A study on Gross Pollutant traps in Drainage Channels

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Abstract

Despite the wide implementation in Australia of Gross Pollutant Traps (GPTs) in local drainage systems, there is limited understanding of their performance and operational requirements. The purpose of this study is to review the available information on the performance and operational requirements of the devices of interest (drainage nets, floating booms and floating traps) through a literature review and consultation with different stakeholders and to standardise a monitoring methodology for the nets based on the current maintenance methodology undertaken by the City of Kwinana. The high frequency of the City of Kwinana's drainage nets inspection and cleaning ensures that the units are efficient at each storm event but additional data would be beneficial to develop a common basis for comparing trap performance.

1. Introduction

During a rainfall event large enough to generate runoff across the surface, accumulated pollutants on urban impervious surfaces may be quickly mobilized by stormwater runoff and discharged into receiving waterways. Gross pollutant traps (GPTs) are a tool to reduce litter and debris being transported in drains. These devices are installed in drainage infrastructure to capture and retain gross pollutants (litter and organic debris greater than 5 mm) by physical screening.

Water Corporation is investigating measures to reduce the level of plastic waste in stormwater discharge to the ocean, as part of its commitment to the State Waste Strategy Action 1.14, and proposes to run a trial installing Gross Pollutant Traps (GPTs) in Herdsman Lake's drainage system. The trial seeks to determine the investment, in terms of life cycle cost and operational and assess the effectiveness of two different types of GPTs. Initially, the GPTs considered as possible options included drainage nets (Figure 1a), floating litter booms (Figure 1b) and floating litter traps (Figure 1c). The net were found unsuitable to install in Herdsman Lake due to the required size of these nets to service the existing pipes, plus the operational and wildlife protection challenges. The Corporation continues to investigate the possibility of installing a trash net(s) in a suitable drainage outlet. Despite the wide implementation of GPTs in local drainage systems in Australia there is little evaluation of their performance in arterial drainage systems, and limited evaluation of their trapping efficiency and operational requirements (Wong et al, 1999).

This study is part of the broader project to install GPTs in Herdsman Lake's drainage system and will assist the Corporation to determine the performance and the economic burden of the selected GPTS and to assess the possibility to broaden their use in the Corporation's drainage network. The project aims to achieve the following objectives:

- Develop an understanding via a literature review of the performance, maintenance and operational requirements of drainage nets, floating litter booms and floating litter traps providing a point of comparison to the actual data that will be collected once the Herdsman Lake GPTs are installed.
- Standardise a feasible, cost-effective methodology for monitoring drainage nets based on the current maintenance methodology undertaken by the City of Kwinana.

Figure 1 GPTs of interest: drainage net (a), floating litter boom (b), floating litter trap (c)

2. Process

2.1 Literature Review and Consultation with Stakeholders

The first objective of the project is to undertake a literature review of previous studies and reports on drainage nets, floating litter booms and floating litter traps and to consult with different stakeholders such as local governments, water utilities and suppliers to collect data on performance, operation activities, costs and monitoring methodologies of the GPTs of interest.

2.2 Analysis and Optimisation of the City of Kwinana's Monitoring Methodology

The knowledge acquired through the literature review and consultation with stakeholders establishes a starting point to standardising a monitoring methodology for the drainage nets. The City of Kwinana consented to collaborate on this project by allowing their nets monitoring methodology to be used as a case study for the optimization and/or standarisation of a monitoring methodology. The following steps are necessary for identifying gaps, determing if and how they could be improved and for capturing any lessons learnt:

- *Analysis of Current Monitoring Methodology* involves a discussion with the City about the drivers behind the nets installation and the maintenance and monitoring activities. This analysis aims to assess the effectiveness of: 1. the devices, 2. the frequency of maintenance and inspection, 3. the cleaning method and costs, 4. the equipment employed and personnel involved and 5. the waste disposal procedures.
- *Catchment Characterisation* and its visual survey aim to investigate the catchment's stormwater pathway, the critical gross pollutants sources and site constraints through a visual survey and a desktop assessment of the catchment. The catchment characterization include assessing:
  - catchment size, land use and site constraints,
  - collection of information on nature and hydraulics of the drains (pipe and open drain locations, dimensions and lengths),
  - key maintenance activities within the catchment that may affect gross pollutant loads (street sweeping, waste removal services, local drainage maintenance),
  - identification of potential sources of gross pollutants through review of available land use planning information and aerial photography to identify key land uses that source gross pollutants.

