

3.3 Permeable Pavement

Type of BMP	LID – Infiltration
Priority Level	Priority 1 – Full Retention
Treatment Mechanisms	Infiltration, Evaporation
Infiltration Rate Range	> 0.8 in/hr factored design infiltration rate
Maximum Drainage Area	10 acres

Description

Permeable pavements can be either pervious asphalt and concrete surfaces, or permeable modular block. Unlike traditional pavements that are impermeable, permeable pavements reduce the volume and peak of stormwater runoff as well as mitigate pollutants from stormwater runoff, provided that the underlying soils can accept infiltration. Permeable pavement surfaces work best when they are designed to be flat or with gentle slopes. This factsheet discusses criteria that apply to infiltration designs.

The permeable surface is placed on top of a reservoir layer that holds the water quality stormwater volume, V_{BMP} . The water infiltrates from the reservoir layer into the native subsoil. Tests must be performed according to the Infiltration Testing Section in Appendix A to be able to use this design procedure.

In some circumstances, permeable pavement may be implemented on a project as a source control feature. Where implemented as a source control feature (sometimes referred to as a ‘self-retaining’ area), the pavement is not considered a ‘BMP’ that would be required to be designed and sized per this manual. Where permeable pavement receives runoff from adjacent tributary areas, the permeable pavement *may* be considered a BMP that must be sized according to this manual. Consult the Engineering Authority and the WQMP for any applicable requirements for designing and sizing permeable pavement installations.

Siting Considerations

The WQMP applicable to the project location should be consulted, as it may include criteria for determining the applicability of this and other Infiltration-based BMPs to the project.

Permeable pavements can be used in the same manner as concrete or asphalt in low traffic parking lots, playgrounds, walkways, bike trails, and sports courts. Most types of permeable pavement can be designed to meet Americans with Disabilities Act (ADA) requirements. Permeable pavements **should not** be used in the following conditions:

- ⊗ Downstream of erodible areas
- ⊗ Downstream of areas with a high likelihood of pollutant spills
- ⊗ Industrial or high vehicular traffic areas (25,000 or greater average daily traffic)
- ⊗ Areas where geotechnical concerns, such as soils with low infiltration rates, would preclude the use of this BMP.

PERMEABLE PAVEMENT BMP FACT SHEET

Sites with Impermeable Fire Lanes

Oftentimes, Fire Departments do not allow alternative pavement types including permeable pavement. They require traditional impermeable surfaces for fire lanes. In this situation, it is acceptable to use an impermeable surface for the fire lane drive aisles and permeable pavement for the remainder of the parking lot.

Where impermeable fire lanes are used in the design, the impermeable surface must slope towards the permeable pavement, and the base layers shall remain continuous underneath the two pavement types, as shown in Figure 1. This continuous reservoir layer helps to maintain infiltration throughout the pervious pavement site, and can still be considered as part of the total required storage area.

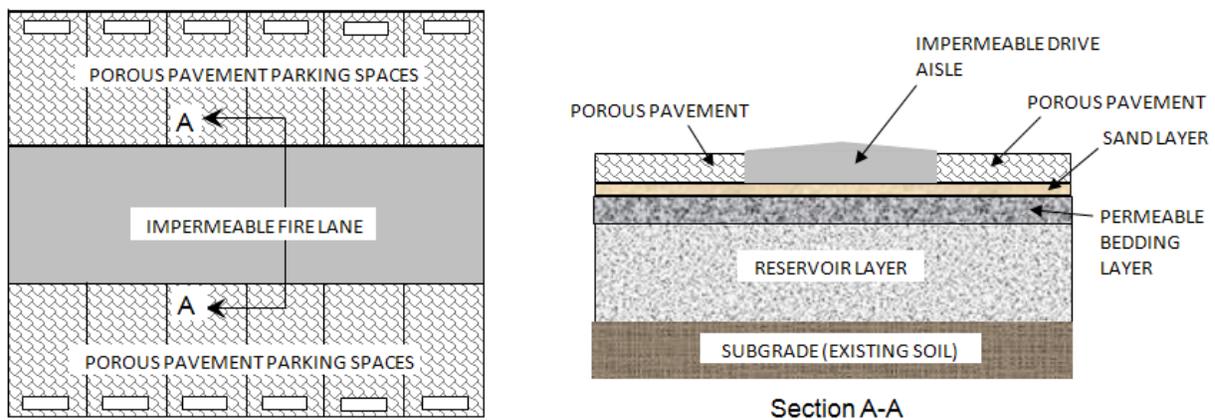


Figure 1: Impermeable Fire Lanes

Also, while a seal coat treatment may be used on the impermeable fire land, traditional seal coat treatments **shall not** be used on permeable pavement.

