Permeable Pavement
(1008)
Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A pavement system such as pervious concrete, porous asphalt, permeable pavers/blocks or similar surface that allows movement of stormwater through the pavement surface and into a base/subbase reservoir designed to achieve water quality and quantity benefits.

II. Purpose

This practice may be applied individually or as part of a stormwater management system to support one or more of the following purposes:

- Promote stormwater infiltration, groundwater recharge, and stream base flow preservation
- Reduce the discharge of stormwater pollutants in surface waters
- Decrease stormwater discharge volumes and rates
- Reduce the temperature of stormwater discharges

III. Conditions Where Practice Applies

Permeable pavement systems are an alternative to other pavements and stormwater control measures in areas where mitigating the adverse impacts of stormwater discharges is an objective or requirement.

Permeable pavement systems are most effective in areas where soil and groundwater conditions are suitable for stormwater infiltration and the risk for groundwater contamination is minimized. Appropriate conditions for infiltration are identified in ss. NR 151.124 and NR 151.241, Wis. Adm. Code.

Permeable pavement systems may be used in areas where infiltration is prohibited by regulations or limited by soil or groundwater conditions when appropriate liners and subsurface drainage mechanisms are installed where needed. However, permeable pavement may not be used in industrial storage and loading areas and vehicle fueling and maintenance areas.

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, and regulations or permit requirements governing permeable pavement systems. This standard does not contain the text of federal, state or local laws.

V. Criteria

A. Site Criteria – Evaluate and locate permeable pavement systems in accordance with the following criteria:

1. For systems that will infiltrate water into the soil subgrade, evaluate the site in accordance with WDNR Conservation Practice Standard 1002, Site Evaluation for Stormwater Infiltration. The requirements for “Subsurface Dispersal Systems” from Table 1 of WDNR Conservation Practice Standard 1002 shall be applied until this table is updated to include permeable pavement.

2. For systems that will not infiltrate water into the soil subgrade, conduct a site evaluation of sufficient detail to establish site-specific conditions, including soil
3. If a hydraulic connection is possible, systems shall be located as follows:

   a. No closer than 50 feet from any POWTS dispersal cell to avoid adverse impacts such as cross contamination or hydraulic overloading.

   b. No closer than 10 feet from adjacent building foundations to avoid adverse impacts such as structural instability, water in basements or short circuiting of the infiltration process unless liners or other measures are used to protect against such impacts.

B. Pavement Surface Design – Permeable pavement surface materials and installation shall be in accordance with industry standards for the intended use:

1. Pervious Concrete - Comply with American Concrete Institute Specification for Pervious Concrete Pavement or recommendations from the Wisconsin or National Ready Mixed Concrete Associations.

2. Porous Asphalt - Comply with recommendations from Wisconsin or National Asphalt Pavement Associations.

3. Permeable Pavers/Blocks - Comply with recommendations published by the Interlocking Concrete Pavement Institute, Brick Industry Association or National Concrete Masonry Association.

C. Pavement Surface Infiltration Design – A design analysis shall be conducted using an accepted continuous simulation model (e.g., WinSLAMM version 10.0). The model shall be run over the entire anticipated pavement life to verify that the pavement surface infiltration rate will be no lower than 10 inches per hour (in/hr) at any time during the pavement life, by design. The following model input parameters shall be used:

1. Rainfall data that is appropriate for the site as determined by the administering authority.

2. An initial surface infiltration rate of 100 in/hr.

3. A surface clogging capacity of 0.4 pounds per square foot (lbs/sf) of permeable pavement surface area.

4. A restoration of 50% of the surface infiltration rate reduction that occurs between cleaning events.

   Note: A detailed description of the model input parameters and sample calculations are found in the Technical Note.

