Article 6. Geotechnical

6.1 General

6.1.1 Scope

(a) This Article 6 [Geotechnical] specifies the geotechnical requirements and criteria for the Design and Construction of the Work.

(b) Without limiting any other provision of this Agreement, the Primary Contractor shall carry out all geotechnical investigations, exploration, analyses, testing and interpretation necessary to perform the Work in accordance with this Agreement.

6.1.2 Codes and Standards

(a) The Primary Contractor shall ensure that the geotechnical aspects of the Design and Construction of the Work and all other aspects of the Work comprising or connected with the geotechnical aspects of the Design and Construction of the Work are carried out in accordance with, as applicable, the following codes and standards and the requirements set out in this Article 6 [Geotechnical]. The Primary Contractor shall apply the following codes and standards in descending order of precedence:

(i) BC Supplement to CAN/CSA-S6-06;

(ii) CAN/CSA-S6-06;

(iii) MoT Technical Bulletin GM9801, "Guidelines for Geotechnical Reports", March 30, 1998;

(iv) AASHTO Standard Specifications;

(v) FHWA Guidelines - NH1-00-043: "Mechanically Stabilized Earth Walls and Construction Guidelines", Section 5.3, (2001);

(vi) Canadian Foundation Engineering Manual;

(vii) Recognized Products List;

(viii) ATC-32 and MCEER/ATC-49;

(ix) Appendix E [Methods of Seismic Analysis of Slopes contained in Guidelines for Legislated Landslide Assessment for Proposed Residential Developments in BC (May 2008)];

(x) Recommendations for Prestressed Rock and Soil Anchors, Post-Tensioning Institute; and

(xi) Manual of Control of Erosion and Shallow Slope Movement.

6.2 Geotechnical Manager

6.2.1 Qualifications

(a) The Primary Contractor shall, at all times, retain and maintain a competent and qualified person to act as the geotechnical manager in connection with this Agreement (the "**Geotechnical Manager**"), which person shall be a Professional Engineer and shall have, at a minimum, the following qualifications:

(i) a post-graduate degree in geotechnical engineering or soil mechanics;

(ii) a minimum of 15 years of supervisory experience in geotechnical design and construction relating to support of tunnels, roadways, bridges, retaining walls and other related elements;

(iii) geotechnical design and construction experience on major projects that are comparable in scope, complexity and nature to the Project;

(iv) experience in establishing geotechnical design parameters and in interpreting and applying geotechnical baseline reports and geotechnical data reports; and

(v) experience in developing and implementing geotechnical instrumentation and monitoring programs.

6.3 Subsurface Investigation Plan

6.3.1 Subsurface Investigation Plan - Content

(a) Subject to Article 6.3.2(a) [Subsurface Investigation Plan - Review Procedure] of this Part 2, the Primary Contractor shall develop, implement, maintain and, as in situ conditions require, update a subsurface investigation plan (the "**Subsurface Investigation Plan**" or the "**SIP**") that demonstrates the methods, measures and processes that the Primary Contractor will implement, as the Primary Contractor deems necessary to meet the requirements of the Project as set out in this Agreement, to supplement the geotechnical reports provided by the Province as part of the Disclosed Data in order to better understand and define the subsurface conditions to be taken into account in the Design and the Construction of the Work. The SIP shall be signed and sealed by the Geotechnical Manager and, at a minimum, shall include the following information:

(i) the specific testhole locations;

(ii) the frequency and type of sampling;

(iii) the type and location of laboratory and/or field testing;

(iv) the schedule for implementation of the SIP (the "**SIP Schedule**");

(v) the locations, procedures and processes to implement the investigations, which investigations must, at a minimum, include the following locations between Ioco Station and Bond Street:

A. for an elevated Guideway system, a minimum set of 3 testholes to confirm dense strata, undertaken at each pier location between Ioco Station and Bond Street, with at least 2 of the 3 testholes of each set undertaken at the crest and the toe of the slope; and

B. for portions of the Guideway not covered by Article 6.3.1(a)(v)A. of this Part 2, a minimum set of 3 testholes to confirm dense strata, undertaken at intervals along the Guideway of no more than 50m between Ioco Station and Bond Street, with at least 2 of the 3 testholes of each set undertaken at the crest and the toe of the slope; and

(vi) the methods, policies and procedures to be implemented to ensure that all investigations and related activities:

A. will be conducted in accordance with all applicable Permits, agreements, plans and Laws;

B. will be completed in accordance with the SIP Schedule; and

C. otherwise will be conducted and completed in accordance with the terms of this Agreement.

6.3.2 Subsurface Investigation Plan - Review Procedure

(a) The Primary Contractor shall not commence any investigations, earthworks or excavations unless and until the SIP has been submitted to the Province's Representative for review, acting reasonably, in accordance with the Review Procedure.

