Permeable Hardscapes

(Source: aaees.org)

(Source: Center for Neighborhood Technology)

Purpose & Benefits

- Stormwater runoff reduction
- High pollutant removal
- Control localized drainage problems
- Attractive alternative for walkways and driveways

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Description

Permeable Hardscape are alternatives to traditional paving materials that allow water to seep into the ground. They can be used in a wide range of settings, from a simple pathway or small patio up to a large commercial parking lot. Over the last few years, the market for these materials has grown. Currently, some very attractive and cost-effective options are available for small projects. The chapter focuses on small-scale, residential applications (e.g., patios, walkways), largely using permeable pavers. Larger applications – including driveways, travelways, and parking – can use a variety of materials, including pervious concrete or porous asphalt, and specifications are commonly included in state stormwater manuals.

What to Expect

Permeable Hardscape are quite similar to and replace traditional paving or hardscaped areas, except the water is intended to move through the surface and percolate into the ground, instead of running off as quickly as possible. The gravel bed underneath the pavement surface is designed to hold water temporarily, so it will be deeper than that of traditional paving. Finally, the paved surface itself is different, and the contractor needs to ensure that the surface is installed correctly and does not become clogged during construction. Routine maintenance of Permeable Hardscaping includes sweeping or using a leaf blower to remove fine particles from between the paver stones. Larger applications may involve using a vacuum sweeper to keep the pavement surface from clogging.

