PERVIOUS PAVEMENT MAINTENANCE GUIDE

TRIVERUS
CLEANING & ENVIRONMENTAL SOLUTIONS

INTRODUCTION

Pervious pavement is a specialized type of pavement that allows water to pass and filter directly through its porous structure. This reduces the water runoff from a site, allows groundwater recharge and limits the surface's contribution to stormwater. Pervious pavement includes pervious concrete, asphalt, and interlocking concrete pavers.

Properly maintaining pervious pavement will result in optimal performance, an operable infiltration rate, increased safety, reduced overall costs, and can prevent the need for total restoration. When needed, cleaning is performed by sweeping, vacuuming, and wet vacuuming to remove accumulated deposits. Each facility or project will have its own unique maintenance plan and schedule.

In this guide, we will review:

- Common misconceptions about maintaining pervious pavement
- Pervious pavement maintenance guidelines
- A pervious surface cleaning case study conducted by the University of New Hampshire Stormwater Center

This guide also includes:

- A sample maintenance log and inspection guide
- A "Best Practices" handout for facilities personnel

HOW DOES PERVIOUS PAVEMENT FAIL?

Before

After

Foreign material and organic deposits such as leaves, dust, and pine needles accumulate on pervious pavement. “Macro-plugging” forms a blocking layer on top of the pavement’s porous structure, preventing water from penetrating the surface. Furthermore, if these organic deposits are not removed regularly, they begin to degrade and begin to plug below the pervious pavement’s surface. This process limits the functionality of the pervious pavement, leading to increased water runoff, less groundwater recharge, and more contribution to stormwater.

According to the State of Washington’s *Industrial Stormwater General Permit Coverage*, “Uncontrolled industrial stormwater runoff discharges oil, grease, silt, and toxic substances into our waterways. Even small concentrations of polluted runoff are bad for fish and other aquatic life. Copper and zinc, which are commonly found in industrial runoff, are harmful to salmon and other aquatic life, even at relatively low concentrations” (learn more about the dangers of uncontrolled industrial stormwater runoff in the *Industrial Stormwater General Permit Coverage* by the State of Washington referenced in the appendix on page 11).

In the *Before* photo to the left, organic deposits are clearly visible on top of the interlocking pervious pavers and aggregate. In the *After* photo, the pavers have been swept and cleaned, restoring the functional permeability and leaving behind only the aggregate between the pavers. All types of pervious pavement must be cleaned to maintain permeability. Routine inspection of your pervious surfaces will allow you to monitor any buildup and assess performance.

COMMON MISCONCEPTIONS ABOUT MAINTAINING PERVIOUS PAVEMENT

FICTION	FACT
Pervious parking lots, sidewalks, or other areas can be maintained just like a conventional non-pervious surface.	To perform properly, pervious pavement requires specific maintenance that differs from conventional maintenance.
It is possible for pervious pavement to be so clogged, replacement is the only way to restore percolation functionality	Almost all intact pervious surfaces can be restored to percolation functionality.
Routine maintenance of pervious pavement is expensive.	Routine maintenance is affordable and is much less expensive than total restoration.
Maintenance of pervious pavement is time-intensive.	Routine maintenance can be performed quickly, with little down-time. Routine maintenance ultimately takes much less time than total restoration or replacement.
Pervious pavement can't be maintained in freezing temperatures.	Pervious pavement can be maintained and will perform in freezing temperatures. They do have to be cleared of snow and ice differently than conventional surfaces.
Pervious pavement clogs from the bottom up.	Pervious pavement clogs from the top down. Organic and inorganic deposits break down on the surface and clog the permeable structure's voids.

