County of Fairfax, Virginia

To protect and enrich the quality of life for the people, neighborhoods, and diverse communities of Fairfax County

DATE: December 21, 2007

TO: All Architects, Attorneys, Builders, Developers, Engineers, and Permit Services Practicing in Fairfax County

SUBJECT: Letter **08-01** Pervious Concrete – Use under the Innovative Best Management Practices (BMP) Provisions of the Public Facilities Manual

On March 12, 2007, the Board of Supervisors adopted amendments to the Public Facilities Manual (PFM) incorporating design and construction standards, plan submission requirements, and requirements for the release of bonds and conservation escrows for 6 Low Impact Development (LID) practices. The approved LID practice for pervious pavement included two types of surface treatment, porous asphalt and open jointed concrete blocks. Although not included in the recent amendments, pervious concrete may be used as a surface treatment for pervious pavement facilities under the innovative Best Management Practices (BMP) provisions of the PFM (§ 6-0402.4). Designs utilizing pervious concrete must meet all PFM requirements generally applicable to pervious pavement systems regardless of the type of surface treatment. The purpose of this letter is to provide design criteria specific to the use of pervious concrete. Your attention also is directed to Letter-to-Industry #07-17 (Low Impact Development Practices – Amendments to the Public Facilities Manual) which provides additional discussion of facility design, plan review, plan processing, and construction requirements for LID practices.

Submission Process:

Requests for approval to use pervious concrete, as provided for under § 6-0402.4, may be included in plan submissions rather than by separate letter of request. In order to facilitate the tracking of requests and evaluation of the performance of pervious concrete, a copy of the attached innovative BMP tracking form shall be filled out and attached to the cover sheet of the plan.

In accordance with § 6-0402.4, requests incorporated into plans must include the following site-specific information (Certain information normally required for requests to use innovative BMPs has been deleted from the list because it is either not applicable or is addressed by the adopted PFM amendment covering pervious pavement.):

- Justification.
- Maintenance consideration and program (private maintenance required).
- Special construction details and specifications if needed.
- Estimated construction cost.
- Estimated 20-year maintenance cost.

Department of Public Works and Environmental Services
Land Development Services
12055 Government Center Parkway, Suite 444
Fairfax, VA 22035-5504
Phone: 703-324-1780, 703-324-1980 TTY: 711 Fax: 703-324-3908
www.fairfaxcounty.gov/dpwes

General Design Requirements:

Designs utilizing pervious concrete shall be in accordance with all PFM requirements generally applicable to pervious pavement systems regardless of the type of surface treatment. Pervious concrete shall conform to VDOT Road and Bridge Specifications for Hydraulic Cement Concrete (Section 217) except where contraindicated. Pervious concrete shall be designed to have a minimum thickness of 6.0 inches and a void space of 15 - 25% with an in-place unit weight of 105 – 135 lbs/ft^3. Designs in the range of 15 - 19% voids with a unit weight of 127 – 132 lbs/ft^3 were found to be optimum for both strength and permeability in a 2006 study by the National Concrete Pavement Technology Center [*Mix Design Development for Pervious Concrete in Cold Weather Climates*, National Concrete Pavement Technology Center (NCPTC), Iowa State University, Final Report, February 2006]. The materials proportions should be within the ranges specified in the table below.

Materials Proportions for Pervious Concrete

Material	Proportion
Water/Cement ratio	0.27 – 0.34 (by mass)
Aggregate/Cement ratio	4.0 – 4.5 (by mass)
Fine/Coarse Aggregate ratio	0 – 0.1 (by mass)

Coarse aggregate shall be VDOT #67, #8, or #8P. Air entrainment shall be used to improve resistance to freeze/thaw cycles. However, air entrainment cannot be verified or quantified by standard test methods and an alternative test method is not currently available. A preliminary mix design must be included in the plan. A plan revision with the final mix design, if different than the preliminary design, must be submitted to DPWES for approval prior to construction. Appendix 6 of ACI 211.3R-02 (Guide for Selecting Proportions for No-Slump Concrete) provides a procedure for determining mix proportions for pervious concrete.

Construction Specifications:

General: Construction of pervious concrete shall follow the requirements of § 6-1304.9(A) through (F). These requirements are common to all types of pervious pavement. The bedding course for pervious concrete shall consist of 1.0 to 2.0 inches of washed VDOT #57 stone. All stone shall be washed with less than 1% passing a #200 sieve. The bedding course shall be placed in a single lift. The bedding course shall be leveled and pressed (choked) into the aggregate base with at least 4 passes of a 10 ton (9 T) steel drum static roller. The bedding course material should be moist to facilitate movement into the aggregate base. Where the base course material (e.g. VDOT #2 or #3 stone) is larger than the bedding course material, the bedding course is sometimes referred to as a choker course.