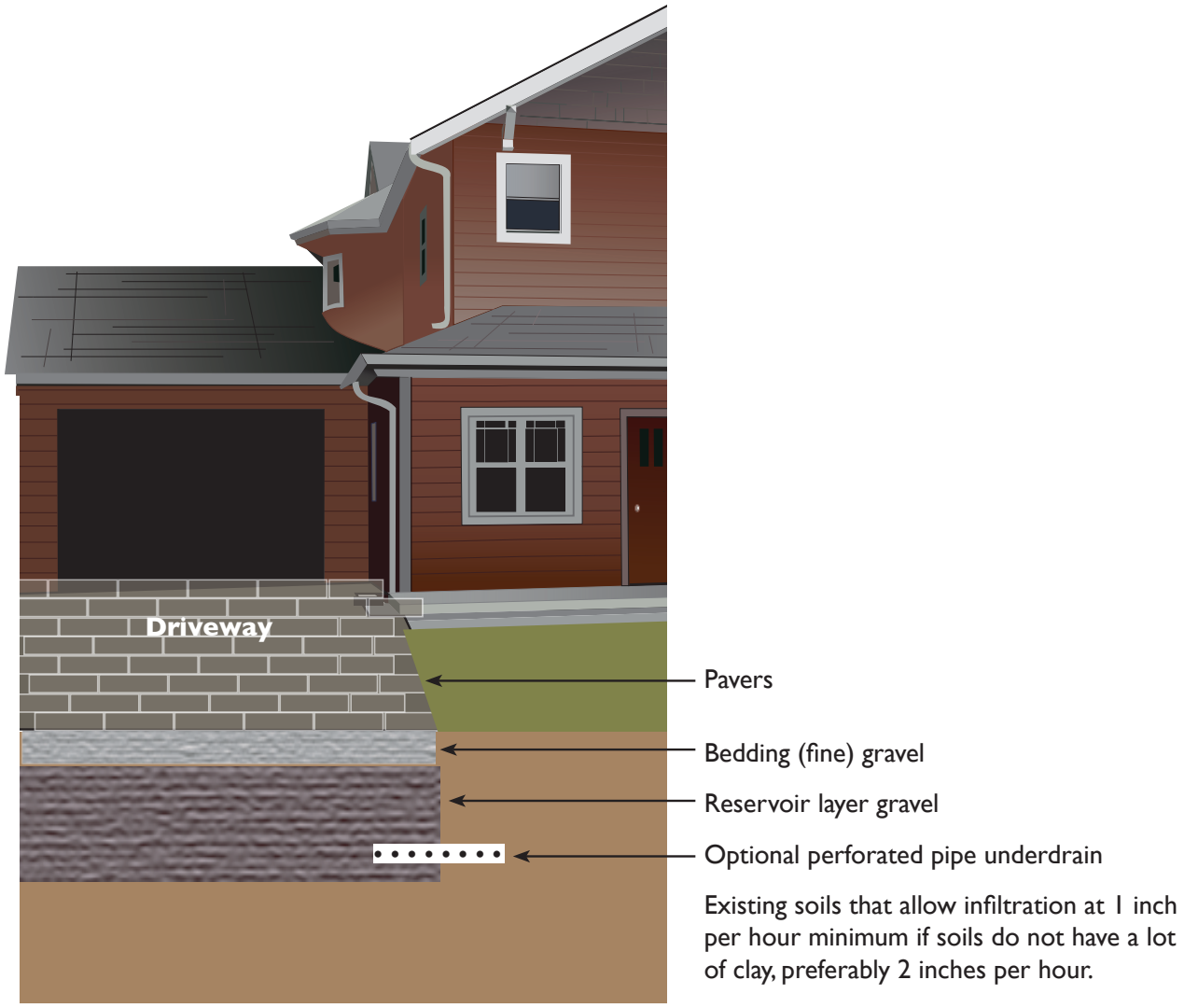


Figure 3.1. *Overview of a typical Permeable Hardscape*

3.1. Complexity

Permeable Hardscaping is similar to traditional paving or hardscaping, but special considerations are needed to ensure functionality for stormwater management. The actual installation is slightly different. The excavation is deeper and extra precaution should be taken to prevent clogging during construction. As the scale of the application increases, the design becomes more complex, and the services of a design professional are advisable, as outlined in **Table 3.1.**

Permeable Hardscapes should be designed and constructed by a contractor with experience and knowledge about this practice. The design and construction details provided in this chapter may allow Stewards and homeowners to better understand the practice, but not to construct this practice without the help of an experienced contractor.



Table 3.1. Design Complexity for Permeable Hardscapes

Design Complexity	Description	Guidance
Simple	• Very small scale pedestrian surfaces, including walkways and small patios	• Design can be completed using simple design tools included in this chapter • Make sure the soil will allow for stormwater to infiltrate • **Appendix B** includes some guidance for simple soils testing • Confirm the practice is separated from any building foundation • Take care during construction to make sure that the pavers do not become clogged
Moderate	• Larger pedestrian surfaces and small driving surfaces • Examples include larger patio surfaces or driveways (>1,000 square feet)	• Consult with a civil engineer, landscape architect, or experienced specialist to ensure that a driveway meets safety and structural standards • Paving surface can include permeable concrete, porous asphalt, reinforced grid pavers, and other proprietary products • If this practice will be installed close to a basement, ensure that proper precautions are taken to prevent leaking or compromising the foundation
Complex	• Parking lots, travelways, or other large impervious areas • Any surface that needs to be designed to support truck traffic • Typically in a commercial or institutional setting	• Design requires a professional engineer, landscape architect, or equivalent, with adherence to appropriate state standards. (MDE, 2009 or VA DEQ, 2013, for example) • Pretreatment often includes a formal forebay cell • May require more maintenance than other permeable surfaces • Depth depends on the structural requirements of the design

Figures 3.2 and 3.3 exemplify residential to light commercial scale projects that fall somewhere between the simple and moderate levels of complexity. They are small, but intended for parking, which makes structural considerations more complex. They do not connect to municipal stormwater infrastructure, therefore eliminating the need to tie an underdrain to an existing storm structure. **Figure 3.1** above shows a typical cross section for a moderate to complex system.

