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4-0100 PROCEDURES

4-0101 General Policy

4-0101.1 This chapter outlines minimum procedures for planning, organizing and conducting subsurface exploration, sampling, testing and engineering analysis in conjunction with geotechnical studies. The guidelines are not to be considered as rigid. The planning of exploration, sampling and testing programs, and close supervision of the work must be vested in a competent geotechnical engineer who has experience in this type of work and who is licensed by the State. Geotechnical reports must be prepared by, or under the direction of, a professional authorized by the State to perform such work.

4-0101.2 The Geotechnical Review Board (GRB) has been established to review geotechnical reports and associated plans referred to it by the Director and to provide recommendations to the Director on the sufficiency of the investigations, analyses and proposed designs and construction techniques. The GRB will review all geotechnical reports and associated plans for projects located in areas of problem soils that the Director determines pose a serious threat of soil-related problems.

4-0102 Scope

4-0102.1 Any grading and/or construction of any building or structure, modification to add to the exterior dimensions of any existing building or structure, or any foundation related work on land containing problem soils, as defined in § 4-0201.3 below, must comply with the applicable provisions of Chapters 107 (Problem Soils), 112 (Zoning Ordinance), and 101 (Subdivision Ordinance) of the County Code and any applicable Federal or State Regulations.

4-0102.2 There are implied warranties for the foundation of new dwellings in accordance with Virginia Code § 55-70.1.

4-0102.3 The geotechnical report is generally prepared in support of an associated site or grading plan. The submission requirements for geotechnical report outlined in this section is in relation to the associated site or grading plan for the proposed project, as required by Chapter 107 (Problem Soils) of the Code. Other agencies may have geotechnical report requirements based on the Virginia Uniform Statewide Building Code (USBC).

1 See also §§ 6-1605, 6-1606, 6-1607, and 11-0103.2C et seq.
4-0102.4 Additions to residential structures and minor commercial buildings exempt from site or grading plan submission requirements only require an engineered foundation design submitted with building permit application.
4-0201 County Soil Units, Map and Classes

4-0201.1 The comprehensive source of information about soils in the County is the Soil Survey of Fairfax County, prepared by the United States Department of Agriculture Natural Resources Conservation Service (NRCS), publicly released in January 2008. This survey describes all soil units mapped in the County. Names for the soil units were formulated using the NRCS’ Soil Taxonomy, 2nd Ed. The soil survey was used to create the County soils map which depicts the soil unit boundaries and includes overlays of Marumsco soils, “marine clays,” non-marine clay high shrink-swell soils, and asbestos-containing soils.

4-0201.2 Based on the severity of problems associated with these soils and the potential difficulty of analyzing and correcting those problems, the units of soils are grouped into four classes (I, II, III, and IV). The designations serve as a guide to determine if and what type of geotechnical engineering study is required for proposed construction.

4-0201.3 As defined in Chapter 107 of the Code, Problem Soils include landslide susceptible soils, shrinking and swelling soils, soils with shallow water tables, soils containing hazardous material, buried waste sites, uncompacted and undocumented man-placed fills, and earthen structures that would require special precautions for safety during and after construction activity. Problem soils include areas of Marumsco soils, “marine clays,” Class III, and Class IV soils, as shown and/or identified on the official map adopted by the Board of Supervisors or any other soil as determined by the Director of Land Development Services.

4-0201.4 “Marine clay” is a term used locally for clay-rich sediments of the Cretaceous-Age Potomac Formation of the Atlantic Coastal Plain. The Potomac Formation, identified as unit Kp on USGS geologic maps, thickens from a few feet along the boundary with the Piedmont Province in the west to over 100 feet along the eastern boundary of Fairfax County. As a result of removal of younger deposits that have since eroded away, the sediments are commonly over-consolidated. The “marine clay” sediments consist mostly of montmorillonite minerals (which results in a high potential for shrink and swell with variations in moisture) that are commonly classified as elastic SILT (MH) and fat CLAY (CH) by the Unified Soil Classification System. Due to physical and chemical weathering, “marine clay” in the uppermost 20 feet of the Potomac Formation are preferentially weakened along fractures, joints and parting planes, and can cause landslides many years after the slopes are created. Sand layers, often water-bearing, are frequently mixed with the “marine clay” layers. The clays and silt are subject to large changes in volume with soil moisture changes.
4-0201.5 Areas containing “marine clay” soils were mapped by the County Soil Science Office\textsuperscript{2} and designated as such on prior County soil maps. The more recent soil mapping by NRCS, which utilizes national standards for soil unit names and descriptions, does not include a specific soil unit for “marine clay.” Areas mapped as containing “marine clay” soils in earlier survey work are identified as “Previously Mapped Marine Clay” and are overlaid on the County soils map. Undisturbed soils within the “Previously Mapped Marine Clay” overlay are mostly Marumsco soils, but in some locations other soil units occur. In those locations within the “Previously Mapped Marine Clay” overlay where the soils are mapped as something other than Class III soils, the requirements outlined in § 4-0205.2 for Class III soil must be met, regardless of the classification based on the County soils map. Regulations in the Fairfax County Zoning Ordinance, regarding “marine clay” are only applicable to the areas mapped as “Previously Mapped Marine Clay.”

4-0201.6 Naturally occurring asbestos (NOA) can potentially be found in the bedrock of some soils. Such areas are shown as an overlay on the County soils map. The Virginia Department of Labor and Industry administers Occupational Safety and Health Administration (OSHA) regulations concerning asbestos exposure in the construction industry. Text of the regulations is found in the Code of Federal Regulations: 29 CFR 1926.1101. The County website contains general information and safety recommendations for construction in areas of NOA.

4-0202 Class I Soils

4-0202.1 Class I soils are undisturbed natural soils that typically have few characteristics that would adversely affect building foundations or surrounding land. Class I soils consist of Soil Numbers 11, 28, 33, 38, 39, 76, 79, 80, 81, 84, 85, 87, 88, and 90. A geotechnical investigation is advised but not required as a condition of site or grading plan approval if the conditions in § 4-0206 are met.

4-0203 Class II Soils

4-0203.1 Class II soils are undisturbed natural soils that typically have shallow water tables or restrictive soil layers. Class II soils consist of Soil Numbers 2, 7, 9, 31, 75, 77, 78, 92, and 93. A geotechnical investigation is strongly advised but not required as a condition of site or grading plan approval if the conditions in § 4-0206 are met.

4-0204 Class III Soils

4-0204.1 Class III soils are undisturbed natural soils that have characteristics such as high shrink/swell potential, high compressibility, low bearing strength, and

\textsuperscript{2} The County Soil Science Office closed in 1996.
shallow water tables, which may result in poor drainage, building settlement, and unstable slopes, etc. Class III soils consist of Soil Numbers 1, 8, 10, 29, 30, 32, 34, 35, 36, 37, 48, 49, 59, 60, 61, 62, 63, 64, 65, 74, 82, 83, 89, 91, 94, and 109. A detailed geotechnical investigation and report are required. Geotechnical report requirements are summarized in § 4-0206 and discussed in detail in § 4-0300. The soil types or conditions included in this group are:

A. Cretaceous-Age Potomac Group Clays (mapped as Marumsco soils and/or “marine clay”);

B. Other soils containing high shrink-swell clays;

C. Soils with a seasonal high water table at or near the surface for prolonged periods and low bearing strength (poor foundation support); and

D. Alluvial or floodplain soils.

4-0205 Class IV Soils

4-0205.1 Class IV soils are soils that have been disturbed or altered as a result of grading or construction resulting in soils with variable characteristics. Class IV soils are divided into two groups, IVA and IVB.

4-0205.2 Class IVA Soils. Class IVA soils are disturbed soils that were originally Class III soils, and consist of Soil Nos. 13, 15, 17, 20, 21, 26, 27, 42, 43, 44, 47, 51, 52, 53, 54, 55, 56, 57, 69, 71, 73, 86, 103, and 106. Landfill and quarry areas are also grouped here. A detailed geotechnical investigation and report are required. Geotechnical report requirements are summarized in § 4-0206 and discussed in detail in § 4-0300.

4-0205.3 Class IVB Soils. Class IVB soils are disturbed soils that were originally Class I or II soils, and consist of Soil Nos. 3, 4, 5, 6, 12, 14, 16, 18, 19, 22, 23, 24, 25, 40, 41, 45, 46, 50, 56, 57, 67, 68, 70, 72, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 107, and 108. A limited geotechnical investigation or soil certification as described in § 4-0206 is required.

4-0206 Geotechnical Report Requirements Summary

4-0206.1 The geotechnical report requirements are summarized in Table 4.1.

4-0206.2 For Class I and II soils, the submission of a geotechnical report is typically not required under the following circumstances:
A. The building or in-ground swimming pool footprint is more than 25 feet from any Class III or IV problem soil. The 25-foot margin allows for errors in soil mapping. If the building or in-ground swimming pool footprint is within 25 feet, a report is required unless waived by the Director.

B. All proposed construction is in Class I and Class II soils and there is no grading activity in problem soils. If the proposed construction is partially located in a problem soil, especially Class III or IV soils, submission of a geotechnical report is required unless waived by the Director.

C. There are no buildings with more than three stories, mat foundations, deep foundations, deep excavations, sheeting and shoring, or retaining walls over 6 feet high. On a case by case basis, any report that is prepared may be submitted with the building plans after site or grading plan approval.