D. Pavement Surface Infiltration Properties – Installed permeable pavement surfaces shall meet the following infiltration criteria:

1. The surface infiltration rate upon completion of the installation shall be at least 100 in/hr.

2. The in service surface infiltration rate shall be no lower than 10 in/hr.

   Note: Initial and in service surface infiltration rate testing is not mandatory per this technical standard. However, surface infiltration rate testing may be required by the administering authority where there are questions or concerns regarding the surface infiltration rate.
E. Pavement Surface Run-on – Run-on from other source areas may be directed onto permeable pavement surfaces based on the potential for surface clogging and/or groundwater contamination in accordance with the following criteria:

1. Run-on from industrial storage and loading areas and vehicle fueling and maintenance areas to permeable pavement surfaces is prohibited.

2. To minimize the potential for pavement surface clogging, the ratio of run-on area to permeable pavement surface area shall be in accordance with Table 1.

3. For run-on areas that consist of more than one source area type, the permeable pavement surface area shall be in accordance with Equation 1:

\[ PPSA \geq A + \frac{1}{3} B + \frac{1}{5} C \]

Where:

\[ PPSA = \text{Permeable pavement surface area} \]

\[ A = \text{Source Area Class A contributing drainage area} \]

\[ B = \text{Source Area Class B contributing drainage area} \]

\[ C = \text{Source Area Class C contributing drainage area} \]

4. For permeable pavement systems that will infiltrate water into the soil subgrade, the following run-on criteria shall also be met:

a. Run-on from roads and parking lots is prohibited unless the permeable pavement system is designed to provide acceptable pretreatment in accordance with s. NR 151.124(7), Wis. Adm. Code. Permeable pavement systems that are designed to meet the following criteria are considered acceptable pretreatment (see Figure 1):

i. The pavement surface percent voids shall be less than 25%.

ii. Joints between pavers or blocks shall be filled to the full joint depth with ASTM No. 8, 89 or 9 aggregate.

iii. The aggregate storage reservoir depth shall be a minimum of 12 inches.

b. The ratio of road and/or parking lot run-on surface area to effective infiltration area shall be no greater than 3:1.

Note: Effective infiltration areas can be increased by extending the aggregate storage reservoir under conventional pavement areas where appropriate.

F. Pavement Surface Cleaning – Cleaning of the pavement surface shall be conducted
at least twice per year using industry recommended methods, such as regenerative air or vacuum sweeping.

**Note:** A surface cleaning frequency greater than twice per year can be included in the pavement surface infiltration design analysis and specified in the operation and maintenance plan.

**G. Aggregate Storage Reservoir –**
Aggregate storage reservoirs shall be designed to achieve site specific pavement structural requirements and stormwater management goals:

1. **Aggregate Specifications –** The following specifications shall apply to pavement base and storage reservoir aggregate:
   a. Use open-graded base consisting of crushed stone or crushed gravel with no greater than 5% passing the No. 200 sieve.
   b. Provide a minimum porosity of 30% per ASTM C29 Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.
   c. Comply with soundness and wear, and fracture requirements listed in Wisconsin DOT Standard Specifications Section 301.2.4.5 - Aggregate Base Physical Properties.
   d. Comply with construction requirement in Wisconsin DOT Standard Specifications Section 301.3 or administering authority.

**H. Pavement System Drainage –** Permeable pavement systems shall be designed to ensure that the base/subbase drains adequately:

1. **Soil Design Infiltration Rate –** For permeable pavement systems that will infiltrate water into the soil subgrade, the design infiltration rate shall be determined in accordance with WDNR Conservation Practice Standard 1002. The requirements for “Subsurface Dispersal Systems” from Table 1 of WDNR Conservation Practice Standard 1002 shall be applied until this table is updated to include permeable pavement.

**J. Underdrains –** Perforated underdrain piping or an equivalent drainage mechanism is required if the aggregate storage reservoir drain down time will exceed 72 hours, by design:

1. **Size and Material –** Perforated pipes shall have a minimum diameter of 4 inches.
2. **Perforations –** The total opening area of all perforation holes combined shall
be sufficient to allow the pipe to discharge at design capacity.