Figure 3.2. *Permeable paver installation for off-street parking, prior to applying grass seed. In this situation, the downspout could be directed to the pavers since the roof is small and the runoff should be relatively clean.*

Figure 3.3. *Permeable paver parking installation, light commercial scale.*
(Source: New York State Stormwater Green Infrastructure)

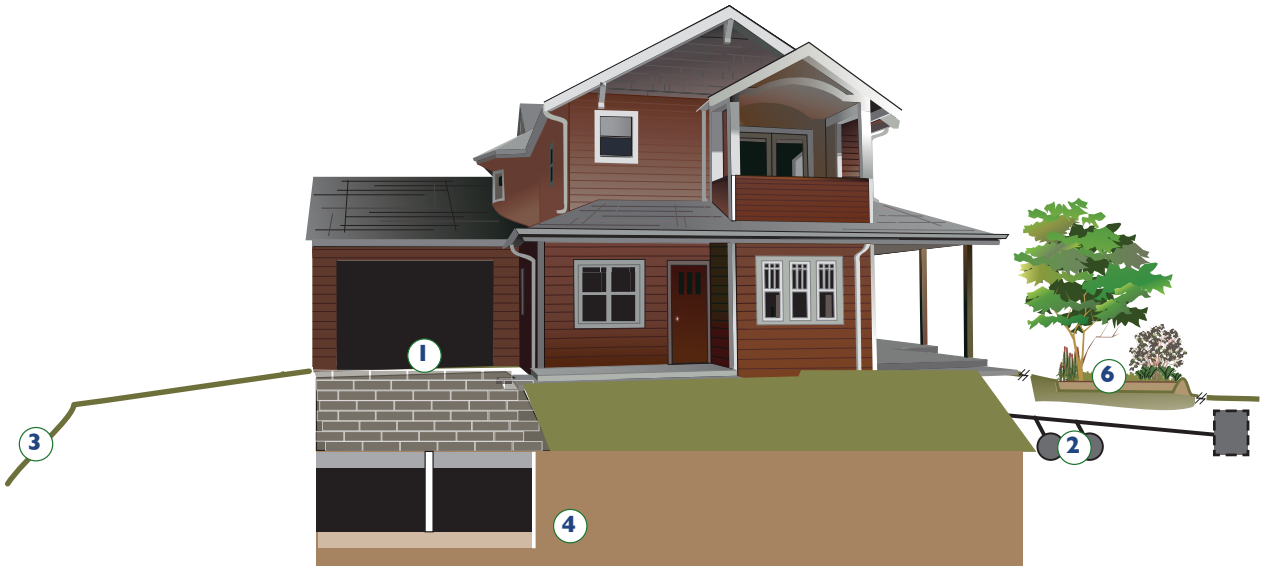


Understand the Complexity of the Hardscaping Project

The intent of this guide is for practices in the SIMPLE to MODERATE categories. Larger paved areas, such as parking lots, or paved areas designed to support vehicular traffic need to be designed by an engineer or landscape architect. For driveways and other projects that are very close to a house or foundation, have a professional designer take a look at the design to ensure that it will not create structural problems or leakage into a basement.

3.2. Location & Feasibility

Where NOT to Locate Permeable Hardscapes



1. Close to building foundation 5 feet downhill, 25 feet uphill (for projects less than 1,000 square feet)*
2. Over utilities or septic systems
3. Near the edge of loose or steep slopes or bluffs
4. Over impermeable soils
5. Where a lot of water runs onto the Permeable Hardscape from upstream.
6. Under trees or over tree roots

*For projects closer than these setbacks, impermeable liners and/or custom drainage systems may be used, with experienced professional guidance and installation.

Figure 3.4. *Examples of site constraints for locating a Permeable Hardscape*
(Original graphic source: Washington State University Extension, 2013)

When deciding where to build a Permeable Hardscape, consider the siting constraints illustrated in **Figure 3.4**, and also the following considerations:

Soils Permeable Hardscape work best when they are installed over soils that allow water to infiltrate. **Appendix B** includes some simple tests and reference tools to determine whether or not the soils are able to infiltrate stormwater. It is strongly advised to conduct an on-site test in accordance with **Appendix B,** with a result of at least 1 inch per hour. If the native soils are too soft and sandy, they may need to be fortified with more stable, construction-worthy soils to support the loads associated with the intended uses.