Installation: Installation of pervious concrete should only be performed by qualified personnel. A National Ready Mixed Concrete Association (NRMCA) Certified Pervious Concrete Craftsman or Installer must be on site, overseeing each placement crew, during all concrete placement and finishing operations. Each placement crew must have at least two NRMCA certified Pervious Concrete Technicians. Information about certification requirements and

programs is available from NRMCA (http://www.nrmca.org) and the Virginia Ready Mixed Concrete Association (http://www.vrmca.com).

Batching, mixing, and delivery: Concrete shall be batched and mixed in accordance with ASTM C 94 except that discharge shall be completed within 60 minutes of the introduction of mixture water to the cement. The time may be increased to 90 minutes when using an extended set control admixture meeting the requirements of ASTM C 494, Type B. Water addition, in accordance with ASTM C 94, is permitted at the point of discharge. However, the maximum water/cement ratio specified may not be exceeded. Dry mixing of about 5% of the cement with the aggregate before adding the batch water is recommended to improve bond strength compared to a more conventional batch sequence of adding the aggregate and water first then followed by the cement [*Mix Design Development for Pervious Concrete in Cold Weather Climates*, National Concrete Pavement Technology Center, Iowa State University, Final Report, February 2006.

Placing and Finishing Pavement: Prior to placing concrete, the subbase shall be moistened and in a wet condition. Failure to provide a moist subbase will result in a reduction in strength of the pavement. Deposit concrete either directly from the transporting equipment or by conveyor onto the subbase. Do not place concrete on frozen subbase. Deposit concrete between the forms to an approximately uniform height. Spread the concrete using a come-along, short-handle, square-ended shovel, or rake. Minimize foot traffic on the fresh concrete. Strike off concrete between forms using a form-riding paving machine or vibrating screed. Other strike-off devices may be used when accepted. Do not use steel trowels or power finishing equipment. Finish the pavement to the elevations and thickness specified on the plans to meet the specified tolerances. Slipform equipment is permitted.

Final surface texture: Compact fresh concrete to stay within the specified tolerances. Compact the concrete along the slab edges as necessary with hand tamper tools.

Edging: Edge top surface to a radius of not less than 1/4 in.

Tolerances: Construct pavement to comply with the following tolerances: Elevation: +3/4 in., –0 in.; Thickness: +1-1/2 in., –1/4 in.; and, Contraction joint depth: +1/4 in., –0 in. Mechanically sweep pavement before testing for compliance with tolerances.

Curing: Curing procedures shall begin within 20 minutes after the final placement operations. The pavement surface shall be covered with a minimum 6-mil thick polyethylene sheet. The cover shall overlap all exposed edges and shall be secured (without using dirt) to prevent dislocation due to winds or adjacent traffic conditions. Prior to covering, a fog or light mist may be sprayed above the surface when required due to ambient conditions (high temperature, high wind, and low humidity). Cure pavement for a minimum of 7 days, uninterrupted. No vehicular traffic shall be permitted on the pavement until curing is complete.

Hot- and cold-weather construction: ACI guidelines for Hot Weather Concreting (ACI 305R) and Cold Weather Concreting (ACI 306R) should be followed during construction as applicable.

Jointing: Control (contraction) joints shall be installed at a spacing of no greater than 20 feet. They shall be installed at depth of 1/4 - 1/3 the thickness of the pavement. These joints can be installed in the plastic concrete with a joint roller (preferred) or saw cut. If saw cut, the procedure should begin after the concrete has hardened sufficiently to prevent aggregate from being dislodged and soon enough to control pavement cracking. If care is taken to vacuum the dust during the sawing operation, this method of installing joints is acceptable. To minimize drying, ensure that curing materials are removed only as needed to make cuts. Prior to re-covering, a fog or light mist may be sprayed above the surface when required due to ambient conditions (high temperature, high wind, and low humidity). Transverse constructions joints shall be installed whenever placing is suspended a sufficient length of time that concrete may begin to harden. Isolation (expansion) joints should be used only where pavement abuts fixed objects such as buildings, foundations, and storm drainage structures.

Testing and Acceptance: Normal testing procedures based on slump and cylinder strength are not applicable to pervious concrete. In addition, there is no standard test for the interconnected void space of pervious concrete. As a result, the best available indicator of the void space in the concrete is the concrete density. Density is determined for both the plastic and hardened concrete.