4-0206.3 For site, grading, subdivision or construction plans, the following items must be addressed in the plan:

A. Foundation drain details for proposed walls below-grade. For Class II soils, foundation drains and backfill must appropriately address potential groundwater problems.

B. Yard or overlot drainage.

C. Construction notes for fill placement (acceptable material, lift thickness, density testing, frequency of testing, construction inspection notes as shown in § 4-0502.1 and § 4-0502.2).

D. Excavation safety.

E. Impact on adjoining property.

4-0206.4 For Class III and IVA Soils

A. Geotechnical problems must be addressed with adequate engineering evaluations and designs before development. A geotechnical report, prepared according to the geotechnical guidelines in this chapter and the Virginia Uniform Statewide Building Code (USBC) is mandatory for all construction and grading within these problem soil areas. The engineering evaluation and report must be submitted for approval, and the recommendations incorporated into the grading plans as requirements before plan approval. Construction inspections and certifications are required from the Engineer-of-Record.

4-0206.5 For Class IVB soils
A. A limited geotechnical investigation is required in the form of a letter report to be incorporated into the first submission of the site, subdivision, grading or construction plans. The information placed on the plans will consist of soil strength tests e.g., SPT boring logs, laboratory test results and construction notes addressing identified problems and other requirements for construction such as those identified under Class II soils (§ 4-0206.3). For example, the letter report should be based on knowledge of the previous site disturbance, proposed construction, site grades, floor elevations, etc. Borings must extend through any fill to depths below the proposed footing elevation. Standard engineering practice is a depth that is two to three times the width of the proposed footing. Depending on the issues identified during the review of the plan, (e.g., depth of existing fill, proposed construction, recommended foundation and slab support, stability of slopes, the need for referral to the Geotechnical Review Board), a detailed geotechnical report submitted separately may be required before the second submission of the site or grading plans. Therefore, a comprehensive geotechnical report should be obtained for these soils earlier in the process.

B. For non-bonded lot grading plans, where proposed residential dwellings or in-ground swimming pools are to be located on properties containing Class IVB soils, a geotechnical report will not be required if a certification is provided stating that all nine of the items below are met. The certification must be signed and sealed by a professional authorized by the State to provide such information and incorporated into the plans. The nine items are:

1. Class III or Class IVA soils are not mapped by NRCS on the property.

2. Project does not require sheeting and shoring, retaining walls over 6 feet high, pile foundations, mat foundation, or ground modification; such as dynamic compaction, stone columns, aggregate piers, chemical stabilization, etc.

3. Geotechnical reports are not required under any other County regulation or building codes.

4. Maximum depth of existing disturbed land on the property is less than 5 feet. To determine the maximum depth of existing disturbed land on the property, the basement floor elevation of the existing building must be subtracted from the existing ground surface. One foot must then be added to the calculated value to account for the existing slab and foundation depths.
5. Footings and floor slabs will be supported on competent natural soils.

6. Existing slopes on the property are not steeper than 3:1 (horizontal:vertical). If existing slopes are steeper than 3:1 (horizontal:vertical), the County’s geotechnical review engineer must be contacted. Evaluation of the slopes may be required, depending on the proposed house location.

7. Structure is located at least 15 feet from the top of any 3:1 (horizontal:vertical) or steeper slope and the influence zone of house footings does not intercept with any slope. The influence zone of a footing is defined as the area beneath a 45-degree line extending outward and downward from the bottom of the footing exterior edge.

8. Foundation drain details are included on the plans.

9. The basement or lowest finished floor elevation of the proposed building meets the requirements of § 4-0305 for setting elevations above the groundwater table.

4-0206.6 For In-ground Swimming Pools

A. Pool designs must always consider the geotechnical effects of subsoil, groundwater, and slopes. In addition, designs of pool construction projects must consider structural stability, drainage impacts, and trees. To improve efficiency associated with review of in-ground swimming pool projects proposed for single-family detached lots with problem soils, the procedure of this section has been established to meet the requirements of Chapter 107 (Problem Soils) of the Code and Chapter 4 (Geotechnical Guidelines) of the PFM.

B. For non-bonded lot grading plans, where proposed in-ground swimming pools are to be located on properties containing Class III or IVA soils, a geotechnical investigation and report will not be required if a certification is provided stating that all eight of the items below are met. The certification must be signed and sealed by a professional authorized by the State to provide such information and incorporated into the plans. The eight items are:

1. The in-ground swimming pool is not proposed on existing slopes steeper than 3H:1V (horizontal:vertical) or the swimming pool is located at least 15 feet from the top of any 3H:1V or steeper slopes. Evaluation of the slopes may be required depending on proposed location of swimming pool relative to existing and proposed structures.
2. The bottom exterior edge of the swimming pool does not intercept the influence zone of any adjacent retaining wall/building foundation ("Footing"). The influence zone of a Footing for the purpose of in-ground swimming pool design is defined as the area beneath a line extending outward and downward at a 2H:1V slope from the bottom of the footing exterior edge.

3. The project does not require sheeting and shoring, retaining walls over 6 feet high, pile foundations, mat foundations or ground modification such as dynamic compaction, stone columns, aggregate piers, chemical stabilization, etc. and geotechnical reports are not required under any other County regulation or building codes.

4. The bottom of the proposed pool does not extend below the water table elevation.

5. The bottom of the swimming pool is supported on a uniform competent natural soil or engineered fill. (Please note when a portion of the pool excavation is in bedrock or in existing uncontrolled fill, differential settlement can occur.)

6. There are no Marumsco soils, Marumsco complexes, or soils previously mapped as marine clays mapped on the property. In case of the existence of expansive or Marumsco soils, the requirements of Chapter 4 must be followed.

7. The construction of the proposed swimming pool will not have an adverse impact on adjoining properties due to existing fill, slide-susceptible soils, steep grades, proximity to existing structures, etc.

8. The geotechnical recommendations addressing fill placement, compaction, foundation slab, and/or drainage are included in the plan and are adequate.

C. The professional authorized by the State must also certify that all of the requirements of § 4-0206.6B have been met and that all field investigations and reviews necessary to evaluate these requirements have been performed.

D. If any of the eight items listed in § 4-0206.6B certification statement is not met, a detailed geotechnical report must be submitted for approval in accordance with § 4-0204.1 and/or § 4-0205.2.

E. For grading plans where residential dwellings and/or swimming pools are to be located in Class IVB soils, a geotechnical investigation and report will not be required if a certification is provided in accordance with § 4-0206.5B.
F. Pool projects that do not require a grading plan, or pool projects for a conservation plan can continue to follow the requirements outlined in the Soil Requirements for Minor Construction Projects.

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<tr>
<th>ITEM</th>
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<tr>
<td>Geotechnical Report</td>
<td>NRQ</td>
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<td>Geotechnical Specification on Plans</td>
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<td>REQ</td>
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Table 4.1 Geotechnical Report Requirements Summary

Footnotes:
1. Advised but not required.
2. Strongly advised, but not required.
3. A geotechnical report, prepared according to the geotechnical guidelines in this chapter and the Virginia Uniform Statewide Building Code (USBC) is mandatory for all construction and grading within these problem soil areas. For non-bonded lots with Class III or IVA soils, where proposed in-ground swimming pools require a grading plan, the certification referenced in § 4-0206.6 may be incorporated instead of submitting a separate report to the County for review.
4. Results of geotechnical investigation are required on the first submission of plans. For non-bonded lot grading plans, where the proposed residential dwellings are to be located on properties containing Class IVB soils, the certification referenced in § 4-0206.5B may be incorporated into plans instead of incorporating the limited geotechnical report into the first submission of the site, subdivision, grading or construction plans.
5. For Class I soils see § 4-0206.2, and for Class II soils see § 4-0206.2. For Class III, and Class IV soils, report recommendations must be stated as requirements in specifications.

NRQ=Not Required    REQ=Required

4-0206.7 The installation of linear structures such as storm sewer or sanitary sewer lines, usually do not require submission of a geotechnical report. Notes addressing placement of backfill and OSHA excavation requirements are sufficient in most cases. The only exception would be in cases where such construction activity might trigger movement in adjoining slopes. Cutting of existing steep slopes in slide-prone areas (Marumsco or “marine clay” areas) requires slope stability analysis and submission of a geotechnical report before plan approval or permit issuance.
4-0301 General Requirements and Procedures

4-0301.1 At the preliminary and pre-site plan stages, notations may be made during review that compliance with the Subdivision Ordinance, Zoning Ordinance, and Chapter 107 (Problem Soils) of the Code will be required for proposed plans.

4-0301.2 For subdivisions and site plans in these difficult areas, a geotechnical report conforming to these guidelines must be submitted with the construction plans, and the construction plans must incorporate the recommendations of the geotechnical report as requirements. A geotechnical report submission fee must be paid upon initial submission of the geotechnical report.

A. It is determined during staff review whether the project should be referred to the GRB.

B. If a determination is made for referral, then three additional copies of the geotechnical report and the construction plans are required.

C. When these additional copies are received, the geotechnical report and the construction plans are forwarded to the members of the GRB for their recommendations.

D. The GRB reviews construction plans only in conjunction with the geotechnical report.

4-0301.3 If the Director determines that proposed construction on a site with problem soils will not adversely impact either the subject property or adjoining properties, the Director may waive the project from the requirement of a geotechnical report in accordance with Chapter 107 of the Code.