Groundwater Depth Permeable Hardscapes filter pollutants as runoff flows through the natural soils. If the groundwater comes too close to the bottom of of the stone reservoir layer, pollutants can potentially flow through to the groundwater. In addition, these surfaces will likely have problems over the long term. As a rule, the grounwater should be at least 2 feet below the bottom of the reservoir layer. **Appendix B** has some tips for determining groundwater levels throughout the year.



Be Careful About Setbacks

Make sure the Permeable Hardscape is either far away from building foundations or (preferably) downhill (see Setbacks section below). If these conditions can't be met, a Permeable Hardscape is still an option, but an experienced installer, civil engineer, or landscape architect should be involved to ensure the design won't threaten the foundation or basement of the adjacent building.

Make Sure the Soils are Right for Infiltration

If the soils on the site are clay or don't allow water to infiltrate at an adequate rate of at least 1 inch per hour, consider the following modifications:

- Add a perforated underdrain system in the stone reservoir layer. The underdrain should allow water to flow to an outlet in the yard or a place that can receive the water (see design section of this chapter).
- For driveways, consider a two-track design that reduces the paved area by only placing asphalt or concrete strips under the path of tires.
- For patios and walkways, allow water to drain to a grassed or vegetated area that will absorb the water.

Setbacks The recommended setbacks, depending on the size of the hardscaped area are:

- For small projects (<1,000 square feet)
  - 5 feet if downhill from building (preferred).
  - 25 feet if uphill
- For larger projects
  - 10 feet if downhill from building
  - 50 feet if uphill

For lots with individual wells, try to locate the Permeable Hardscape at least 50 feet away from the well if it is cased down to bedrock, or 100 feet if it is an unconfined well, and at least 25 feet from a septic system.

Be aware of Critical Areas, as defined by the Maryland Department of Natural Resources. In Maryland, a 100-foot buffer zone from average high tide water level, wetlands, and streams is a particularly sensitive area. Generally, it is best to avoid installing practices in these areas, but if a practice will be installed in Critical Areas, they *must* adhere staunchly to the State specifications, including soil permeability. Consultation with a professional engineer is advised in these cases.

Proximity to Utilities Always call Miss Utility before digging. Interference with underground utilities should be avoided whenever possible, particularly water, sewer, electric and gas lines. Conflicts with water and sewer lateral pipes (e.g., house connections) might be unavoidable, in which case excavation should be done very carefully to avoid damaging those pipes. Also, be aware that Miss Utility may not always mark private cable, propane, electric, and similar lines, so some additional site work may be necessary to locate these.

Do:

- Test soil to determine suitability for permeable pavement (types A/B/C – infiltration rate 1 inch/hour or faster)
- Add underdrain if soils infiltrate slowly, or if the drainage area is large
- Add a grass filter strip or other pre-treatment of incoming water to minimize maintenance and chances of failure

Don't:

