GEOTECHNICAL PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall conduct geotechnical investigations, analyses, design, and construction in accordance with all applicable criteria and standards cited herein and in accordance with this Geotechnical Performance Specification.

2.0 PERFORMANCE GOALS

A) Provide foundations compatible to the existing bridge without overstressing the existing structure.

B) Minimize settlement impact to the existing embankment from the new embankment.

3.0 APPLICABLE STANDARDS AND REFERENCES

The geotechnical investigation and design shall be in accordance with this Geotechnical Performance Specification and the relevant requirements of the following standards unless otherwise stated in this Performance Specification. Standards and references specifically cited in the body of this Geotechnical Performance Specification establish requirements that shall have precedence over all others. Should the requirements in any standard conflict with those in another, the standard highest on the list presented below shall govern. The Design-Builder may use References as guidelines in addressing the requirements. It is the Design-Builder's responsibility to obtain clarification of any unresolved ambiguity prior to proceeding with design or construction. Items listed as standards or references in this Geotechnical Performance Specification shall be the most recent version available at the time of issuance of the Scope of Services Package.

3.1 STANDARDS

A) AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007 with 2008 and 2009 Interim Revisions;

B) LA DOTD Standard Specifications for Roads and Bridges, 2006 Edition except Section 804; and

C) LA DOTD Special Provisions – Section 804 (Revised for LRFD).

3.2 REFERENCES

A) Subsurface Investigations, FHWA-HI-97-021, 1997;

B) Drilled Shafts: Construction Procedures and Design Methods Manual, FHWA IF-99-025, 1999;

C) Design and Construction of Driven Pile Foundations, Volumes 1 and 2, FHWA HI-95-038, 1998;

D) Soils and Foundation Workshop Manual, FHWA;

E) Earth Retaining Structures, FHWA-NHI-99-025, 1999;

F) Prefabricated Vertical Drains, Vol. No. 1, FHWA- RD-86-168, 1986;

G) XSTABL, Version 5, Interactive Software Designs, Inc. 1994 or PCSTABL4;

H) LA DOTD MSEW Design Guide, Pavement and Geotechnical Services Section;

I) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines, FHWA NHI-00-0043, 2001;

J) Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, FHWA Demonstration Project 82 Ground Improvement, FHWA NHI-00-044, 2000;

K) Geosynthetic Design and Construction guidelines, FHWA HI-95-038, current edition;

L) Geotechnical Instrumentation Manual, FHWA HI-98-034, 1998;

M) Advanced Technology for Soil Slope Stability, Volume 1: Slope Stability Manual FHWA-SA-94-005, 1994;

N) LA DOTD Bridge Design Manual, including memorandums and any revisions issued by the State Bridge Engineer prior to date of the Final Scope of Services Package;

O) LA DOTD Special Provisions and Supplemental Specifications;

P) LA DOTD Standard Drawings;

Q) Subgrade Soil Borings from Amite River to Juban Road; and

R) As-Built Plans for Range Avenue, Grey’s Creek, and 4H Club Road.

4.0 REQUIREMENTS

4.1 GEOTECHNICAL PLANNING REPORT

The Design-Builder shall prepare a Geotechnical Planning Report for the Project and submit the Geotechnical Planning Report within 60 days from Notice to Proceed for review and written comment. The Geotechnical Planning Report shall include a detailed method statement describing the general philosophy and methods of design and construction and the rationale for selection of the proposed construction methods for all geotechnical and foundation aspects of the Project. The method statement shall indicate how material and design details are chosen to match selected construction methods, construction details, and the soil and groundwater environment for the site.

The Design-Builder shall provide details of equipment and methods proposed for foundation and earthwork construction and demonstrate how they are consistent with the design approach and assumptions. The details presented shall demonstrate compliance with the Geotechnical Performance

Specification requirements and shall demonstrate an understanding of the ground conditions and Project constraints as defined within this Contract.

