

Permeable Pavement Fact Sheet Information for Howard County, Maryland Homeowners

Purpose of this Fact Sheet:

To provide objective information about permeable pavement for Howard County, Maryland homeowners who may wish to install or retrofit a permeable pavement driveway, patio or sidewalk on their property.

Some of the references cited apply to commercial or public spaces and are provided only to give the homeowner background information about permeable pavement. Vendor information was excluded except for some illustrations.

What is permeable pavement?

In this document the term “permeable pavement” will be used most often for the sake of consistency, however the terms porous and pervious are often used in the literature. In this document these terms will be considered interchangeable. For those who will be doing further searching on the Internet or in other sources, terms often used are: pervious pavers, pervious concrete, porous asphalt, resin-bound paving, open-jointed blocks or cells and porous turf.

Permeable pavement is a method of paving that allows stormwater to seep into the ground as it falls rather than running off into storm drains, waterways and eventually the Chesapeake Bay.

“Permeable pavements function similarly to sand filters, in that they filter the water by forcing it to pass through different aggregate sizes and typically some sort of filter fabric. Therefore most of the treatment is through physical (or mechanical) processes. As precipitation falls on the pavement it infiltrates down into the **storage basin** where it is slowly released into the surrounding soil.”¹

“Long term research on permeable pavers shows their effective removal of pollutants such as total suspended solids, total phosphorous, total nitrogen...zinc, motor oil, and copper. In the void spaces, naturally occurring micro-organisms break down hydrocarbons and metals adhere.”²

“By stopping stormwater from pooling and flowing away, porous paving can help recharge underlying aquifers and reduces peak flows and flooding. That means that streams flow more consistently and at cooler temperatures, contributing to healthy ecosystems. Stormwater pollutants are broken down in the soil instead of being carried to surface waters.”¹² Below is a graphic that illustrates the relationship between surface flow, groundwater flow and aquifers.

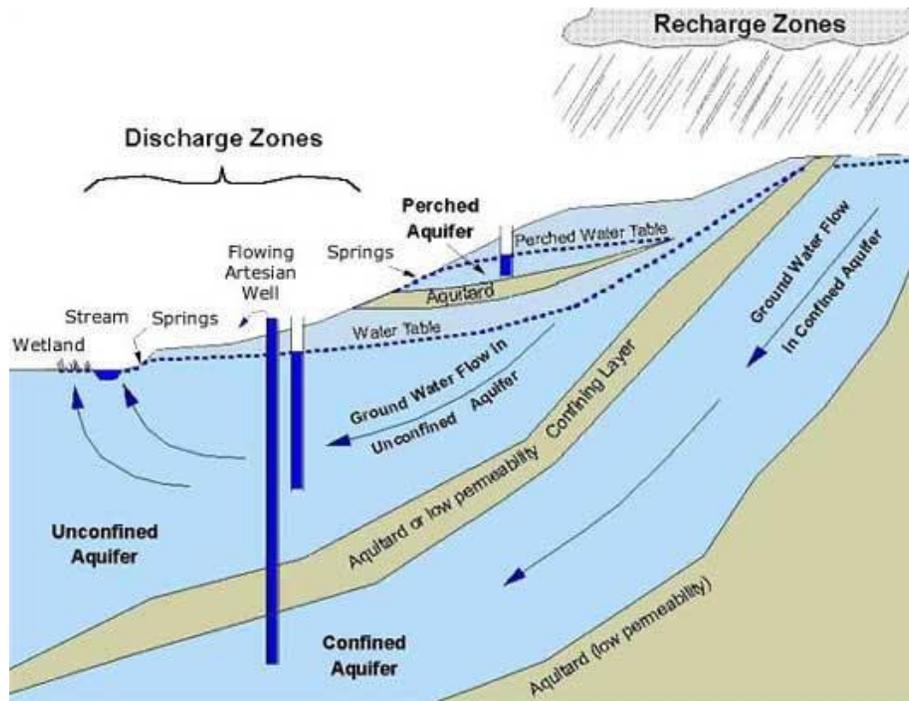


Illustration: <http://imnh.isu.edu/digitalatlas/hydr/concepts/gwater/imgs/6comp.jpg>

