

## 12.0 Supplemental Requirements for Best Management Practices

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### 12.1 Soil Investigation Procedures for Stormwater Best Management Practices (BMPs)

12.1.1 All applicable federal, state and local laws, rules, regulations or permit requirements governing soil investigations shall be followed.

#### 12.1.2 General Soil Investigations

12.1.2.1 Borings and pits shall be excavated to verify soil profile and to determine depth to groundwater and bedrock as applicable.

##### 12.1.2.2 Soil Characterization

12.1.2.2.1 The minimum number of borings or pits shall be conducted for each BMP as follows:

12.1.2.2.1.1 For surface areal BMPs, two (2) borings or pits required for the first 8,000 square feet, three (3) borings or pits required for up to 16,000 square feet, four(4) borings or pits required for up to 25,000 square feet and one additional boring or pit required for each additional 25,000 square feet. Boring or pit locations shall be distributed within the facility and sufficient to determine variability.

12.1.2.2.1.2 For linear BMPs, two (2) borings or pits required up to 500 linear feet and one (1) additional boring or pit per 500 linear feet of trench, and sufficient to determine variability.

12.1.2.2.2 Borings or test pits must be advanced to the depth of groundwater or a minimum of 3 feet below bottom of a proposed facility, whichever is encountered first.

#### 12.1.3 Infiltration Testing Procedures

##### 12.1.3.1 Planning and Design Phase

12.1.3.1.1 Any deviation from these procedures must be approved by the Department or Delegated Agency having jurisdiction.

12.1.3.1.2 Individuals in responsible charge of infiltration testing shall possess a Class D On-Site License issued by DNREC Division of Water Groundwater Discharges Section or be licensed in the State of Delaware as a Professional Engineer or Professional Geologist.

12.1.3.1.3 An initial screening of readily available data is required to determine feasibility of infiltration practices. Screening shall include at a minimum:

12.1.3.1.3.1 Site topography

12.1.3.1.3.2 Soil characteristics as defined in the

USDA NRCS Web Soil Survey

12.1.3.1.3.3 Depth to groundwater and seasonal high groundwater

12.1.3.1.3.4 Historical groundwater level data from the nearest Delaware Geological Survey (DGS) monitoring well or wells.

12.1.3.1.4 Separation to a limiting zone such as bedrock or groundwater shall be at least two (2) feet.

12.1.3.1.5 Field Permeability Testing shall be done in accordance with ASTM-D5126 "Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone".

12.1.3.1.5.1 Single Ring or Double Ring Infiltrometer are preferred test methods.

12.1.3.1.5.2 Cased Borehole Permeameter method is allowable only in cases where test pit excavation depths or site constraints pose safety concerns. Results from tests conducted using the Cased Borehole permeameter method will only be accepted when approval is granted by the Department or Delegated Agency to use the Cased Borehole permeameter method prior to conducting the test. Casing for Cased Borehole test shall have a minimum 4 inch diameter.

12.1.3.1.6 The minimum number of field measured infiltration tests are as follows:

12.1.3.1.6.1 For infiltration trenches with less than 10,000 square feet of impervious drainage area, one (1) test required up to 500 linear feet and one (1) additional test per 250 linear feet of trench, and sufficient to determine variability.

12.1.3.1.6.2 For infiltration trenches with greater than 10,000 square feet of impervious drainage area, one (1) test required up to 250 linear feet and one (1) additional test per 250 linear feet of system, and sufficient to determine variability.

12.1.3.1.6.3 For infiltration trenches used with roadway perforated pipe layouts, one (1) test required up to 500 linear feet and one (1) additional test per 500 linear feet of trench, and sufficient to determine variability.

12.1.3.1.6.4 For infiltrating bioretention systems, one (1) test required for the first 8,000 square feet, two (2) tests required for up to 16,000 square feet, three (3) tests required for up to 25,000 square feet and one additional test required for each additional 25,000 square feet. Test locations shall be distributed within the facility and sufficient to determine variability.