3. Results and Discussion

3.1 Literature Review and Consultation with Stakeholders

From an analysis of previous reports emerged the general lack of data collected on GPTs and specifically about those designs that are considered in this study. Despite several GPTs installations across the country, very few local authorities collect extensive and detailed data about their GPTs. The performance data are available in the form of the weight or volume of gross pollutants removed from the traps, but the lack of other meaningful data such as gross pollutants not captured by the unit, catchment area, rainfall and water levels data doesn't allow the development of a common basis for comparing the capture efficiency of different waste interception devices (Wong et al., 1999).

As part of the literature review, 60 stakeholders were consulted across Australia including local governments, water utilities and suppliers and the main findings of this process are summarized in Table 1. Their responses varied greatly in term of GPTs' efficiency and maintenance method and this variance could indicate that the devices are actually operating at various degrees of performance, as already reported by a CSIRO's review (Neumann & Sharma, 2010). The effectiveness of a GPT is not only defined by its design but is also strictly dependant on its individual maintenance and operational actions. Because these factors are impacted by budget, site accessibility, catchment characteristics and gross pollutant load in the catchment, it is important to adjust monitoring activities and schedule to the specific catchment and location on a case by case basis (Wong et al, 1999). The devices of interest in this review require regular and frequent maintenance in order to prevent problems such as water quality issues, sediment buildup, performance decline and deterioration of the structure itself. To this end, standard procedures in assessing and reporting the system's efficiency and in scheduling and reporting maintenance activities would ease the management requirements of these units.

	Drainage nets	**Floating litter booms and traps**
Performance	Capture efficiency of gross pollutant around 90% Performance is catchment specific. Less efficient the bigger the pipe	Capture efficiency of floating pollutants ranging from 12% to 50% Efficiency is rainfall and water-depth dependant
Main issues	Water quality issues	During high flows trapped material may escape
Maintenance frequency	Varies from 'every 6 months' to 'twice per month'	Varies from 'monthly' to 'weekly'
Inspection frequency	Varies from 'every 6 months' to 'after every heavy rain'	Varies from 'monthly' to 'after every heavy rain'
Equipment	Front-end loader and tipper truck Boom truck crane	Excavator or vacuum truck Manually with a pool scoop Skimmer vessel

Table 1 Summary of the results of the literature review and consultations with local authorities

3.2 Analysis of the City of Kwinana's Monitoring Methodology

The City of Kwinana reported one of the most efficient method in managing the drainage nets which represents a valuable basis for the development of a standard monitoring methodology for the nets. The City has five drainage nets in their drainage system. The first 2 nets were installed in 2018 and additional three nets were installed in 2020 (Table 2). The installation of drainage nets and GPTs is one of the actions outlined in the City's Sustainable Water Management Plan to address the litter impact on water quality of stormwater and to improve ecological health and ensure quality urban space (City of Kwinana, 2018).

The Council maintains the drainage nets through in-house personnel and equipment. As part of the monitoring activities, they developed a Safe Work Instruction for handling the nets and dedicated training course for the personnel involved. The City did not attempt to assess the effectiveness of the devices but from an analysis of the nets' maintenance data (Table 2) it can be concluded that there are variations in gross pollutant loads due to different catchment characteristics. Based on visual observations, the waste is made up mostly by organic matter and a minimal percentage (10%) of litter such as plastic bottles and cans. Additional data in their maintenance sheets related to catchment area, rainfall and water levels data would be helpful to be collected to develop a deeper understanding of nets performance.

The City proved being actively committed to improve the nets maintenance method, as shown in Table 3, by halving the required time to clean the nets from two hours to just one per device. In this way, they reduced the cleaning cycle cost per device from \$304 to \$152. The high frequency of the City of Kwinana's inspection and cleaning of their devices ensures that the unit trapping efficiency is optimum for each storm event and that materials do not decompose or stagnate causing water quality problems.

Locations of the Nets	Installation Year	Waste Collected in 2018 (kg)	Waste Collected in 2019 (kg)	Waste Collected in 2020 (kg)	Total
Site A	2018	670	892	395	1957
Site B	2018	260	147	90	497
Site C	2020			172	172
Site D	2020			60	60
Site E	2020			155	155

Table 2 Waste collected from the different locations of the nets since their installation. The data of 2020 refer to the waste that has been collected in 7 months (until July 2020) .