4-0301.4 The geotechnical report must have been signed and dated within one year before submittal to the County. For geotechnical reports prepared more than one year before submittal, an updated report or letter is required, at a minimum, to verify the validity and applicability of the original report. For data older than five years, the Director may request verification that the previous soils information is still valid and supported by new data such as borings and laboratory tests. Consultants using other consultants’ data should update and confirm findings with new data such as borings and laboratory tests.

4-0302 Purpose of Geotechnical Investigation
4-0302.1 The purpose of any geotechnical investigation is to determine the character and physical properties of soil deposits for use as structure foundation or material for earthwork construction purposes. The type of structure to be built and anticipated geologic and field conditions have a major bearing on the type of investigation to be conducted.

4-0302.2 The investigation must, therefore, be planned with a knowledge of intended project size, land utilization and a broad knowledge of the geologic history of the area. Advice on geological features should be obtained from an experienced engineering geologist as required.

4-0303 General Guidelines for Geotechnical Investigation and Engineering Recommendations. The site and soil exploration should include the following detailed factual information, analysis and recommendations:

4-0303.1 Surface Features. Surface contours include, but are not limited to, old construction, rock outcrops, water courses, ditches, ponds, wooded areas, and filled-in areas. Particular emphasis must be given to identification of possible old slide areas. This should include a thorough surface reconnaissance of both the site being developed and surrounding area. Consideration should also be given to reviewing aerial photographs of the area.

4-0303.2 Hydrologic Features. The presence of seepage zones, depth to groundwater and the possible fluctuations with the seasons should be investigated.

4-0303.3 Subsurface Features

A. A plotted record of the stratification of the soil deposits, both horizontal and vertical, must be included in the geotechnical report. This record should indicate, in the soil profile, the surface elevation of all borings and test pits, and should also indicate the thickness and character of the soils encountered. The profiles should reach to such a depth as may be required, and are to include 24-hour water level readings.

B. Information on the degree of compactness of granular soils and on the consistency of cohesive soils should be provided.

4-0303.4 Exploration Methods. Field explorations should follow the applicable standards and recognized procedures of geotechnical engineering as set forth by ASTM, ASCE, AASHTO, etc.

A. The interval of soil sampling should be determined on the basis of soils encountered, the type of structure and other conditions. Continuous sampling may be required. Test procedures utilized must be identified.
B. The spacing and depth of borings must be based on the site conditions and the proposed construction.

C. Borings must extend sufficiently into an underlying material of adequate bearing capacity and below the depth of a possible slope failure. The bore holes must be plugged after completion of the borings and obtaining 24-hour water level readings.

D. All the information and data obtained from the explorations must be recorded properly in the geotechnical report.

E. The minimum exploration acceptable for a building less than 5,000 ft² is two exploration boreholes. In addition to the minimum exploration requirements, a more comprehensive scope for the geotechnical subsurface exploration can be adopted by consultants for a safe, environmentally suitable, and economical foundation system.

4-0303.5 Groundwater Measurements. Information on groundwater elevations must be provided, including depth of permanent and perched water tables.

A. Water level reading within the boring must be determined after completing the boring and a minimum of 24 hours later. Under proposed roadways and borrow areas outside building pads, determination of the 24-hour groundwater depth may not be necessary.

B. Perforated casings or piezometers may be required in selected bore holes satisfactory to the Director to obtain long-term water level readings.

4-0303.6 Classification and Description. Direct observation of soil samples from various depths and locations is required for correlation with the known geology of the area. Classification and description of soils must be done by the USCS (ASTM Specification D2487), and by the Visual Manual Identification Procedure (ASTM D2488). All terms and nomenclatures used for textural description of the soils must be clearly defined. Complete soil descriptions must also include in-place conditions, geologic names, local names and any other information that is pertinent to the interpretation of the subsoil characteristics.

4-0303.7 Laboratory Testing. The nature and extent of laboratory testing deemed necessary is dependent upon the characteristics of the soil and the anticipated geotechnical problems requiring analysis. The laboratory must be approved by a recognized accreditation organization (i.e., WACEL or the American Association of State Highway and Transportation Officials (AASHTO)). Technicians performing specific tests must be certified, per the requirements of either WACEL, the
National Institute for Certification in Engineering Technologies (NICET), the International Code Council (ICC), or AASHTO, to perform those specific tests.

A. On granular soils, gradation tests on representative samples and water content determinations often are adequate.

B. Testing of cohesive soils samples may include, but are not limited to, determination of water content, dry density and unconfined compressive strength.

C. In stiff, fissured clays such as the Cretaceous Marumsco, Marumsco complexes, and soils previously mapped as marine clays, the results of unconfined compression tests alone cannot be used to assess the structural property of the soil in-situ. Atterberg limits and hydrometer analysis tests aid in classification and in the prediction of physical properties.

D. Consolidation tests should be performed on samples from relatively soft clayey soils (i.e., primarily, but not limited to, those mapped as Dulles, Elbert, Jackland, Kelly, Haymarket, Hattontown, Orange and their complexes) that may underlie the foundations. Expansive pressure of the soft clayey soils should also be determined for foundation design.

E. For the stiff fissured clays and deltaic clays that have undergone relatively large strains in the past, the important properties for predicting long-term slope behavior are the residual effective friction angle and the residual cohesion intercept (the absolute minimum strength of clay material). Any cohesion of the fissured and deltaic clays should be ignored in the evaluation of the long-term stability of a slope. The shear strength parameters should be determined by appropriate laboratory tests (drained direct shear tests using sufficient stress reversals to obtain large strains as discussed in the USACE laboratory testing procedure EM 1110-2-1906).

1. Many reversals are required to reach residual strengths, but must never be less than three reversals at any particular normal stress. The strain rate(s) selected to shear the samples must be based on either the consolidation data at the first normal stress or experience with similar soils. The strain rate used during each reversal may be varied (i.e., a slightly higher rate than specified in EM 1110-2-1906), but the rate during the last reversal at each normal stress may not exceed 1.44 inches per day. The geotechnical engineer must be aware of unintended buildup of pore water pressure during testing and must lower the strain rates accordingly. To obtain the strength envelope for the sample, the direct shear test must be repeated at two other normal stresses.
2. Some references suggest using a pre-split sample (Ref. *Engineering Properties of Clay Shales Report No. 1*, by W. Haley and B. N. MacIver). Shearing an intact, stiff to hard in-situ specimen may overestimate the results (see *U.S. Geological Survey Professional Paper 1344: Relationship Between Geology and Engineering Characteristics of Soils and Weathered Rocks of Fairfax County and Vicinity, Virginia [1986]*). Shearing such a specimen could also pose practical difficulties with some lab equipment (see *EM 1110-2-1906*); the test results from such samples should only be used with extreme caution. Only an intact or a reconstituted sample or a pre-split in-situ sample must be selected for the testing. The geotechnical report must identify the type of sample and the strain rates used in the testing.

3. For less complex situations subject to approval of the Director, the required shear strength parameters may be estimated by comparison of other index properties (particularly the Atterberg limits and grain-size sieve analysis) with those of similar soils for which test results are reported in published literature and on the basis of past experience. Correlations may be based on either *U.S. Geological Survey Bulletin 1556: Engineering Geology and Design of Slopes for Cretaceous Potomac Deposits in Fairfax County, Virginia, and Vicinity (1984)* or “Empirical Correlations - Drained Shear Strength for Slope Stability Analyses” by Stark & Hussain (ASCE Journal of Geotechnical and Geoenvironmental Engineering [2013]). Documentation must be furnished when shear strength parameters are based on results other than laboratory tests. Such documentation must set forth the reasoning by which the parameters were estimated. The residual friction angle must be limited to a maximum of 12° when obtained through correlations, however, the Director may allow an angle greater than 12° when shear testing data from an adjoining site suggest that such an angle may be acceptable.

4-0303.8 Engineering Analysis and Recommendations

A. The report of the soil studies must include sufficient analytical foundation and slope stability studies to allow a reviewer to follow the logic and assumptions on which the analysis was based and conclusions reached. Recommendations and advice concerning pavement design, foundation design, earthwork, site grading, drainage, slope stabilization and construction procedures must be included in the report. The report must include a complete record of the field and laboratory findings, information concerning structures to be built (types and elevations of basements), the conclusions reached from the study and the recommendations for use by the designer and the owner. Probable total and differential settlement of foundations, special basement problems and retaining wall design must be discussed and recommendations set forth. A “Critical”
slope or retaining structure is defined as any slope or retaining structure that meets one of the following criteria:

1. Greater than 25 feet in height and a slope inclination of 3H:1V or steeper for non-Potomac formation soils, or greater than 25 feet in height and a slope inclination of 5H:1V or steeper for Potomac formation soils;

2. Greater than 8 feet in height with a proposed/existing structure (excluding surface parking areas) within its active failure zone;

3. Impoundment slopes or structures that retain water for more than 48 hours.

B. Where Marumsco soils, Marumsco complexes, and soils previously mapped as marine clays are found, an engineering analysis of the short- and long-term stability of the existing and planned slopes must be performed. The analyses must include a careful evaluation of potential adverse effects on adjoining properties. The stability analyses must be performed using methods acceptable to the Director. The long-term stability of slopes containing these soils must be performed using the “residual” shear strength parameters as well as a conservative representation of the long-term groundwater conditions. Perched groundwater is common over these soils during wet seasons and must always be modeled in the long-term stability analysis as being at least 1 foot above the top of the formation. A model without perched groundwater may be allowed if the Director decides either that the model would result in unreasonable flooding or an extended-time set of groundwater level readings demonstrates that the assumed perched water level is unreasonable. For long-term stability, a minimum Factor of Safety (FS) of 1.25 is required when supported with sufficient field and laboratory characterization of the soils. Otherwise, a minimum FS of 1.5 is required. In case of Critical slope or structure, a minimum FS of 1.5 is required unless a laboratory measured residual strength test is obtained and used in the analysis. In this case, a minimum FS of 1.25 is required when supported with sufficient field and laboratory characterization of the soils. Cohesion values must be ignored in the long-term stability analysis.

