

Appendix B: Infiltration Testing and Geotechnical Requirements

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B.1 General Notes Pertinent to All Geotechnical Testing

A geotechnical report is required for all underground stormwater best management practices (BMPs), including infiltration-based practices, filtering systems, and storage practices, as well as stormwater ponds and wetlands. The following must be taken into account when producing this report.

- Testing is to be conducted at the direction of a qualified professional. This professional shall either be a registered professional engineer, soils scientist, or geologist and must be licensed in the State.
- Soil boring or test pit information is to be obtained from at least one location on the site. Additional borings or test pits are required within the proposed BMP facility under three conditions: (1) when the soils or slopes vary appreciably from the findings in the initial boring or test pit, (2) when the groundwater level is found to be significantly higher than the initial boring or test pit indicated, and (3) when the groundwater level may adversely affect the performance of the proposed BMP facilities. However, the location, number, and depth of borings or test pits shall be determined by a qualified professional, and be sufficient to accurately characterize the site soil conditions.
- Depth to the groundwater table (with 24-hour readings) must be included in the boring logs/geotechnical report.
- Laboratory testing must include grain size analysis. Additional tests such as liquid limit and plastic limit tests, consolidation tests, shear tests and permeability tests may be necessary where foundation soils or slopes are potentially unstable based on the discretion of the qualified professional.
- The geotechnical report must include soil descriptions from each boring or test pit, and the laboratory test results for grain size. Based upon the proposed development, the geotechnical report may also include evaluation of settlement, bearing capacity and slope stability of soils supporting the proposed structures.
- All soil profile descriptions should provide enough detail to identify the boundary and elevations of any problem (boundary/restrictions) conditions such as fills and seepage zones, type and depth of rock, etc.

In addition to the testing requirements described above, infiltration tests must be performed for all BMPs in which infiltration will be relied upon, including permeable pavement systems, bioretention, infiltration, and dry swales. Specific requirements for infiltration testing are discussed below.

B.2 Initial Feasibility Assessment

The feasibility assessment is conducted to determine whether full-scale infiltration testing is necessary, screen unsuitable sites, and reduce testing costs. However, a designer or landowner may opt to skip the initial feasibility assessment at his or her discretion and begin with soil borings.

The initial feasibility assessment typically involves existing data, such as the following:

- On-site septic percolation testing, which can establish historic percolation rates, water table, and/or depth to bedrock. Percolation tests are different than tests for coefficient of permeability or infiltration rate;
- Previous geotechnical reports prepared for the site or adjacent properties; or
- Natural Resources Conservation Service (NRCS) Soil Mapping.

If the results of initial feasibility assessment show that a suitable infiltration rate (typically greater than 0.5 inches per hour) is possible or probable, then test pits must be dug or soil borings drilled to determine the saturated hydraulic conductivity (K_{sat}).

B.3 Test Pit/Boring Requirements for Infiltration Tests

- Excavate a test pit or drill a standard soil boring to a depth of 2 feet below the proposed BMP bottom.
- Do not construct, maintain or abandon a well in a manner that may create a point source or non-point source of pollutants to waters of the State, impair the beneficial uses of waters of the State, or pose a hazard to public health and safety or the environment.
- Determine depth to groundwater table if within 2 feet of proposed bottom.
- Determine Unified Soil Classification System (USCS) and/or United States Department of Agriculture (USDA) textures at the proposed bottom to 2 feet below the bottom of the BMP.
- Determine depth to bedrock (if within 2 feet of proposed bottom).
- Include the soil description in all soil horizons. Perform the infiltration test at the proposed bottom of the practice. If any of the soil horizons below the proposed bottom of the infiltration practice (within 2 feet) appear to be a confining layer, additional infiltration tests must be performed on this layer (or layers), following the procedure described below.
- The location of the test pits or borings shall correspond to the BMP locations; a map or plan that clearly and accurately indicates the locations(s) of the test pits or soil borings must be provided with the geotechnical report.