6.3.3 Subsurface Investigation Plan - Implementation

(a) The Primary Contractor shall ensure that it is able to undertake the investigations set out in the SIP during Construction from within the completed Tunnel where necessary.

(b) The Primary Contractor shall, in implementing the SIP and subject to Article 6.3.3(c) of this Part 2:

(i) survey the location of each testhole, which survey shall determine station and offset, elevation, and coordinates, all of which shall be included on the testhole records; and

(ii) retain all samples:

A. resulting from the drilling of the testholes; or

B. examined as part of the laboratory and/or field testing work.

(c) The Primary Contractor shall retain all surveys prepared and samples taken during the implementation of the SIP until the Total Completion Date and shall, upon request made by the Province prior to Total Completion, deliver to the Province all surveys and samples taken during the implementation of the SIP.

(d) The Primary Contractor shall backfill all borings, test pits, rotosonic holes, probe holes and any other testholes in a manner that prevents:

(i) any subsequent settlement of the backfill;

(ii) any leakage of water under artesian pressure; and

(iii) the creation of hazards to persons, animals, or equipment.

(e) The Primary Contractor shall ensure that all testholes that are abandoned are abandoned in accordance with all applicable Laws.

(f) The Primary Contractor shall restore all finished and landscaped surfaces that are disturbed in connection with the implementation of the SIP in accordance with the applicable Conditions of Access and Article 4 [Existing Conditions], Part 1 of Schedule 4.

(g) The Primary Contractor shall remove all surplus material, temporary structures and debris resulting from the Work upon completion of all field investigations.

6.4 Guideway and Fixed Facilities Foundations

(a) The Primary Contractor shall carry out the Design and the Construction of the foundations for the Guideway and the Fixed Facilities in accordance with the requirements and criteria set out in this Article 6.4 [Guideway and Fixed Facilities Foundations] and so as to ensure that:

(i) the total and differential settlements of the foundations are compatible with the function and performance requirements of the Evergreen Line over the design life of each of the components of the Guideway and the Fixed Facilities as set out in this Agreement; and

(ii) the foundations do not adversely impact any Existing Facilities.

(b) The Primary Contractor shall demonstrate, through comprehensive geotechnical and structural analyses and designs forming part of its submissions for review under Part 3 [Certification and Completion] of Schedule 4, that the stringent tolerances set out for the track and the Alignment in this Schedule 4 will continue to be met over the design life of each of the components of the Evergreen Line.

(c) The Primary Contractor shall carry out:

(i) sufficiently detailed field and laboratory investigations to characterize the subsurface variations; and

(ii) analyses and modeling of deformations under static, live and seismic loading conditions anticipated over the design life of each of the components of the Evergreen Line,

if foundation loads resulting from the Work are not transferred directly to competent dense strata through structural elements.

(d) For greater certainty, the results of the analyses required by Articles 6.4(b) and 6.4(c), both of this Part 2, in no way limit the Primary Contractor's obligations under this Agreement and the Primary Contractor shall remain responsible for satisfying the overall performance objectives of the Evergreen Line over the design life of each of its components, as set out in this Agreement.

(e) The seismic requirements and criteria for foundations are set out in Article 5 [Seismic]of this Part 2.

6.5 Slope Stability

(a) The Primary Contractor shall:

(i) ensure that the factor of safety for the slope stability analysis of any new or existing (whether modified or not by the Primary Contractor as part of the Work) cut and fill slopes located within the Permanent Project Lands and Zone of Influence, including such slopes that may be impacted by the Work, is not less than 1.5 under static loading conditions;

(ii) investigate all existing cut and fill slopes to determine whether each existing slope meets the functional and performance requirements of this Article 6 [Geotechnical];

(iii) with respect to the slopes investigated under Article 6.5(a)(ii) of this Part 2, carry out all work necessary to bring such cut and fill slopes that may be impacted by or may impact the Work into compliance with this Article 6 [Geotechnical]; and

(iv) provide all new and existing cut and fill slopes that may be impacted by or may impact the Work with protection against erosion and shallow slope movement in accordance with the Manual of Control of Erosion and Shallow Slope Movement.

(b) The seismic requirements and criteria for cut and fill slopes are set out in Article 5 [Seismic] of this Part 2.