C. For long-term stability of the soil formations other than Potomac Formation clay if slope stability analysis is deemed necessary by the engineer or if it is required by the County, a minimum Factor of Safety (FS) of 1.25 is only acceptable when the slope is not Critical and the analysis is supported with sufficient site-specific in-situ or laboratory strength tests of the encountered soils. Otherwise, a minimum factor of safety of 1.5 must be used in the analysis. Cohesion values must be ignored in the long-term stability analysis. Site specific in-situ tests include both ground water measurements and
Standard Penetration Test (SPT) but may also include Cone Penetrometer Test (CPT) or Flat Dilatometer (DMT).

D. In areas that are susceptible to high water table conditions (permanent, perched and/or seasonal), the engineer must recommend sub-drainage design and other measures necessary to address potential problems associated with wet basements, yards, etc.

E. Design criteria for retaining walls or structures must be provided. A preliminary global stability analysis for retaining walls over 8-feet tall must be performed to determine whether structural or earthwork measures are needed in order to achieve a sufficient factor of safety against slope failure as defined in § 4-0303.8B.

F. The report must include a discussion on the problems associated with expansive soils as defined in § 4-0501.3. Expansive clay soils containing montmorillonite, which generally have a high expansion potential, have been found in various locations in southern and eastern Fairfax County. Expansive properties may also exist in other problem soil types mapped in other parts of the County. It is suggested that the design recommendations be based on expansive properties of the clay unless it is shown otherwise by X-ray diffraction studies or other appropriate laboratory tests.

4-0304 Minimum Geotechnical Exploration Requirements for Deep Foundations

4-0304.1 Deep foundations, such as piles or drilled shafts, must be designed considering the capabilities of the supporting material based on laboratory test results and geotechnical data. The geotechnical engineer must obtain onsite data a minimum of 10 feet, or two times the foundation diameter, whichever is greater, below the bottom of the proposed foundation. If auger refusal is encountered due to shallow rock before reaching the minimum required depth of exploration, the rock must be cored to reach a minimum of 10 feet below the bottom of the proposed foundation. The foundation must be designed for all column and wall base reactions (axial, lateral, and moment) and downdrag loads for compressible soils. Secondary consolidation caused by soil creep should also be considered when determining the foundation design loads.

4-0304.2 For piles greater than 24 inches in diameter, regulate capacity by limiting the settlement to that established by the structural engineer of record or up to a maximum of 1 inch. Pile tip elevations must be clearly established by the geotechnical engineer. The design criteria must meet or exceed the minimum standards and criteria described in this chapter.
4-0304.3 Logs of borings, CPT soundings, test pits, and other subsurface data should be obtained.

4-0304.4 Boring logs must provide raw (unmodified) N-values if SPT’s are performed; CPT probe logs must provide raw QC-values and plots of raw sleeve friction values.

4-0305 Setting Basement or Lowest Finished Floor Elevation Above the Groundwater Table for Residential Structures

4-0305.1 For construction of residential single-family detached and attached dwellings, including stacked townhouses, where the results of a geotechnical investigation and/or report must be submitted for approval, design engineers must evaluate the proposed basement floor elevation or the lowest finished floor elevation as compared to the seasonal high water table (SHWT) elevation and include appropriate mitigation on the plans to address potential problems with groundwater intrusion into basements or lowest finished floors and its impacts on the site and adjacent or downstream properties. The required groundwater mitigations depend on the freeboard outlined below. Freeboard is defined as the distance between the SHWT and the basement or lowest finished floor elevation.

A. Case 1: Freeboard is greater than 2.5 feet (SHWT is more than 2.5 feet below the basement or lowest finished floor elevation). For this case:

1. Groundwater mitigation is not required and standard perimeter underdrains, both exterior and interior, connected to a sump pit are considered adequate.

2. Foundation drain details must be included on the plans.

B. Case 2: Freeboard is greater than 1 foot and up to 2.5 feet. For this case:

1. The basement or lowest finished floor elevation must be raised to achieve the required freeboard of Case 1.

2. If the basement or lowest finished floor elevation cannot be raised to meet Case 1 and the site topography allows for a gravity outfall, an underdrain system that connects to a structure associated with a gravity storm drainage system or to a free gravity outfall condition may be used. Any plan for a gravity storm drainage system or a free gravity outfall condition must reflect the design engineer’s consideration of the hydraulic gradient of the receiving system and the underdrain pipe.

3. Foundation drain details must be included on the plans.
4. In case the site topography or storm drainage system elevation do not allow for a gravity outfall or gravity connection from the underdrain, a dual pump system will be permitted provided each pump is rated and designed for the anticipated load, and the system is equipped with backup power.

C. Case 3: Freeboard is negative, and groundwater is above the surface of the basement or the lowest finished floor or freeboard is less than or equal to 1 foot. For this case:

1. The basement or lowest finished floor elevation must be raised to achieve the required freeboard of Case 1.

2. If the basement or lowest finished floor elevation cannot be raised to meet Case 1, the basement or lowest finished floor elevation must be raised to achieve the freeboard and required groundwater mitigations of Case 2, with the approval of the Director.

3. If the Case 2 requirements cannot be met and a crawlspace is proposed, it should meet Case 1; if not possible, a crawlspace meeting Case 2 may be used.

4-0305.2 The Director may modify the policy for setting the basement or lowest finished floor elevation above the groundwater table. In considering the request, the Director will apply the provisions of § 1-0100.8, subject to conditions deemed appropriate by the Director to address the potential for basement flooding and adverse impact on the site and adjacent or downstream properties. A request for such a modification may be submitted concurrently with the soils report.

4-0305.3 Determination of the SHWT by direct observation of groundwater levels must be performed in accordance with § 4-0702.2; however, where final design cannot be based on a confirmatory investigation performed during the months of November through May (or anytime of the year when the PDSI is greater than 2.0), the geotechnical engineer may consider compensating for the possible seasonal fluctuations by adding a minimum of 2 feet to the encountered water table elevation reading. Alternatively, the location of the SHWT may be determined using soil morphology in accordance with § 4-0702.3.

4-0305.4 If the SHWT is determined using soil morphology, it must be performed by a certified professional as defined in § 4-0702.3. Field investigations (i.e., test pits, test borings, etc.) should extend no less than 6 feet below the proposed basement or lowest finished floor elevation. Water level readings must be determined a minimum of 24 hours after completing the field investigation. In the case of test borings, if boreholes are likely to cave within the 6-foot depth below the proposed
basement or lowest finished floor elevation, standpipes can be used to perform the required ground water monitoring. For subdivisions, the number of borings may be determined by the geotechnical engineer with expertise in the local geology to provide an accurate estimate of the water table profile across the site.
4-0400 CONSTRUCTION PLANS

4-0401 General Information

4-0401.1 The recommendations in the geotechnical report must be incorporated into the plans as requirements to be performed during construction. The geotechnical engineer’s requirements must be stated in such a way that the intent is clear using a directive, such as “shall” and “will” with each provision. Where required by the Director, changes to requirements must be made by the geotechnical engineer who certified the plan.

4-0401.2 The soils engineer must review the final construction plans and state their opinion as to whether the plans have been prepared in accordance with their recommendations and note deviations from those recommendations.

4-0402 Footing and Drainage Design

4-0402.1 Where Cretaceous Age deltaic clays occur (i.e., Marumsco soils or soils previously mapped as marine clay), roof drains are required and the downspouts from these drains must be piped to a storm drainage system. However, the requirement may be waived or modified by the Director where soil conditions warrant.

4-0402.2 Foundations of structures must be placed at depths that will minimize the possibility of heaving or shrinkage settlement due to desiccation of underlying expansive soils. The emplacement depth must be based on the soil characteristics of the site. Consideration must be given to stratification of underlying materials, natural moisture content, gradation of backfill soils, site grading and adjacent vegetation. Consideration should also be given to special cases of potential volume change of expansive soils underlying footings embedded in thin layers of natural or artificially compacted granular soils. Exterior foundations in Marumsco soils, Marumsco complexes, other soils previously mapped as marine clays, and expansive soils (i.e., those mapped as Dulles, Elbert, Jackland, Kelly, Haymarket, Hattontown, Orange and their complexes) should be at least 4 feet below the nearest finished exterior grade, or to the bottom of the expansive soil stratum, whichever occurs first. Where the Director has determined that the geotechnical study has demonstrated that a 4-foot vertical buffer is insufficient, the proper buffer depth must be recommended by the geotechnical engineer.

4-0402.3 Surface and subsurface drainage must be planned to minimize the amount of water entering Marumsco soils, Marumsco complexes, and other soils previously mapped as marine clays.