12.1.3.1.6.5 For surface infiltration basins, one (1) test required for the first 8,000 square feet, two (2) tests required for up to 16,000 square feet, three (3) tests required for up to 25,000 square feet and one additional test required for each additional 25,000 square feet. Test locations shall be distributed within the facility and sufficient to determine variability.

12.1.3.1.6.6 For subsurface infiltrating practices, one (1) test required per infiltration area with an additional test for every 8,000 square feet of infiltration area, and sufficient to determine variability.

12.1.3.1.7 A saturation period of 1 hour or a drop of 12 inches or 30 cm is required. The saturation period shall not be used in determining field verified infiltration rate.

12.1.3.1.8 After the saturation period, a minimum of two test periods are required or until at least two consecutive test periods are consistent. Each test period shall meet one of the following criteria:

12.1.3.1.8.1 A minimum of one hour,

12.1.3.1.8.2 A drop of 12 inches, or

12.1.3.1.8.3 A stabilized infiltration rate as defined below. The maximum reading interval shall be 15 minutes.

12.1.3.1.8.3.1 A difference of 0.25 (1/4) inch or less of drop between the highest and lowest reading of four consecutive readings for infiltration rates greater than 2 inches per hour.

12.1.3.1.8.3.2 For infiltration rates equal to or less than 2 inches per hour, stabilized infiltration rate is defined by a difference of 0.125 (1/8) inch or less of drop between the highest and lowest reading of four consecutive readings.

12.1.3.1.9 When using the constant head test method, the water level inside the casing shall be maintained at a constant level or refilled to the starting level after each reading throughout the test period at no more than 15 minute intervals.

12.1.3.1.10 When using the falling head test method each test period shall start with the same initial head of six inches to normalize the effect of head on the measured drop.

12.1.3.1.11 Field verified infiltration rate shall be the final steady state reading of the test performed.

12.1.3.1.12 Reporting requirements shall be in accordance with Soil Investigation Report.

#### 12.1.3.2 Construction Phase

12.1.3.2.1 For all infiltration facilities, confirmatory infiltration testing or verification shall be performed during facility construction to verify design rate. Unless a review by the soils professional indicates otherwise and is accepted by the Department or Delegated Agency prior to conducting the tests, the minimum number of confirmatory infiltration tests shall be in accordance with the original testing procedures used for design.

12.1.3.2.2 The confirmatory infiltration testing rates shall be no less than 150% of the original design rate for the facility. If a deviation of less than

150% is observed, the facility shall be re-evaluated by the design engineer to determine if the facility will function as originally designed. The Department or Delegated Agency shall be notified of the observed conditions.

12.1.3.2.3 In addition to confirmatory infiltration testing, a hand auger shall be performed adjacent to the confirmatory infiltration test location or at locations recommended by the soils professional to a minimum depth of 3 feet below the bottom of the facility to confirm that a limiting layer is not present within 2 feet and to log the soils conditions. If a limiting layer is observed at a depth less than 2 feet, the licensed professional shall re-evaluate the design and submit to the Department or Delegated Agency for review and approval.

12.1.3.2.4 If confirmatory infiltration testing is not required by the Department or Delegated Agency, hand augers shall be performed within the proposed practice to log the soils and groundwater conditions within 3 feet of the bottom of the practice.

#### 12.1.4 Soil Investigation for Embankments

12.1.4.1 A detailed review of the existing site conditions and proposed embankment construction shall be performed by the responsible geotechnical engineer as part of the design process.

##### 12.1.4.2 Site Characterization

12.1.4.2.1 The soil investigation for embankment plan shall include the following:

12.1.4.2.1.1 Development of performance criteria, which may include but not be limited to allowable settlement, time available for construction, and seismic design requirements.

12.1.4.2.1.2 Identification of potential geologic hazards, areas of concern such as soft soils, and potential variability of local geology.

12.1.4.2.1.3 Identification of engineering analyses to be performed which may include but not be limited to: limit equilibrium slope stability analyses, liquefaction susceptibility, lateral spreading and slope stability deformations, and settlement evaluations.

12.1.4.2.1.4 Identification of engineering properties required for these analyses.

12.1.4.2.1.5 Determination of methods to obtain parameters and assess the validity of such methods for the material type.