6.6 Retaining Walls

(a) The Primary Contractor shall design all retaining walls in accordance with the requirements and criteria set out in this Article 6.6 [Retaining Walls].

(b) The Primary Contractor shall use the retaining wall systems and abutment wall types identified in the Recognized Products List, other than the following:

(i) mechanically-stabilized earth ("**MSE**") walls with dry cast concrete block facings;

(ii) metal bin walls;

(iii) steel sheet pile walls in areas that are visible to the public; and

(iv) walls with wire facings, where visible to the public and/or subject to spray or surface runoff containing de-icing chemicals.

(c) Notwithstanding any other provision of this Agreement, the Primary Contractor shall not use:

(i) MSE walls with extensible reinforcement as abutment walls or wing walls; or

(ii) geotextiles as soil reinforcement.

(d) The Primary Contractor shall apply the requirements of the FHWA Guidelines – NH1-00-043 for MSE walls if the requirements of the AASHTO Standard Specifications do not apply.

(e) The Primary Contractor shall use:

(i) precast concrete facing panels for all MSE abutment walls and MSE wing walls; and

(ii) a precast concrete coping along the top of such walls.

(f) The Primary Contractor shall ensure that the minimum soil reinforcement length for walls influenced by abutment footings is the greater of:

(i) 70% of the distance from the top of the leveling pad to the surface of the road or the Guideway; and

(ii) the minimum length required by the AASHTO Standard Specifications.

(g) For the purposes of this Article 6.6 [Retaining Walls], any reinforcing strip within a 1:1 slope of an abutment footing or a pile cap shall be considered as being influenced by the footing.

(h) The Primary Contractor shall, for all walls described in this Article 6.6 [Retaining Walls]:

(i) finish the tops of all straight-line wall segments; and

(ii) provide sufficient drainage for all walls such that the walls meet the Design requirements of this Agreement.

6.7 Lightweight Fills

(a) The Primary Contractor shall ensure that all lightweight fills used in the Construction of the Project comply with this Article 6.7 [Lightweight Fills].

(b) The Primary Contractor shall ensure that the proper function of all lightweight fills is preserved and maintained throughout the 100 year design life of the structural components of the Evergreen Line and that such fills are protected against:

(i) applied loads;

(ii) ground water;

(iii) road salts;

(iv) weather and fire;

(v) flotation under flood conditions; and

(vi) fuel spills.

(c) The Primary Contractor shall ensure that, where walls are used to contain flammable lightweight fills, the walls have a 2-hour fire rating.

(d) The Primary Contractor shall ensure that the foundation system and landscaping do not compromise any protective covers used to protect the lightweight fills.

(e) The Primary Contractor shall base the Design, selection and placement of lightweight fills on flotation forces corresponding to the inundation of the

lightweight fill to the 200-year flood level, regardless of the flood protection for the area in which the lightweight fills are to be used.

(f) The Primary Contractor shall not use any of the following as lightweight fills:

(i) shredded rubber tires; or

(ii) hog fuel or woodwaste.

(g) The Primary Contractor shall, wherever EPS lightweight fills are used, ensure that the EPS:

(i) is supplied in the form of blocks;

(ii) is classified as to surface-burning characteristics in accordance with CAN/ULC-S102.2-10, having a flame spread rating not greater than 500;

(iii) has a minimum compressive strength, measured in accordance with ASTM D1621, of 125 kPa at a strain of not more than 5%;

(iv) has a density of not less than 22 kg/m^3; and

(v) blocks are fully wrapped with minimum 10-mil thickness black polyethylene sheeting, with sheeting joints overlapped by a minimum of 0.5m.

6.8 Ground Improvement

(a) Subject to Articles 6.8(b) and 6.8(c), both of this Part 2, the Primary Contractor shall develop, implement, maintain and update, as in situ conditions require, a ground improvement plan (the "**Ground Improvement Plan**") that demonstrates the methods, measures and processes of ground improvement that the Primary Contractor will implement as part of the Work. The Ground Improvement Plan shall, at a minimum, include the following information:

(i) a complete description of the Design of each of the ground improvements (including design methods, criteria and assumptions);

(ii) the Construction methodology of each of the ground improvements (including equipment, construction procedures, materials and personnel);

(iii) the quality management of ground improvements, including monitoring, in accordance with Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring] of this Part 2 and Schedule 6 [Quality Management]; and

(iv) all other information necessary to demonstrate that the proposed methods, measures and processes of ground improvement set out in the

Ground Improvement Plan are in accordance with the requirements of this Agreement, including this Schedule 4.