For more information about aquifers see “What is an Aquifer?” (Idaho State University-Reference 3)

“Depending on design, paving material, soil type and rainfall, permeable paving can infiltrate as much as 70% to 80% of annual rainfall.”⁴ Combining permeable pavement with other Low Impact Development (LID) strategies, such as vegetated swales, increases the overall effectiveness of permeable paving. According to Mark W. Clark and Glenn A. Acomb (Reference 5) the percent of rainfall converted to runoff volume for various pavement scenarios is:

- Asphalt with no swale--51%
- Asphalt with swale--34%
- Cement with swale--32%
- Permeable pavement with swale--10%

“For the best success, a few key factors must be considered when undertaking a project involving permeable pavement alternatives:

- 1. Choose the correct pavement for the task at hand.** Permeable pavement options vary depending upon whether the pavement will receive light, moderate, or heavy use. Therefore, it is imperative to choose the right material for the expected use.
- 2. Prepare the subbase.** Choose the appropriate subbase preparation for the application. The type of subbase used and depth of the subbase materials determine the amount of infiltration provided, as well as durability over time. In locations with poor soils or numerous freeze-thaw cycles, a thicker subbase is usually required.
- 3. Install properly.** In many cases, the manufacturer will install, oversee the installation, or recommend certified contractors.
- 4. Understand and carry out maintenance requirements.** Appropriate maintenance is critical to the continued effectiveness and durability of permeable pavement materials.”⁶

A homeowner might consider permeable paving for a driveway or walkway. A patio that **does not** adjoin the house might also be considered. Permeable paving immediately adjacent to the house may not be advisable since water should always be directed **away** from the house. As mentioned above it is important to choose the correct pavement for the planned project.

Permeable pavement is designed to carry **moderately** heavy loads, such as automobiles. "If permeable pavement will be used in a ...setting that involves vehicles, the pavement surface must be able to support the maximum anticipated traffic load. The structural design process will vary according to the type of pavement selected, and the manufacturer's specific recommendations should be consulted. The thickness of the permeable pavement and reservoir layer must be sized to support structural loads and to temporarily store the design storm volume (e.g., the water quality, channel protection, and/or flood control volumes). On most new development and redevelopment sites, the structural support requirements will dictate the depth of the underlying stone reservoir." ⁷

"Concrete block pavers...have the highest load bearing capacities, followed by porous asphalt and concrete pavements and then plastic grid pavers." ⁶

Three of the major types of permeable pavements are compared in the table below from The Virginia DCR Stormwater Design Specification No. 7 ⁷

Table 7.2. Comparative Properties of the Three Major Permeable Pavement Types

Design Factor	Porous Concrete (PC)	Porous Asphalt (PA)	Interlocking Pavers (IP)
Scale of Application	Small and large scale paving applications	Small and large scale paving applications	Micro, small and large scale paving applications
Pavement Thickness ¹	5 to 8 inches	3 to 4 inches	3 inches 1, 8
Bedding Layer 1, 8	None	2 inches No. 57 stone	2 inches of No. 8 stone
Reservoir Layer 2, 8	No. 57 stone	No. 2 stone	No. 2 stone 3-4 inches of No.57 stone
Construction Properties 3	Cast in place, seven day cure, must be covered	Cast in place, 24 hour cure	No cure period; manual or mechanical installation of pre-manufactured units, over 5000 sf/day per machine
Design Permeability ⁴	10 feet/day	6 feet/day	2 feet/day
Construction Cost 5	\$ 2.00 to \$6.50/sq. ft.	\$ 0.50 to \$1.00/ sq. ft.	\$ 5.00 to \$ 10.00/ sq. ft.
Min. Batch Size	500 sq. ft.		NA
Longevity 6	20 to 30 years	15 to 20 years	20 to 30 years
Overflow	Drop inlet or overflow edge	Drop inlet or overflow edge	Surface, drop inlet or overflow edge
Temperature Reduction	Cooling in the reservoir layer	Cooling in the reservoir layer	Cooling at the pavement surface & reservoir layer
Colors/Texture	Limited range of colors and textures	Black or dark grey color	Wide range of colors, textures, and patterns
Traffic Bearing Capacity 7	Can handle all traffic loads, with appropriate bedding layer design.		
Surface Clogging	Replace paved areas or install drop inlet	Replace paved areas or install drop inlet	Replace permeable stone jointing materials
Other Issues		Avoid seal coating	Snowplow damage