12.1.4.2.1.6 Determination of the number of tests or samples needed and appropriate locations for them.

##### 12.1.4.3 Methods of Subsurface Exploration

12.1.4.3.1 The subsurface exploration method shall be selected by the design professional based on the existing and proposed site conditions and their experience.

#### 12.1.4.3.2 Minimum Number of Explorations

12.1.4.3.2.1 Embankments shall have explorations every 200 feet on center along the length of the embankment.

12.1.4.3.2.2 Pond Bottom explorations shall follow the General Soil Investigation requirements. Exploration locations shall be distributed as uniformly as possible within the facility.

#### 12.1.4.3.3 Minimum Depth of Explorations

12.1.4.3.3.1 Unless bedrock is encountered at a shallower depth, explorations shall be at a depth twice the proposed height from bottom of pond to top of embankment.

12.1.4.3.3.2 If bedrock is encountered, a minimum 5 foot rock core shall be performed. If organic, plastic, or soils with an actual or estimated N-value less than 4 are encountered, extended exploration to 4 times the proposed height.

12.1.4.3.4 If there is a potential for a significant groundwater gradient beneath an embankment or surface water levels are significantly higher on one side of the embankment than the other, the effect of reduced soil strength caused by water seepage shall be evaluated.

12.1.4.3.5 Seepage effects shall be considered when an embankment is placed on or near the top of a slope that has known or potential seepage through it.

#### 12.1.5 Soil Investigation Report

12.1.5.1 Geotechnical reports shall include the following:

12.1.5.1.1 The report shall be signed, sealed and dated by a professional engineer or professional geologist experienced in soils licensed in the State of Delaware. Reports for embankments must be signed and sealed by a professional engineer licensed in the State of Delaware.

12.1.5.1.2 A general description of the project, project elements, and project background.

12.1.5.1.3 Project site surface conditions and current use.

12.1.5.1.4 Regional and site geology.

12.1.5.1.5 Borehole or test pit logs must provide the following information:

12.1.5.1.5.1 Project name

12.1.5.1.5.2 Name of individual collecting the field data

12.1.5.1.5.3 Date field data was collected

12.1.5.1.5.4 Type of boring or test pit excavation method and equipment used

12.1.5.1.5.5 Air temperature and precipitation, including significant precipitation prior to investigation

12.1.5.1.5.6 Elevation of boring location based on site benchmark

12.1.5.1.5.7 Visual description of soil profile layers, and depths below grade encountered

12.1.5.1.5.8 Sample numbers

12.1.5.1.5.9 Depths of instability such as cave in, sloughing, flowing sands, or obstructions

12.1.5.1.5.10 Blow counts if Standard Penetration Test (SPT) borings are performed

12.1.5.1.5.11 Depth of seasonal high groundwater indicators such as mottling

12.1.5.1.5.12 Depth of encountered free water during and after excavation

12.1.5.1.5.13 Depth to bedrock if encountered

12.1.5.1.5.14 General observations

12.1.5.1.5.15 Testing standards

12.1.5.1.6 Depth and type of field testing performed. A summary of the laboratory testing conducted, if applicable.

12.1.5.1.7 Project soil and rock conditions shall include a description of the soil and rock units encountered, and how the units tie into the site geology.

12.1.5.1.8 Groundwater conditions shall be described, including the identification of any confined aquifers, artesian pressures, perched water tables, potential seasonal variations, if known, any influences on the ground water levels observed, and direction and gradient of groundwater, if known.

12.1.5.1.9 If rock slopes are present, the report shall discuss rock structure, including but not limited to the results of any field structure mapping using photographs as needed, joint condition, rock strength, and potential for seepage.

12.1.5.1.10 Summary of geological hazards identified and their impact on the project design, if any. Describe the location and extent of the geological hazard.

12.1.5.1.11 For analysis of unstable slopes including existing settlement areas, cuts, and fills, include background regarding the analysis approach, assessment of failure mechanisms, and determination of design parameters. A description of any back-analyses conducted, the results of those analyses, comparison of those results to any laboratory test data obtained, and the conclusions made regarding the parameters that shall be used for final design shall be included in this section.