The Design-Builder shall submit the following technical information with the Geotechnical Planning Report:

A) Description of geology and various ground types to be encountered along the alignment;

B) A description of the geotechnical information that was collected and analyzed in developing the interpretation used to develop the Design-Builder's Proposal and pricing for the Project;

C) Assessment of the engineering properties of all soil types, including the expected average and range of soil strengths and deformation properties;

D) Design parameters for all soil types;

E) Anticipated ground behavior and categorization of ground during excavation, filling, and foundation and retaining structure construction;

F) Support of excavation and groundwater control considerations;

G) A narrative describing how any interpretation was derived from the geotechnical data;

H) Consideration for, discussion of, and rationale for protection of existing structures, bodies of water, and environmentally or historically sensitive areas; and

I) Any pertinent geotechnical data used as a basis for selection, design, and installation of the proposed foundation elements.

The Geotechnical Planning Report shall define the engineering and design approach that will be followed in order to develop technically and environmentally acceptable and durable foundations, cut and fill slopes, retaining structures, and geotechnical designs for the Project. The Geotechnical Planning Report shall discuss all aspects of the required geotechnical effort and design and analysis, including the following:

1) Additional Subsurface investigations;

2) Determination of geotechnical and foundation design parameters;

3) Erosion control measures and design and analysis;

4) Embankment and fill settlement and slope stability analysis;

5) Retaining wall design and analysis;

6) Planned field testing quality control programs, including pile and drilled shaft integrity and load testing and ground improvement testing;

7) Ground improvement or treatment of in-situ soils;

8) Selection, design, and analysis of foundation systems;

9) Lateral and vertical earth pressures;

10) Instrumentation and monitoring programs; and

11) Expected serviceability and durability of proposed solutions.

The Geotechnical Report shall be prepared and signed and sealed by a Licensed Professional Engineer registered in the State of Louisiana meeting the qualification requirements in Appendix 108C – Key Personnel Qualifications and Requirements.

4.2 SUBSURFACE INVESTIGATION AND DATA ANALYSIS

4.2.1 General

The geotechnical information including soil boring logs are included in the LA DOTD as-built bridge plans for Gray's Creek Bridges; westbound 4H Club Road bridge and westbound Range Avenue Bridge. The Design-Builder shall conduct additional investigations in accordance with the scope specified herein and any additional investigations the Design-Builder deems necessary to establish the geotechnical conditions and to perform all geotechnical and foundation design and analyses.

These additional investigations and testing shall be conducted in accordance with the reference items identified in Section 3.2.

The Design-Builder shall form its own interpretation of the existing geotechnical data and satisfy itself as to the nature of the ground and sub-soil, the form and nature of the site, and nature of the Work that may affect its detailed design, construction method, and tools. LA DOTD neither assumes nor implies any other warranty regarding the data provided, other than that the information was obtained at locations and depths indicated and to the accuracy of the data at the time of testing.

The additional investigations to be performed by the Design-Builder shall supplement the data provided by the LA DOTD. The Design-Builder shall determine the number and location of additional investigations in accordance with the requirements presented in Table 10.4.2-1 of the AASHTO LRFD Bridge Design Specifications (herein after AASHTO Specifications). Subsurface investigation requirements not covered in the AASHTO Specifications are presented in Table 3.2.1. Existing investigation borings may be combined with the additional investigations to comply with the requirements presented in Table 3.2.1. Cone Penetration Test soundings may be considered as an alternative to all borings where the Design-Builder considers it appropriate provided that a sufficient number of borings are performed at Cone Penetration Test sounding location to develop reliable correlation between the boring and Cone Penetration Test results. The Design-Builder shall provide the results of investigations to the LA DOTD in a memo as follows:

A) The logs of borings,

B) Cone Penetration Test soundings,

C) the field records of any field investigations; and

D) Laboratory test results.

Table 3.2.1 Minimum Requirements for Additional Investigations

Geotechnical Feature	Minimum Investigation Locations
Roadways	The spacing of borings or Cone Penetration Tests along the roadway alignment shall not exceed 200 feet. The spacing and location of the borings shall be selected considering the geologic complexity and soil/rock strata continuity within the Project area with the objective of defining the vertical and horizontal boundaries of distinct soil units within the Project limits.
Embankments and Cuts	The spacing between borings shall be no greater than 200 feet. At critical locations, provide a minimum of three borings in the transverse direction to define the existing geological conditions for stability analysis.
Culverts	A minimum of one boring at each culvert with embankment height greater than five feet. Additional borings shall be provided for long culverts or in areas of erratic subsurface conditions.