(b) The Ground Improvement Plan must be sealed in accordance with the applicable requirements of APEGBC.

(c) The Primary Contractor shall submit the Ground Improvement Plan to the Province's Representative for review, acting reasonably, in accordance with the Review Procedure not less than three months prior to carrying out any ground improvements.

6.9 Geotechnical Reports

6.9.1 General

(a) The Primary Contractor shall prepare all geotechnical reports, including documentation from, and consistent with, the findings of the activities of this Article 6 [Geotechnical] and the other Articles of this Agreement, which geotechnical reports shall include, at a minimum, the following:

(i) a summary of the results of the field testing;

(ii) all instrumentation data;

(iii) all laboratory investigation programs;

(iv) all engineering studies;

(v) all engineering parameters; and

(vi) all geotechnical design analyses and recommendations, including those provided in technical memoranda.

(b) The Primary Contractor shall follow MoT Technical Bulletin GM9801, "Guidelines for Geotechnical Reports", March 30, 1998, for the general format of all geotechnical reports and shall ensure that such reports include the information listed in this Article 6.9 [Geotechnical Reports], as applicable.

(c) The geotechnical reports shall be signed and sealed by the Geotechnical Manager.

(d) Except as provided in Articles 6.9.2 [Geotechnical Investigation Report(s)] and 6.9.3 [Geotechnical Design Report(s)], both of this Part 2, with respect to Geotechnical Investigation Report(s) and Geotechnical Design Report(s), respectively, the Primary Contractor shall submit geotechnical reports to the Province's Representative for review, acting reasonably, in accordance with the

Review Procedure no later than two months following completion of the Work that such report(s) document.

(e) The Primary Contractor shall, for record purposes, also provide to the Province's Representative an electronic copy of all geotechnical reports without password protection.

6.9.2 Geotechnical Investigation Report(s)

(a) The Primary Contractor shall, within one month of completion of field and laboratory testing with respect to the site investigation for any design segment of the Work, submit report(s) ("**Geotechnical Investigation Report(s)**") in accordance with the Review Procedure, for review by the Province's Representative acting reasonably, setting out the documentation from, and consistent with, the findings of the investigation activities carried out by the Primary Contractor in accordance with this Article 6 [Geotechnical], which report(s) shall include, at a minimum:

(i) an executive summary;

(ii) a description of purpose and scope of report;

(iii) a description of methodology and equipment used;

(iv) all results and factual data collected;

(v) a description of site conditions, geology, inferred subsurface stratigraphy and groundwater levels;

(vi) plans, sections and profiles showing surveyed test locations and inferred stratigraphy; and

(vii) a summary of engineering properties of strata.

6.9.3 Geotechnical Design Report(s)

(a) The Primary Contractor shall prepare geotechnical design report(s) in support of the Design for the Work in accordance with this Article 6.9 [Geotechnical Reports] ("**Geotechnical Design Report(s)**").

(b) The Primary Contractor shall, at the Interim Design completion stage, submit Geotechnical Design Report(s), which report(s) shall include, at a minimum:

(i) an executive summary;

(ii) a description of the purpose and the scope of the report;

(iii) an outline of design codes, criteria, parameters and philosophies applied in the report;

(iv) interpretation of factual data and summary of inferred subsurface conditions and geotechnical design parameters at each major component of the Work;

(v) methodologies, references and descriptions of all computer models used;

(vi) discussion of the geotechnical design and construction issues, and the geotechnical approach to developing the Site and the facilities to meet performance requirements;

(vii) results of all geotechnical analysis and recommendations in support of the Design and the Construction. At a minimum, the Primary Contractor shall address the following:

A. the Site preparation and proposed treatment to achieve design grades and total and differential settlement tolerances within the Work;

B. the recommended geotechnical instrumentation program, including instrumentation details and monitoring frequency so as to confirm performance of the Design and the Work during Construction and the General Defect Warranty Period, and the Evergreen Line, once operational, during the design life of each of the components of the Evergreen Line;

C. the seismic performance and Design recommendations, addressing seismic site response to input ground motions, liquefaction potential, lateral spreading/displacements, soil-structure interaction, and lateral earth pressures;

D. the foundation Design for each component to be constructed by the Primary Contractor, including:

(1) vertical and lateral load capacity;

(2) bearing capacity of shallow and deep foundations;

(3) settlement predictions both during the General Defect Warranty Period and through the design life of the applicable facility;

(4) consideration of differential settlement within and along Structures and the Guideway, and between piled and grade-supported facilities; and

(5) recommendations for mitigative measures, where required, to ensure satisfactory performance throughout the design life of the applicable facility;