3. Pipe Protection – Perforated pipes shall be placed within a trench of granular material when located within 4 inches of the bottom of the aggregate storage reservoir:

   a. The trench shall provide at least one pipe diameter of open-graded aggregate material on each side of the pipe.

   b. The pipe shall have an open-graded aggregate bedding layer no less than 4 inches in thickness.

4. Outlet – Discharges from the underdrain or equivalent drainage mechanism shall be non-erosive.

K. Pollutant Removal Credit - Total suspended solids (TSS) and total phosphorus (TP) removal efficiency for permeable pavement system shall be determined as follows:

1. No pollutant removal credit shall be provided for the portion of the average annual runoff volume that does not infiltrate through the pavement surface.

2. A pollutant removal credit of 100% shall be provided for the portion of the average annual runoff volume that infiltrates into the subgrade soils.

3. No pollutant removal credit shall be provided for the portion of the average annual runoff volume that passes through the pavement surface and discharges through underdrain piping (or equivalent) unless the following conditions are met (see Figure 1):

   a. The pavement surface percent voids shall be less than 25%.

   b. Joints between pavers or blocks shall be filled to the full joint depth with ASTM No. 8, 89 or 9 aggregate.

   c. The aggregate storage reservoir depth shall be a minimum of 12 inches.

If each of these conditions is met, underdrain discharge pollutant removal credit shall be selected from Table 2 unless site-specific credit is determined using accepted computational methods.

<table>
<thead>
<tr>
<th>Table 2. Permeable Pavement Underdrain Discharge Credit</th>
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<tbody>
<tr>
<td>TSS Removal Credit</td>
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<td>55%</td>
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L. Infiltration Volume and Pollutant Load Reduction - Infiltration volume and/or pollutant load reductions provided by permeable pavement systems shall be quantified using a model (e.g., WinSLAMM version 10.0) or other accepted computational methods.

M. Peak Discharge Rate Control - Accepted stormwater hydrologic and hydraulic computational methods shall be used to determine the peak discharge rate control provided by permeable pavement systems.

N. Thermal Mitigation – Accepted computational methods shall be used to determine stormwater temperature reductions provide by permeable pavement systems.

O. Construction Practices – Potential adverse impacts associated with construction operations shall be minimized or mitigated as follows:

1. Prior to the start of construction, the schedule of permeable pavement system construction relative to other
construction operations at the site shall be determined.

2. Protect the subgrade soil interface, aggregate storage reservoir and pavement surface from construction site runoff until achieving final stabilization:

   a. Where possible, divert runoff from disturbed areas away from entering the permeable pavement system.

   b. If runoff diversion is not possible, protect the permeable pavement system in a manner that prevents sediment and pollutants from entering to the maximum extent practicable.

3. For systems that will infiltrate to the subgrade soil:

   a. Protect the soil subgrade from compaction by construction equipment.

   b. Suspend construction if residual soil moisture contributes significantly to the potential for soil smearing, clumping or other forms of compaction.

4. Protect the subgrade soil interface, aggregate storage reservoir and pavement surface from other construction site operations, such as landscaping equipment operation and material storage.

5. Aggregates shall be stored and handled to keep sediment-free and placed to avoid segregation of the aggregate.

6. When construction is complete, inspect the permeable pavement surface and, if necessary, clean the surface using industry recommended methods, such as regenerative air or vacuum sweeping.

VI. Considerations

A. Permeable pavement surfaces are highly susceptible to clogging from runoff source areas with significant sediment or particulate loading. Run-on source areas that should not be directed to permeable pavement surfaces include disturbed lands, agricultural lands and industrial facilities with operations or material storage areas exposed to rainfall or runoff. Consider limiting run-on source areas to other pavements, sidewalks or roofs.

B. The susceptibility of permeable pavement surfaces to clogging can increase with increasing run-on ratios. Run-on source areas should be carefully considered when the run-on ratio will exceed 2:1. A higher cleaning frequency may be required based on the site-specific run-on ratio and source area characteristics.

