ barrier bags (from grocery store etc.)													2	0.65		
	Dog poo & nappy bags (empty)	4	0.87					1	0.62								
	Dog poo & nappy bags (full)							2	1.24					2	0.65		
	Garbage, rubbish bags, bin liners (empty)					1	1.09							1	0.33	8	1.99
	Garbage, rubbish bags, bin liners (full)													1	0.33		
Soft Plastics	**Soft Plastics <5mm**	**8**	**1.75**	**16**	**6.75**	**3**	**3.26**	**18**	**11.18**	**1**	**2.17**	**28**	**14.51**	**56**	**18.24**	**60**	**14.89**
	Soft plastic pieces >5mm	**269**	**58.73**	**57**	**24.05**	**21**	**22.83**		**0**	**12**	**26.09**	**24**	**12.44**	**71**	**23.13**	**49**	**12.16**
Other Plastics	**Hard plastic pieces < 5mm**	5	1.09	6	2.53	1	1.09	3	1.86	**2**	**4.35**	**13**	**6.74**			5	1.24
	Rubber type balloons only	3	0.66													2	0.50
	Balloon sticks & clips															1	0.25
	Cable ties & fasteners			1	0.42												
	Strapping band (whole)	3	0.66														
	Strapping band scraps	2	0.44	2	0.84			1	0.62							2	0.50
	handles etc.)															3	0.74
	Duct tape, masking tape etc.	1	0.22	5	2.11	1	1.09	2	1.24			1	0.52			2	0.50
	Pipe, PVC, irrigation & articulation									2	4.35	1	0.52			1	0.25
	Sheeting (tarpaulin, woven bags, pallet wrap)	1	0.22													2	0.50
	Other OH&S items (gloves etc.)													1	0.33		
	Hard plastic pieces 5mm & greater	**11**	**2.40**	**3**	**1.27**	**12**	**13.04**	**50**	**31.06**	**8**	**17.39**	**11**	**5.70**	**15**	**4.89**	**7**	**1.74**
	First aid materials & equipment (band aids, thin gloves etc.)	1	0.22	1	0.42			1	0.62							10	2.48
	Other drug paraphernalia					1	1.09									1	0.25
	Cotton buds (plastic stick)			1	0.42												
	Wet wipes/ baby wipes	2	0.44													1	0.25
	Pens, markers & other stationary	2	0.44											1	0.33		
	Personal care & pharmaceutical packaging													1	0.33		
	Hair ties			1	0.42												
	Toys, party poppers etc.							1	0.62							1	0.25
	Recreation & sporting equipment	1	0.22			1	1.09										
	Gardening items															1	0.25
	Lids, pump spray, bottle tops etc. (Not from beverages)															2	0.50
	Signs (corflute etc.)	1	0.22	1	0.42												
	Wrap non-food & bubble wrap							1	0.62	**5**	**10.87**						
	Municipal activities (tree guards, barrier fence etc.)													1	0.33		
	Shotgun cartridges & wadding	1	0.22														
	Plastic-type material shopping dockets, receipts, tickets					1	1.09										
	Syringes											1	0.52				
EPS	**Unidentifiable polystyrene pieces <5mm**	**12**	**2.62**	**9**	**3.80**	**2**	**2.17**			**2**	**4.35**	**17**	**8.81**	**13**	**4.23**	**11**	**2.73**
	Unidentifiable polystyrene pieces >5mm			**2**	**0.84**	**2**	**2.17**					**32**	**16.58**	**3**	**0.98**	**13**	**3.23**
	Packaging peanuts & beads >5mm	2	0.44	6	2.53	1	1.09					3	1.55				
	Foam sponge sheet							2	1.24			2	1.04				
	Other packaging	9	1.97									2	1.04				
Glass	Unidentifyable broken pieces	1	0.22	1	0.42	2	2.17					15	7.77				
	Tableware (plates, cups, etc)					1	1.09										
Paper items	Paper bags (not fast food)			2	0.84												
	Newspapers & magazines							1	0.62								
	Junk mail / free circulars															1	0.25
	Cardboard packages, boxes, sheets & tubes							1	0.62							2	0.50
	Paper shopping dockets, receipts, tickets	3	0.66	6	2.53			1	0.62							2	0.50
	Paper sheets, strips etc.	**16**	**3.49**	**14**	**5.91**	**3**	**3.26**	**12**	**7.45**	**5**	**10.87**	**2**	**1.04**			**59**	**14.64**
Other	IT, telecommunications & TV equipment (computers, laptops, remote controls)									1	2.17						
	Toys,Leisure,Sport equipment,Trains,Cars,hand Held Video,Games,radios,Amps													1	0.33	1	0.25
	Wooden material (processed timber, pallets, crates & similar pieces)											3	1.55				
	Other materials (bricks, cement, ceramic/ concrete pipes, tiles & similar)	3	0.66									3	1.55				
	Paper tissues	1	0.22	2	0.84			2	1.24								
	Cotton buds (paper/cardboard/ wood stick)									1	2.17						
	Clothing, shoes, hats & towels			1	0.42	1	1.09										
	Other textiles (pieces of cloth, rags etc.)	**14**	**3.06**	**5**	**2.11**	**4**	**4.35**	**2**	**1.24**	**2**	**4.35**	**3**	**1.55**	**4**	**1.30**	**27**	**6.70**
	Personal effects (wallets, money, keys, jewellery)							**7**	**4.35**								
	Rubber bands	1	0.22														
	Tyre fragments			2	0.84												
	Matches & pencils etc.			**70**	**29.54**												
	Organic materials & food scraps, including dog poo (not bagged)	1	0.22			1	1.09										
	Medical tablets/capsules							1	0.62								
	Natural material cleaning sponges, cloths, wipes & brushes	1	0.22			1	1.09					5	2.59				
	masks	1	0.22													2	0.50
	TOTAL LITTER ITEMS	**458**		**237**		**92**		**161**		**46**		**193**		**307**		**403**	