Infiltration

Section 5.3: Appendix F.3 & H.1

Infiltration - Design Notes

- Field verification of soil permeability/texture essential
- Pretreatment essential – minimum 25% of WQv
- Bottom of infiltration facility cannot be located in fill*, must have 3’ separation from gw and bedrock*
- Size based on design infiltration rates (Table 5-3)
- Guidance: Keep drainage areas to each practice small, may reduce some potential problems

* Reduced requirements for residential areas (2’)

<table>
<thead>
<tr>
<th>USDA Soil Texture</th>
<th>Design Infiltration Rate (in/hr)</th>
<th>Design Infiltration Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt Loam</td>
<td>0.12</td>
<td>0.0007</td>
</tr>
<tr>
<td>Loam</td>
<td>0.27</td>
<td>0.0115</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>1.02</td>
<td>0.0014</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>2.41</td>
<td>0.0033</td>
</tr>
<tr>
<td>Sand</td>
<td>5.27</td>
<td>0.0115</td>
</tr>
</tbody>
</table>
Design Notes (cont’d)

**Approved WQ BMPs**

- Cannot be used if contributing drainage is a LUHPPL
- Higher maintenance burden
- Stabilize site prior to installation
- Must meet variety of setbacks* (Table 5-2)
- May be used for larger storm events if infiltration rate > 8.3 in/hr**, mounding analysis may be required

* Reduced requirements for small-scale BMPs in res. areas
** 100% WQv treatment required by separate BMP in these areas

Soil Testing Requirements

- Appendix H
- Required?
  - Infiltration Practice
  - Filter Practice*
  - Dry Swale*
- What does it tell us?
  - Feasibility of proposed BMP (too high or too low inf rate, depth to SHGT)
  - Design infiltration rate for sizing and models
- Who can do the soil testing?
  - DEM-licensed Class IV soil evaluator or RI-registered P.E.

Table H-1 Infiltration Testing Summary

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Design Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration Practice/Infiltrating</td>
<td>1 infiltration test and 1 test pit per 5,000 ft²</td>
</tr>
<tr>
<td>Permeable Pavement Practices</td>
<td></td>
</tr>
<tr>
<td>Filter Practice**</td>
<td>1 infiltration test and 1 test pit per 5,000 ft² (no</td>
</tr>
<tr>
<td></td>
<td>underdrains required if infiltration rate &gt; 0.5 in/hr***</td>
</tr>
<tr>
<td>Dry Swale**</td>
<td>1 infiltration test and 1 test pit per 1.0 ft of dry</td>
</tr>
<tr>
<td></td>
<td>swale (no underdrains required if infiltration rate &gt; 0.5 in/hr ***)</td>
</tr>
</tbody>
</table>

* For use with residential rooftops, stormwater requirements are reduced to 1 infiltration test and 1 test pit per 0.5 ft². The areas are not considered to be in the floodplain or VHI.

** Underdrains required if infiltration rate > 0.5 in/hr.
*** Underdrains strongly suggested.
### Test Pit/Boring Requirements

- Excavate a test pit or dig a standard soil boring to a depth of 4 ft below the proposed facility bottom.
- Determine depth to SHGT. May establish in test pits based on redoximorphic features.
- Soil borings: conduct Standard Penetration Testing (SPT) every 2 ft to a depth of 4 ft below facility bottom.
- Determine USDA textures at the proposed bottom and 4 ft below the bottom of the proposed BMP.
- Determine depth to bedrock.
- The soil description should include all soil horizons.
- The location of the test pit or boring shall correspond to the BMP location.

### Field Infiltration Testing

Acceptable field test methods to assess saturated hydraulic conductivity

- Guelph permeameter - ASTM D5126-90 Method
- Falling head permeameter - ASTM D5126-90 Method
- Double ring permeameter/infiltrometer - ASTM D3385-03, D5093-02, D5126-90 Methods
- Amoozemeter or Amoozegar permeameter - Amoozegar 1992

* Apply Safety Factor=2 to field-derived value
** Use of lab test to establish infiltration rates is prohibited