PERMEABLE PAVEMENT BMP FACT SHEET

Setbacks

Always consult your geotechnical engineer for site specific recommendations regarding setbacks for permeable pavement. Recommended setbacks are needed to protect buildings, walls, onsite wells, streams and tanks.

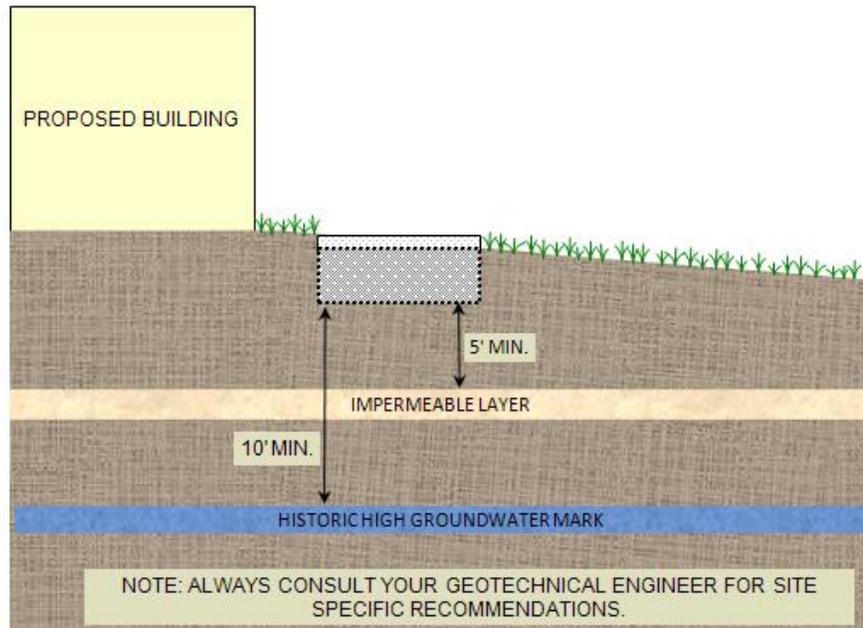


Figure 2: Permeable Pavement Setback Requirements

A minimum vertical separation of 10 feet is required from the bottom of the reservoir layer to the historic high groundwater mark, see Figure 2. A minimum vertical separation of 5 feet is required from the bottom of the reservoir layer to any impermeable layer in the soil. If the historic high groundwater mark is less than 10 feet below the reservoir layer section, or less than 5 feet from an impermeable layer, the infiltration design is not feasible.

Design and Sizing Criteria

To ensure that the pavement structural section is not compromised, a 24-hour drawdown time is utilized for this BMP instead of the longer drawdown time used for most volume based BMPs.

Reservoir Layer Considerations

Even with proper maintenance, sediment will begin to clog the soil below the permeable pavement. Since the soil cannot be scarified or replaced, this will result in slower infiltration rates over the life of the permeable pavement. Therefore, the reservoir layer is limited to a maximum of 12 inches in depth to ensure that over the life of the BMP, the reservoir layer will drain in an adequate time.

PERMEABLE PAVEMENT BMP FACT SHEET

Note: All permeable pavement BMP installations (not including Permeable Pavement as a source control BMP i.e. a self-retaining area) must be tested by the geotechnical engineer to ensure that the soils drain at a minimum allowable rate to ensure drainage.. See the Infiltration Testing Section of this manual for specific details for the required testing and applied factors of safety.

Sloping Permeable Pavement

Ideally permeable pavement would be level, however most sites will have a mild slope. If the tributary drainage area is too steep, the water may be flowing too fast when it approaches the permeable pavement, which may cause water to pass over the pavement instead of percolating and entering the reservoir layer. If the maximum slopes shown in Table 1 are complied with, it should address these concerns.

Table 1: Design Parameters for Permeable Pavement

Design Parameter	Permeable Pavement
Maximum slope of permeable pavement	3%
Maximum contributing area slope	5%

Regardless of the slope of the pavement surface design, the bottom of the reservoir layers **shall be flat and level** as shown in Figure 3. The design shown ensures that the water quality volume will be contained in the reservoir layer. A terraced design utilizing non-permeable check dams may be a useful option when the depth of gravel becomes too great as shown in Figure 3.