C. High run-on ratios may reduce the effective life of permeable pavement systems.

D. Runoff from run-on source areas should be distributed as evenly as possible across the permeable pavement area.

E. Consider conducting surface cleaning operations in the spring and fall.

F. In areas where the slope of the soil subgrade is significant (typically > 2%), it may be necessary to design and construct a series of aggregate storage reservoir cells to prevent seepage through downgradient portions of the permeable pavement system. Selection of smaller sized aggregate (e.g., ¾ inch No. 57 stone rather than 3 inch No. 2 stone) for the aggregate storage reservoir will reduce the rate of discharge along the subgrade slope and the rate of accumulation at the
downgradient end of the system that can cause seepage through the surface.

G. For the aggregate storage reservoir, consider using open-graded base consisting of crushed stone or crushed gravel with no greater than 2% passing the No. 200 sieve if available.

H. Caution should be used when discharging runoff directly to the aggregate storage reservoir (e.g., roof downspouts). Without proper energy dissipation, high velocity/high pressure discharges can displace the aggregate, leading to failure of the pavement. Further caution should be exercised to prevent the discharge of organic and other debris directly to the aggregate storage reservoir that can potentially clog the system.

I. If verification of in place pavement surface infiltration rates is necessary, consider conducting pavement surface infiltration rate testing per ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete for pervious concrete and porous asphalt. ASTM C1781 Standard Test Method of Surface Infiltration Rate of Permeable Unit Pavement Systems should be used for permeable pavers/blocks.

J. The use of geotextile filter fabrics, underdrain check valves or underdrain clean-out ports may be considered where appropriate.

K. Consider constructing the permeable pavement system as late in the site construction schedule as possible.

L. Permeable pavement systems that will infiltrate into the subgrade soil should be located a sufficient distance from downgradient steep slopes to minimize the potential for slope failures or erosion due to seepage.

M. Consider the impact of seasonal high groundwater on all permeable pavement systems.

N. Consider minimizing the use of road salt (sodium chloride) on permeable pavement and run-on surfaces to reduce the potential for the development of sodic soil conditions that could have an adverse impact on subgrade soil infiltration rates.

O. If the subgrade soil is compacted during construction, consider refracturing or ripping the soil subgrade to a depth of 12 to 20 inches. Additional base/subbase aggregate may be needed, as well as additional compaction of these materials, to reduce the risk of surface settlement and to render a stable structure for supporting vehicular traffic.

P. Consider conducting subgrade inspections to verify compliance with design parameters prior to system installation.

Q. Consider installing signage to identify the location and purpose of the permeable pavement system. Signage should also identify any activities that should not occur on permeable pavement surfaces and run-on areas.

VII. Plans and Specifications

A. The following design and construction documents shall be prepared for each site in accordance with the criteria in this standard:

1. A design report that describes the requirements for applying the permeable pavement system to achieve its intended use and objectives.

2. Include the following in design reports:

   a. Hydrologic and hydraulic computations and pollutant
removal calculations for the design of the permeable pavement system.

b. An exhibit showing the tributary area, flow paths and run-on ratio(s) for the permeable pavement system.

c. Documents or reports that support any infiltration design parameters, including infiltration rate field test results and/or soil boring logs that identify the depth to seasonal high groundwater.

3. Plans and specifications that identify materials, construction processes and sequence, location, size and elevations of all components of the system to allow for the determination of compliance of the permeable pavement system with the design report and this standard, upon completion.

4. Include the following on plans:

a. Erosion and sediment control measures to prevent the discharge of sediment during construction and clogging of any portion of the permeable pavement installation.

b. Plan views of the permeable pavement system showing its shape, dimensions, grades, underdrain locations and elevations (if applicable), and observation wells and control structures, including surface and pipe invert elevations.

c. Longitudinal and/or cross-sectional views of the pervious pavement system, showing locations and depths of system components.