Design Reference	American Concrete Institute # 522.1.08	Jackson (2007) NAPA	Smith (2006) ICPI
1 Individual designs may depart from these typical cross-sections, due to site, traffic and design conditions. 2 Reservoir storage may be augmented by corrugated metal pipes, plastic arch pipe, or plastic lattice blocks. 3 ICPI (2008) 4 NVRA (2008) 5 WERF 2005 as updated by NVRA (2008)	6 Based on pavement being maintained properly, Resurfacing or rehabilitation may be needed after the indicated period. 7 Depends primarily on on-site geotechnical considerations and structural design computations. 8 Stone sizes correspond to ASTM D 448: <i>Standard Classification for Sizes of Aggregate for Road and Bridge Construction.</i>		

“Sources: CWP and CSN (2008) and CWP (2007)”⁷

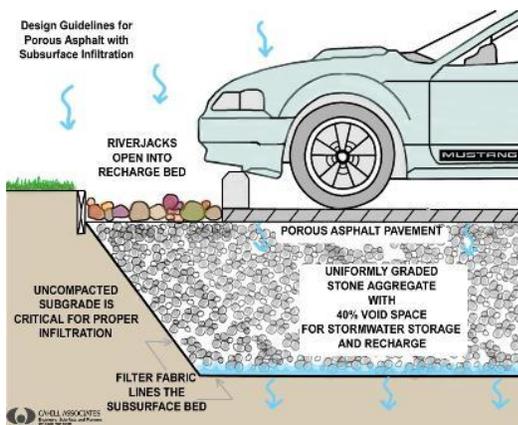
Why would a homeowner choose permeable pavement?

- To prevent/remedy erosion on property
- To minimize excessive pooling in low lying areas due to runoff
- To retain water on property which will
 - Benefit plants on property
 - Return water to the water table on property
 - Contribute to the improvement of the environment by
 - Diminishing stormwater contaminants in streams, rivers and the Chesapeake Bay
 - Providing “groundwater recharge and reduc(ing) stormwater runoff volume”⁴
 - Preserving and preventing erosion of stream beds and river banks if property drains directly into a stream

What materials/methods are used for permeable paving?

- **Porous asphalt**
Homeowner use: driveways, parking areas

Porous asphalt is the same as regular asphalt except it is manufactured with the fine material omitted, leaving open spaces that allows water to filter through to a “recharge” or drainage bed.



<http://www.mytorontohomeimprovement.com/wp-content/uploads/2008/08/permeable-pavement.JPG>

- **Pervious concrete**

Homeowner use: driveways, parking areas, sidewalks, patios not adjoining house, pool decking

Pervious concrete is composed of materials that result in voids when it is dry, thus allowing water to drain through. Installation requires the same type of drainage bed as that described under Porous Asphalt.