Note: Except as specified herein, LA DOTD and AASHTO standards shall be followed with respect to planning and performing subsurface exploration programs.

4.3 FOUNDATION DESIGN

Maximum pile loads, foundation embedment and geotechnical design for Project structures shall conform to AASHTO Specifications, 4th Edition. The Design-Builder shall not use screw piles or existing foundations. Timber piles and spread footing foundations shall not be used for bridge foundations, but may be considered for support of retaining walls in accordance with Section 3.4 of the Geotechnical Performance Specification.

The LRFD method shall be used to design the foundations. Foundation types that are not included in the AASHTO Specifications shall be allowed, if the Design-Build provides the properly calibrated resistance factors for Louisiana soils based on the calibration methods presented in NCHRP 507. All backup of the calibration shall be submitted for review and approval. LA DOTD may reject the resistance factors at its discretion.

4.3.1 Deep Foundations

Allowable pile loads for piles fully laterally supported shall not exceed the values Listed in the LADOTD Bridge Design Manual (herein after Bridge Design Manual).

Pile bent structures shall meet buckling requirements as per the Bridge Design Manual. The Design-Builder shall consider non-axial pile loads and shall analyze pile bent structures considering slenderness limitations to determine if they are acceptable.

For shaft penetration considerations, the geotechnical support capacity of the drilled shafts shall be determined and shall be verified by appropriate number of field load testing acceptable to LADOTD. In addition, the Design-Builder shall demonstrate that the differential settlement between the existing foundation and drilled shaft shall not exceed ¼ inches.

Concrete for drilled shafts shall be in accordance with Class S Concrete as specified in the LA DOTD Standard Specifications for Roadways and Bridges (herein after Standard Specifications), except that, a) the minimum concrete strength shall be 3,800 psi, b) the coarse aggregate shall be Grade P, but with a maximum size of ¾ inch, and c) the slump shall be between 7 and 9 inches.

The center to center spacing of drilled shafts and piles shall be at least three times the larger diameter (drilled shaft or pile) of the adjacent foundation elements. This spacing requirement applies to both between the new foundations and between the new and existing foundations. At the locations where the available space does not allow for the space of foundations to meet this requirement, the Design-Builder shall design the foundation so that interaction between the closed spaced foundations does not induce more than 1/8 inch of movement of the existing foundation.

4.3.2 Vertical Capacity

Deep foundations shall be analyzed for axial compression and uplift resistance, using static analysis methods in accordance with AASHTO Specifications. A resistance factor consistent with the level of construction control (i.e., test piles, wave equation, and dynamic monitoring) and site variability shall be applied to the ultimate capacity in accordance with AASHTO Specifications. The capacity shall be verified by appropriate number of field tests as specified in the AASHTO Specifications. The effectiveness of base preloading, if used for drilled shafts, shall be demonstrated by Osterberg load tests conducted both prior to and following preloading operations, with the number of Osterberg load tests determined in accordance with Article 4.3.7 of this Geotechnical Performance Specification.

4.3.3 Settlement

The design of deep foundations shall consider the total and differential settlement tolerances of the proposed structures. Settlement and differential settlement shall not exceed the design tolerances, or the tolerances specified in the Bridge Design Manual, whichever is less. Settlement induced by the deep foundation group or individual deep foundation elements in the subsoil shall be evaluated.

4.3.4 Downdrag (Negative Skin Friction)

The design of deep foundations shall consider the effect of downdrag (negative skin friction) from ongoing ground settlement, construction dewatering, variable groundwater conditions, placement of fill or embankments, and/or pile installation. Downdrag loads shall be determined by considering the load transfer distribution along the deep foundation element as well as the group layout. Appropriate load factors in accordance to the AASHTO Specifications shall be applied to evaluate the foundation behavior.

4.3.5 Lateral Load Capacity

Deep foundations shall be designed to adequately resist the lateral loads transferred to them from the structure without exceeding the allowable deformation of the structure or overstressing the structure or foundation elements.

Where the lateral resistance of the soil surrounding the piles is inadequate to resist the applied loads, the use of batter piles may be considered. Where battered piles are proposed, the battered piles shall not encroach on property outside the Right-of-Way (ROW). Battered drilled shafts shall not be used.