Note: A single cross-section may provide sufficient detail in some cases.

5. Include the following in specifications:

a. A description of the contractor’s responsibilities.

b. A requirement for the contractor to submit test reports and other evidence that materials for the project meet the specifications.

c. A requirement for the contractor to provide documentation demonstrating training in construction of the permeable pavement systems or acceptable experience and references in the construction of permeable pavement systems. This can include pervious pavement technician by the National Ready Mix Concrete Association or a certificate for a permeable interlocking concrete pavement technician from the Interlocking Concrete Pavement Institute.

d. Descriptions of applicable standards, material requirements and installation procedures.

e. Requirements for system acceptance at the conclusion of construction.

VIII. Operations and Maintenance

A. An operation and maintenance plan shall be written for the intended life of the permeable pavement system. The plan shall include an inspection checklist and schedule.

B. The following activities shall be prohibited from occurring on the permeable pavement surface:
1. Temporary or permanent stockpiling of soil or other material that can potentially cause or contribute to clogging.

2. Application of seal coating.

3. Application of sand for deicing.

C. Inspection of the permeable pavement system shall be conducted at least once per year to evaluate the following:

1. Pavement Condition – Inspect permeable pavement surfaces for settlement, deformation or cracking.

2. Surface Infiltration – Inspect permeable pavement surfaces for sedimentation or evidence of ponding.

3. Drainage – Inspect observation wells within 72 hours after a rain event of 0.5 inches or greater for adequate infiltration into the soil subgrade.

4. Outfalls - Inspect underdrain outfall locations for obstructions and erosion.

5. Run-on Areas – Inspect run-on areas for adequate cover and stability.

D. Maintenance of the permeable pavement system shall be conducted as follows:

1. Clean the pavement surface using industry recommended methods, such as regenerative air or vacuum sweeping, at least twice per year in accordance with Section V.F.

2. If water ponding persists on the pavement surface after a storm event, clean the pavement surface to mitigate clogging.

3. Repair any settlement, deformations or cracking that are significant enough to adversely impact the water quality function of the system.

4. Repair blocked, restricted or eroding underdrain outfalls.

5. Repair and/or replant eroding run-on areas.

6. For permeable pavers/blocks with joints that are filled with aggregate:

   a. Replenish the joint aggregate in accordance with industry recommendations.

   b. If necessary, remediate the system by extracting accumulated debris and aggregate from the joints using a vacuum and re-filling the joints with new aggregate.

7. For porous asphalt and pervious concrete, repairs may be done with conventional impervious materials if the total impervious repair areas do not exceed 10% of the original permeable surface area and the repair areas will run on to adjacent permeable areas. The 10% threshold may only be exceeded if design calculations confirm that the system can accept the full loading for which it was originally designed after repairs.

E. If the pavement surface infiltration rate is questionable at any time during the effective life of the pavement, the administering authority may require infiltration rate testing to verify that the surface infiltration rate is no lower than 10 in/hr. If the surface infiltration rate is lower than 10 in/hr, appropriate action shall be taken to restore the infiltration rate to an acceptable level based on the remaining effective life of the pavement.

F. Qualified personnel, as determined by the administering authority, shall perform
inspection, infiltration testing and maintenance work.

G. All inspection, infiltration testing and maintenance activities shall be documented in written reports. All written reports shall be made available on request by the administering authority.

IX. References


NR 151, Wisconsin Administrative Code.


Wisconsin Department of Transportation, *Standard Specifications for Highway and Structure Construction*. 
X. Definitions

**Administering Authority (V.C.1.):** State and/or local units of government with stormwater management regulatory authority.

**Compaction (V.O.3.a.):** Densification of soil where porosity and permeability are reduced. (Compaction of permeable pavement surfaces, bases and subbases achieve higher stability under traffic loads.)

**Continuous Simulation Model (V.C.):** A computer model that continuously tracks system response over time according to a set of equations.