Porous concrete pavement at Robinson Nature Center, Cedar Lane, Columbia, MD



Illustration: <http://www.uri.edu/cve/ritrc/wpe2.jpg>

- **Concrete/brick pervious pavers**

Homeowner use: Parking areas, patios not adjoining house, sidewalks, pool decks
Driveways--Snow removal equipment may catch edges, rollers may be needed

Precast concrete or brick manufactured in many sizes and shapes are laid with a drainage base and permeable joint material, allowing water to slowly seep into the ground. "Pervious pavers are most effective with other LID (Low Impact Development) treatment...(e.g. vegetated swales, cisterns or exfiltration tanks" ¹

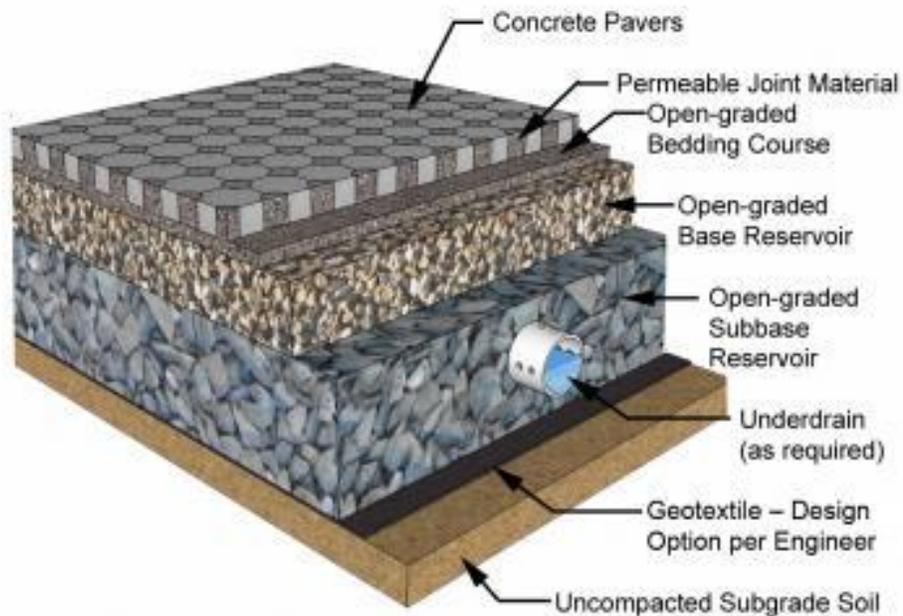
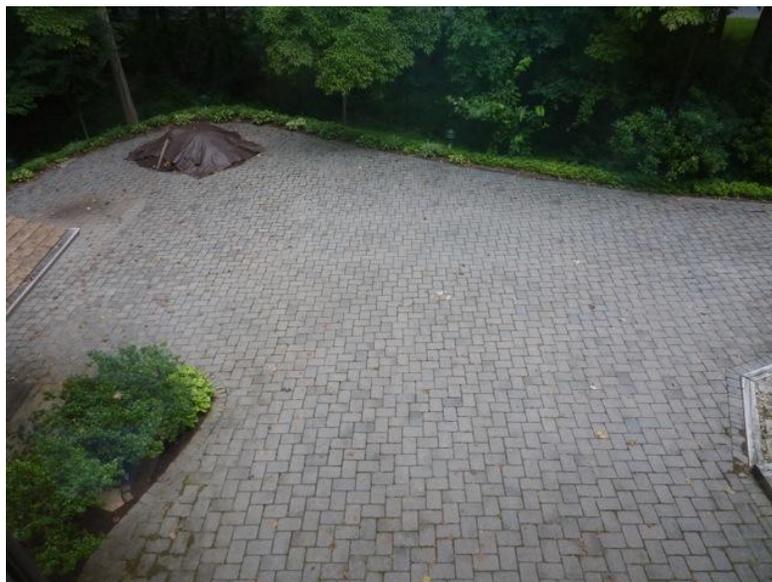


Illustration: http://www.icpi.org/sites/default/files/images/PICP-XC_label-1.img_assist_custom-365x265.jpg

Permeable concrete/brick paver driveway at Howard County residence. This driveway has been in place for several years.