4-0402.4 Perimeter drains must be provided around all basement areas.
4-0402.5 Floor slabs that will be designed to be ground-supported may not directly bear on expansive soils, even when the floor slab is at the basement level, to minimize the possibility of heaving or shrinkage settlement. Slabs underlain by Marumsco soils, Marumsco complexes, other soils previously mapped as marine clays, and expansive soils (e.g., Dulles, Elbert, etc.) must bear on a vertical buffer of at least 2 feet of non-expansive soils, or below the bottom of the expansive soil stratum, whichever occurs first. Where the geotechnical study has demonstrated that a 2-foot vertical buffer is insufficient to reasonably reduce the impact of shrink-swell cycles of the expansive soil, the proper depth of the buffer must be a part of the geotechnical engineer’s recommendation.
4-0500 CONSTRUCTION TECHNIQUES

4-0501 Sheeting, Shoring and Filling

4-0501.1 Sheeting and shoring or other approved methods for trench bracing may be required with the construction of underdrain or utility trenches and foundations.

4-0501.2 Engineered fill and backfill around structures must be placed with approved select materials and uniform compaction throughout must be provided in 6-inch to 8-inch layers. Each layer of engineered fill must be compacted at optimum moisture, plus or minus 2 percent, to a density of not less than 95 percent in accordance with AASHTO T-99 or ASTM D-698. The use of alternative fill and backfill from what is recommended by the geotechnical report must be reviewed and approved by the geotechnical engineer and the Director before the fill placement. The use of flowable fill as backfill material for retaining structures must also be approved by the Director before the fill placement.

4-0501.3 Expansive Soils, such as Marumsco and/or “marine clays” are not permitted as structural fill for building pads, foundation backfill, backfill around structures, or behind retaining walls. Expansive Soil is defined by the International Building Code and International Residential Code as:

A. “Soils meeting all four of the following provisions must be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.
2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D 422.
3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.
4. Expansion Index greater than 20, determined in accordance with ASTM D 4829.”

B. If the PI of the soil is 20 or less (e.g., PI ≤ 20) and the LL is 45 or less (e.g., LL ≤ 45), the Plasticity Index Corrected (Pl_{cor}) or the Expansion Index Corrected (El_{cor}) may be substituted in the above definition of expansive soils. Pl_{cor} and El_{cor} are defined as:

\[ \text{Pl}_{\text{cor}} = \text{Pl} \times (\% \text{ Passing No. 40 Sieve}) \quad \text{and} \quad \text{El}_{\text{cor}} = \text{El} \times (\% \text{ Passing No. 4 Sieve}) \]
4-0502  Inspection

4-0502.1  All construction involving problem soils must be performed under the full-time inspection of the geotechnical engineer.

4-0502.2  The geotechnical engineer must furnish a written opinion to the County as to whether work has been performed in accordance with the approved plans, and recommendations for work in the vicinity of the units to be occupied before the issuance of residential or nonresidential use permits.

4-0503  Minimum Standards Required for Density Testing of Compacted Fill Soil

4-0503.1  The minimum frequency of field density testing must be as listed in Table 4.2, unless otherwise approved by the Director. The testing frequencies are the minimums considered necessary to provide effective quality control of soil and aggregate material compactive effort under normal conditions. Additional testing other than that specified should be performed if deemed necessary by the Inspection and Testing Agency, the Geotechnical Engineer of Record, or the Fairfax County Site Inspector. All testing must conform to approved VDOT test methods. If the testing frequencies are specified to be greater in other applicable standards or specifications, those frequencies must supersede the frequencies listed in Table 4.2.
<table>
<thead>
<tr>
<th>TEST LOCATIONS</th>
<th>TESTING FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Embankments</strong></td>
<td>One density test must be performed per 5,000 ft² per 6-in. compacted lift. The embankment test may not be performed at the same spot where the utility trench backfill test was performed. Trench testing must be performed in addition to the embankment test. Under curb and gutter, one density test must be performed per 300 ft. on alternating sides.</td>
</tr>
<tr>
<td>Fill sections for streets, travelways, and pipestem driveways</td>
<td></td>
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<tr>
<td><strong>Subgrade</strong></td>
<td>Proofrolling, evaluation and approval by the geotechnical engineer of record (undercut and stabilization may be necessary as determined by the geotechnical engineer of record). The exception to this is in the proposed underground utilities, where the existing fill must be completely removed and replaced with new engineered fill placed and compacted as per § 4-0503.1, for utility support.</td>
</tr>
<tr>
<td>Cut in existing fill for streets, travelways, and pipestem driveways</td>
<td></td>
</tr>
<tr>
<td><strong>Subgrade</strong></td>
<td>Proofrolling, evaluation and approval by the geotechnical engineer of record.</td>
</tr>
<tr>
<td>Cut in natural soils</td>
<td></td>
</tr>
<tr>
<td><strong>Subbase Material</strong></td>
<td>One density test must be performed per 5,000 ft² per 6-in. compacted lift. When the subbase aggregate is placed in layers or lifts, each lift must be tested. Under curb and gutter when placed before the subbase material in the street, perform one density test per 300 ft. on alternating sides.</td>
</tr>
<tr>
<td>For streets, travelways, and pipestem driveways</td>
<td></td>
</tr>
<tr>
<td><strong>Base Material</strong></td>
<td>One density test must be performed per 5,000 ft² at the finished base grade. When the base aggregate is placed in layers or lifts, each 6-in. compacted lift must be tested at the required frequency.</td>
</tr>
<tr>
<td>**Storm Drainage System - Backfill ***</td>
<td>One density test must be performed per 300 ft. and at vertical intervals not to exceed 12 inches.</td>
</tr>
<tr>
<td>**Sanitary Sewer, Water and Gas Mains - Backfill ***</td>
<td>One density test must be performed per 300 ft. or between manholes if less than 300 ft. apart and at vertical intervals not to exceed 12 inches. Refer to § 10-0104.2L(13) and Plates Nos. 18-10 or 19-10.</td>
</tr>
<tr>
<td>(Note: Field density test reports must be provided to the Fairfax County Site Inspector before field approval is given for issuance of tap permits.)</td>
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<tr>
<td>**Sanitary Sewer, Water and Gas Laterals - Backfill for Stub Constructed in Conjunction with Utility Main ***</td>
<td>One density test must be performed per 5 laterals and at vertical intervals not to exceed 12 inches.</td>
</tr>
<tr>
<td><strong>Sidewalks and Driveway Aprons</strong></td>
<td>Sidewalk subgrade: One density test must be performed per 500 ft. on alternating sides at the subgrade elevation. A minimum of two density tests per street is required. Driveway apron: One density test per apron must be performed.</td>
</tr>
<tr>
<td>TEST LOCATIONS</td>
<td>TESTING FREQUENCY</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Asphalt Concrete Pavement</strong></td>
<td>* Saw Cuts or Cores *</td>
</tr>
<tr>
<td><em>(Note: The thin lift nuclear density test can be used for any surface course placed directly over an aggregate pavement or on a lift of 135 lbs/yd² (or greater) that is placed on an asphalt pavement course).</em></td>
<td>* Two cuts or cores represent one test. A minimum of two tests per street are required regardless of the street length. *</td>
</tr>
<tr>
<td></td>
<td>* One test must be performed per 500 ft. of roadway or 1000 ft. of any pass made by a paving train.</td>
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<tr>
<td></td>
<td>* OR Conventional Nuclear Density Gauge *</td>
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<tr>
<td></td>
<td>* One test must be performed per 500 ft. of roadway. *</td>
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<tr>
<td></td>
<td>* Five tests must be performed in each test section. A minimum of two test sections per street is required regardless of the length of the street. *</td>
</tr>
<tr>
<td></td>
<td>* Thin Lift Nuclear Density Gauge *</td>
</tr>
<tr>
<td></td>
<td>Test areas are defined as lots and sublots. A lot consists of 5,000 ft. of a pass made by a paving train. Each lot is divided into five sublots of equal size. Two tests will be performed on each sublot. Each separate street must consist of at least one lot. Streets less than 500 ft. in length must be tested a minimum of twice.</td>
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</tbody>
</table>

* Testing required beneath structures only, including but not limited to sidewalks, driveways, streets and stoops.
4-0600 GEOTECHNICAL REVIEW BOARD

4-0601 Membership. The Geotechnical Review Board (GRB), as established by the Board, consists of three members and three respective alternates appointed by the Board.

4-0601.1 Members and alternates must be either Professional Engineers registered in Virginia, specializing in soil and foundation engineering, or Engineering Geologists, licensed to practice engineering in Virginia.

4-0601.2 Appointments are made for three years, with staggered terms, from a list of eligible nominees recommended by the Director.

4-0602 Nominations

4-0602.1 The list of eligible nominees will be furnished to the County Executive by the Director.

4-0602.2 The Director should solicit candidates or nominees from the following professional organizations of soil engineers and engineering geologists and from other sources: ASCE, American Council of Engineering Companies of Metropolitan Washington (ACEC/MW), Geoprofessional Business Association (GBA), Virginia Society of Professional Engineers, University of Maryland, Virginia Tech, and WACEL. Names of candidates will be submitted along with supporting data to substantiate the qualifications of the candidate(s).

4-0602.3 The Director of Land Development Services, will serve as secretary to the GRB, and will be a nonvoting member.

4-0602.4 The respective alternate to a member of the GRB will serve whenever that member cannot serve due to illness, conflict of interest or other reasons.