**Design Infiltration Rate (V.I.):** The infiltration rate of the native soil selected as a basis to size and infiltration device. For permeable pavements the design infiltration rate includes application of 2-fold safety factor.

**Effective Infiltration Area (V.E.4.b.):** The area of the infiltration system that is used to infiltrate runoff to the native soil.

**Final Stabilization (V.O.2.):** All land disturbing construction activities at the construction site have been completed and a uniform perennial vegetative cover has been established with a minimum density of 70% for unpaved areas and areas not covered by permanent structures.

**Infiltration (II):** Entry and movement of precipitation or runoff into or through the soil. Infiltration includes water that may be subsequently evapo-transpired. Infiltration does not include water discharged through underdrains or overflow devices.

**Landscape Areas (Table 1):** Planting beds that consist of annual and/or perennial vegetation and are maintained by routine mulch application.

**Lawns (Table 1):** An area that is covered with grass and maintained in a healthy condition by conducting necessary maintenance activities, such as routine mowing. The grass cover shall be uniform with a minimum density of 70% and no erosion rills or gullies.

**Liners (III):** Barriers made of appropriate materials, such as clay or high density polyethylene (HDPE), that minimize the migration of water.

**Pavement Surface Percent Voids (V.E.4.a.i.):** The area of the voids over the total area expressed as a percent. Percent voids can also be referred to as percent open area.

**Permeable (Title):** For the purposes of this standard, permeable is used interchangeably with the words pervious and porous.

**Permeable Pavers/Blocks (I):** Paver or block units when assembled into a pattern allow water to drain through the joints.

**Pervious Concrete (I):** Concrete with a lower concentration of fine aggregates to allow water to drain through.

**Porosity (V.G.1.b.):** The volume of voids over the total volume expressed as a percent. Porosity is sometimes referred to as void ratio. However, void ratio is technically defined as the volume of voids over the volume of solids.

**Porous Asphalt (I):** Asphalt with a lower concentration of fine aggregates to allow water to drain through.

**POWTS (V.A.3.a.):** A private on-site waste treatment system.

**Run-on (V.E.):** Runoff from other pavement or source areas that drains onto the permeable pavement surface.

**Run-on Ratio (Table 1):** The ratio of run-on surface area to permeable pavement surface area.

**Seasonal High Groundwater (V.A.2.):** The elevation to which the soil has been seasonally or periodically saturated as indicated by soil color patterns throughout the soil profile.

**Source Areas (V.E.):** A component of urban land use including rooftops, sidewalks, driveways,
parking lots, storage areas, streets and lawns from which urban runoff pollutants and volumes are generated during periods of snow melt and rainfall runoff.

**Surface Cleaning (V.F.):** Routine removal of material accumulated on or near the pavement surface.

**Surface Clogging Capacity (V.C.3.):** The capacity of the permeable pavement surface to accumulate pollutants to the point where void spaces are full and surface infiltration can no longer occur.
FIGURE 1. CRITERIA FOR UNDERDRAIN DISCHARGE AND INFILTRATION PRETREATMENT CREDITS

NOTES:
1. PAVEMENT SURFACE PERCENT VOIDS SHALL BE LESS THAN 25%.
2. JOINTS SHALL BE FILLED TO FULL JOINT DEPTH WITH ASTM 8, 9, OR 89 AGGREGATE.
3. AGGREGATE STORAGE RESERVOIR DEPTH SHALL BE A MINIMUM OF 12 INCHES.
4. CHOKER, BASE AND OR SUBBASE COURSES WITH MINIMUM POROSITY OF 30% CAN BE CONSIDERED AGGREGATE STORAGE RESERVOIR.
5. UNDERDRAINS CAN BE LOCATED WITHIN OR BELOW THE AGGREGATE STORAGE RESERVOIR. UNDERDRAINS (OR EQUIVALENT) ARE REQUIRED IF THE AGGREGATE STORAGE RESERVOIR DRAIN DOWN TIME WILL EXCEED 72 HOURS.