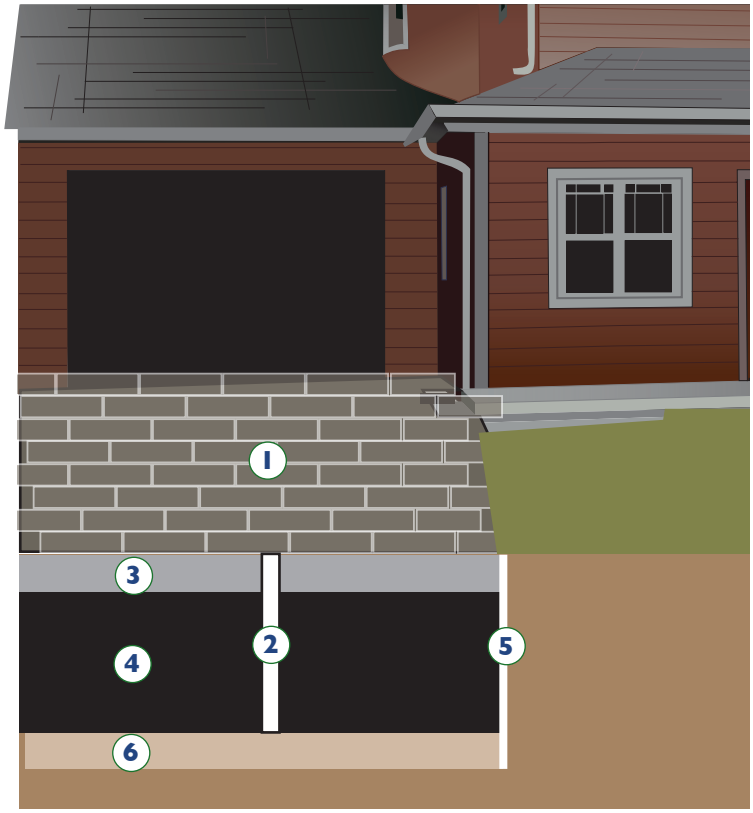
- Locate next to a building foundation, water well, septic field, or beneath trees
- Direct runoff toward a building foundation
- Send too much water to a Permeable Hardscape, especially from pervious surfaces – too much fine sediment = clogging

Shape of the Land Permeable Hardscaping is the most effective when it is used on flat or nearly flat areas (less than or equal to 5% slope). If permeable pavers are used along a path or other surface that has steeper sections, consider using steps to create a flat surface. To prevent clogging, make sure that the permeable area does not receive too much runoff from upslope, non-paved areas, such as mulched or landscape beds and especially areas of exposed soil. Also, Permeable Hardscape shouldn't take too much runoff from roof downspouts.

As a rule, the total area of rooftop or other impervious surface directed to the hardscape should not be more than two times the area of the hardscape itself. If the Permeable Hardscape is replacing an existing impervious surface, check to see how dirty the existing surface is after a rain storm. This is a good indication of how much dirt and sediment will wash onto the permeable replacement. If the proposed Permeable Hardscape area seems to receive too much water and/or sediment from upslope areas, consider using simple swales or French drains to divert a portion of the runoff around the practice, or, preferably, stabilize upslope areas with denser vegetation.

3.3. Design

The materials used to design Permeable Hardscape are readily available from various suppliers and manufacturers. The design is fairly simple when the practice is designed to treat small areas. **Figure 3.5** shows a typical cross-section of this practice. It is important to have an accurate plan showing the various layers and their respective depths and dimensions.



1. Permeable Pavement Surface Material
2. Observation Well, Solid (No Perforations) 4"-6" PVC (Optional, not typical)
3. Bedding Layer (as directed by manufacturer)
4. Reservoir Layer
5. Non-Woven Geotextile (sides only)
6. 2"-4" Sand Filter Layer or No. 8 choker stone (Optional, not typical)

Figure 3.5. *Typical Permeable Hardscape Cross-Section*
(Source: Washington State University Extension, 2013)

Sizing At a minimum, the stone reservoir layer below the permeable surface should be 6 inches deep. For parking areas or driveways, the reservoir should be at least 12 inches deep, or an adequate depth to support structural and vehicular loads. In addition, read the pavement system manufacturers' guidance to ensure that the paved areas are structurally sound. If the Permeable Hardscape receives runoff from conventionally-paved areas, a good rule of thumb is the area of the impervious surface draining to the pavers should be roughly the same area as the paver system itself. If the stone reservoir is deeper than 6 inches, this ratio can be pushed up to 2:1, as long as some form of pre-treatment is provided (see below).