E. the recommendations for quality management testing of all geotechnical aspects of the Work, such as static and dynamic pile testing, and for quality management testing of any other ground support or improvement systems;

F. the geotechnical Design of embankments and retaining structures, including stability, bearing capacity, settlements during construction, and, during the design life of each of the components of the Evergreen Line, consideration of long-term settlements and methods to mitigate any such settlements;

G. the subsurface and site drainage requirements;

H. the Design and installation of any underground facilities;

I. the recommendations for all fill material specifications and placement; and

J. the recommendations on all geotechnical aspects of the Construction, including temporary excavation and shoring design, staged fill placement, and dewatering;

(viii) recommendations for any additional geotechnical investigation, testing, or analysis required to address any insufficiency in the information and data regarding the Site available to the Primary Contractor; and

(ix) drawings showing the proposed geotechnical Designs.

(c) The Primary Contractor shall, as part of each of the Final Design submissions stage and of the Records Documentation, submit a neat, bound, indexed set of Design calculations, along with electronic copies on CD of software model data files, for any geotechnical Design work completed for the Work. All calculations shall be initialed by both the Designer and the Designer's checker.

(d) The Primary Contractor shall update the Geotechnical Design Report(s) prepared at the Interim Design completion stage and shall submit the updated Geotechnical Design Report(s) with the Final Design submissions to be submitted in accordance with Article [Design and Construction Certification Procedures], Part 3 of Schedule 4.

6.10 Geotechnical and Hydrogeological Instrumentation and Monitoring

6.10.1 Scope

(a) Monitoring of the geotechnical and hydrogeological aspects of the Work is required in order to:

(i) verify the Primary Contractor's compliance with the requirements of this Agreement, including this Schedule;

(ii) verify the parameters, assumptions and analyses developed and used by the Primary Contractor in:

A. the Design and Construction of the Work; and

B. the ground improvements as described by the Primary Contractor in the Construction Risk and Impact Assessment Report prepared in accordance with Article 4 [Existing Conditions], Part 1 of Schedule 4, and the Ground Improvement Plan;

(iii) permit the Primary Contractor to control the Construction of the Work;

(iv) detect evidence of any impending failures of any aspects of the Work;

(v) measure the impact, if any, of each of the Work and the Evergreen Line, once operational, on Existing Conditions within the Zone of Influence;

(vi) provide evidence to assist with the handling of Construction-related damage claims made by third parties; and

(vii) measure and identify the causes and distribution of ground movement and deformations with respect to the Guideway and the Stations so as to ensure the performance of the Evergreen Line in accordance with this Agreement.

(b) To achieve the objectives set out in Article 6.10.1(a) of this Part 2, the Primary Contractor shall, in accordance with this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring]:

(i) develop a plan for the installation and monitoring of geotechnical and hydrogeological instrumentation described in Article 6.10.7 [Instrumentation & Monitoring Plan] of this Part 2;

(ii) procure and install the geotechnical and hydrogeological instrumentation in accordance with the Instrumentation & Monitoring Plan;

(iii) until the Total Completion Date, monitor the instrumentation, collect data from the instrumentation and report on the collected data to the Province's Representative in accordance with the Instrumentation & Monitoring Plan; and

(iv) in accordance with the Instrumentation & Monitoring Plan and as of the Total Completion Date, transfer to the Province or its designate the geotechnical and hydrogeological instrumentation required to monitor the ongoing performance of the Guideway and the Stations, and the responsibility for the monitoring, data collection and reporting associated with such instrumentation.

6.10.2 Monitoring of Existing Conditions

(a) Without limiting the generality of Article 6.10.1 [Scope] of this Part 2, the Primary Contractor shall undertake the following in respect of Existing Conditions within the Zone of Influence:

(i) install instrumentation to monitor and record the effects of each of the Design, the Construction and the Evergreen Line, once operational, on such Existing Conditions; and

(ii) conduct monitoring of such instrumentation until the Total Completion Date, with monitoring sufficient and frequent enough to facilitate management and control of the Work such that the continued safe use and operation of such Existing Conditions is ensured.

(b) Where there are Laws, standards or procedures relating to use and operation of any Existing Facilities within the Zone of Influence, such as those operated by Municipalities, Public Utilities, Regulated Utilities, or CPR, the Primary Contractor shall:

(i) undertake sufficient monitoring to address the facility owner's responsibilities in relation to such Laws, standards or procedures; and

(ii) communicate the results of all monitoring to each applicable facility owner and the Province's Representative within the timelines established by the Province or, if the owner is a Municipality, a Public Utility, a Regulated Utility or CPR, then within the timeline established by such Municipality, Public Utility, Regulated Utility or CPR.