- **Open-Celled pavers**

Homeowner use:

Parking areas: Only for overflow parking if grass fill is used; grass will die if there is not enough sun

Patios not adjoining house: For summer use, and only with furniture that has legs wider than the cells

Open-celled pavers are made by installing a plastic or concrete grid over a bed of drainage material and soil. Then the voids are seeded with grass or turf plugs are embedded. Alternatively the voids may be filled with aggregate. They must be constructed with a drainage bed similar to the illustration shown above under Concrete/Brick Pervious Pavers.



Illustration: <http://www.grassypavers.com/pavclose.jpg>



Illustration:

<http://www.buildinggreen.com/cgi-bin/scale.cgi?width=250&src=/articles/images/1309/ecogrid.jpg>

Grass pavers used in parking area at Centennial Park, Howard County, MD, off Old Annapolis Road



What maintenance does permeable pavement require?

In order to maintain porosity it is imperative that sediment not be allowed to accumulate on the pavement. “[Permeable pavement] should be used carefully where frequent winter sanding is necessary because the sand may clog the surface of the material. Periodic maintenance is critical and surfaces should be cleaned with a vacuum sweeper at least three times per year.”⁴

“If clogging occurs in porous pavement and the surface infiltration rate is reduced lower than the rainfall rate, then either water will pond or runoff will be produced. Therefore, periodic maintenance is required for continuing functioning.”¹

Maintenance checklist for all types of permeable pavements

“Post signs identifying porous pavement areas.

Keep landscape areas well-maintained and prevent soil from being transported onto the pavement.”⁴

“Clean the surface using vacuum sweeping machine”⁴[except grass pavers] or “with high pressure hosing”⁸

“Monitor regularly to ensure that the paving surface drains properly after storms,

Do not reseal or repave with impermeable materials.

Inspect the surface annually for deterioration.”⁴

Additional maintenance of specific permeable pavement types

Porous Asphalt and Pervious Concrete

“Potholes and cracks can be filled with patching mixes unless more than 10% of the surface needs to be repaired.”⁶

“Spot clogging may be fixed by drilling 0.5” holes through the pavement layer every few feet.”⁶

Concrete/brick pervious pavers

“...periodically add joint material (sand) to replace material that has been transported,”⁴

Open-Celled Pavers with aggregate fill

Refill displaced gravel when necessary

Plastic cells may need to be replaced periodically

Open-Celled Pavers with grass fill

“Needs mowing, irrigation, fertilization and seeding”⁶

Plastic cells may need to be replaced periodically

For more detailed information about maintenance **see references 4, 6 and 8** below (Massachusetts Low Impact Development Fact Sheet, California Coastal Commission—Permeable Pavement, What’s It Doing on My Street, New Jersey Stormwater Best Practices Manual)

What other factors should be considered?

Frost heave

“In cold climates the potential for frost heave may be a concern...Some design manuals recommend excavating the base course to below the frost line, but this may not be necessary in rapidly permeable soils. In addition the dead air and void spaces in the base course provide insulation so that the frost line is closer to the surface”⁴

Contiguous Drainage Areas

“Permeable paving should not receive stormwater from other drainage areas, especially any areas that are not fully stabilized”.⁴

Permeable pavements are only capable of infiltrating precipitation that falls directly on them. A backup channel or infiltration area for overflow should be designed so they don't flood during major storms or long periods of rain. This can be a swale of turfgrass, sand, gravel or fine mulch sloping downward from the paved area. This swale can also catch uphill runoff to prevent it from reaching the paved area.