MAINTENANCE GUIDELINES

TYPE OF MAINTENANCE	WHAT'S INVOLVED	HOW OFTEN
Inspection	• Visually inspect pervious pavement to ensure that it is clean of leaves, pine cones, pine needles, moss growth, and other organic deposits. • Visually inspect pervious surface for inorganic solids being deposited by rainwater flow from upland or adjacent areas and traffic. • Is the surface maintaining a satisfactory infiltration rate? Is there puddling or is water remaining within 30 minutes after rainfall has ended? If so, refer to periodic maintenance and/or spot cleaning. • Inspect for deterioration or spalling.	• Monthly
Routine Maintenance	• Remove organic deposits that have settled on the pervious surfaces. This can be done with blowing (with leaf blower or similar equipment), truck-sweeping, and/or dry vacuuming. • If organic deposits can be removed before they begin to degrade and break down, this can postpone the need for deeper cleaning.	• 2 to 4 times per year, more frequently for high use sites, sites near heavy trees or bush cover, or areas with high potential for run-off contamination. • As needed based on inspection
Periodic Maintenance	• Vacuum-assisted high-pressure water jet cleaning can be used regularly to remove foreign material and organic debris from above and below the permeable surface to restore percolation. • At a minimum, pavement vacuuming should occur following the last snow event of the year and just prior to the first snow event of the year to remove accumulated debris.	• Every 6 months • Immediately before and after winter
Spot Cleaning	• Clay soils are generally easy to remove using a Shop-Vac for a small area, a walk behind vacuum for a medium sized area, or a vehicle-mounted vacuum for larger areas. • For small areas of acute or subsurface clogging, high-pressure washing or high-pressure washing and vacuuming have proven to be more effective than vacuuming alone to regain lost infiltration.	• As needed

MAINTENANCE GUIDELINES *continued*

TYPE OF MAINTENANCE	WHAT'S INVOLVED	HOW OFTEN
Winter Maintenance	• Snow removal should be performed using a rotary broom. • If a rotary broom is not available, snow should be removed using a plow with a non-metallic cutting edge. Metallic cutting edges tend to catch stones and cause raveling. Consider hybrid rubber, rubber composite, or ceramic composite cutting edges for the application. • Do not use deicing chemicals. If the pavement is working properly there should not be ice. Small crushed aggregate (1/4 – 10, or similarly sized) can be used for anti-skid purposes. Do not use fine sands for this purpose. If anti-skid material is applied, it must be removed when winter maintenance ends (learn more about using crushed aggregate in the *Pervious Concrete Pavement Maintenance and Operations Guide* by the National Ready Mixed Concrete Association referenced in the appendix on page 11). • Perform aggressive periodic maintenance just before winter to ensure pervious voids are unclogged and free of organic deposits that may limit draining and contribute to freeze-thaw damage.	• Late fall prior to snowfall • During or after snowfall
Restoration	• Over time, restoration of pervious concrete percolation rates will become necessary, particularly if routine and periodic maintenance is not performed. • Typically, an average infiltration rate decrease of 25% from the initial value, or an infiltration rate less than 100 inches per hour, triggers the need for deep cleaning/unclogging. Neglected projects that have never been cleaned and are completely clogged should be restored to a drainage rate of 100-200 inches per hour, per ASTM C1701, by using specialized cleaning equipment. • Restoration is best accomplished by simultaneous pressure washing and vacuuming. There are several commercially available cleaning systems available to rehabilitate the pore structure of pervious pavement. Use of chemicals to clean pervious concrete should be done with extreme caution to prevent damage to the aquifer, the biological organisms within the pervious system, or the pervious concrete pavement itself.	• As needed
Administrative	• Fill out maintenance logs and record changes, results, etc. • Review the maintenance plan and adjust as necessary • If selling the property, pass on the maintenance history and maintenance plan to the new owners	• As needed

CASE STUDY: University of New Hampshire Stormwater Center

1. BACKGROUND

Triverus' high-efficiency surface cleaning technology has the ability to remove critical stormwater pollutants from impervious surfaces and restore the functionality of pervious/ porous surfaces. In 2019, an independent third party, the University of New Hampshire Stormwater Center (UNHSC), sought to quantify the capabilities of Triverus' cleaning technology.

A series of surface infiltration tests were conducted on various pervious pavements located on the UNH campus. These tests were performed using ASTN C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete. This test is the industry standard for measuring pervious surface performance. Measurements were taken prior to and following cleaning with a Triverus Municipal Cleaning Vehicle (MCV), a commercially available cleaning vehicle that integrates Triverus 3800 PSI spray cleaning and recovery technology onto a Bobcat® Toolcat™ all-wheel steer carrier.