6.10.3 Monitoring of Ground Movement and Deformations

(a) Without limiting the generality of Article 6.10.1 [Scope] of this Part 2, the Primary Contractor shall, at a minimum, carry out monitoring of ground deformations within:

(i) the Zone of Influence; and

(ii) the following, whether or not they are included in the Zone of Influence:

A. any Existing Facilities adjacent to excavations, the bases of which fall within lines sloping down and away from the foundation support zone of such facilities at 35 degrees or more from the horizontal; and

B. any area defined by lines projected at 1.5 horizontal to 1 vertical from the centreline of the applicable Tunnel.

6.10.4 Monitoring of Ground Improvements and Other Geotechnical Aspects of the Work

(a) Without limiting the generality of Article 6.10.1 [Scope] of this Part 2, in the areas of the Site where the Primary Contractor will be undertaking or constructing ground improvements (which, for the purposes of this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring], includes foundations, cuts, fills, dewatering or retaining walls), the Primary Contractor shall install and monitor until the Total Completion Date, geotechnical and hydrogeological instrumentation so as to:

(i) measure the impact of the Work on the improvements and the impact of such improvements on Existing Facilities within the Zone of Influence; and

(ii) provide assurance to the performance of the Evergreen Line in accordance with this Agreement, including this Schedule 4.

(b) The geotechnical instrumentation installed and monitored by the Primary Contractor shall include shallow and deep settlement monitoring gauges, slope indicator casings, piezometers/wells, surface monitoring points, and tiltmeters.

6.10.5 Monitoring of Guideway and Station Deformations

(a) Without limiting the generality of Article 6.10.1 [Scope] of this Part 2, the Primary Contractor shall develop and implement an instrumentation plan, which plan shall comply with the requirements of Article 6.10.7 [Instrumentation & Monitoring Plan] of this Part 2, that will accurately monitor the Guideway and Station deformations so as to ensure that such deformations do not, during the design life of each of the applicable components, exceed the deformation tolerances of each of the Guideway and the Stations permitted by this Agreement.

(b) Without limiting the generality of Articles 6.10.1 [Scope] and 6.10.5(a), both of this Part 2, the Primary Contractor shall carry out monitoring so as ensure that ground movements and deformations of the Guideway are consistent with the requirements of this Schedule 4, as well as any analyses carried out by the Primary Contractor with respect to such movements and deformations.

(c) The Primary Contractor shall, upon completion of each of the following:

(i) the erection of each Guideway span;

(ii) each concrete pour for any at-grade slab of the Guideway; and

(iii) the superstructure of each Station,

establish accessible survey monitoring hubs to facilitate the monitoring of Guideway and Station deformations so as to ensure that such deformations do not, during the design life of each of the applicable components, exceed the deformation tolerances of each of the Guideway and the Stations permitted by this Agreement.

(d) The Primary Contractor shall ensure that the accessible survey monitoring hubs described at Article 6.10.5(c) of this Part 2 are located, at a minimum:

(i) at each pier and at the midway point between any two piers; and

(ii) at 20m intervals where the track is not elevated or is not in a Tunnel.

6.10.6 Submittals Regarding Instrumentation and Monitoring

(a) The Primary Contractor shall submit the following to the Province's Representative:

(i) for review, acting reasonably, under the Review Procedure, the Instrumentation & Monitoring Plan at least:

A. three months prior to commencing any Construction that the instrumentation is intended to monitor; and

B. one month prior to the installation of such instrumentation;

(ii) for review, acting reasonably, under the Review Procedure and in accordance with Article 6.10.9(b) [Quality Management of Instrumentation and Monitoring] of this Part 2, the qualifications of all Instrumentation Specialist(s) within 45 days of the Effective Date;

(iii) Instrumentation & Monitoring Report(s) as described in Article 6.10.8(a) [Instrumentation & Monitoring Reporting] of this Part 2;

(iv) the testhole log for any instrumentation installed in testholes, which log must be submitted before monitoring of such instrumentation begins but no later than 10 Business Days after the completion of installation of the applicable instrumentation;

(v) the location data of each instrument, which data must be submitted before monitoring of such instrumentation begins but no later than 10 Business Days after the completion of the installation of each instrument;

(vi) except where provided otherwise in this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring], all monitoring data within 48 hours of being acquired;

(vii) in accordance with Schedule 6 [Quality Management] and this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and

Monitoring], quality management procedures with respect to the geotechnical and hydrogeological instrumentation and monitoring; and

(viii) decommissioning records, including testhole abandonment logs, waste disposal certificates, and other completed forms and documents, within 10 Business Days after completion of any work to decommission instrumentation and testholes.

