
4. Findings and recommendations

4.1 Recommended cleaning approaches

The following provides a summary of recommended cleaning approaches based on the study outcomes.

4.1.1 Method

Equipment needed

- Traffic cones.
- Personal protective equipment.
- High pressure cleaning and waste collection equipment. A vehicle with both high pressure washing and vacuum for waste collection is recommended.
- Bunding to control runoff from entering drainage network.
- Protective measures to shield pedestrians, surrounding infrastructure, and assets from cleaning operation (i.e. self-standing protective screens).

Prior to Cleaning

1. Arrange any required permits to clear the area for cleaning (i.e. carparks).
2. All loose material is to be collected from the permeable pavement via street sweeping. This could include organic materials such as leaves and pollen, and aggregates such as fine sediments.
3. Traffic cones are to be placed around the cleaning area to warn others of the works and protect onsite personnel.
4. Appropriate waste collection equipment is to be installed to capture all generated runoff. All reasonable efforts must be employed to prevent sediment-laden runoff from entering the stormwater network (Table 5). This could include bunding drainage channels and stormwater pits and collecting waste materials via vacuum.



Figure 21. Flexible vacuum nozzle in drainage channel



Figure 22. Hard vacuum pipe resting in drainage channel

5. Protective measures are to be installed to protect people and surrounding infrastructure from the cleaning operation (Figure 23). Consideration should be given to the impact the cleaning method may have on site users (i.e. pedestrians, cars, cyclists) and existing public and private infrastructure.
6. Before the cleaning commences, a range of pressures should be trialled to establish a safe and effective pressure level for the site. A very high water pressure should be first trialled on a small patch of permeable pavement to understand its structural limit, and then it should be lowered till no further impacts can be seen. Impact may be seen through the dislodging of aggregate (Table 5).



Figure 23. Protective shield is used to protect a parked car from thrown material.

Cleaning Process

Slow, thorough pressure washing is recommended for cleaning permeable asphalt. Below is the recommended cleaning process for a high pressure wand:

7. The pressure cleaning should be completed in sections and started at the furthest point upstream of the waste collection equipment. A minimum of 30 seconds per m² should be adopted to ensure a thorough clean is provided. All waste should be directed to the collection equipment for capture and removal (Figure 24).



Figure 24. Vacuum waste collection system - waste is directed towards a vacuum nozzle rested in the downstream drainage channel.

8. Cleaning **must be conducted using a slow and thorough action, spending a reasonable amount of time on each area** and additional time where there is evidence of greater sediment accumulation and build-up. A minimum cleaning rate of 30 seconds per m² should be adopted.
9. Any remaining waste material is to be removed, and all equipment is to be packed up.

4.1.2 Frequency

Every permeable pavement site is exposed to different types and volumes of pollutants and this influences its optimal cleaning regime. As a general guide on cleaning frequency, the following points are provided based on the outcomes of this study:

- A cleaning frequency of 1.5 years is recommended. It is expected this value will range between 1-2 years depending on the site context.

- Cleaning is recommended in late Autumn if deciduous trees are present or late Spring if local vegetation drops significant volumes of pollen.

In the case of Harris St, bi-annual would be adequate while annual cleaning would maintain and ensure a higher level of performance.

4.1.3 Estimated costs

The potential time involved and related costs for cleaning were estimated. These values are provided in Table 11 and Table 12 respectively. These values may vary significantly depending on the size of site, access and traffic, number of sites to be cleaned, type of equipment used, and approaches adopted.

Table 11. Cleaning time for wand pressure washing

Location		
Eades Place	Number of carparks	35 spaces approx. (including driveways) Approx. car park dimensions: 2.6m x 4.9 m
	Total area	450 m ² approx.
	Time to clean	4 hours (assuming cleaning rate of 30 seconds per m ²)
Harris St	Number of carparks	34 spaces approx. (including driveways) Approx. car park dimensions: 2.6m x 4.9 m
	Total area	433 m ²
	Time to clean	4 hours (assuming cleaning rate of 30 seconds per m ²)
General	Time to clean	6.5 mins per carparking space

Table 12. Cleaning costs

Method	Cost
Wand pressure washing	~\$3,000 per day ex GST (10 hours). This includes: <ul style="list-style-type: none"> - 2 hours travel - 1.5 hours setup, pack up and breaks - 6.5 hours of cleaning (approx. 65 car parking spaces)

4.2 Recommended monitoring program

The following general monitoring program is recommended:

- **Initial clean:** an initial clean and infiltration test should be conducted to fully restore and understand the asset's infiltration capacity.
- **Post clean:** Infiltration testing should be conducted every 6 months to establish the site's unique rate of clogging for the first 1-2 years.
- **Ongoing monitoring:** At a minimum, all assets should be inspected and tested annually to confirm if cleaning is needed. Cleaning should be conducted when median infiltration rates fall below 100 mm/hr. An infiltration test that exceeds 35 minutes will indicate this point.

4.3 Recommendations for future installation of permeable pavement

Appropriate placement of permeable pavement is key in ensuring long term performance and minimal maintenance. The following site attributes are recommended for future permeable pavement site selection:

- As a limit, permeable pavements should be no less than 50% of their own catchment, and ideally be between 80-100% of catchment.
- Areas that are not exposed to fine sediments and organic debris. This includes organic matter from overhanging deciduous trees (i.e. leaves, pollen) and spillage or overflow of fine aggregates (i.e. tree pit toppings, loose soils, sand) within the catchment.
- Areas that can be safely tested and cleaned without significant traffic management implications.

4.4 Other recommendations

It is recommended Council source equipment that allows for a uniform application of pressure washing, is suitable for large areas, and limits associated off spray that may fling debris (i.e. commercial surface cleaner, ride-on pressure washer).

5. Summary of recommendations

Table 13. Cleaning and monitoring assumptions

Cleaning and monitoring	
Cleaning method	Slow, thorough pressure washing is recommended for cleaning permeable asphalt.
Cleaning method technology	It is recommended Council source equipment that allows for a uniform application of pressure washing, is suitable for large areas, and limits associated off spray that may fling debris (i.e. commercial surface cleaner, ride-on pressure washer). A high pressure wand is suitable for small areas.
Proposed rate of cleaning	30 seconds per m ² (6.5 mins per carparking space)
Frequency of cleaning	18 months (1.5 years)
Timing of cleaning	Late Autumn if deciduous trees are present or late Spring if local vegetation drops significant volumes of pollen.
Frequency of monitoring	6 months for first the 2 years, and annually thereafter. Cleaning should be conducted when median infiltration rates fall below 100 mm/hr. An infiltration test that exceeds 35 minutes will indicate this point.
Cost of cleaning	<p>\$3,000 for 65 carparking spaces (approx.).</p> <p>Includes:</p> <ul style="list-style-type: none"> • 2 hours travel • 1.5 hours setup, pack up and breaks • 6.5 hours of cleaning (approx. 65 car parking spaces)

Table 14. Future site selection

Permeable pavement site selection	
Catchment	Ideally assets will be between 80-100% of their own catchment. As a maximum, assets should be no less than 50% of catchment area.
Site debris	While recognising permeable pavements will be used to passive irrigate trees, avoid areas that contain fine sediments and organic debris where possible. This includes organic matter from overhanging deciduous trees (i.e. leaves, pollen) and fine aggregates (i.e. tree pit toppings, loose soils, sand).
Safety	Avoid areas that require significant traffic management interventions and pose higher safety risks for cleaning and testing personnel.