Item	2018	2019
Inspection frequency	After heavy rainfall	After heavy rainfall
Maintenance frequency	Wet Season: Twice per month Dry Season: Every 2 months	Wet Season: Twice per month Dry Season: Every 3 months
Annual Cleaning Cycles	8	6
Equipment and staff required	Front end loader, Tipper truck Two Officers	Front end loader, Tipper truck Two Officers
Time to clean 1 drainage net	2 hours (Each officer)	1 hour (Each officer)
Cost to clean 1 drainage net	$304	$152
Vandalism cost	$220	$220
Waste disposal cost/tonne	$80	$80

Table 3 Maintenance method, frequency and costs of the nets of the City of Kwinana from 2018 to 2019.

3.3 Site E's Catchment Characterisation (City of Kwinana)

The selected location at which to undertake a catchment characterisation is a drainage net installed in 2020 at Site E. The unit is located on the north-east perimeter of a park, draining a predominantly residential zoned R12.5/20 and commercial sub-catchment (Figure 2). The catchment covers an area of approximately 140 ha and the potential gross pollutant sources include pharmacy shop, takeaway food outlet, grocery shop, and liquor store. Based on an analysis of the waste collected in the net during the last seven months, the catchment contributed 1.11 kg per hectare of gross pollutants.

There are approximately 550 m of City of Kwinana's drainage network between the top end of the catchment and its discharge point. Side entry pits and grated pits are the primary types of pits seen within the catchment area. The information on the drainage system in the catchment derives from historical data and part of its hydraulic information is missing which doesn't allow a hydraulic analysis of the system to be undertaken.

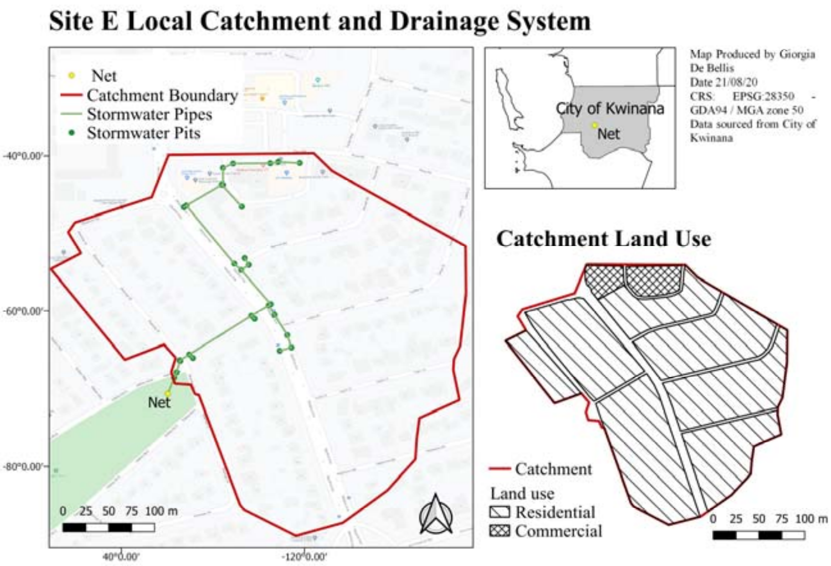

Figure 2 Site E Catchment identification and Drainage system.

4. Conclusions and Future Work

The drainage nets effectively address the litter problem the City of Kwinana has in its bush reserves because of the effective and frequent maintenance the City performs on their devices. Additionally, the selected drain outlets were highly suitable for the nets given that the discharge basins are mostly dry systems with ease of access for maintenance vehicles.

The remaining work of this study will endeavor to optimise/standarise the City's monitoring methodology based on the findings of this analysis. It is advisable to test the benefits of the proposed process by applying it to other local governments GPTs locations. It is also recommended to study the impacts of these GPTs on water quality and hydraulics to fully understand the implications of these devices and guide informed future decisions on their use and applications.

5. Acknowledgements

I would like to recognize the inestimable assistance and enormous support of my Water Corporation mentor Paola Duarte Romero, without whom I would not have made it through this research. Thanks to my supervisor Anas Ghadouani for believing in me and always supporting me. My deepest gratitude to my mentor Jason MacKay and to Suzanne Brown, Amanda Best and the rest of the Drainage and Liveable Communities team for embodying the essence of the One Team value. I am grateful to the City of Kwinana for their collaboration in this project, particularly Kim Logue for her time and help.

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