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City of Melbourne

Permeable pavements maintenance and monitoring outcomes

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Executive Summary

Permeable asphalt installed over carparks at Eades Place (West Melbourne) and Harris St (North Melbourne) was cleaned and monitored over a period of 12 months to identify an effective cleaning method for surface clogging and to understand an appropriate cleaning frequency to keep them at a functional level (>100 mm/hr). Three cleaning methods were employed to understand their relative effectiveness in restoring infiltration rates. This included dry vacuuming, pressure washing, and a combination of dry vacuuming and pressure washing. A sweeping and more thorough approach of these methods was also trialled to understand their sensitivity to restoring functionality.

The results demonstrated that pressure washing via the through approach is the most effective cleaning method in improving performance. This method was able to restore infiltration rates beyond 12 months, with over 55% of the testing sites at Harris St providing greater than 300mm/hr.

Figure 1. Before pressure washing (wet), Harris St

Figure 2. After pressure washing (wet), Harris St

Table 1 provides a summary of the recommended cleaning approach based on the study outcomes. Appropriate placement of permeable pavement is also key in ensuring long term performance and minimal maintenance. Table 2 includes the site attributes that are recommended for future permeable pavement site selection. Further recommended actions from this study are as follows:

- Experiment with different water pressures to determine an optimal operating range.
- Investigate technologies for pressure washing large scale areas efficiently such as mobile or ride-on equipment. Consider dual pressure washing and suction technologies to remove existing debris, limit runoff, and minimise risk of pushing surface pollutants into the porous aggregate matrix of the pavement.

Table 1. 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	$3,000 for 65 carparking spaces (approx.). Includes: • 2 hours travel • 1.5 hours setup, pack up and breaks • 6.5 hours of cleaning (approx. 65 car parking spaces)

Table 2. 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 safely risks for cleaning and testing personnel.

1. Introduction

1.1 Purpose of study

The City of Melbourne (Council) is undergoing a transition to align its urban water management practices with the natural water cycle and become a water sensitive city. Increasing the permeability of the Council's urban environments is one initiative the Council is trialling to provide stormwater quality treatment, reduce flood risks and increase soil moisture availability for trees. E2Designlab has been commissioned to study the effectiveness of several permeable pavement trial projects to develop a set of monitoring and maintenance recommendations for their ongoing management.

There is concern that some of the trial sites are not infiltrating effectively. Failure of infiltration systems such as permeable pavements most commonly occurs due to clogging or design and construction issues. A prior study identified that cleaning of these pavements was effective in restoring infiltration capacity in circumstances where the initial infiltration capacity was lower than expected or even no longer observable. This study has set out to undertake cleaning of a more extensive area of permeable paving using a range of cleaning methods and then to monitor these to understand the change in infiltration rates over time and assess what frequency cleaning is likely to be needed.

1.2 Background

The City of Melbourne has previously constructed a number of trial permeable pavements and permeable interlocking concrete pavements (PICP), referred henceforth as permeable pavements. In the future Council intends to construct much larger areas of similar permeable pavements but needs to be confident that they are effective and that it has the knowledge and understanding to be able to maintain these effectively.

There is concern that some of the trial sites appear to not be infiltrating effectively and may have clogged. Failure of infiltration systems such as permeable pavements most commonly occur due to clogging or design and construction issues.

Clogging may occur at either the exposed infiltration surface or at the interface with the underlying and surrounding subsoil (or less commonly an internal interface). Clogging may be of a physical, biological or chemical nature and the processes are common for infiltration systems such as permeable pavements, infiltration basins and trenches, aquifer storage and recovery and media filtration systems. In stormwater treatment measures, physical clogging due to fine sediment (2-6 um) is the most common and likely cause as demonstrated in experiments at Monash University (Siriwardene, 2007) while biological clogging due to organic material from trees can also lead to clogging.