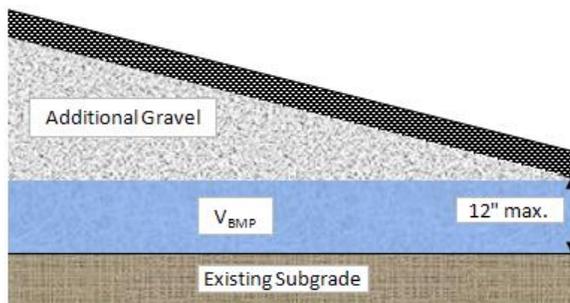


Figure 3: Sloped Cross Sections for Permeable Pavement

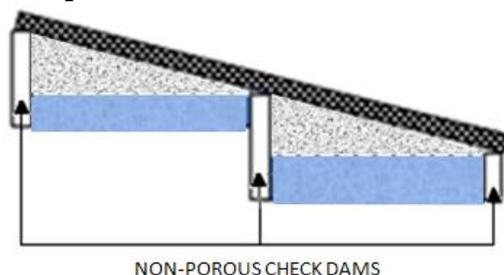


Figure 4: Permeable Pavement with Non-permeable Check Dams

PERMEABLE PAVEMENT BMP FACT SHEET

In Figure 4, the bottom of the gravel reservoir layer is incorrectly sloped parallel to the pavement surface. Water would only be allowed to pond up to the lowest point of the BMP. Additional flows would simply discharge from the pavement. Since only a portion of the gravel layer can store water, this design would result in insufficient capacity. This is not acceptable.

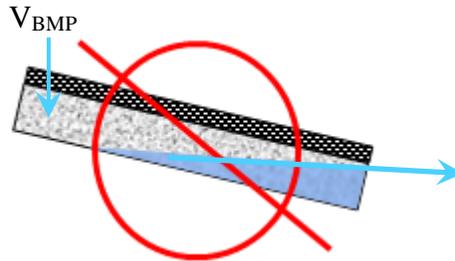


Figure 5: Incorrect Sloping of Permeable Pavement

To assure that the subgrade will empty within the 24 hour drawdown time, it is important that the maximum depth of 12 inches for the reservoir layer discussed in the design procedure is not exceeded. The value should be measured from the lowest elevation of the slope (Figure 4).

Minimum Surface Area

The minimum surface area required, A_s , is calculated by dividing the water quality volume, V_{BMP} , by the depth of water stored in the reservoir layer. The depth of water is found by multiplying the void ratio of the reservoir aggregate by the depth of the layer, b_{TH} . The void ratio of the reservoir aggregate is typically 40%; the maximum reservoir layer depth is 12”.

Sediment Control

A pretreatment BMP should be used for sediment control. This pretreatment BMP will reduce the amount of sediment that enters the system and reduce clogging. The pretreatment BMP will also help to spread runoff flows, which allows the system to infiltrate more evenly. The pretreatment BMP must discharge to the surface of the pavement and not the subgrade. Grass swales may also be used as part of a treatment train with permeable pavements.

Liners and Filter Fabric

Always consult your geotechnical engineer for site specific recommendations regarding liners and filter fabrics. Filter fabric may be used around the edges of the permeable pavement; this will help keep fine sediments from entering the system. Unless recommended for the site, impermeable liners are not to be used below the subdrain gravel layer.

Overflow

PERMEABLE PAVEMENT BMP FACT SHEET

An overflow route is needed in the permeable pavement design to bypass storm flows larger than the V_{BMP} or in the event of clogging. Overflow systems must connect to an acceptable discharge point such as a downstream conveyance system.

Roof Runoff

Permeable pavement can be used to treat roof runoff. However, the runoff cannot be discharged beneath the surface of the pavement directly into the subgrade, as shown in Figure 6. Instead the pipe should empty on the surface of the permeable pavement as shown in Figure 7. A filter on the drainpipe should be used to help reduce the amount of sediment that enters the permeable pavement.