{Permeable pavement} “should not be used on stormwater “hot spots” with high pollutant loads because stormwater cannot be pretreated prior to infiltration”⁴

For a list of potential “hot spots” see Table 5 in Minnesota Pollution Control Agency ISSUE PAPER “H” Potential Stormwater Hotspots⁹

Heavy Loads

[Permeable pavement] “cannot be used..where it will be subject to heavy axle loads.”⁴

Site Slope

“Permeable paving can only be used on gentle slopes (<5%)”⁴

Snow Removal

“Snow plows can catch the edge of grass pavers and some paving stones. Rollers should be attached to the bottom edge of a snowplow to prevent this problem”⁴

Construction details

A good overview of various types of permeable pavement alternatives and comparisons of permeable pavement commercial products, available as of 2007, can be found at:

<http://www.coastal.ca.gov/nps/lid/PermeablePavement-What'sitDoingonMyStreet.pdf>

(Reference 6)

A brief description of construction details is available in Massachusetts Low Impact Development Fact Sheet #6 (Reference 4) and in Montgomery County Permeable Paver Retrofit (Reference 11)

Much more detailed information is available in The New Jersey Stormwater Best Practices Manual (Reference 8) and Virginia DCR Stormwater Design Specification No.7 (Reference 7)

What is the cost of permeable pavement?

Although costs are constantly changing some types of permeable pavement can be compared using the data from a 2009 EPA study (Reference 10)

Pavement	Paved Area (sq ft)	Quote (\$)		Quote (\$ sq yd)	
		Highest	Lowest	Highest	Lowest
Hot Mix Asphalt	36,225	98,600	92,620	24.50	23.01
Porous Asphalt	5,328	28,650	18,352	48.40	31.00
Porous Pavers	5,328	67,960	61,755	114.80	104.32
Porous Concrete	7,988	63,200	53,919	71.21	60.75

Source: Permeable Pavement Research –Edison New Jersey, Amy Rowe EPA National Risk Management Research Laboratory Final proposed costs reported by Kirit Shaw, S Services, Inc, June 2009 (2)

The Virginia DCR Stormwater Design Specification Table 7.2 (Reference 7) gives these cost comparisons as of 2007.

Construction Cost	Porous Concrete	Porous Asphalt	Interlocking Pavers
	\$ 2.00 to \$6.50/sq. ft.	\$ 0.50 to \$1.00/ sq. ft.	\$ 5.00 to \$ 10.00/ sq. ft.

References:

1. University of Florida Permeable Pavement Fact Sheet
http://buildgreen.ufl.edu/Fact_sheet_Permeable_Surfaces.pdf
2. Capital Regional District, Victoria, British Columbia Permeable Pavement
<http://www.crd.bc.ca/watersheds/lid/permeable.htm>
3. Idaho State University-What is an Aquifer?
<http://imnh.isu.edu/digitalatlas/hydr/concepts/gwater/aquifer.htm>
4. Massachusetts Low Impact Development Toolkit—Fact Sheet #6 Permeable Paving. Metropolitan Area Planning Council
http://www.mapc.org/sites/default/files/LID_Fact_Sheet_-_Permeable_Paving.pdf
5. University of Florida, Mark W. Clark and Glenn A. Acomb-Water Resources Roundtable Low Impact Development Presentation
http://publicfiles.dep.state.fl.us/dwrm/stormwater/stormwater_rule_development/docs/fl_asla_presentation.pdf
6. California Coastal Commission--Permeable Pavement-What's It Doing on My Street
<http://www.coastal.ca.gov/nps/lid/PermeablePavement-What'sItDoingonMyStreet.pdf>
7. Virginia DCR Stormwater Design Specification No 7
<http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec7PERMEABLEPAVEMENT.html>
8. New Jersey Stormwater Best Practices Manual, Chapter 9-7, Standard for Pervious Paving Systems
http://www.state.nj.us/dep/stormwater/bmp_manual/NJ_SWBMP_9.7.pdf
9. Minnesota Pollution Control Agency ISSUE PAPER “H” Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues V.3 (final)
<http://www.pca.state.mn.us/index.php/view-document.html?gid=8946>
10. Permeable Pavement Research--Edison New Jersey, Amy Rowe, EPA National Risk Management Research Laboratory
<http://nyccpc.org/Documents/2010/RoweNYCCPC.pdf>
11. Montgomery County RainScapes Rewards Rebate--Permeable Paver Retrofit
http://www.montgomerycountymd.gov/Content/dep/downloads/helpguide_PermeablePavers.pdf
12. Environmental Building News, Vol 18, Number 4--Porous Paving
<http://www.buildinggreen.com/auth/article.cfm/2009/3/26/Porous-Paving/>

Further information about permeable pavement can be found at the web sites listed below. As noted earlier some of these references include information that is applicable to commercial and government installations and are provided as a source for the homeowner to obtain more detailed information about permeable pavement.

