Geotechnical and Structural Assessment - Hopedale Mission Provisions House, Hopedale Mission National Historic Site, Hopedale, NL

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1.0 INTRODUCTION

Acting at the authorization of the Nunatsiavut Government (NG), on behalf of Aivek Stantec Limited Partnership (Aivek), Stantec Consulting Ltd. (Stantec) has carried out a geotechnical and structural assessment at the Hopedale Mission Provisions House, Hopedale, Newfoundland and Labrador. It is understood that the purpose of this assessment was to provide information to support implementation of repairs to the Provisions House which is at risk of long-term deterioration, loss of the character-defining elements and posing a safety risk to visitors.

1.1 Background

The Provisions House is a Cultural Resource of National Historical Significance built in 1817. The 2008 Commemorative Integrity Statement Evaluation listed the resource as in Poor Condition including deterioration of materials and a notable structural lean. Based on initial investigations by Parks Canada Agency (PCA) assets and structural engineers at Public Works and Governments Services of Canada (PWGSC), it is suspected by PCA and PWGSC that settlement is most likely the cause of the lean as well as possible deterioration of sill plates. A follow-up site evaluation was completed by a Heritage Conservation Engineer confirming the condition and providing a report [ref. 1].

1.2 Scope of Work

Further to our proposal dated September 19, 2016, the following scope of work was completed as outlined below:

1.2.1 Geotechnical

- Review all available existing geotechnical reports and documentation related to the Provisions Warehouse;
- A site visit was conducted by a geotechnical engineer from Stantec who completed the following:
  - Perform a cursory visual assessment of the site and significant above grade features that relate to the subsurface conditions that may affect future foundation designs, such as ground covering, soil and loose fill, exposed bedrock, and water features.
  - Perform a visual assessment of the six (6) test pits which were excavated by archeologists from Gerald Penney Associates Limited (GPA). Five (5) test pits were originally proposed, however, an additional test pit was completed at the exterior of the northeast corner of the structure.
  - Perform soundings of soil (rebar probes) up to 1000 mm beyond the exterior face of the foundation walls.
- Conduct geotechnical laboratory testing on selected soil samples, as required;
  - Submit a draft geotechnical report as outlined below.

- Summarize background information, current site conditions, and observations.
- Assess the soil and bedrock characteristics and provide a summary of findings.
- Prepare geotechnical recommendations to support the two designs proposed; new shallow foundation system and/or rehabilitation of the existing foundation walls using piles.
- Provide recommendations for protection against frost heave and soil erosion.
- Submit a final report following receiving comments of the draft report.

1.2.2 Structural

- Review all available existing structural reports and documentation related to the Provisions Warehouse;
- Conduct a site visit by a structural engineer from Stantec who will complete the following:
  - Perform a cursory visual assessment of the structure and existing above ground foundations.
  - Assess the current site conditions compared to the previous findings.
- Submit draft structural report as outlined below.
  - Prepare a summary of foundation options for the following:
    - new shallow foundation system, or
    - rehabilitation of the existing foundation walls using piles.
  - Prepare conceptual structural sketches for the two possible foundation options.
  - Develop a Class D cost estimate for both designs.
  - Submit a final report following receiving comments on the draft report.

This report has been prepared specifically and solely for the project described above.

1.3 Conservation Approach

Conservation is defined as all actions or processes that are aimed at safeguarding the character defining elements of an historic place to retain its heritage value and extend its physical life. This may involve preservation, rehabilitation, restoration, or a combination of these actions or processes.

Preservation is the action or process of protecting, maintaining, and/or stabilizing the existing materials, form, and integrity of an historic place, or of an individual component, while protecting its heritage value.

Rehabilitation is the action or process of making possible a continuing or compatible contemporary use of an historic place, or an individual component, while protecting its heritage value.

Restoration is the action or process of accurately revealing, recovering, or representing the state of an historic place of an individual component, as it appeared at a particular period in its history, while protecting its heritage value.