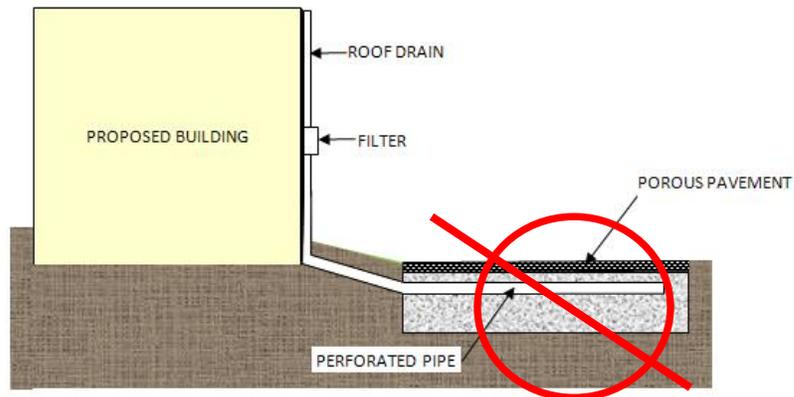


Figure 6: Incorrect Roof Drainage

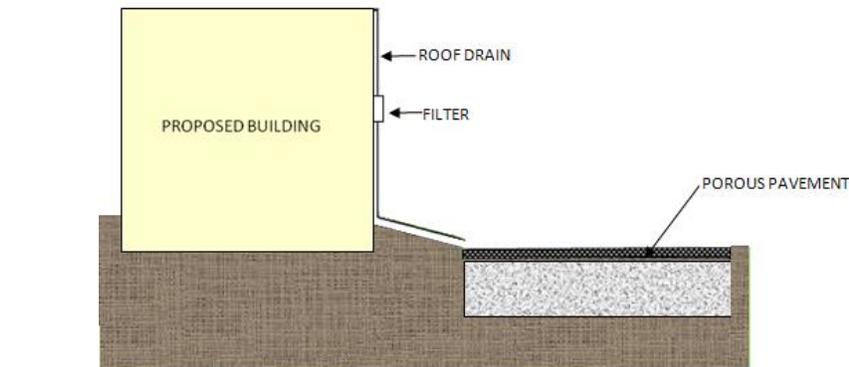


Figure 7: Correct Roof Runoff Drainage

PERMEABLE PAVEMENT BMP FACT SHEET

Infiltration

Refer to the Infiltration Testing Section (Appendix A) in this manual for recommendations on testing for this BMP.

Pavement Section

The cross section necessary for infiltration design of permeable pavement includes:

- The thickness of the layers of permeable pavement, sand and bedding layers depends on whether it is permeable modular block or pervious pavement. A licensed geotechnical or civil engineer is required to determine the thickness of these upper layers appropriate for the pavement type and expected traffic loads.
- A 12" maximum reservoir layer consisting of AASHTO #57 gravel vibrated in place or equivalent with a minimum of 40% void ratio.

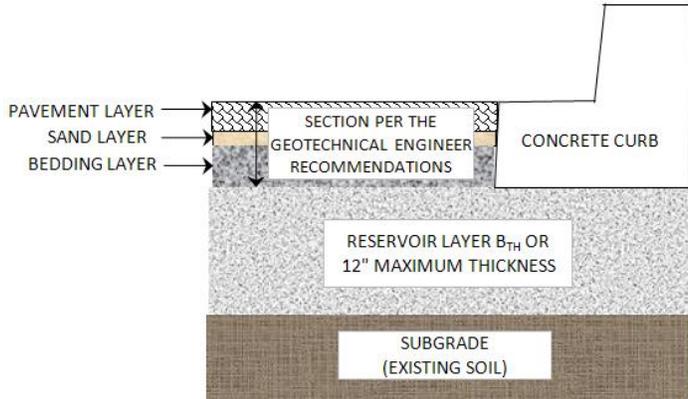


Figure 8: Infiltration Cross Section

Inspection and Maintenance Schedule –Modular Block

Schedule	Activity
Ongoing	<ul style="list-style-type: none"> • Keep adjacent landscape areas maintained. Remove clippings from landscape maintenance activities. • Remove trash and debris
Utility Trenching and other pavement repairs	<ul style="list-style-type: none"> • Remove and reset modular blocks, structural section and reservoir layer as needed. Replace damaged blocks in-kind. • Do not pave repaired areas with impermeable surfaces.
After storm events	<ul style="list-style-type: none"> • Inspect areas for ponding
2-3 times per year	<ul style="list-style-type: none"> • Sweep to reduce the chance of clogging
As needed	<ul style="list-style-type: none"> • Sand between pavers may need to be replaced if infiltration capacity is lost