Note that heavy rains may overwhelm a Permeable Hardscape, regardless of soil quality below the reservoir. It is important to point out to the client that sometimes the water will not be able to infiltrate fast enough, and water will run off the Permeable Hardscape.

Pre-Treatment As stated above, Permeable Hardscape should not receive too much runoff from other surfaces. Runoff that is directed to these areas should have some kind of pre-treatment or pre-filtering before it flows onto the permeable surface. Leaf screens should be installed in gutters or downspouts. Other areas can flow over a shallow-sloped grassed or vegetated area (filter strip) or through a gravel or stone-filled trench adjacent to the permeable surface. This is to prevent small particles from clogging the spaces between the pavers, and therefore to minimize maintenance. **Figure 3.6** shows a permeable paver installation that has significant clogging from sand and fine soil particles. The area draining to this installation is large, and there is no filtering between the asphalt parking area and the permeable pavement. **Figure 3.7** shows examples of pretreatment options

Figure 3.6. *Permeable paver installation without pretreatment or filtering. Clogging evident from sediment and grit from adjacent surfaces.*

Figure 3.7. *Gravel diaphragm and grass filter strips to catch sediment before runoff reaches permeable pavement*

Excess Soil Plan for the disposal or use excess dirt that will come from excavation. Add some topsoil to excavated dirt if it will be reused onsite for grass or vegetation.

Site Drainage Although Permeable Hardscape are designed to infiltrate stormwater, they will not work long if they are flooded with runoff from large storms. When laying out the site, make sure that ponded water has somewhere to go during larger storms. This is no different than traditional hardscapes. The water flowing to and away from the hardscapes should be conveyed in a stable manner, and should not cause erosion issues.



3.4. Materials

Table 3.2 includes a list of materials needed to construct Permeable Hardscaping. Note that the actual permeable pavers include many different options. In addition, some manufacturers may specify a different subgrade material. For example grassed pavers require a soil medium below the paver to support grass growth.

Table 3.2. Material Specifications for Permeable Hardscapes

(Listed in order of location in a Permeable Hardscape cross-section, from TOP to BOTTOM)

Material	Specifications	Size	Depth	Notes
Permeable surface	Varies	Varies	Varies	Per manufacturer
Bedding layer	#8 or #78 stone, clean, washed	⅜ - ½ inch	Per manufacturer	Manufacturer may indicate different bedding material
Reservoir	#57 clean, washed rounded gravel	½ - to 1 ½ inch gravel	6 inches minimum for patios and walkways 12 inches or minimum needed for structural/vehicular load (e.g., driveways)	Depth may also be dictated by structural considerations Consult with supplier or manufacturer Avoid angular, crushed stone; prefer rounded gravel
Filter fabric	Standard filter fabric or non-woven geotextile	N/A	Sides ONLY	This is also considered optional, and is more applicable to moderate or larger-scale applications
Underdrain pipe (if used)	Perforated, corrugated (with smooth-wall interior) HDPE landscape pipe or equivalent	3 – 4 inches	Placed in stone reservoir layer at 0.5 to 1% slope Once the pipe leaves the Permeable Hardscape area itself, it should continue until the pipe meets the ground surface somewhere in the yard via a non-perforated section	Optional (typically not included)

3.5. Construction

Permeable Hardscape can require more precision in construction than some of the other BMPs. Surfaces should align and be flat, the base layers should be evenly applied and uniformly compacted to an appropriate degree. Pay particular attention to critical areas, such as where Permeable Hardscape edges meet other surfaces (e.g., asphalt, grass areas). It is best to work from a thorough plan, including plan view, profile or cross-section views, with depths and dimensions labeled. Measure carefully and frequently to ensure the installation is staying on plan.

Step 1 - Outline the Project & Mark Utilities Mark the excavation area for the hardscape. Call Miss Utility before excavating, and also check for private cable, propane, electric, and other lines. Also try to identify private propane, cable, electric, and other small lines. Make sure to have a plan and phone numbers of who to call in case there is any damage to utilities. Ensure only very small areas of landscaped surfaces are directed to the pavement and there is a pathway for water to flow during large rain events. In some cases, this may require using a survey level or hand level and a survey rod to check spot elevations and confirm flow paths.