#### 12.1.5.1.12 Geotechnical recommendations for earthwork

shall include:

12.1.5.1.12.1 Embankment design recommendations, if any are present, such as the slope required for stability, any other measures that need to be taken to provide a stable embankment, embankment settlement magnitude and rate, and the need and extent of removal of any unsuitable materials beneath the proposed fills.

12.1.5.1.12.2 Cut design recommendations, if any are present, are also provided in this section, such as the slope required for stability, seepage and piping control, erosion control measures needed, and any special measures required to provide a stable slope.

12.1.5.1.12.3 Determination of adequacy of excavated material for use as structural fill or spoil and include data for structural designs of BMP outlet works.

12.1.5.1.13 Long-term or construction monitoring needs if applicable. Provide recommendations on the types of instrumentation needed to evaluate long-term performance or to control construction, the reading schedule required, how the data should be used to control construction or to evaluate long-term performance, and the zone of influence for each instrument.

12.1.5.1.14 Address issues of construction staging, shoring needs and potential installation difficulties, temporary slopes, potential foundation installation problems, earthwork constructability issues, and dewatering, as applicable.

12.1.5.1.15 Appendices to support geotechnical recommendations.

12.1.5.2 Infiltration test reports shall include the following:

12.1.5.2.1 Description of approved infiltration testing method performed.

12.1.5.2.2 Summary table of location of test, depth of test, elevation of test if available and field verified infiltration rate.

12.1.5.2.3 Infiltration test log must state:

12.1.5.2.3.1 Name of individual performing test

12.1.5.2.3.2 Date test was performed

12.1.5.2.3.3 Type of test method

12.1.5.2.3.4 Air temperature and precipitation

12.1.5.2.3.5 Depth of test below ground surface and elevation

12.1.5.2.3.6 Diameters of boring and casing

12.1.5.2.3.7 Depth of casing penetration

12.1.5.2.3.8 Time and depth from reference point for each time increment

12.1.5.2.4 Infiltration rate graph for each test. The graphs shall be field verified infiltration rate versus elapsed time of test. Appended to each graph shall be a table of the testing results.

12.1.5.2.5 Geotechnical recommendations shall be provided for each stormwater management facility, including recommendations regarding design infiltration rate, impact of infiltration on adjacent facilities, effect of infiltration on slope stability, if the facility is located on a slope, stability of slopes within the facility, and foundation bearing resistance.

12.1.5.2.5.1 A minimum factor of safety of 2.0 shall be applied to field results from single ring and double ring testing.

12.1.5.2.5.2 A minimum factor of safety of 2.5 shall be applied to field results from cased borehole testing.

12.1.5.2.5.3 The soil professional shall provide an elevation range over which the recommended design rates are applicable.

12.1.5.2.6 If steady state conditions for a given test are not achieved, the professional in responsible charge of infiltration testing shall provide an explanation as to why steady state could not be achieved and their professional opinion regarding the use of the results for design purposes. If steady state is not achieved for a given test and a reasonable professional opinion is not provided, the Department or Delegated Agency may require additional testing.

12.1.5.3 Geotechnical reports for embankments shall include the following:

12.1.5.3.1 Summary of design analyses, which provides the project description and basis of the design recommendations.

12.1.5.3.2 Summary of stability analysis, which provides the results of the stability analyses performed for the given embankment dimensions.

12.1.5.3.3 Summary of settlement analyses, including design assumptions and settlement results for above-grade embankments.

12.1.5.3.4 Design recommendations, which address the requirements for the construction of the embankment. These recommendations shall identify actions such as:

12.1.5.3.4.1 Construction procedures for placement of material in embankment widening areas;

12.1.5.3.4.2 Embankment cut-off and core trench materials for above-grade embankments;

12.1.5.3.4.3 Special notes for excavation of unsuitable material, with specific backfill requirements.

placing embankment material.

12.1.5.3.4.4 Specific measures required prior to

and vegetative cover.

12.1.5.3.4.5 Installation of appropriate erosion control