PERMEABLE PAVEMENT BMP FACT SHEET

Inspection and Maintenance Schedule –Pervious Concrete/Asphalt

Schedule	Activity
Ongoing	<ul style="list-style-type: none"> • Keep adjacent landscape areas maintained. Remove clippings from landscape maintenance activities. • Remove trash and debris
Utility Trenching other pavement repairs	<ul style="list-style-type: none"> • Replace structural section and reservoir layer in kind. • Re-pave using pervious concrete/asphalt. Do not pave repaired areas with impermeable surfaces.
After storm events	<ul style="list-style-type: none"> • Inspect areas for ponding
2-3 times per year	<ul style="list-style-type: none"> • Vacuum the permeable pavement to reduce the chance of clogging
As needed	<ul style="list-style-type: none"> • Remove and replace damaged or destroyed permeable pavement

Design Procedure Permeable Pavement

1. Enter the Tributary Area, A_T .
2. Enter the Design Volume, V_{BMP} , determined from Section 2.1 of this Handbook.
3. Enter the reservoir layer depth, b_{TH} for the proposed permeable pavement. The reservoir layer maximum depth is 12 inches.
4. Calculate the Minimum Surface Area, A_S , required.

$$A_S(\text{ft}) = \frac{V_{BMP} (\text{ft}^3)}{(0.4 \times b_{TH} (\text{in}))/12(\text{in}/\text{ft})}$$

Where, the porosity of the gravel in the reservoir layer is assumed to be 40%.

5. Enter the proposed surface area and ensure that this is equal to or greater than the minimum surface area required.
6. Enter the dimensions, per the geotechnical engineer's recommendations, for the pavement cross section. The cross section includes a pavement layer, usually a sand layer and a permeable bedding layer. Then add this to the maximum thickness of the reservoir layer to find the total thickness of the BMP.
7. Enter the slope of the top of the permeable pavement. The maximum slope is 3%.
8. Enter whether sediment control was provided.

9. Enter whether the geotechnical approach is attached.
10. Describe the surfaces surrounding the permeable pavement. It is preferred that a vegetation buffer is used around the permeable pavement.
11. Check to ensure that vertical setbacks are met. There should be a minimum of 10 feet between the bottom of the BMP and the top of the high groundwater table, and a minimum of 5 feet between the reservoir layer the top of the impermeable layer.

Reference Materials Used to Develop this Fact Sheet:

Adams, Michelle C. "Porous Asphalt Pavement with Recharge Beds: 20 Years and Still Working." Stormwater Magazine May-June 2003.

Atlanta Regional Commission, et. al. Georgia Stormwater Management Manual. 1st Edition. Vol. 2. Atlanta, 2001. 3 vols.

Bean, E. Z., et al. "Study on the Surface Infiltration Rate of Permeable Pavements." Water and Environment Specialty Conference of the Canadian Society for Civil Engineering. Saskatoon, 2004. 1-10.

California Department of Transportation. CalTrans Standard Plans. 15 September 2005. May 2010 <http://www.dot.ca.gov/hq/esc/oe/project_plans/HTM/stdplns-met-new99.htm>.

Camp Dresser and McKee Inc.; Larry Walker Associates. California Stormwater Best Management Practice Handbook for New Development and Redevelopment. California Stormwater Quality Association (CASQA), 2004.

Colorado Ready Mixed Concrete Association (CRMCA). "Specifier's Guide for Pervious Concrete Pavement Design, Version 1.2." 2010.

County of Los Angeles Public Works. Stormwater Best Management Practice Design and Maintenance Manual. Los Angeles, 2009.

Program, Ventura Countywide Stormwater Quality Management. Technical Guidance Manual for Stormwater Quality Control Measures. Ventura, 2002.

Sacramento Stormwater Quality Partnership and the City of Roseville. Stormwater Quality Design Manual for the Sacramento and South Placer Regions. County of Sacramento, 2007.

Taylor, Chuck. "Advanced Pavement Technology." Riverside, 2008.

Tennis, Paul D., Michael L. Leming and David J. Akers. Pervious Concrete Pavements. Silver Spring: Portland Cement Association and National Ready Mixed Concrete Association, 2004.

Urban Drainage and Flood Control District. Urban Storm Drainage Criteria Manual Volume 3 - Best Management Practices. Vol. 3. Denver, 2008. 3 vols.

Urbanas, Ben R. Stormwater Sand Filter Sizing and Design: A Unit Operations Approach. Denver: Urban Drainage and Flood Control District, 2002.