6.10.7 Instrumentation & Monitoring Plan

(a) The Primary Contractor shall develop, implement, maintain and update, as in situ conditions require, an instrumentation and monitoring plan (the "**Instrumentation & Monitoring Plan**") that:

(i) is based on the requirements of this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring] and the geotechnical instrumentation program set out in the Construction Risk and Impact Assessment Report;

(ii) demonstrates the methods, measures and processes that the Primary Contractor will implement in order to fulfill the objectives set out at Article 6.10.1 [Scope] of this Part 2, including identifying which instrumentation will remain operational following the Total Completion Date and which instrumentation is to be decommissioned at or prior to the Total Completion Date;

(iii) for each instrument installed by the Primary Contractor to monitor Existing Facilities pursuant to Article 4.2.2(b)(vii) [Construction Risk and Impact Assessment Report], Part 1 of Schedule 4, defines Action Levels and the specific actions that are to be taken at each Action Level; and

(iv) identifies the proposed frequency of monitoring and reporting as developed by the Primary Contractor:

A. in accordance with the overall requirements of this Article 6 [Geotechnical]; and

B. such that timely notice is provided of significant deformations and movements (e.g. the Action Levels being approached for any instrument), as well as instrumentation malfunction or loss.

(b) The Primary Contractor shall ensure that the frequency of monitoring and reporting developed and proposed in the Instrumentation & Monitoring Report complies with the following minimum requirements:

(i) for instrumentation installed in the Bored Tunnel, monitoring is no less frequent than:

A. one reading per eight hour shift where the Bored Tunnel face is within 25m of the applicable instrument;

B. one reading per day where the Bored Tunnel face within is 50m of the applicable instrument;

C. one reading per week where the Bored Tunnel face is within 100m of the applicable instrument; and

D. one reading per month where the Bored Tunnel face is greater than 100m from the applicable instrument;

(ii) the data from the readings required under Article 6.10.7(b)(i) of this Part 2 is provided to the Province's Representative within four hours of the time of measurement; and

(iii) where not specifically identified in Article 6.10.7(b)(i) of this Part 2, otherwise in compliance with the requirements of this Article 6 [Geotechnical].

(c) By not later than 25 Business Days prior to the commencement of construction activities, the Primary Contractor shall submit the Instrumentation & Monitoring Plan, which plan shall be sealed by the Instrumentation Specialist(s), to the Province's Representative for review, acting reasonably, in accordance with the Review Procedure.

6.10.8 Instrumentation & Monitoring Reporting

(a) By not later than five Business Days prior to the commencement of construction activities, the Primary Contractor shall prepare and submit to the Province's Representative for review, acting reasonably, in accordance with the Review Procedure, report(s) ("**Instrumentation & Monitoring Report(s)**") in order to confirm that the Primary Contractor has implemented the Instrumentation & Monitoring Plan and that the objectives set out in Article 6.10.1 [Scope] of this Part 2 are being and will continue to be met. Without limiting the generality of the foregoing sentence, the Instrumentation & Monitoring Report(s) prepared by the Primary Contractor shall include the following:

(i) a summary table for all instrument installations by number and location, showing the date and the time of installation;

(ii) an initial schedule of monitoring readings to obtain baseline readings;

(iii) for any proposed instrumentation, the instrumentation specifications, including the manufacturer's technical specifications, installation procedures, operating and maintenance manuals and other descriptive literature;

(iv) for any vibrating wire instruments, test data demonstrating that the sensor has, when thermal effects have been considered, been stable for a period not less than five years under laboratory conditions;

(v) a description of the materials to be used for grout backfill of testholes;

(vi) the calibration certificates for each instrument installed;

(vii) sample reports for each instrument installed; and

(viii) a description of the baseline reading procedures employed for each instrument.

For the purposes of this Article 6.10.8(a), the 15 Business Day period referred to in Section 2.1(b) of Schedule 2 [Representatives, Review Procedure and Consent Procedure] shall be reduced to 5 Business Days.