4-0603 Review and Processing of Reports, Plans and Specifications

4-0603.1 The GRB will review reports, plans, and specifications submitted to the Director and make recommendations to the Director. The recommendations may be for approval, denial, additional information or revisions of plans and specifications as appropriate. This review is intended to be limited to geotechnical aspects and foundation design only.

4-0603.2 Decisions for approval of plans are to be made by the Director taking into consideration recommendations received from the GRB. The recommendations of the GRB will not be binding on the Director.
4-0604  Compensation. GRB members will be compensated at the rate determined by the Board for work performed in connection with the review of projects assigned by the Director.
4-0700 TESTING FOR INFILTRATION FACILITIES

4-0701 Purpose and Scope

4-0701.1 The purpose of infiltration testing is to determine the character, physical properties and Seasonal High Water Table (SHWT) of natural soil deposits proposed to be used for infiltration of stormwater. Infiltration facilities include facilities such as percolation trenches (§ 6-1303), pervious pavement with full or partial exfiltration (§ 6-1304) and bioretention basins or rain gardens (§ 6-1307). For a general discussion of the design of the infiltration facilities see Virginia DEQ Stormwater Design Specification No. 8, Infiltration Practices.

4-0701.2 The scope of the investigation must be planned with knowledge of the intended project size, facility size, land utilization and general subsurface characteristics. The complete evaluation must include a Geotechnical Investigation in the field, laboratory testing of select soil samples retrieved in the field to confirm soil and strata classifications and a final report.

4-0702 Geotechnical Investigation

4-0702.1 Geotechnical investigation to be performed by borings or a combination of borings and test pit per § 4-0702.5.

4-0702.2 Determination of the SHWT by direct observation of groundwater levels should be performed during the months of November through May. SHWT determination by direct observation of the ground water level should not be performed during the months of June through October unless the value of the Palmer Drought Severity Index (PDSI) is equal to or greater than 2.0 (i.e., wet). If the value of the PDSI is less than 2.0 (i.e., near normal or drier), the determination of SHWT by direct observation and testing conducted during the months of June through October may be used for preliminary design only. Final design must then be based on a confirmatory investigation performed during the months of November through May (or anytime of the year when the PDSI is greater than 2.0). Weekly values of the PDSI are available online from the National Weather Service Climate Prediction Center. Fairfax County is located in Virginia Climate Division #4.

4-0702.3 The SHWT may be determined using soil morphology throughout the year by a certified/licensed professional registered in the Commonwealth of Virginia with training and experience in soil morphology (certified/licensed professional soil scientist, licensed onsite soil evaluator, certified professional wetland delineator, or certified professional geologist). Professional engineers registered in Virginia with experience in the field of geotechnical engineering may also be certified to determine the SHWT, if they have successfully completed the Soil Morphology
Training Class offered by the Northern Virginia Soil and Water Conservation District (NVSWCD) and are on its list of certified professionals.

4-0702.4 Evaluation of the SHWT utilizing soil morphology should be based on low-chroma colors, mottles and redoximorphic features of the soil. Unlike other types of field tests which may be performed by an individual under the responsible charge of the registered professional, this evaluation must be performed by the registered professional personally. If the registered professional performing the evaluation determines that a follow-up confirmatory field measurement of the SHWT is required, or if required by the County, the follow-up evaluation must be performed when the Palmer Drought Severity Index (PDSI) is equal or greater than 2.0, or anytime during the months of November through May.

4-0702.5 Each proposed facility requires a minimum of three borings, or a test pit and two borings, located within the footprint of the proposed infiltration facility.

   A. The first or initial boring, which could also be a test pit, should be located approximately in the center of the footprint of the proposed facility. The first boring or test pit is performed to document the soil profile, horizons, groundwater table, depth of bedrock (defined in § 4-0702.5B) and the general suitability of the site for infiltration.

   B. Bedrock is defined as materials exhibiting a minimum SPT N-value of 60. In the Triassic (Culpeper) Basin and Piedmont Upland physiographic provinces, the aforementioned minimum SPT N-value will correlate approximately to weathered rock (i.e., in such areas, the separation is measured to a weathered rock surface, especially where underlain by shale, siltstone, sandstone and/or schist).

   C. The soil description must include all soil horizons.

   D. Soil textures should be identified according to the Unified Soil Classification System (USCS) per ASTM D-2488 (Description and Identification of Soils Visual-Manual Procedure) and the USDA Textural Classification.

   E. Dynamic Cone Penetrometer (DCP) [ASTM Special Technical Publication #399] test or Standard Penetration Test (SPT) [ASTM D1586-99] results should be provided for the initial boring or test pit.

   F. The boring or test pit depth must extend no less than 48 inches below the invert of the proposed facility.
G. The boring must be continuously sampled from 24 inches above the anticipated or proposed facility invert to the termination depth of the boring to better evaluate the subsurface conditions.

H. Groundwater elevations are to be recorded at the time of the boring and at least 24 hours following its completion.

I. The shallowest measurement may be used as the SHWT if the conditions of § 4-0702.2 are met.

4-0702.6 The second and third borings, with minimum diameters defined in § 4-0703.2B and drilled at an offset distance of not less than 5 feet from the initial boring or test pit, are used for the infiltration tests.

4-0702.7 Additional profile borings/test pits must be provided for every 100 linear feet or every 10,000 square feet of the proposed infiltration facility. Additional borings/test pits may also be performed at the discretion of the certified/licensed professional to adequately characterize infiltration characteristics.

4-0702.8 Additional infiltration tests are required for every 50 linear feet or every 2,000 square feet of the proposed facility. Additional infiltration tests may also be performed at the discretion of the certified/licensed professional to adequately characterize infiltration characteristics.

4-0702.9 The field infiltration rate is based on the average of all field tests located within the facility.

4-0703 Infiltration Testing

4-0703.1 Actual infiltration rates must be determined via on-site test(s) conducted within 24 inches of the anticipated or proposed facility invert.

4-0703.2 Specific requirements are as follows:

A. Drill two borings adjacent to the initial test pit or boring, each at an offset of greater than 5 feet, and to a depth of within 24 inches of the anticipated or proposed invert of the facility. The diameter of the boring must snugly fit the diameter of the casing (see § 4-0703.2B). Remove any loose material from each boring.

B. Install a solid casing 3 to 5 inches in diameter to the bottom of the boring. Remove any smeared soil surfaces and loose material from the casing. A 2-inch layer of coarse sand or fine gravel may be placed at the bottom of the boring to prevent scouring and sedimentation.
C. Fill the standpipe with water to a height of at least 24 inches above the bottom of the casing, and allow pre-soaking for 24 hours.

D. After 24 hours, refill the standpipe to a height of 24 inches above the bottom of the casing and record the water level drop in inches after one hour. Repeat the procedure three times by filling the standpipe to a height of 24 inches and measuring the drop in water level after one hour. A total of four observations must be completed. The infiltration rate of each test boring is the average of the change in water level readings in inches per hour, or the last reading, whichever is the most representative of the subsurface conditions based on the opinion of the certified/licensed professional conducting the tests. Should the infiltration rates in the two borings prove inconsistent, additional borings and infiltration tests must be performed or the lowest infiltration rate obtained must be used as the field infiltration rate.

E. The field infiltration rate for a proposed facility is the average of all field infiltration rates conducted within that facility, per § 4-0702.9. A field infiltration rate of at least 0.5 inches per hour at the design depth of the proposed facility must be obtained for the infiltration to be considered feasible. The design infiltration rate for the facility is one-half of the field infiltration rate. If field infiltration rates of 8 or more inches per hour are recorded, the design professional must be contacted to confirm that the facility is in a suitable location with respect to environmental concerns.

F. Soil boring locations must be accurately documented on the plans.

G. Infiltration testing must be performed by a qualified professional or his/her authorized representatives. The professional must either be a Virginia licensed professional engineer with experience in geotechnical engineering and soil evaluation, a Virginia certified/licensed professional soil scientist, or a Virginia certified professional geologist.

H. A change in design at the permitting plan review stage may necessitate additional testing. The final design invert of the proposed facility must be within 24 inches of the elevation at which the infiltration test(s) used for design were conducted.

I. Septic percolation tests are not acceptable as an alternative to infiltration tests.
4-0704 Laboratory Testing

4-0704.1 Grain-size sieve analyses and hydrometer tests must be performed to determine the USDA textural and USCS classifications at the proposed or anticipated invert of the facility.

4-0704.2 The tests should also be done on representative samples from all soil layers encountered to a depth of 4 feet below the final invert of the facility.

4-0705 Report Presentation and Submission

4-0705.1 The report must include the proposed infiltration facility plan, the boring locations, all boring logs and laboratory test data.

A. USDA textural classification and USCS soil description must be provided in the report as well as on the boring logs.

B. A table must be included in the report showing the dates, times and hourly readings of the water level for each infiltration test along with the averaged field infiltration rates for each test within the proposed facility.

C. The report must discuss the feasibility of the proposed facility and the impact of the proposed facility on adjoining properties. The report must provide recommendations for construction as well as the design infiltration rate for the proposed facility.

4-0705.2 The report can be included as part of the formal geotechnical report submitted for a site, subdivision or infill grading plan.

A. The report may also be submitted as part of the site, subdivision or infill grading plan, if it is included on the first submission.

B. The report may also be submitted separately as a geotechnical report or as an addendum to a geotechnical report if a separate report was previously submitted.