The 2010 PWGSC Moravian Mission Structural Investigation report and historical places website provides a summary of the relevant components included under the historical designation. The Hopedale Mission site is National Historic building in part since by itself and collectively, the mission buildings are good examples of Moravian Mission architecture in Labrador and as such it is assumed that if falls under Section 4.3 Guidelines for Buildings. Although the foundations are not specifically mentioned in the character statement it is assumed that they fall under this section and are specifically covered under Subsection 4.3.8 Structural System of Standards and Guidelines of Historic Places in Canada. Foundation inspection, assessment, and recommendations have been conducted to provide the least alterations and impact while ensuring the structural integrity of the whole building.

2.0 SITE AND GEOLOGY

The Hopedale Mission Provisions House is part of the Hopedale Mission National Historic Site of Canada which is a complex of large, wooden buildings constructed by the Moravian Church in Hopedale, Newfoundland and Labrador. The Provisions House is a two-storey timber framed structure supported on a dry laid stone foundation. The Moravian Mission at Hopedale was first established in 1782, with Provisions House being constructed later in 1817.

The topography in Hopedale is dominantly bedrock controlled and has been shaped by glacial and glaciofluvial events. Generally thicker overburden deposits can be expected in valleys. Exposed bedrock or concealed by vegetation and overburden veneers is common along the crests of ridges. In the area of the Provisions House, bedrock is exposed along the east side of the structure and appears to slope downwards to the west.

Based on previous site investigations completed by Stantec in Hopedale, the overburden materials generally consist of veneers of organic soils overlying exposed bedrock or sequences of till, and occasional glaciomarine, colluvial and fluvial deposits overlying bedrock. Overburden thicknesses on the order of 9 m have been encountered in previous investigations. A variety of depositional environments have occurred in the Hopedale area (i.e., glacial melting, river flow, moraines, marine regression/transgression). Therefore, there is a range of surficial materials across the area, which may include organic soil, sands and gravels (with varying proportions of clay, silt, cobbles and boulders), clays and silts.

Based on a review of the published regional bedrock map (map 1668A) and memoire 43, from The Geological Survey of Canada, the community of Hopedale is situated within the geological block known as the Hopedale Block. In general, the bedrock within the community consists of a variety of volcanic and sedimentary type rock that have been metamorphosed to form green schist and amphibolite type rock.

3.0 FIELD PROCEDURES

3.1 Geotechnical

The field work was completed on September 27, 2016 and consisted of visually assessing the site and surrounding topography, inspecting six (6) test pits and completing seven (7) rebar probes around the outside perimeter of the structure. The original test pit locations were selected by PCA. TP-06 was added to the field program to further assess the soil and bedrock conditions at the northeast corner of the structure.

Test pits were hand dug by archeologists from GPA and the approximate test pit locations are shown on Drawing No. 01 located in Attachment E. The test pits were backfilled with the excavated material following completion. Results of the test pits are presented on the Test Pit Records located in Attachment B.

The field work was conducted under the inspection of a senior geotechnical engineer from Stantec who maintained detailed field records of the various soil strata and groundwater conditions encountered. The soils were classified in general accordance with the procedures outlined in the attached explanatory key: Symbol and Terms Used on Borehole and Test Pit Records. Representative soil samples were obtained directly from the test pits. All soil samples were stored in moisture proof containers and sent to our laboratory in St. John's for classification and testing. Samples remaining after testing will be stored for a period of three (3) months at which time they will be discarded, unless instructions to the contrary are received.

Rebar probes were completed by driving rebar of 1.22 m (48 inch) length and 12.7 mm (1/2 inch) diameter into the ground using a medium-sized sledge hammer. Probes were advanced to refusal on bedrock or to practical depths ranging from 0.08 m to 1.04 m below the ground surface. Results of the bedrock probes are summarized below in Table 5.1. Rebar probes were also completed at the base of select test pits. Results of the probes completed in the test pits are presented on the attached Test Pit Records.

The rebar probe locations were selected by Stantec considering accessibility and of exposed bedrock around the building. The approximate locations of the probes are shown on the attached Drawing No. 01. It is recommended that a final survey of the test hole locations be completed by others to determine elevations and co-ordinates.