4.3.6 Wave Equation Analyses

The constructibility of a pile design and the development of pile driving criteria shall be performed using a wave equation computer program. The use of dynamic pile driving formulas will not be an acceptable method for developing driving criteria or performing drivability studies to determine hammer energy requirements.

4.3.7 Deep Foundation Testing and Monitoring

Field testing shall be performed for deep foundations to evaluate foundation capacity and integrity, to verify design assumptions, to determine foundation installation characteristics, to evaluate the pile driving system performance, and to establish foundation depths. The foundation testing and monitoring shall include indicator, monitor, and test piles or drilled shafts; dynamic testing; static load testing; non-destructive integrity testing; and Quality Control (QC) testing. All foundation testing shall be performed by the Design-Builder, using testing personnel or Subconsultants, qualified and experienced in performing and interpreting the required foundation testing.

A pile driving analyzer shall be used to determine if each hammer is delivering the energy required by the design. Dynamic pile testing and static load testing shall be performed in accordance with the Bridge Design Manual and the Standard Specifications, except as specified herein. Dynamic testing shall be performed on all test piles, indicator piles and monitoring piles. Not less than five percent of the production piles shall be used as monitoring piles.

Static load tests shall be performed on piles in accordance with the Bridge Design Manual and the revised Section 804.11 of the Standard Specification (revised for LRFD), except as specified herein. Static load tests shall be performed at each of the locations representative of the different subsurface conditions, pile types, pile capacities, and pile depths. The number and locations of these other load test piles shall be determined by the Design-Builder and included in their cost estimate and planning report.

Osterberg Load Cell tests shall be performed on drilled shafts at each of the locations representative of different subsurface conditions, drilled shaft capacities, and drilled shaft diameter and depths in accordance with LA DOTD EM804. The number and locations of these other load test shafts shall be determined by the Design-Builder.

Integrity testing consisting of Crosshole Sonic Logging shall be performed on all drilled shafts. The testing shall be performed in accordance with Section 814.19 of the Standard Specifications.

Prior to the start of construction activities, the Design-Builder shall prepare and submit a detailed description of the proposed foundation testing and monitoring programs to the LA DOTD for their review and comment. The description shall include specifications and plans presenting the type, purpose, number, location, and procedures for each test and the recording and reporting procedures. Testing and monitoring of deep foundations shall be in accordance with the applicable LA DOTD, ASTM, and AASHTO specifications.

4.3.8 Drilled Shaft Foundations

Drilled shaft foundations may be considered. In addition to the structural requirements, the design of the drilled shaft foundations will consider minimizing the impact to the existing foundations. The new drilled shaft foundation shall be designed to cause no more than 1/8 inch of settlement to the existing foundations. The Design-Builder shall show the calculations and monitor the settlement during construction and one year post construction to verify the achievement of the design objectives.

4.4 RETAINING WALL DESIGN

Retaining walls may consist of mechanically stabilized earth (MSE) walls, cast-in-place concrete cantilever walls, or other types of walls suitable to the required application and all performance requirements. Wall types that shall not be used for permanent applications are identified in the Structures performance Specifications. All walls shall be designed for a minimum service life of 75 years for general case and for a minimum service life of 100 years when the walls support structure loads.

MSE walls used for the Project shall include only those wall systems included on the LA DOTD's list of qualified wall systems. The Design-Builder may propose a MSE wall system that is not currently included on the LA DOTD list of qualified wall systems, but it will be necessary to submit all information required by LA DOTD regarding the proposed wall system and for LA DOTD to add the proposed wall system to the LA DOTD list of approved wall systems before the proposed wall system can be used for the Project.

Design of MSE walls shall be in accordance with procedures presented in the FHWA's "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines" (referenced in Section 3.2). Design of other types of retaining walls shall conform to current engineering practice as defined in the AASHTO Standard Specifications for highway Bridges indicated in Section 3.1 as applicable to the specific type of wall used.

4.4.1 Design Loads

4.4.1.1 Vertical Loads

The loads used in the design of permanent Work shall be in accordance with the requirements of the relevant design codes and Standards, except where herein modified or augmented.

Estimation of live loads due to pedestrian, or highway traffic shall be in accordance with the requirements of AASHTO LRFD Specifications.