4-0706 Pre-construction Meeting

4-0706.1 A pre-construction meeting must be held with representatives of the owner/developer, the contractor, the third-party inspection firm and the Site Development and Inspections Division. The PFM and site-specific requirements and the third-party inspection certification must be reviewed and discussed.
GUIDELINES FOR THE USE OF LIME FOR DRYING, MODIFICATION & STABILIZATION OF SOIL

Applicability and Restrictions

This section presents geotechnical guidelines and minimum requirements for the design and construction of projects using lime for drying, modification and stabilization of soil. The following definitions apply to this geotechnical guideline:

A. **Active Zone or Zone of Seasonal Fluctuation** is the zone under and around a structure where the soil’s moisture content is appreciably affected by climatic conditions and environmental factors. For building footings, the Active Zone extends up to a minimum of 4 feet below the exterior finished grade, or 2 feet below the bottom of the footing, whichever is deeper. For pavements, the Active Zone extends to 4 feet below the finished pavement surface.

B. **Expansive Soil within the Active Zone** is defined by the *International Building Code* as follows: “Soils meeting all four of the following provisions shall be considered expansive, except that tests to show compliance with Items 1, 2, and 3 shall not be required if the test prescribed in Item 4 is conducted, and the Expansion Index is found to be equal to or less than 20:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D4318.

2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D422.

3. More than 10 percent of the soil particles are less than 5 microns in size, determined in accordance with ASTM D422.

4. Expansion Index greater than 20, determined in accordance with ASTM D4829.”

C. **Mellowing** is the textural change of soil due to the phenomenon of cation exchange followed by flocculation and agglomeration due to the chemical reaction between lime and clay soil particles.

D. **Soil Drying** is a rapid decrease in soil moisture content due to the chemical reaction between water in the soil and lime and is limited to non-expansive soil.

E. **Soil Modification** is a reduction in soil plasticity, increase in optimum moisture content, decrease in maximum dry density, and improved
compactibility due to the chemical reaction between soil and lime. Soil Modification will not be considered permanent.

F. **Soil Stabilization** is a permanent reduction in soil plasticity or expansion index, so the soil is not expansive, and permanent strength gain occurs through pozzolanic reaction due to the chemical reaction between soil and lime.

G. **Lime** is quicklime or hydrated lime meeting the requirements of **ASTM C977**, “Standard Specification for Quicklime and Hydrated Lime for Soil Stabilization.”

4-0801.2 Soil Drying is limited to soils that meet the standards of suitable structural fill material as established by the **VDOT Road and Bridge Specifications, Virginia Uniform Statewide Building Code**, the Public Facilities Manual, and project documents approved by the Director. For Soil Drying, a separate geotechnical study or report is not required to be submitted to LDS; however, notice in writing must be given to LDS prior to the use of lime for Soil Drying.

4-0801.3 Soil Modification is limited to soils that are present below the Active Zone. For Soil Modification, a geotechnical study or report must be submitted to LDS for approval. The lime modified soils below the Active Zone must have a Plasticity Index (PI) of 20 or less.

4-0801.4 Stabilization of expansive soils by mixing or blending with dry or slurry lime may be considered for various engineering applications requiring the placement of structural or engineered fill within the Active Zone. For Soil Stabilization, a geotechnical study or report must be submitted to LDS for approval. The recommendations made in the approved report must be incorporated into the project plans as specifications or requirements to be implemented during construction.

4-0801.5 Lime storage, handling and mixing may not allow airborne dust particles to leave the property. Additionally, lime storage, handling and mixing may not occur where occupied structures or areas of public use are within 300 feet, unless the contractor can demonstrate, to the satisfaction of the Director, that the construction techniques will not allow visible airborne dust particles to drift over the occupied structures or areas of public use.

4-0801.6 Before plan approval, regardless of location, adjoining property owner notices must be served on all properties adjoining the proposed lime project site. A minimum of five adjoining properties must be served with notices at the time of geotechnical report submission. The format of such notices must be approved by the Director.
4-0801.7 Each proposal to use lime will be reviewed and approved on a case by case basis, except when lime is used for Soil Drying, in which case a written notice must be provided to the Site Inspector before the use of lime for Soil Drying.

4-0801.8 Lime Stabilization may not be used if the soluble sulfate content by weight in the expansive soils exceeds 5,000 parts per million. The soluble sulfate content in soils to be stabilized must be determined in accordance with AASHTO T 290.

4-0801.9 Strength gain due to the pozzolanic reaction of lime treated soils may not be included in the design of slopes.

4-0801.10 Soil Stabilization will only be recognized in pavement design in the following manner: The Thickness Index must be determined based on the CBR values in accordance with VTM-8 of the natural subgrade soils before stabilization. Only the top 8 inches of the stabilized soil may be considered as part of the pavement structure necessary to achieve the required Thickness Index.

4-0801.11 Soil modified or stabilized by lime may not be used as backfill for basement walls and retaining walls unless approved otherwise by the Director.

4-0801.12 Lime modification and lime stabilization will not be permitted when the soil, aggregate or the surface on which the lime treated soil is to be placed is frozen, and manipulation (i.e., mixing) may not be started until the surface is free of frost. Lime stabilization may not start until the air temperature at the project site is at least 40 degrees Fahrenheit.

4-0801.13 All lime stabilization within the VDOT Right-of-Way must be completed in accordance with the current VDOT Road and Bridge Specifications and this policy. If there is a conflict between the current VDOT Road and Bridge Specifications and this policy, the most restrictive requirement will apply.

4-0801.14 Lime may not be used in Storm Water Management facilities.

4-0802 Expansive Soil Determination

4-0802.1 The geotechnical engineer must use the properties identified in § 4-0801.1B to evaluate the volume change of potentially expansive soils. These tests must be performed on representative samples from each soil mapping unit deemed potentially expansive soils impacting the proposed construction.

4-0802.2 All laboratory test data, interpretations and supporting graphs must be included in the geotechnical report.

4-0803 Mixture Design for Lime Stabilization of Soil
4-0803.1 The appropriate lime content for field application must be determined in accordance with the National Lime Association (NLA) Technical Brief, Mixture Design and Testing Procedures for Lime Stabilized Soil, dated October 2006 with the following amendments:

A. Organic Content – The soil proposed to be stabilized must be natural inorganic soil as defined by ASTM D2487 and may contain no more than two percent organic material by weight as determined by ASTM D2974. The intentional mixing of organic material with natural inorganic soil is not permitted.

B. Expansion Index (EI) Testing Procedures – In accordance with the Virginia Uniform Statewide Building Code, ASTM D4829 must be used for EI Testing.

C. Lime used to perform the laboratory tests must be of the same type, grade, and consistency as the lime to be used for field application.

D. The prescribed minimum amount of lime for stabilization of soil must be determined based on one of the following validation tests:

1. Determine the Expansive Index (EI) of the cured specimens using a minimum of two duplicate tests conducted in accordance with ASTM D4829. The EI must be equal to or less than 20 for lime stabilization to be considered as effective in controlling soil expansion; or

2. Determine the Plasticity Index (PI) of the material from the cured specimens in accordance with ASTM D4318. The PI must be less than 15 for lime stabilization to be considered as effective in controlling soil expansion.

E. To allow for variations in the soil properties in the field, increase the required minimum lime content as determined by the procedures in § 4-0803.1D by at least 0.5 percent by dry weight and use this value as the design lime content.

F. Maps, boring logs and laboratory test data and their interpretations (including analysis; plots; the location of each of the proposed lime mix designs including the depth and lateral extent of the proposed lime stabilization; and conclusions) must be included in the geotechnical report.

4-0804 Lime Treatment Requirements for Lime Stabilization of Soil

4-0804.1 The minimum depth and lateral extent of treatment specified below must be used in the absence of engineering analyses and/or controlled experiments or pilot studies substantiating the adequacy of alternative treatment depths and areas. If
vegetation is to be established, it must be planted in non-stabilized soil in accordance with standard landscaping practices.

A. Fills – The depth and extent of treatment must conform to the minimum requirements specified below for the specific engineered structure to be supported by the fill.

B. Building Pads – When lime stabilization is used, the depth of stabilization must extend throughout the active zone. The lime stabilization must extend at least five feet beyond the projected perimeter of the building’s or structure’s footing/foundation.

C. Backfill behind Basement Walls and Retaining Walls – Lime modified and lime stabilized soils may not be placed as backfill behind basement walls and retaining walls, unless approved otherwise by the Director.

D. Backfill for Utility Trenches – Lime modified and lime stabilized soils may be used to backfill utility trenches.

E. Roadway and Parking Lot Subgrades – In fill areas, the depth of stabilization must be at least 4 feet below the finished pavement surface. In cut areas, the depth of stabilization must extend to at least 2 feet below the subgrade elevation. The lime stabilization must extend at least 2 feet beyond the proposed edges of the pavement, shoulders and sidewalks.

4-0804.2 If lime stabilized soils are to be used in the determination of the Thickness Index for the pavement design, the stabilized soil must have a minimum unconfined compressive strength of 150 psi when prepared and tested in accordance with VTM-11. The required pavement Thickness Index is determined based on the CBR values in accordance with VTM-8 of the natural subgrade soils before stabilization. Only the top 8 inches of the stabilized soil may be considered as part of the pavement structure necessary to achieve the required Thickness Index.