Two locations were identified for detailed testing: the West Edge porous asphalt lot and the Elliot Alumni Center porous asphalt lot. Both locations were on the UNH campus in Durham, New Hampshire.

A Triverus MCV cleaning pervious asphalt at UNHSC

West Edge Porous Asphalt Lot

Elliot Alumni Center Porous Asphalt Lot

UNIVERSITY OF NEW HAMPSHIRE
STORMWATER CENTER

CASE STUDY: University of New Hampshire Stormwater Center

2. TESTING LOCATIONS

The West Edge Porous Asphalt Lot

Built in 2005, the West Edge porous asphalt lot was 14 years old at the time of testing and received maintenance for at least the first five years of operation. Since 2010, minimal studies and maintenance had taken place. The area is approximately 5,000 square feet in size and had an average pre-cleaning infiltration rate of 3 in./hr. Due to the variability of the testing method, any permeable pavement with a surface infiltration rate less than 10 in./hr. is considered failed from a hydraulic perspective.

The West Edge lot was cleaned on July 8th, 2019. Climate statistics for Durham, New Hampshire during testing are below.

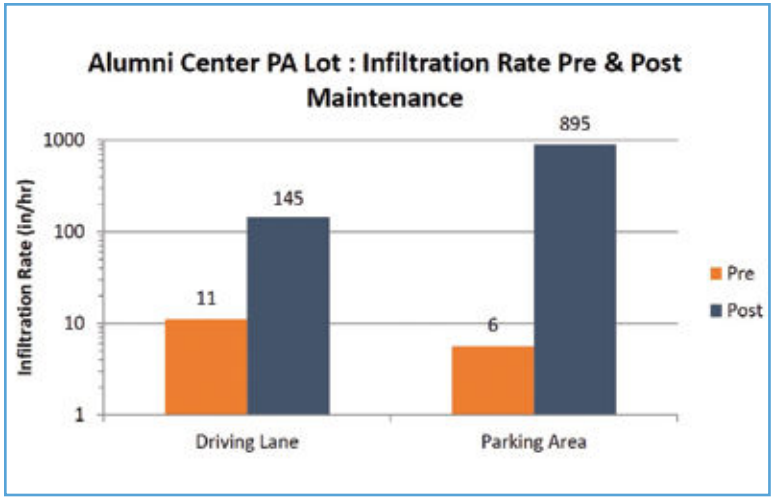
Parameter	Value
High Temperature	79 °F
Low Temperature	57 °F
Day Average Temperature	69.29 °F
Precipitation (past 24 hours from 04:56:00)	0.00 in
Dew Point	52.33 °F
High Dew Point	56 °F
Low Dew Point	49 °F
Average Dew Point	49 °F
Maximum Wind Speed	10 mph
Visibility	10 mi

Alumni Center Porous Asphalt Parking Lot

Built in 2012, the Alumni Center porous asphalt lot was seven years old at the time of testing and received maintenance for at least the first two years of operation. Since then, it was unclear how much maintenance was performed or if the maintenance was effective. From the very low pre-cleaning infiltration rate, it appeared no maintenance had occurred since 2014.

In 2015, a small test area of approximately 200 square feet in a parking spot and 200 square feet in a driving lane was conducted to assess restoration potential. The cleaning was conducted by UNHSC staff and consisted of low angle power washing into a vacuum. The overall restoration work took two staff approximately two hours per location. The experiment demonstrated the restoration potential of the technology and the need for advanced cleaning technology; at just over 50,000 square feet, the effort using staff and handwork was not insignificant (~125 hours for two staff).

The Alumni Center lot was cleaned on July 10th, 2019. Climate statistics for Durham, New Hampshire during testing are below. The infiltration results from this testing are shown below.