Loads due to soils or backfill shall be derived using the maximum values of the saturated densities. Only where it can be clearly demonstrated that the fill is well drained, and will remain well drained in the future, shall any reduction in the degree of saturation be allowed. The submerged densities shall be used for soil unless the location is above the standing water table.

4.4.1.2 Lateral Pressure

Lateral earth pressures shall be estimated on the basis of the anticipated movement of the structure. For yielding retaining structures, Rankine's active pressure theory shall be used. However, for unyielding structures, where the movement of the structures is not sufficient to mobilize active pressures, and/or where compacted backfill is placed behind the structure, the lateral pressure on the structures shall be evaluated on the basis of anticipated movements, site-specific subsurface conditions and construction methods. The pressure on unyielding structures shall not be less than at-rest pressure. The design of the retaining structures shall be based on the maximum lateral pressures that will develop behind the structures.

Hydrostatic pressure induced by the groundwater table, when present, shall be included in the lateral pressures. Additional hydrostatic pressures and variations in groundwater conditions due to flooding and rapid drawdown conditions shall be considered in the design of the retaining structures.

4.4.2 Deep Foundations

Deep foundations for retaining walls shall be designed in accordance with Subsection 4.3.

4.4.3 Shallow Foundations

Shallow foundations for retaining walls are permitted where there is a suitable bearing stratum near the surface. But shallow foundations shall not be used where scour or erosion could undermine or adversely impact the performance of the foundation.

Shallow foundations shall be analyzed for bearing capacity in accordance with AASHTO Specifications. Punching and local failure of the footing shall also be evaluated. Walls shall be proportioned so that the resultant of all forces acting falls within the middle third of the footing base.

Analyses shall be conducted to estimate the total and differential soil settlement, induced by the foundation loads. The analyses shall consider immediate settlement for granular soils and immediate settlement, primary consolidation and secondary compression for cohesive soils. Shallow foundations shall be designed to maintain wall settlements (total and differential) within the applicable tolerances specified in the FHWA Manual on Earth Retaining Structures (Reference E in Section 3.2).

4.4.4 External and Internal Stability

The external analyses shall be conducted in accordance with the AASHTO Specifications (Article 11.6.2.3) and the internal stability analyses shall be in compliant with the AASHTO Specifications.

4.5 FILL/EMBANKMENT DESIGN

4.5.1 Excavation and Embankment

Excavations and embankment construction shall be in accordance with the requirements of Section 203 of the Standard Specifications for Roads and Bridges. Embankment cross sections shall be in accordance with the requirements of the Roadway Performance Specification.

4.5.2 Slope Stability

Particular attention shall be given to the design of all soil and rock embankment side slopes, whether temporary or permanent. The analyses shall consider the effects of deterioration and loss of soil resistance due to local climatic and construction conditions. All slopes shall be designed to minimize erosion by rainfall and runoff. Adequate drainage and erosion control provisions should be incorporated in the design and construction of the embankments in accordance with Subsection 4.9.

Slope stability analyses shall be conducted using a suitable computer program acceptable to LA DOTD. Circular and wedge type failures shall be analyzed for potential occurrence for each embankment configuration and slope. The evaluation of global slope stability shall consider potential seepage forces and any weak deposits and seams that are adversely impacted by water flow. The AASHTO resistance factors (Article 11.6.2.3) shall be used to analyze the stability of slopes.

4.5.3 Settlement

Analyses shall be conducted to estimate the soil settlement induced by the embankment loads. Immediate settlement in granular soils and both immediate and consolidation settlements in cohesive soils shall be considered. Embankments shall be designed to keep estimated total long term settlements limited to one inch during a period of 75 years after completion of the pavement construction. Differential settlement both within fill sections and across fill/structure interfaces shall be limited to 1/300. Embankment settlement shall be monitored and assessed during the duration of the Contract to verify that the specified settlement criteria will be achieved.

4.6 REINFORCED SOIL SLOPE (RSS) DESIGN

The design procedures and considerations for reinforced soil slopes shall conform to the requirements of the FHWA Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines, [see Section 3.2(I)]. Performance requirements shall follow the requirements set forth in the AASHTO Specifications.

Adequate drainage provisions, slope protection and erosion control provisions shall be incorporated into the RSS designs in accordance with requirements of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines and as required in Subsection 4.9.