Infiltration systems (including permeable pavements) and clogging processes are well researched internationally (Duchene, 1994, Fujita, 1994, Hamacher and Hausmann, 1999, Bouwer, 2002, Dierkes et. al, 2002, Dechesne, 2004, Le Coustumer and Barruad, 2007, Endo et. al., 2008, Aryal 2015, Winston et. al., 2016 as well as in Australia (Browne, 2007, 2008, 2009, 2011, 2012, Siriwardene, 2007, Argue et. al., 2004, Newton, 2005, Pezzaniti et. al., 2009, Pezzaniti and Shackel et. al., 2009. The research shows that clogging will occur over time with the longevity of systems ranging from short (<1 year) to long (>10 years) before clogging significantly constraining infiltration occurs. Clogging occurs as an exponential function with infiltration rates rapidly declining then approaching an asymptote. While the initial high infiltration rates will rapidly decline, it may be preferable to clean systems relatively frequently to maintain infiltration rates within a moderate range.

Research into cleaning of permeable pavements and infiltration systems, Gerrits, 2002, Sansalone, 2012 and others has found cleaning can be quite effective in restoring infiltration capacity. Even sweeping or vacuuming can significantly restore infiltrative capacity while suction and water jetting combined has been found to be the best approach in other studies.

1.3 How do permeable pavements work?

1.3.1 Function

Permeable surfaces allow water to pass through to a sub-surface base course and from there slowly infiltrate into surrounding soils and/or into the drainage network.

1.3.2 Design

Permeable pavement systems comprise of four layers, usually with a geotextile permeable liner between them (Figure 3).

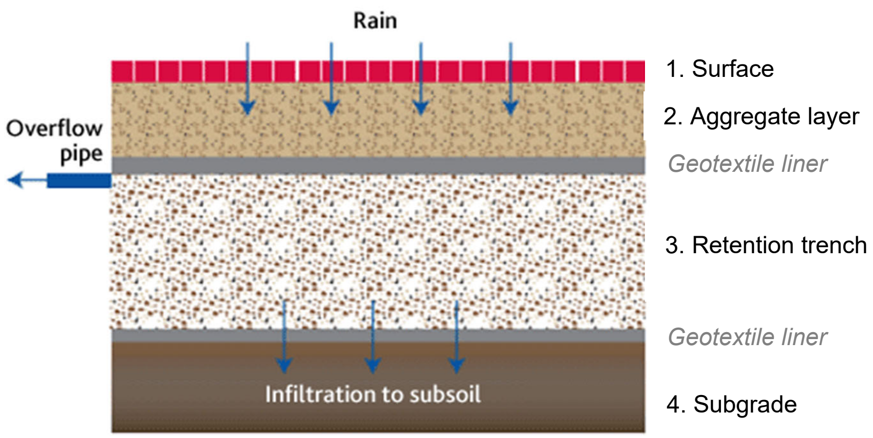

Figure 3. Permeable paving layers (Melbourne Water, 2017)

- **Surface layer -** The surface layer is a porous material that allows the infiltration of water into the subsurface layers. This can comprise open graded asphalt (with air voids between 20-25%), permeable pavers or interlocking paver arrangements with voids between pavers.

- **Aggregate layer -** The permeable pavement is directly underlain by a washed aggregate layer. The aggregate layer is to be a minimum of 75mm thick, compacted to 95% modified compaction.

- **Retention trench (structural soil layer):** Structural soils are a weight-bearing substrate made largely of crushed stone (basalt) and a small amount of filler soil mix (loam to clay loam with nutrient additives) at a ratio of typically 5:1 of volume (assuming void space of 40%). Under compaction, structural soils form a uniform, rigid, stone "lattice" with dispersed spaces (pores or voids) that allows for the controlled passage of oxygen, water and tree roots deep beneath concreted pavements and roads. These voids also provide room for an uncompacted soil mix rich in nutrients and trace elements for plant growth and water retention.

  Subgrade: The subgrade underlying structural soils should be compacted as per standard road construction.

1.4 Why should we use them?

Permeable pavement provides many benefits over conventional pavement systems:

- Reduces nuisance flooding by lowering peak stormwater discharges from paved areas.
- Improves the health of aquatic environments from a reduction in stormwater flows and improvement in stormwater quality.
- Increases the health of soils through greater soil moisture and groundwater recharge. Healthier soils support healthier and more drought-resilient street trees and green areas. This allows trees to grow and sustain a larger canopy area and to live longer.
- Reduces the need for large-scale stormwater management infrastructure.
- Provides for a cooler urban environment in summer due to the circulation of precipitation, air and water as well as increased shading.