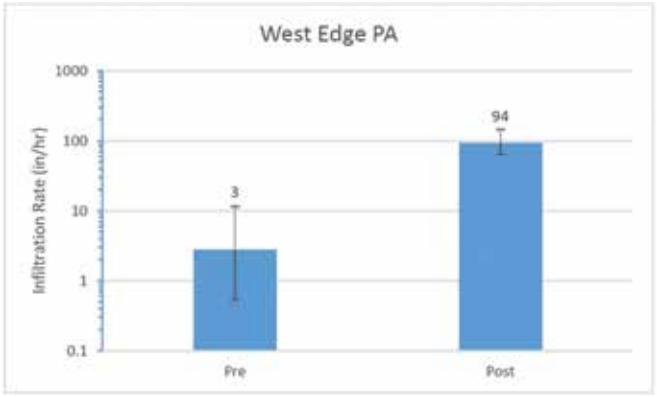


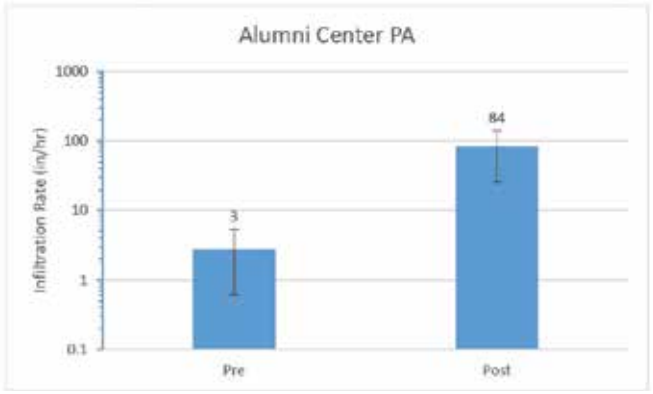
Parameter	Value
High Temperature	86 °F
Low Temperature	63 °F
Day Average Temperature	72.21 °F
Precipitation (past 24 hours from 04:56:00)	0.00 in
Dew Point	58.46 °F
High Dew Point	62 °F
Low Dew Point	54 °F
Average Dew Point	58.46 °F
Maximum Wind Speed	14 mph
Visibility	10 mi

CASE STUDY: University of New Hampshire Stormwater Center

3. CLEANING AND TESTING

During cleaning at both sites, material was removed from the pervious surfaces by the Triverus MCV and was separated and saved for testing. The water used and recovered by the MCV during the cleaning process was also saved for testing. The coarse solids were weighed and samples collected for laboratory analysis. Grab samples of the water slurry were taken and sent as a composite sample for laboratory analysis. The restoration process was inevitably longer and more time-intensive than typical routine maintenance, but resulted in a great performance increase. The average post-cleaning infiltration rate for the West Edge lot was 94 in./hr. This is considered functional and effectively restored. The cleaning took approximately 6 hours, and 150 lbs. of coarse sediment were removed from the area. The average post-cleaning rate for the Alumni Center lot was 84 in./hr. This is considered functional and effectively restored. The cleaning took approximately 4 hours, and 350 lbs. of coarse sediment were removed from the area*.





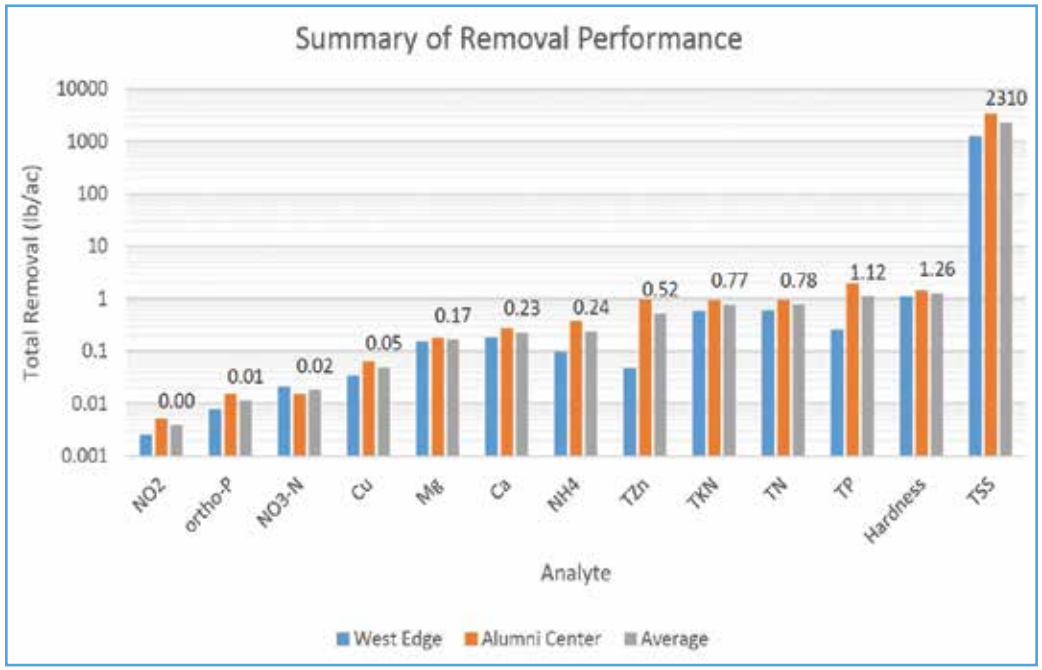
The coarse solids collected in the solids tray after several passes on the West Edge PA.