Table 1 indicates the number of test pits or soil borings and subsequent infiltration tests that must be performed per BMP. In cases where multiple BMPs are proposed in 1 area with generally uniform conditions, a circular shape that fully encompasses all of the BMPs may be substituted for the “area of practice” that determines the number of required infiltration tests.

Table 1. Number of Infiltration Tests Required per BMP.

Area of Practice (ft ²)	Minimum Number of Test Pits/Soil Borings
< 1,000	1
1,000–1,999	2
2,000–9,999	3
≥ 10,000	Add 1 test pit/soil boring for each additional 10,000 ft ² of BMP.

When 1 test pit or boring is required, it must be located as near to the testing area as possible. When more than 1 test pit or boring is necessary for a single BMP or area, the pit or boring locations must be equally spaced throughout the proposed area, as directed by the qualified professional. The reported saturated hydraulic conductivity for a BMP shall be the median or geometric mean (area-weighted average) of the observed results from the soil boring/test pit locations.

B.4 Infiltration Testing Requirements

The following tests are acceptable for use in determining soil infiltration rates. The geotechnical report shall include a detailed description of the test method and published source references:

- 1) Constant Head Bore-Hole Infiltration Tests (also referred to as bore-hole permeameter tests and constant-head well permeameter tests). These types of tests determine saturated hydraulic conductivity (coefficient of permeability) by measuring the rate of water flow to a borehole. Analytical solutions utilize principles of Darcy's Law, borehole geometry, and head (or multiple heads) of water in determining saturated hydraulic characteristics. Where the soil characteristics meet all of the above described requirements for infiltration BMPs, the hydraulic gradient element of Darcy's Law is often estimated as 1 for determining infiltration rate.

One published standard developed by the United States Bureau of Reclamation for this method is USBR 7300-89. Some of the commercially available equipment is listed below:

- Amoozemeter
- Guelph Permeameter
- Johnson Permeameter

- 2) Testing Requirements for Infiltration, Bioretention, and Sand Filter Subsoils, as modified below. The data obtained from this infiltration testing procedure shall be used to calculate the saturated hydraulic conductivity (see Section B.5 Saturated Hydraulic Conductivity Calculations).
 - a. Install solid casing in the boring or test pit to the proposed BMP bottom or other required test depth (i.e. confining layer encountered within 2 feet below the BMP bottom). When installing casing, drive the casing between 3 to 5 inches below the test surface to promote a good casing-to-soil seal.
 - b. Remove any smeared, soiled surfaces, and provide a natural soil interface into which water may infiltrate. Remove all loose material from the casing. At the tester's/registered professional's discretion, a 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill the casing with clean, potable water 24 inches above the test surface (24 inches of head), and allow to presoak for 24 hours.

- c. Protect the open borehole with suitable cover such as a sanitary well cap and steel plate with surrounding sandbags to prevent the introduction of surface water runoff, trash, debris, and other pollutants.
- d. Twenty-four hours later, refill the casing with approximately 24 inches of clean water (24 inches of head), and monitor the water level for 1 hour, recording the depth of water at the beginning and end of the test.
- e. Repeat step 4 (filling the casing each time) three additional times, for a total of four observations. At the registered professional's discretion, the saturated hydraulic conductivity calculations may be performed based on the values recorded during the average of the four readings or the last observation. The testing interval can be increased at the discretion of the registered professional.