4-0804.3 Alternative treatment depths and areas may be used provided their adequacy is satisfactorily demonstrated and pursuant to obtaining approval from the Director. All supporting data, logic, rationale, assumptions, field control procedures and conclusions must be thoroughly documented in the geotechnical report.

A. The geotechnical engineer must evaluate the variation of the swell potential and swell pressure with depth for the expansive soils encountered at a particular site.

B. Swell tests must be conducted on disturbed or undisturbed soil samples or both depending on the requirements of the particular application. These tests must
be conducted in accordance with ASTM D4546 (Method B), ASTM D4829 and/or other testing methods approved by the Director. The tests must take into account field conditions, including moisture variation, compacted densities, and surcharge loads.

C. Based on pilot studies, the geotechnical engineer may recommend alternative treatment for the depth and lateral extent to which treatment should extend in order to achieve the desired performance or required design parameters, such as allowable differential movement and swelling pressures.

4-0805 Health and Safety Precautions for Soil Treatment with Lime

4-0805.1 Various types of lime can be used in a dry or slurry form for soil treatment. Care must be taken during construction to avoid skin and eye burns, especially if quicklime is used. Water must be applied, and mixing operations must be started immediately after spreading lime in order to avoid or minimize unnecessary exposure.

4-0805.2 The contractor is responsible for controlling fugitive dust due to lime application, on and off the project limits. Dry lime may not be delivered, spread or mixed when wind or other conditions would allow lime dust to leave the construction site. If lime leaves or appears likely to leave the construction site or will impact any onsite tree save areas—as determined from visual observation—the contractor must immediately cease operations. Operations may not be resumed until working conditions are suitable or alternate construction techniques are employed to ensure that lime dust does not leave the construction site.

4-0805.3 Water runoff from any project site must be controlled by the contractor. Lime must not be allowed to flow with water runoff to any surface water body on or off a project site, into any tree save area, or onto an adjacent site.

4-0805.4 Before approval of the soil report or site plan, a Health and Safety Plan must be provided for incorporation into the project specifications. The Health and Safety Plan must include the identification of precautions for exposure to lime, associated operations and products, protocols for ensuring adherence to the plan requirements, and emergency medical treatment available on and near the job site. The Health and Safety Plan must be prepared by a competent professional for the contractor. A copy of the Health and Safety Plan must remain on site at all times for reference. The Health and Safety Plan must be incorporated into the approved set of plans.

4-0806 Lime Stabilization Specifications
4-0806.1 Lime stabilization must be accomplished according to a set of specifications prepared by the Geotechnical Engineer of Record registered in the Commonwealth of Virginia, which must include a Field Quality Control Plan meeting the minimum requirements of §§ 4-0801, 4-0804, and 4-0807. These specifications must be submitted in the form of a geotechnical report. The complete package provided for submission must include the Health and Safety Plan and the site, subdivision or grading plans. After the geotechnical report has been approved, the approved recommendations must be incorporated into the plans as project specifications.

4-0806.2 The specifications must describe the work, identify suitable material (lime, water, etc.) requirements, identify the type of equipment for mixing, describe the contractor’s experience and address at a minimum, the following construction methods: soil preparation; lime spreading; mixing and watering; mellowing; and compaction and finishing.

4-0807 Field Quality Control for Lime Modification and Stabilization of Soil

4-0807.1 Field quality control must be provided on every project where lime modification and lime stabilization are used and must be monitored under the direction of the Geotechnical Engineer of Record qualified and experienced in soil and foundation engineering. Daily written documentation of all monitoring activities, including field observations, construction equipment, source, type, grade and consistency of lime distribution, sampling and test locations, test results and supporting measurements, etc., must be maintained and readily available at the project field office and be made available upon request.

4-0807.2 At a minimum, the following elements must be included in the geotechnical report which must be submitted for review before approval of the Site Plan. Where required, random sampling, measurement and testing locations, and random locations must be determined in accordance with ASTM D3665.

A. Depth of Lime Treatment – The depth of treatment must be investigated for every application by digging test holes and spraying a non-hazardous color sensitive indicator solution on the treated soil exposed on the sides of the test holes. If lime is present in the soil, it should react with the indicator solution and cause a change in color to develop. For subgrade stabilization applications, one test hole is required per 3,000 square foot area of treated soil. A minimum of three test holes are required for any subgrade stabilization application. The test holes must be randomly located. The minimum number of test holes required is on a per layer (lift) basis when mixing is accomplished in-place by a traveling mixer. When lime-soil mixing is accomplished using a stationary mixer, the minimum number of test holes required may be based on the surface area of the total thickness of lime stabilized soil.
B. Lateral Extent of Lime Treatment – Before stabilizing an area, the limits of lime treatment must be established in the field by a survey. The extent of the treated areas will be identified by the geotechnical engineer and the field surveys must be conducted by a professional land surveyor or registered design professional registered in the Commonwealth of Virginia. In addition, test holes used to check the depth of treatment must also be used to verify the lateral extent of treatment.

C. Dry Lime Spread Rate – The spread rate of dry lime must be determined or measured for every lift in terms of pounds of lime per unit area of surface. If lime is applied in bags, the spread rate can be determined from: the number of bags used, the weight of lime per bag, and the area being treated. If lime is applied in bulk via mechanical means, a one-square-yard piece of canvas or other suitable material must be placed on the ground at random locations at least once per day during continuous operation, and the weight of lime spread on it measured after lime application is completed. A minimum of three measurements must be conducted for bulk applications, with one test being conducted at the start of spreading lime.

D. Spread Rate of Lime-Slurry Composition – The spread rate of lime-slurry over a known (measured) area can be based on the lime solids content. The amount of lime solids in a lime-slurry mixture can be determined by measuring the specific gravity of the slurry. The specific gravity must be determined via hydrometer test in accordance with ASTM D422. Alternative methods to measure the specific gravity of lime slurry may be proposed for review and approval. A minimum of one test must be conducted for every 2,500 gallons of slurry mix or portion thereof. Samples must be taken at random locations after slurry spreading begins.

E. Mellowing and Pulverization – A minimum duration of 24 hours is required for mellowing, unless laboratory studies show that the PI is reduced to less than 15 in a shorter period of time. Tests must be conducted in the field to assure proper pulverization after mellowing and before final placement or compaction. The lime treated material must be mixed until 100 percent of it, exclusive of the coarse aggregate, passes the 1-inch sieve and a minimum of 60 percent of it, exclusive of the coarse aggregate, passes the U.S. Number 4 sieve. If the lime stabilization is completed in two days or less, three tests must be conducted, with one test being conducted at the start of operations. If the lime stabilization is completed in more than 2 days, at least one test per lift must be conducted each day during continuous operation.

F. Testing Before Final Compaction – The maximum allowable loose lift thickness is 8 inches. After pulverization, and before final compaction, samples
from random locations within each lift must be taken for pH (ASTM D6276) and PI (ASTM D4318) or EI (ASTM D4829) determinations. One soil sample must be taken and tested for every 1,000 cubic yards of stabilized soil with a minimum of one soil sample per day from each lift of stabilized soil. However, if the test results indicate the work is not in compliance with the approved specifications, the Director may require a greater testing frequency. The pH determination may not be less than a pH of 12.2 and no more than 10 percent of pH determinations must be less than a pH of 12.3. Field pH testing is not required for lime modified soil.

G. Compaction Characteristics – For every type of expansive soil to be modified or stabilized at the job site, laboratory moisture density curves must be determined for a mixture of that soil with the design lime content. The laboratory compaction test must be conducted for soil and soil-lime mixtures in accordance with ASTM D698. The compaction in the field must be monitored based on the laboratory moisture-density test results. One field density test must be conducted per 10,000 square foot area of each compacted lift, with a minimum of three tests per lift. Tests must be made at random locations within each lift. Field density tests must be conducted in accordance with ASTM D6938 or ASTM D1556 or a combination of the two standards. Since the moisture-density relationships change with time during curing, testing for field moisture-density characteristics must be conducted as soon as the compaction of the mixture has been completed.

H. Other Engineering Characteristics – Other field tests may be appropriate to demonstrate the quality control or verify the anticipated performance of the lime-treated material for the particular application. The type, purpose, frequency, and location of all other field tests must be documented in the quality control plan.

I. The Geotechnical Engineer of Record must compile a summary report of all site observations and testing performed daily and submit signed and sealed reports within 5 business days. All technicians performing work within the VDOT Right-of-Way must obtain certification through VDOT, and certification by any other agency is not acceptable.

4-0808 Quality Assurance

4-0808.1 Quality assurance must be provided by the Geotechnical Engineer of Record on every project where lime treatment is used, and must include at a minimum, a weekly audit of field quality control activities and a final written summary report.

A. The final report must be signed and sealed by the Geotechnical Engineer of Record and must include a summary of all monitoring data; audit results; steps
taken to correct any deficiencies or items not in compliance with the specifications and Field Quality Control Plan; a statement indicating whether or not lime modification or stabilization for all applications of the subject project has been performed in accordance with the specifications and Field Quality Control Plan; a recommendation for any work to be completed before the release of performance bonds and/or the issuance of residential or non-residential use permits; and all supporting data.

B. The audits and final summary report must be conducted and prepared under the direction of a Virginia registered design professional, specializing in soil and foundation engineering.

C. The final summary report must be submitted to LDS within 30 days following the completion of lime stabilization. Review and approval of the final summary report is required before the release of performance bonds and/or the issuance of the Certificate of Occupancy related to the subject project.