*The decrease in cleaning time from the West Edge lot was due in part to process efficiencies. Additional time reductions could be realized, particularly with respect to MCV support with a vacuum truck to reduce downtime associated with the disposal of removed material and refilling the water reservoir on the MCV. The detailed characterization and testing of the efforts take time and reduce restoration efficiency as well.

CASE STUDY: University of New Hampshire Stormwater Center

4. RESULTS

Overall, the restoration effort was extremely successful. UNHSC's research supports further exploration of restoration activities followed by more routine operation and maintenance such as vacuum sweeping twice per year. This data also reveals some significant differences in the pollutant partitioning between the liquid and solid fractions of the removed materials. It underscores the importance, particularly in nitrogen sensitive areas, of properly treating the removed waste materials. Learn more about this case study in the *Triverus Cleaning Technology Demonstration Report* by the University of New Hampshire Stormwater Center referenced in the appendix on page 11.



Summary of performance by site for the total removal of the solids, water, and slurry (note the logarithmic scale).

	REMOVAL (LB/AC)		
Analyte	Coarse Solid	Water & Fines	Total
Ca	-	0.23	0.23
Cu	0.05	0.00	0.05
Hardness	-	1.26	1.26
Mg	-	0.17	0.17
NH_4	0.22	0.02	0.24
NO_2	0.00	0.00	0.00
NO_3-N	0.00	0.02	0.02
ortho-P	0.00	0.01	0.01
TKN	0.49	0.27	0.77
TN	0.49	0.29	0.78
TP	1.01	0.12	1.12
TSS	2210	100	2310
TZn	0.48	0.04	0.52

Summary of average analyte removal rates for coarse solids, water and fines, slurry, and the total removed. Note the italicized values were measured BDL and assumed to be half the DL.

	Total Removal (lb/ac)			Equivalent Detection Limit (lb/ac)	
Analyte	West Edge	Alumni Center	Avg.	Solids	Water
Ca	.19	0.27	0.23	-	0.02
Cu	0.03	0.06	0.05	0.00	0.00
Hardness	1.10	1.42	1.26	-	0.11
Mg	0.15	0.18	0.17	-	0.00
NH_4	0.10	0.38	0.24	0.04	0.02
NO_2	0.00	0.01	0.00	0.00	0.00
NO_3-N	0.02	0.02	0.02	0.00	0.00
ortho-P	0.01	0.02	0.01	0.00	0.00
TKN	0.58	0.95	0.77	0.01	0.04
TN	0.60	0.96	0.78	0.01	0.04
TP	0.26	1.99	1.12	0.01	0.00
TSS	1253	3376	2310	0.00	0.75
TZn	0.05	0.99	0.52	0.00	0.00

Summary of performance by site for the total removal of the solids, water, and slurry. Note the Equivalent Detection Limit is converted to removal units from laboratory detection limits in units of mg/L. Detection Limits for Ca, Hardness, and Mg were not tested in the solids. Laboratory values BDL were assumed to be half the DL and are shown in italics.

Analyte	Coarse Solid	Water & Fines
NO_3-N	12%	88%
ortho-P	16%	84%
NO_2	47%	53%
TN	63%	37%
TKN	64%	36%
TP	90%	10%
NH_4	91%	9%
TZn	93%	7%
Cu	95%	5%
TSS	96%	4%

Percentages of the total mass of analyte found in the coarse solids and slurry (water & fines) fractions.