1) Plastic Concrete. Density (unit weight) shall be determined for each 100 cubic yards[10] or fraction thereof delivered with a minimum of one test for each day's placement. Plastic concrete shall be collected in accordance with ASTM C 172 (Practice for Sampling Freshly Mixed Concrete). Density shall be determined in accordance with ASTM C 138 [Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete] following the consolidation procedures described in ASTM C 29 [Test Method for Bulk Density (Unit Weight) and Voids in Aggregate] jigging procedure. Determine the density using a minimum 0.25 cubic foot cylindrical metal measure. The measure is to be filled and compacted in accordance with ASTM C 29 jigging procedure. The density of the delivered concrete shall be within $\pm$ 5 pounds per cubic foot of the specified design density.

2) Hardened Concrete. A minimum of 7 days following each placement, three cores from each lot of 5,000 square feet or fraction thereof shall be taken in accordance with ASTM C 42 (Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete). Select 3 locations in accordance with ASTM D 3665 (Practice for Random Sampling of Construction Materials). The cores shall be measured for thickness and density in accordance with ASTM C 42 and ASTM C 140 (Standard Methods of Sampling and Testing Concrete Masonry Units) respectively. Untrimmed, hardened core samples shall be used to determine placement thickness. After thickness determination, the cores shall be trimmed and measured for density in the saturated condition as described in paragraph 8.3.1, Saturation, of ASTM C 140. The trimmed cores shall be immersed in water for 24 hours, allowed to drain for one (1) minute, surface water removed with a damp cloth, then weighed immediately. The average of the cores for each lot shall not be more than ¼ inch less than the specified thickness nor more than 1½ inch greater than the specified thickness with no individual core being more than ½ inch less than the specified thickness. The average density of the hardened concrete for each lot shall be within $\pm$ 5 pounds per cubic foot of the specified design density. Core holes shall be filled with concrete meeting the pervious mix design.

3) Permeability. The full permeability of the pavement surface shall be tested by application of clean water at a rate of at least 5 gpm over the surface. All water must infiltrate directly without puddle formation or surface runoff. Water is typically applied using a hose.

4) Drainage from Base. The facility shall be inspected at 18-30 hours after a significant rainfall (0.5-1.0 inch) or artificial flooding to determine that the facility is draining properly.

Drainage Area to Pervious Concrete:

The total drainage area to pervious concrete, consistent with all types of pervious pavement, shall not be greater than 5 acres (2.0 hectares). The maximum ratio of impervious areas to the area of pervious concrete for facilities designed to capture and treat a water quality volume of 0.5 inches (1.27 cm) is 15:1. The maximum ratio of impervious areas to the area of pervious concrete for facilities designed to capture and treat a water quality volume of 1.0 inch (2.54 cm) is 7:1.

Hydrologic and Hydraulic Parameters:

For hydrologic computations using the Rational Method, the runoff coefficient ("C" factor) for pervious concrete shall be computed based on the following formula:

$C = (I - k_p) / I$

Where:

I = design rainfall intensity (in/hr)
k_p = coefficient of permeability (in/hr)

Use a coefficient of permeability of 4.0 in/hr for pervious concrete. For hydrologic computations using National Resource Conservation Service (NRCS) methods, use a Curve Number "CN" of 40 for pervious concrete. For hydraulic computations, use a roughness coefficient ("n" value) of 0.03 for pervious concrete.

If you have any questions, please contact a stormwater engineer in the Environmental and Site Review Division at **703-324-1720, TTY 711**

Sincerely,

James W. Patteson, PE
Director

Attachments: As Stated

cc: Jimmie D. Jenkins, Director, Department of Public Works and Environmental Service

INNOVATIVE BMP TRACKING FORM

Request for permission to use an Innovative BMP
PFM Section 6-0402.4 - No fee required

Attach to Site or Subdivision Plan Date _____/_____/_____

Plan and Document Control – Herrity Building
Land Development Services
Department of Public Works and Environmental Services
12055 Government Center Parkway
Fairfax, Virginia 22035-5503

PROJECT NAME _____ TAX MAP AND PARCEL #_____

APPLICANT/OWNER/DEVELOPER _____ PHONE: (____)_____

ADDRESS _____

APPLICANT'S AGENT/ENGINEER _____ PHONE: (____)_____

ADDRESS _____

Innovative BMP type:

[ ] 3.06 Retention Basin III (Wet Pond with Sediment Forebay an Aquatic Bench)

[ ] 3.07 Extended Detention Dry Pond (with Sediment Trap)

[ ] 3.07 Enhanced Extended Detention Dry Pond (with Sediment Forebay and Shallow Marsh)

[ ] 3.09 Constructed Wetlands

[ ] 3.10D Pervious Concrete

[ ] 3.14 Vegetated Filter Strip

[ ] 3.15 Manufactured BMP Systems

Hydrodynamic Structures	Filtering Structures
[ ] Bay Saver	[ ] StormFilter
[ ] Downstream Defender	[ ] StormTreat System
[ ] Stormceptor	
[ ] Vortechs	

Construction Cost _____ Maintenance Cost (20-year cycle) _____