All soil borings and test pits shall be properly backfilled after conclusion of the tests. A person shall not construct, maintain or abandon a well in a manner that may create a point source or non-point source of pollutants to waters of the State, impair the beneficial uses of waters of the State, or pose a hazard to public health and safety or the environment. To prevent a soil boring from becoming a conduit for stormwater or other contaminants to enter groundwater and create a low-permeability seal against vertical fluid migration, follow these steps:

- 1) Use a positive displacement technique, inject a sodium-based bentonite slurry through a tremie pipe at least 1 inch in diameter starting at the bottom of the borehole. The slurry shall be composed of 2 pounds of sodium-based bentonite powder to 1 gallon of water.
- 2) If the borehole is too narrow to accommodate a tremie pipe or the borehole is less than 10 feet deep, slowly place uncoated, medium-sized, sodium-based bentonite chips in the borehole to create a 2-foot lift of chips measured from the bottom of the borehole.
- 3) Tamp down the bentonite chips to prevent bridging.
- 4) Using a ratio of 1 gallon of water to 12.5 pounds of bentonite chips, add potable water to the borehole and allow 15 to 30 minutes to elapse to ensure proper hydration of the bentonite chips.
- 5) Adjust these instructions as necessary in accordance with the manufacturer's instructions, providing that the resulting seal will have an effective hydraulic conductivity of no more than 1×10^{-7} cm/s.
- 6) The process should be repeated until the boring is filled 1 to 2 feet from the ground surface.
- 7) The remainder of the borehole should be backfilled with material to match the surrounding cover and must not include the use of a coal-tar product.

Further details are provided in SCDHEC Regulations R.61-71, Well Standards.

Note: If the infiltration testing procedure reveals smells or visual indications of soil or groundwater contamination then the boring or test hole must be filled in accordance with wellhead protection best practices, unless laboratory analysis determines groundwater or soil is not contaminated.

B.5 Saturated Hydraulic Conductivity Calculations

To convert the field infiltration measurements to a saturated hydraulic conductivity value (K_{sat}), the following calculations must be performed.

$$K_{sat} = \frac{\pi D}{11(t_2 - t_1)} \times \ln(H_1/H_2)$$

where:

- K_{sat} = saturated hydraulic conductivity (in/hr)
- D = casing diameter (in) (minimum 4 inches)
- t_2 = recorded end time of test (hr)
- t_1 = recorded beginning time of test (hr)
- H_1 = head in casing measured at time t_1 (ft)
- H_2 = head in casing measured at time t_2 (ft)

This equation was adapted by the U.S. Bureau of Reclamation in 1975 from Lambe and Whitman, 1969.

B.6 Infiltration Restrictions

If a Phase I Environmental Site Assessment identifies a Recognized Environmental Concern at a site indicating that site contamination is likely or present; or if DHEC is aware of upgradient or downgradient contaminant plumes, the presence of a brownfield or historic hotspot use, such as any of the following current or previous uses, then an impermeable liner must be used for BMPs, and infiltration is prohibited.

- Leaking underground storage tank (LUST),
- Above ground storage tanks (AST),
- Gas stations,
- Vehicle maintenance or repair facility,
- Dry cleaner,
- Transformer sub-station,
- Waste transfer or holding facility,
- Print shop,
- Chemical storage warehouse,
- Illicit hazardous wastes generator,
- Greenhouse with unlined floor,
- Septic system,
- Cement or asphalt plant, or
- Dump or landfill.

If an ASTM Phase II Environmental Site Assessment is performed based on a DHEC-approved workplan and DHEC reviews the results and determines that stormwater infiltration BMPs may impact on-site contamination by the following means, then an impermeable liner must be used for BMPs, and infiltration is prohibited.

- Spreading of contamination vertically or horizontally at the site,
- Increasing on-site groundwater contamination by leaching contaminants from the soil,

- Causing or enhancing contaminant migration to go offsite,
- Interfering with contaminant remedial activities,
- Decreasing or reversing the natural degradation of contaminants, or
- Causing a pollutant discharge to a surface water body.

If DHEC concludes there is no evidence of a Recognized Environmental Concern based on ASTM Phase I and II Environmental Site, and there is no current site use that could result in the foreseeable creation of a Recognized Environmental Concern, then impermeable liners are not required, and infiltration is not restricted.

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