SOURCES CITED & FURTHER READING

Triverus Cleaning Technology Demonstration Report
University of New Hampshire Stormwater Center
https://www.unh.edu/unhsc/sites/default/files/media/triverus_infiltra□on_and_cleaning_report_final_10-19.pdf

Pervious Concrete Pavement for Stormwater Management
University of New Hampshire Stormwater Center
https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/unhsc_pervious_concrete_fact_sheet_4_08.pdf

Tech Brief: Pervious Concrete
U.S. Department of Transportation Federal Highway Administration
https://www.fhwa.dot.gov/pavement/concrete/pubs/hif13006/hif13006.pdf

Industrial Stormwater General Permit Coverage
State of Washington
https://apps.oria.wa.gov/permithandbook/permitdetail/17

Best Management Practice Fact Sheet 7: Permeable Pavement
Virginia Tech—Virginia State University
https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/426/426-126/BSE-275.pdf

Minnesota Stormwater Manual: Design criteria for permeable pavement
State of Minnesota
https://stormwater.pca.state.mn.us/index.php?□tle=Design_criteria_for_permeable_pavement

Standard Test Method for Infiltra□on Rate of In Place Pervious Concrete
ASTM
https://www.astm.org/Standards/C1701.htm

Pervious Concrete Pavement Maintenance and Operations Guide
National Ready Mixed Concrete Association
http://www.perviouspavement.org/downloads/pervious_maintenance_operations_guide.pdf

REGO PARK, QUEENS, NY

PERVIOUS RECOVERY

MCV in Action!

See the Municipal Cleaning Vehicle in action. View the video on Youtube!

Pervious Concrete Maintenance Log

Site Name & Loction: ____ Site #: __________ of __________

Date of Inspection	Weather & Pavement Conditions	ASTM C1701 Performed?	ASTM C1701 Results	Type(s) of Maintenance Performed	Type & Amount of Organic Buildup/ Debris Removed	Notes:	Maintenance Performed by:	Signature
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						
	❑ Yes ❑ No	Before (in/hr): After (in/hr):						

PERVIOUS SURFACE INSPECTION:

ISSUE	CAUSE	REMEDY
	**ORGANIC DEPOSITS:** Organic deposits such as leaves, pine cones, and pine needles, collecting on pervious surfaces is normal.	• Cleaning with a blower (leaf blower or similar equipment), truck-sweeping, dry vacuuming, and/or vacuum sweeper fitted with water jets • Consistent, immediate cleaning will help prevent the need for deep cleaning or full restoration
	**LANDSCAPING RUNOFF:** Mulch, dirt, or grass can be deposited from upland or adjacent grassy areas that have loose soil or improper water flow. This is also caused by “track on/track off” deposits left by vehicles or workers leaving nearby worksites and travelling across the pervious pavement.	• Maintain upland and adjacent grassy areas • Seed upland and adjacent bare areas • Excessive water flow carrying debris toward the pavement should be diverted • Minimize “Track on/track off” deposits

WHAT TO LOOK FOR

ISSUE	CAUSE	REMEDY
	**SPALLING:** Spalling is caused by winter salt application leading to thawing and refreezing underneath the surface. This causes the surface to pop out, peel off, or flake off.	• Repair • Limit or stop use of salt in winter months • Initiate deep cleaning protocol prior to snowfall and cold weather
	**MOSS GROWTH:** Moss growth is caused by clogged pavement pores.	• Remove organic and inorganic deposits by aggressive pressure washing and vacuuming • Apply baking soda to the surface and vacuum within one to two weeks. Additionally, moss growth can be controlled with applications of limewater
	**PUDDLING:** Puddling is caused by clogged pavement pores, which in turn limits the permeability of the surface.	• Test with perking process • Remove organic and inorganic deposits by aggressive pressure washing and vacuuming

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MCV Applications

- Pervious maintenance and recovery
- Parking structure hygiene
- Oil / grease accumulations
- Paint & crack seal surface prep
- Curing compound removal
- Spill response
- General surface cleaning

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