APPENDIX C – SITE INVESTIGATION REQUIREMENTS FOR PUBLIC WORKS STREET PROJECTS (PART F3)

F3. SITE INVESTIGATION REQUIREMENTS FOR PUBLIC WORKS STREET PROJECTS (2021)

F3.1 This guideline provides basic principles and requirements for site investigations and testing with which to guide the designer in the preparation of proposals and completion of their investigations. Irrespective of the requirements listed in this document, it is important that the Engineer clearly outlines what assumptions were made in estimating the effort and resources necessary to complete the scope of work. A proposal should be submitted for approval to the City's Project Manager.

F3.2 When using this guideline, he designer remains responsible for the proposed plan in accordance to good engineering standards that address the specific needs and site conditions of the project. Without limiting that broad and general obligation, this guideline should be the minimum requirement.

F3.3 Boreholes and pavement core spacing, and material testing guidelines presented in this guide are only applicable to pavement investigations. Site investigation and testing may also be conducted as per common industry practice for other road elements such as sidewalks boulevards, and medians. The City's Project Manager should be notified of any unusual conditions or difficulties encountered, and any changes made in the investigation program.

F3.4 New Construction and Reconstruction Projects

(a) The number of boreholes can be calculated using Table 1.

Table 1 : Number of Boreholes and Depths

Lanes/Locals	Industrials and Collectors	Arterials
Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.45}$ A minimum of two boreholes, 2 m ± 150 mm depth from the bottom of the proposed or the existing pavement per project location.	Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.46}$ A minimum of three boreholes, 2.5 m ± 150 mm depth from the bottom of the proposed or the existing pavement per project location.	Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.48}$ A minimum of three boreholes, 2.5 m ± 150 mm depth from the bottom of the proposed or the existing pavement per project location.

[1]If previous soil information is available and relevant, the number of boreholes can be reduced - confirm with the City's Project Manager.
[2]Additional boreholes should be undertaken where adverse soil conditions are expected or encountered during the course of field drilling.

(b) Offset the boreholes as appropriate to provide coverage across the full width of the proposed construction. Boreholes should not be advanced on utility cut patching. The locations of the boreholes should be shown clearly on a scaled plan map of the site under investigation.

(c) The following factors should be considered while selecting borehole locations:

(i) Visual sub-grade variability;

(ii) Significant pavement failures (rutting, fatigue cracking, settlement and faulting) which are often associated with sub-grade issues to diagnose the cause of these conditions; and

(iii) Existing buried infrastructure.

(d) Information regarding the sampler type, date and time of sampling, sample type and color, sample depth, ground water elevations, borehole location, etc. should be shown in log form using notations and a graphical system. The log form should distinguish between visual evaluations of soil samples in the field versus a more precise laboratory evaluation supported by tests. Detailed boring logs including the results of laboratory tests should be included in the geotechnical report.

(e) Measure and identify pavement materials (thickness and type of pavement structure materials) Photograph core samples recovered from the pavement surface (concrete, asphalt, or composite).

(f) Visual identification of the soil must be reported at the following depths from the bottom of the proposed or existing pavement – 0.6m, 0.9m, 1.2m 1.6m, 2.0m, and 2.5m (if required). Ensure that each soil type encountered in the boreholes is identified. The visual identification should describe the existing pavement structure, if any, including the materials encountered and the layer thickness.

(g) Backfill boreholes with granular fill. Patch pavement surface with an approved cold patch asphalt or rapid set cementitious product to mat the surface pavement type.

(h) Where significant embankments are proposed along the roadway, specific testing and recommendations for the fill materials and placement should be made including expected settlements, load compensation requirements, and potential buoyancy of the embankment. The size, complexity and extent of the testing program will depend primarily on the type, height and size of embankment as well as the expected imported soil conditions - confirm with the City's Project Manager.

(i) For embankments less than 100 m in length, a minimum of two boreholes are required. For embankments more than 100 m in length, the spacing between boreholes along the length of the embankment should not exceed 75m with a minimum of two (2) boreholes. Extend th boreholes depths to a minimum of 2m +/- 150 mm below the proposed subgrade level. At critical locations and where embankment heights exceed 1.0m, a minimum of two (2) boreholes are required in the transverse direction to define the existing geological conditions for stability analyses.

(j) Laboratory Testing Program:

  (i) Determine the moisture content of the soils encountered in every borehole in accordance with ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, at the following depths from the bottom of the proposed or existing pavement – 0.6m, 0.9m, 1.2m, 1.6m, 2.0m, and 2.5m (f required).

  (ii) Classify and test the anticipated sub-grade soil in accordance with Table 2. The sub-grade soil is the material on which the pavement structure will be built; 0.6m, 0.9m, and 1.2m may be used for locals, collectors, and arterials, respectively – confirm with the City's Project Manager.

Table 2: Boreholes Testing Frequency

Lanes/Locals	Collectors	Arterials
Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.4}$ A minimum of two boreholes should be tested per project location.	Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.41}$ A minimum of three boreholes should be tested per project location.	Number of boreholes = $0.1 \times (\text{Street area } (m^2))^{0.42}$ A minimum of three boreholes should be tested per project location.

  (iii) The testing program should include:

- Particle Size Analysis – ASTM D6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis and ASTM D7928 Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis;
- Atterberg Limits – ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; and,

- ♦ California Bearing Ratio (CBR) – ASTM D1883 Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils. CBR test shall be performed at 95% maximum dry density and optimum water content. All samples shall be soaked prior to testing.

(ii) The sub-grad classification should be in accordance with:

- ♦ ASTM D3282 – Standard Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes; and,
- ♦ ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes.

(b) The designer should consider the site specific factors listed above for borehole locations while selecting testing location and frequency.

(c) More advanced testing may be required depending upon site conditions including direct shear tests, triaxial tests, unconfined compressive tests, permeability tests, consolidation tests, point load test, slaking tests, pinhole dispersion tests or other tests as deemed appropriate and justified by the designer – confirm with the City's Project Manger.

F3.4.1 Rehabilitation Projects

(a) For any rehabilitation projects (Concrete, Asphalt or Composite), measure and identify pavement materials (thickness and types of pavement structure material). Photograph core samples recovered from the pavement.

(b) For concrete rehabilitation projects, 150mm-diameter cores shall be taken at joints to identify proper rehabilitation strategies (i.e. mill/fill, partial depth repair, full depth repair). The number and location of cores will be determined by the designer after visiting the site – confirm with the City's Project Manager. A minimum of two (2) cores shall be collected mid-slab to determine the existing pavement thickness and concrete strength in accordance with CSA A23.2-14C – wet condition.

(c) Factors that should be considered while selecting pavement core locations include but are not limited to:

(i) Significant variation in joint condition;

(ii) Pumping slabs, cracks or distress and perceived moisture issues from side slopes/edge cracking; and,

(iii) Significant changes in pavement structure thickness.

(d) Non-destructive testing (i.e. Falling Weight Deflectometer and Ground Penetrating Radar) can be used to identify layer thickness and structural adequacy, load transfer at joints, and appropriate rehabilitation strategies, including partial depth repairs, full depth repairs, slab replacement, and overlays – confirm with the City's Project Manager.