### Soil Evaluation Form
Permeability Testing
(double ring infiltrometer)

<table>
<thead>
<tr>
<th>Inner Ring Diameter (cm)</th>
<th>Outer Ring Diameter (cm)</th>
<th>Annulus Area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>60</td>
<td>2121</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Δt (hr)</th>
<th>Ring Flow (cm³)</th>
<th>ΔVIR (cm³)</th>
<th>Space Flow (cm³)</th>
<th>ΔVA (cm³)</th>
<th>VIR (cm/h)</th>
<th>VA (cm/h)</th>
<th>VIR (in/h)</th>
<th>VA (in/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3.00</td>
<td>0.05</td>
<td>1100</td>
<td>750</td>
<td>1100</td>
<td>750</td>
<td>3500</td>
<td>3500</td>
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<td>33.00991</td>
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<tr>
<td>4.50</td>
<td>0.03</td>
<td>1850</td>
<td>750</td>
<td>5100</td>
<td>1600</td>
<td>42.4413</td>
<td>30.18049</td>
<td>16.709</td>
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<tr>
<td>7.00</td>
<td>0.04</td>
<td>2600</td>
<td>750</td>
<td>7600</td>
<td>2500</td>
<td>25.4648</td>
<td>28.29421</td>
<td>10.026</td>
<td>11.13945</td>
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<tr>
<td>9.00</td>
<td>0.03</td>
<td>600</td>
<td>600</td>
<td>1000</td>
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<td>700</td>
<td>2800</td>
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<td>20.37183</td>
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<td>600</td>
<td>9600</td>
<td>3100</td>
<td>25.4648</td>
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<td>850</td>
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<td>21.50</td>
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<td>27.00</td>
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<td>900</td>
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<td>2100</td>
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<td>31.50</td>
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<tr>
<td>36.00</td>
<td>0.08</td>
<td>4900</td>
<td>1050</td>
<td>13500</td>
<td>1900</td>
<td>19.8059</td>
<td>11.94645</td>
<td>7.7976</td>
<td>4.703325</td>
</tr>
</tbody>
</table>

**Average**
VIR = \( \frac{\Delta V_{IR}}{A_{IR} \Delta t} \)

- Inner ring incremental infiltration velocity (cm/h)

\( \Delta V_{IR} \)
- Volume of liquid used during time interval to maintain constant head in the inner ring (cm³)

\( A_{IR} \)
- Internal area of inner ring (cm²)

\( \Delta t \)
- Time interval (hr)

Vₐ = \( \frac{\Delta V_{AA}}{AA \Delta t} \)

- Annular space incremental infiltration velocity (cm/h)

\( \Delta V_{AA} \)
- Volume of liquid used during time interval to maintain constant head in the annular space between the ring (cm³)

\( AA \)
- Area of annular space between the rings

\( \Delta t \)
- Time interval (hr)
### BMP Pretreatment Requirements

<table>
<thead>
<tr>
<th>BMP Group</th>
<th>Required %WQ</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVTs</td>
<td>10%</td>
<td>Provided at each inlet, unless inlet provides &lt;10% of inflow</td>
</tr>
<tr>
<td>Infiltration</td>
<td>25%</td>
<td>Grass channel, filter strip, sediment forebay, proprietary device</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep sump catch basin combined with one of the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Upper sand layer or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Washed pea gravel (1/8” to 3/8”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Not required for permeable pavements (unless there is “run-on”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or drywells</td>
</tr>
<tr>
<td>Filtering Practices</td>
<td>25%</td>
<td>Deep sump catch basins may not be used as sole pretreatment.</td>
</tr>
<tr>
<td>Open Channels</td>
<td>10%</td>
<td>Forebays/checkdams at pipe inlets and/or driveway crossings.</td>
</tr>
<tr>
<td>Green Roofs</td>
<td>Not Applicable</td>
<td>No pretreatment required for direct rainfall.</td>
</tr>
</tbody>
</table>

### Infiltration: Basins & Trenches

- Approved WQ BMPs

**Figure 5-6 Infiltration Basin**
Cross-section Views of Chambers

Approved WQ BMPs

Filter Fabric
Infiltration Chambers

Filter Fabric

- Non-woven geotextile fabric with a flow rate of > 110 gal./min./sf.
- For use over the underdrain (where applicable) and along the side walls
Gravel (Underdrains and Storage)

- Porosity = 33%
- AASHTO M-43 standard
- Washed, clean and open graded
- Size Varies;
  - ASTM #2 or 3 Stone (<2 to 2 1/2")
  - ASTM #57 Stone (<1½")
  - ASTM #8 (1-2")

Storage Chambers

- Injection molded from virgin polypropylene resin;
- Rows shall provide continuous, unobstructed internal space with no internal support panels;
- Chambers shall be open-bottomed.
- Shall incorporate an overlapping corrugation joint system.