4.7 SOIL IMPROVEMENT

The use of soil improvement to increase soil strength and reduce compressibility in order to increase the safety factors for external and internal stability and reduce settlements to the allowable range specified herein will be allowed in the design. It shall be necessary to demonstrate their suitability for local conditions and installation methods. Techniques such as vertical drains, surcharge, stone columns, vibrocompaction, lime columns, cement columns, deep soil mixing, rammed aggregate pier, and grouting may be included in the design in order to expedite consolidation of the subsoils, where it is required to increase bearing capacity or reduce post-construction settlements.

All soil improvement systems shall be designed using current practice and procedures. The performance of all ground improvement techniques shall be verified with a pre-production field testing program developed to demonstrate that the proposed methods and design will provide the ground improvement level required to satisfy the performance requirements specified herein.

4.8 SOIL CUT SLOPES

Geotechnical analyses of soil cut slopes shall be performed to assess soil slope stability along new and existing soil cuts.

Potential circular and wedge type failure modes shall be analyzed for each soil cut and each slope and orientation. Geotechnical analysis of soil cut slopes shall be performed using suitable computer programs approved by LA DOTD (see Section 3.2, Reference G). The resistance factors from Article 11.6.2.3 of AASHTO specifications shall be used.

4.9 EROSION CONTROL AND DRAINAGE

Slopes in both cut and fill areas are subject to erosion and deterioration through the action of water, wind and freeze/thaw cycles. Numerous existing slopes along the Project alignment have been significantly affected by erosion. Erosion control and drainage measures shall be evaluated, considered and designed for all new and existing slopes. Erosion of slopes presents a significant maintenance issue and stability problem on slopes. Soil strata that are susceptible to erosion shall be mapped and delineated for all existing and new fills and cuts. Slope protection measures shall be evaluated on site-specific conditions, such as surface and subsurface conditions, cut geometry, and susceptibility of erosion or deterioration. Each cut and fill slope that requires erosion control and drainage measures shall be evaluated for the following:

A) Reduction of Water Flow across Slope;

B) Slope Revegetation;

C) Slope Armor;

D) Subsurface Water Control.

4.10 CONSTRUCTION INSTRUMENTATION MONITORING PROGRAM

The Design Builder shall prepare a geotechnical instrumentation program to monitor settlement, lateral movement of temporary and permanent embankments, cuts and structures during construction. Consideration shall be given to extending instrumentation monitoring for a period after completion of construction when long-term performance issues are a concern. For foundations placed within 4 diameters (the larger of the adjacent pile, pile group, or drilled shaft) of the foundation element, the Design-Builder shall provide settlement monitoring for the new and the existing foundations during construction and one year post construction to verify the design objectives are met. The Design-Builder shall prepare a report detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. Upon acceptance of the instrumentation plan, threshold values and response plan, the Contractor shall provide, install and monitor the instrumentation during and after construction and interpret the data. Construction instrumentation monitoring reports shall be submitted to the LA DOTD not less than every two weeks. Corrective actions shall be taken where the instrumentation data so warrant.

The design shall protect adjacent structures and utilities against damage due to the construction of the permanent Work. Limiting values of movement (horizontal and vertical) and distortion on each structure and utility within the zone of influence of the Work shall be established and submitted to LA DOTD for review. Instrumentation shall be used to monitor all preload embankments to verify the effectiveness and duration of the surcharge loading. Vibration monitoring shall be performed in according with the requirements in the Environmental Mitigation and Compliance Performance Specification. The extent of the monitoring program will depend on the size and type of the facilities.

A detailed monitoring program shall be prepared for each structure, utility and embankment affected by the Work, subject to review by LA DOTD. The instrumentation and monitoring program shall include appropriate types and quantities of monitoring instruments capable of measuring horizontal and vertical movements, soil pore water pressures, vibrations, and noise, as applicable.

The design and distribution of instrumentation shall demonstrate an understanding of the need, purpose and application of each proposed type.

4.11 AS-BUILT PLANS

As-Built Plans shall include foundation detail sheets signed and sealed by the Geotechnical Engineer. These sheets shall include appropriate information necessary to detail the design and construction of foundations. Examples of such information to be provided include the following:

A) Pile data tables;

B) Pile lengths;

C) Pile tip elevations; and

D) Pile cutoff elevations.