Do:

- Check levels and elevations carefully and frequently during installation
- Rake, till, or otherwise scarify the bottom surface of the excavation to improve infiltration
- Make sure the edges around the installation are solid – if the surroundings slump or get washed away, so will the hardscape!

Don't:

- Ignore manufacturer specifications and recommendations – each product may have different requirements
- Pressure wash the spaces between pavers to clean sediment – light vacuuming is recommended instead

Figure 3.8. *Excavation of permeable paver installation in small parking lot*

Figure 3.9. *Installation of gravel reservoir layer*

Step 2 - Excavate It is best to excavate when the weather is expected to be dry for several days. Excavate to dimensions and depths, as per the plan. Account for all the layers and be aware of variation that can occur based on the materials. For example, for ½-inch diameter gravel that is angular, it will be difficult to get the surface to be completely flat; expect ¼ inch dips and protrusions.

Step 3 - Rake or Till Rake or till the bottom soils to promote greater infiltration.

Figure 3.10. *Installation of pavers (top left), compaction (top right), and filling spaces with pea gravel (bottom).*

Step 4 - Filter Fabric Line the sides ONLY (never between the stone reservoir and underlying soil) of the excavated area with filter fabric (optional). This can be held in place with landscape staples.

Step 5 - Install Gravel Install the amount of gravel called for in the plans, followed by a 2-4 inch layer of bedding material, specified by the supplier or manufacturer. Place gravel and other base materials in layers of no more than 4-6 inches. Compact layers of gravel and base materials lightly by tamping manually. For heavier load applications, like driveways or parking spaces, compaction of base layers should follow manufacturer recommendations and municipal or state specifications, such as the Maryland Stormwater Design Manual (MDE, 2000).

Step 6 - Install Paving Install permeable paving material at the surface. Ensure that the surface is even and flat, and level or with a very slight slope, based on the plans. It is best to limit the difference between the elevations of two adjacent blocks to no more than ¼ inch to avoid tripping hazards and additional disturbance to the pavers.

Step 7 - Stabilize If the design calls for grass seed to be planted, spread seed and stabilize with a temporary stabilization method, such as paper mulch or jute mat.

Step 8 - Inspect Inspect the area after several rain events to look for any needed adjustments. Ensure that the surface is draining properly and that the surface is not becoming clogged.

3.6. Maintenance

Table 3.3. Recommended Maintenance for Permeable Hardscapes

Maintenance Tasks	Schedule
• Sweep the surface if sand or debris accumulates • Leaf blowers can also be used, but make sure debris is removed from the pavement surface • Agitate with a rough brush and vacuum the surface with a wet/dry vac if the joints fill with sand • Remove and replace clogged blocks in segmented pavers • Hire a vacuum sweeper to restore the surface for moderate or larger applications • Repair any structural damage to the paver surface (e.g., cracking, broken pavers, sinkholes)	As needed, particularly at change of seasons when leaves, winter sanding, and other debris may accumulate
• Repair and stabilize any areas that are eroding or washing dirt or debris onto the surface • Check downspouts and channels leading to the Permeable Hardscape and remove any accumulated debris	Quarterly, if other areas drain to the hardscape

3.7. Resources

Maryland Department of the Environment. 2009. *2000 Maryland Stormwater Design Manual – Rev. 2009.* Baltimore, MD. . Available at:

Smith, D. 2006. Permeable Interlocking Concrete Pavement-selection design, construction and maintenance. Third Edition. . Interlocking Concrete Pavement Institute. Herndon, VA

Virginia Department of Environmental Quality. 2013. *Virginia Stormwater BMP Specifications – Rev. 2013 (DRAFT).* Richmond, VA. Available at: http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/Publications.aspx