When Fill is Required

- Medium Concrete Sand (AASHTO M-6 or ASTM C-33)
- Clean
- No substitutions such as Diabase, rock dust, etc.
- Compaction (Standard Proctor) - AASHTO Method T-99

3/23/2011
Infiltration Practices
Landscaping Requirements

- Drainage area completely stabilized prior to bringing infiltration facility on-line. A dense and vigorous vegetative cover is needed over pervious areas.
- Routine mowing of facility and adjacent areas
Infiltration Practices
Maintenance Requirements

- Never use basin or area as temporary E&SC facility
- Provide observation well in all trenches
- Provide direct access for maintenance/rehab
- Follow OSHA standards for excavation
- Designs should consider dewatering alternatives should failure occur
Observation Wells

- Rigid schedule 40 PVC pipe with 5/8" perforations @ 6" O.C. meeting ASTM D 1785 (burr removed)
- Lockable Cap (should coordinate method with maintenance authority)

Maintaining a Permeable Basin Surface

- Large surface area of practice
- Avoid compaction
- Apply/retain organic material in basin floor
- Incorporate micro topography
Infiltration Basin with back-up Underdrain

Construction

• Good erosion & sediment control
• Sequence of construction
• Stabilized drainage area
• Protect infiltration site
Infiltration Maintenance Requirements/Guidelines

- Basin: Routine sediment cleanout, mowing (2x/yr), re-vegetate bare areas, litter & debris removal, & rejuvenation (roto-till surface soils).
- Trench: Pretreatment and trench sediment cleanout, & mowing. Check 2 days after storm.
- Drywell: Pretreatment cleanout. Gutter / downspout system cleaning if needed.
Section 5.3: Permeable Paving

Two main categories:
- Porous asphalt and pervious concrete
- Pavers
  1. Permeable solid blocks (min. void ratio 15%) or reinforced turf
  2. Solid blocks with open-cell joints >15% of surface
  3. Solid blocks with open-cell joints <15% of surface with 1” surface storage

Permeable Pavements – Design Notes
- May be used as infiltration and/or detention system
- For infiltrating practices:
  - Field verification of soil permeability/texture essential
  - Bottom of facility cannot be located in fill and must have 3’ separation from gw and bedrock
  - Size based on design infiltration rates (Table 5-3)
  - Cannot be used if contributing drainage is a LUHPL
  - Must meet variety of setbacks (Table 5-4)
- Frequent maintenance necessary to retain permeability (vacuum)
- Use on low traffic/speed areas with gentle slopes (<5%)
- Generally not designed to accept runoff from other areas

* Reduced requirements for resid. areas

Approved WQ BMPs
Porous Pavements

Porous Pavements (General)
- Aggregate gradation: No fines added to mix
- Air voids: 18-20%
- Cold climate and WQ functionality dependent on subbase design

Pervious Concrete
- Placement is challenging and requires certified installers
- Compressive strength: 3000 psi at 7 days
- Concrete is very resistant to aging

Porous Asphalt
- Modification of Open Grade Friction Course (OGFC)
- Asphalt binder often modified (polymers, fibers) but not necessary
- QC production at plant is crucial; install is simple

Permeable Pavers

3 1/8 in. (80 mm) thick pavers with permeable joints
- Open-graded bedding course
- Open-graded base course (OGB)
- Open-graded subbase on non-compacted soil subgrade

Courtesy PICP and LIDC

Typical Applications
Typical Applications

Pre-Construction Conditions

LID Technologies Demonstrated
**Typical Section: Porous Asphalt**

- 4-6 inch surface asphalt course (no fines)
- 4-8 inch granular filter layer (No. 57 Stone)
- 24 inch upper reservoir (bank run gravel, sand mix)
- Up to 24 inch crushed gravel layer with 6 inch optional underdrain (underdrain raised 12 inches above bottom)

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**Typical Porous Pavement Parking Lot System Cross-Section**