(b) In the event that the Primary Contractor replaces, moves or repairs any instrument installed pursuant to this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring], the Primary Contractor shall, within 24 hours of any damage to any instrumentation and further within five Business Days of any decision to replace, move or repair any instrumentation but prior to undertaking any such replacement, movement or repair, advise the Province's Representative in writing of the following:

(i) the type and location of the instrument that has been damaged or is to be replaced, moved or repaired;

(ii) the reason why the instrument is being replaced, moved or repaired;

(iii) the intended timeline for the replacement, movement or repair of any instrument;

(iv) for any replacement of an instrument:

A. the type, as-built location, and calibration sheets of the new instrument; and

B. the date on which the new instrument became operational;

(v) for any instrument that is repaired:

A. the date on which the instrument is reinstalled and operational; and

B. the calibration sheets of the repaired instrument; and

(vi) for any instrument that is moved:

A. the as-built location and calibration sheets of such instrument; and

B. the date on which such instrument became operational after being moved.

6.10.9 Quality Management of Instrumentation and Monitoring

(a) In addition to the requirements set out in Schedule 6 [Quality Management], the Primary Contractor shall comply with the quality management requirements of this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring].

(b) The Primary Contractor shall retain instrumentation specialists (each an "**Instrumentation Specialist**") who must be a person who is registered as a Professional Engineer or geoscientist with ABEGBC and who must have a minimum of five years' experience designing, installing, and monitoring instrumentation systems similar to those required for the Project. The Instrumentation Specialist may be an independent individual or employee of an engineering firm, testing laboratory, or similar organization, but shall not be an employee of the Primary Contractor. The Primary Contractor shall demonstrate each proposed Instrumentation Specialist's experience by way of resume and references.

(c) The Primary Contractor shall perform all instrumentation activities described in this Article 6.10 [Geotechnical and Hydrogeological Instrumentation and Monitoring], including procurement, installation and monitoring of the instruments, under the direct supervision of the Instrumentation Specialist(s).

(d) The Primary Contractor shall perform all geotechnical and hydrogeological instrumentation surveying activities described in this Article 6 [Geotechnical] under the direct supervision of a professional land surveyor licensed with the Association of British Columbia Land Surveyors.

(e) The Primary Contractor shall carry out all surveying to tolerances of ±2mm relative to established, reliable, stable benchmarks located on competent ground, which benchmarks shall not be subject to deformations.

(f) For the Guideway deformation monitoring instrumentation, the Primary Contractor shall take three independent sets of readings to establish an initial baseline reading, which readings shall be taken no less than 20 Business Days following installation of each instrument. Thereafter, the Primary Contractor shall carry out monitoring of the instrumentation, at intervals of no more than one month, until the Total Completion Date.

6.10.10 Calibration of Instrumentation

(a) The Primary Contractor shall, in accordance with the instructions of and under the direct supervision of the Geotechnical Manager:

(i) perform all calibration in accordance with the instrument manufacturer's recommended methods;

(ii) calibrate all instruments prior to installation;

(iii) verify that calibration results are within the tolerances for the particular instrument as listed on the manufacturer's standard published data sheet for that instrument;

(iv) ensure that calibration equipment and standards are in compliance with the applicable standards of the Canadian Standards Association and are themselves in current calibration; and

(v) confirm the proper functioning of each instrument upon completion of installation.

(b) The Primary Contractor shall not utilize any instruments with calibration results that do not fall within the manufacturer's standard tolerances for monitoring purposes.

(c) The Primary Contractor shall, upon request, submit evidence of compliance with and calibration to the standards set out in this Article 6.10.10 [Calibration of Instrumention].

6.10.11 Province's Access to Instrumentation Activities

(a) Except where such access will interfere with the Work, the Primary Contractor shall:

(i) permit the Province's Representative to observe all instrumentation activities; and

(ii) during the Access Period in respect of any part of the Site, make such part of the Site available to, and otherwise accommodate this observation activity by, the Province's Representative.

6.10.12 Post-Construction Monitoring

(a) Effective as of the Total Completion Date, the Province or its designate will assume responsibility for the geotechnical and hydrogeological instrumentation required to monitor the performance of the Guideway and the Stations, including the causes and distribution of ground movements and deformations associated with the Guideway and the Stations and the deformation tolerances of each of the Guideway and the Stations. To facilitate this transfer of responsibility, the Primary Contractor shall:

(i) verify the transfer of such responsibility; and

(ii) provide the Province with all keys associated with such instrumentation.

(b) In the event that the monitoring data collected by or on behalf of the Province during the General Defect Warranty or the Latent Defect Warranty Period shows that the performance objectives of the Evergreen Line as set out in this Agreement are not being or will not be met, the Province shall be entitled to make a warranty claim in accordance with the provisions of Part 6 [Work and Warranties] of this Agreement.