Please note that the web is a constantly changing environment and addresses might have been changed or documents might have been removed. The following information was current as of August 13, 2011.

American Trails Permeable Pavers (2003)

<http://www.americantrails.org/resources/trailbuilding/PermPavers.PDF>

California Permeable Asphalt Pavements with Stone Recharge

http://www.californiapavements.org/Files/Milar_0804_Perm_Aspphalt_Present_CA_Coast.pdf

Howard County MD Centennial and Wilde Lake Watershed Restoration

http://www.howardcountymd.gov/DPW/Docs/Section3_Study_Methods_and_Assessment_Results.pdf

Idaho State University-What is an Aquifer?

<http://imnh.isu.edu/digitalatlas/hydr/concepts/gwater/aquifer.htm>

Marcus De La Fleur web site--landscape architect featured in Organic Gardening article (below)

http://www.delafleur.com/168_Elm/05_P_Pvmt_01.html

Minnesota Permeable Pavement research 2007

http://www.terreroadalliance.org/events/innovation_series/2008/documents/07-lebens-porous.pdf

Minnesota Pollution Control Agency, ISSUE PAPER "H" Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues V.3 (final)

<http://www.pca.state.mn.us/index.php/view-document.html?gid=8946>

Montgomery County MD Permeable Pavement Help Guide

http://www.montgomerycountymd.gov/Content/dep/downloads/helpguide_PermeablePavers.pdf

North Carolina State University Permeable Pavement Research Update 2008

<http://www.bae.ncsu.edu/stormwater/PublicationFiles/PermPave2008.pdf>

North Carolina State University Interlocking Concrete Fact Sheet

<http://www.ncsu.edu/picp/FactSheets/DesignProfessionals-PICP.pdf>

North Carolina State University Interlocking Pavement site

<http://www.ncsu.edu/picp/>

North Carolina State University Permeable Pavement Research web site

<http://www.bae.ncsu.edu/info/permeable-pavement/>

North Carolina State University Hydrologic and Water Quality Comparison of Four Types of Permeable Pavement and Standard Asphalt in Eastern North Carolina

<http://www.bae.ncsu.edu/info/permeable-pavement/ICPI.2007Report.Final.EDITED.pdf>

North Carolina State University Surface Infiltration Rates of Permeable Pavement

<http://www.bae.ncsu.edu/info/permeable-pavement/icpi.pdf>

Organic Gardening Permeable Pavement article

<http://www.organicgardening.com/learn-and-grow/going-flow>

Permeable Pavement Research Study Summary Lake County Forest Reserves 2003

<http://atfiles.org/files/pdf/PermPavers.PDF>

Toronto Permeable Pavement Fact Sheet

http://www.riversides.org/rainguide/riversides_hgr.php?cat=2&page=54&subpage=95

University of Florida Permeable Pavement Study 2005

<http://www.stormwater.ucf.edu/>

University of Washington--Derek Booth describes several options for stormwater management including permeable pavement 2007

<https://digital.lib..edu/dspace/handle/1773/16583>

University of Washington Permeable Pavement Fact Sheet

<http://water.washington.edu/Outreach/FactSheets/permeablepavements.pdf>

Virginia DCR Stormwater Design Specification No.7--Permeable Pavement Version 1.8, March 1, 2011

<http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec7PERMEABLEPAVEMENT.html>

Watuaga County Extension North Carolina Permeable Pavement Workshop

http://www2.mountaintimes.com/entertainment_focus/About_Those_Permeable_Pavers_..._id_003643