*Figure F-2 Typical Parking Area Cross-Section for Permeable Pavement System*

---

**Design Steps**

1. Assess site and soil conditions
2. Compute increased runoff depth from area contributing to the permeable pavement
3. Compute the depth of the base for storage
Design (continued)

5. Determine the base thickness for traffic
   - Provide sufficient pavement thickness to protect the sub-grade from being over-stressed by traffic loads
   - Provide quality base and subbase materials that can support the applied loads

6. Compare to base thickness for water storage:
   - Always use thicker base

7. Check clearance from bottom of base to seasonal high water table

8. Check geotextile filter criteria

Soil Design Strength

Design assumptions

Subgrade strength for vehicular traffic:
Min. 96-hour soaked CBR = 5%
(Min. R-value = 24)

What if < 5% CBR?
   Capping layer of geotextile and aggregate base
   Stabilize soil with cement

Stone Gradation

by Course

<table>
<thead>
<tr>
<th>Standard Size</th>
<th>Choker Course</th>
<th>Filter Course</th>
<th>Reserve Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16 in.</td>
<td>1/32 in.</td>
<td>1/64 in.</td>
<td>3/32 in.</td>
</tr>
<tr>
<td>1/32 in.</td>
<td>1/64 in.</td>
<td>3/64 in.</td>
<td>1/16 in.</td>
</tr>
<tr>
<td>1/64 in.</td>
<td>3/64 in.</td>
<td>1/32 in.</td>
<td>1/16 in.</td>
</tr>
<tr>
<td>3/64 in.</td>
<td>1/32 in.</td>
<td>1/16 in.</td>
<td>1/8 in.</td>
</tr>
<tr>
<td>1/32 in.</td>
<td>1/16 in.</td>
<td>1/8 in.</td>
<td>1/4 in.</td>
</tr>
<tr>
<td>1/16 in.</td>
<td>1/8 in.</td>
<td>1/4 in.</td>
<td>1/2 in.</td>
</tr>
<tr>
<td>1/8 in.</td>
<td>1/4 in.</td>
<td>1/2 in.</td>
<td>1 in.</td>
</tr>
<tr>
<td>1/4 in.</td>
<td>1 in.</td>
<td>2 in.</td>
<td>3 in.</td>
</tr>
<tr>
<td>1 in.</td>
<td>2 in.</td>
<td>3 in.</td>
<td>4 in.</td>
</tr>
<tr>
<td>2 in.</td>
<td>3 in.</td>
<td>4 in.</td>
<td>5 in.</td>
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<tr>
<td>3 in.</td>
<td>4 in.</td>
<td>5 in.</td>
<td>6 in.</td>
</tr>
<tr>
<td>4 in.</td>
<td>5 in.</td>
<td>6 in.</td>
<td>7 in.</td>
</tr>
</tbody>
</table>

*Note: CBR values not as listed, R-values may require additional consideration.
*Reprinted from the AASHTO No. 51 with permission from the American Association of State Highway and Transportation Officials.
Porous Asphalt Mix

- Pages F-44 through F-48 for Material Specs;
  - Mix Materials;
  - Performance Graded Asphalt Binder (PGAB);
  - Anti-Stripping Mix Additives;
  - Course Aggregate;
  - Fine Aggregate;

Pervious Concrete Surfaces

- Pages F-62 through F-69
  - Suppliers
  - General (ASTM References, QC, Testing, etc);
  - Materials; and
  - Execution;

Horsley Witten Group, Inc.
Maintenance

- Areas shall not to be used for temporary ESC;
- Minimize use of sand and salt
- Keep adjacent landscape areas well maintained and stabilized
- Clean surface with vacuum sweepers
- Post signs identifying permeable pavement
- Do not repave with impermeable materials
- Grass pavers need mowing and often need reseeding of bare areas.

Reinforced turf

Application and location important

Compaction and Backfill Soils
Limitations

- Not appropriate for high traffic/high speed areas - load bearing limitations and clogging potential
- Stormwater LUHPPs and any area with a modest to high spill potential
- Areas with heavy winter sanding
- Expansive and fill soils
- Periodic maintenance a must (vacuum sweeper, mowing, paver block repair)
- To avoid frost heave: base designed to drain quickly (depth > 24 inches)