3.2 Structural

The structural field work was also completed on September 27, 2016 and consisted of a general visual inspection of the existing dry stack stone foundation. The field work was conducted under the inspection of a structural engineer from Stantec and utilized the archeologists test pits to view the extents of the foundation. A walkthrough of the entire building was also completed to ensure understanding of the overall load transfer and supporting system of the structure including looking for signs of structural distress further to the 2010 Structural Investigation report.

4.0 LABORATORY TESTING

Laboratory testing consisting of gradation analysis, moisture content, and organic content testing were performed on representative samples obtained from test pit locations. Results of the laboratory testing are located in Attachment C and are also presented on the Test Pit Records (Attachment B).

5.0 SUMMARIZED SUBSURFACE SOIL CONDITIONS

Subsurface conditions observed in the test pits are summarized in the subsections below and described in detail on the attached Test Pit Records along with an accompanying explanatory key: Symbols and Terms used on Borehole and Test Pit Records. Representative photographs of the excavated test pits located in Attachment D.

In general, the test pits encountered a gap/void beneath the building floor boards, which extended to the top of the soil materials. The upper soil materials consisted of intermixed sand and gravel fill with trace to some organics in all test pits except TP-02. A highly organic soil was encountered as at TP-02.

Underlying the upper soil materials, a loose to compact, brown, poorly graded sand with silt (SP-SM) to a silty sand (SM) layer was encountered with the exception of TP-02. In the test pits, rebar was driven into this silty sand layer and terminated on inferred refusal on bedrock, or reached the limits of the rebar. No evidence of fine-graded soils (i.e., silt or clay) was observed in the test pits, or as soil smear on the rebar surface.

Bedrock was inferred based on the rebar refusal at some rebar probe and test pit locations. A summary of the rebar probes (PB's) are presented in Table 5.1.

Table 5.1 Summary of Soil Soundings/Rebar Probes

Rebar Probe ID	Rebar Depth Below Ground Surface (m)	Inferred Bedrock Refusal
PB-01	1.04	No
PB-02	0.99	No
PB-03	0.97	No
PB-04	0.84	No
PB-05	0.08	Yes
PB-06	0.23	Yes
PB-07	0.94	No

Based on the limited bedrock data along the west side of the structure, as well as the lack of elevation survey data at the test holes, the presentation of the current bedrock data by way of contour mapping would not be representative of the actual bedrock conditions under the structure. To better understand the depth to bedrock beneath the structure, a borehole investigation would be required.

Groundwater seepage was not encountered in the test pits. Wetting of the rebar was noted at several test pits and is presented on the attached Test Pit Records.

6.0 STRUCTURAL FOUNDATION ASSESSMENT

The existing building foundation consists of a shallow dry stacked stone that is approximately 3 courses high. The stones are small and of irregular shape that appear to have limited interlocking features and do not allow for a proper coursing or bonding. The foundation is in poor condition and could have contributed to the current deferential settlement causing the overall building to lean to the west. This is consistent with the current understanding of the geotechnical conditions in the area which shows the building foundations on the east side founded on or near bedrock and the bedrock sloping down as it approaches the west side for the building. This is also consistent with past reports including the 2010 structural investigation report by the Heritage Conservation Directorate. The soils present are also susceptible to frost heave action and the relative difference in depth to bedrock on the east versus the west also compounds the issue.

Previous attempts to repair the foundation have been completed and documented. Some of the repairs included mortaring areas of the stone work together and infilling gaps between the foundation and timber sill with cement based mortars and concrete. Some stones were observed to be loose and were able to be removed by hand including some of the stones that were unearthed in the test pit areas.

As developed and discussed in the 2010 Moravian Mission Structural Investigation report, the settled foundation and building lean does not appear to be a recent or new occurrence. No additional distress of a structural significance was noted when compared to the 2010 structural investigation in the wood frame components during the recent site walk through. When taking both points into consideration and the fact that it has withstood the environmental and usage loading since its original construction in 1817, the building is not considered to be at immediate structural risk.

7.0 DISCUSSION

7.1 Geotechnical Discussion

The comprehensive report completed by the Heritage Conservation Directorate (HCD) from the PWGSC was reviewed by Stantec for the preparation of this report [ref. 1]. A thorough discussion of the foundation and highlights from a previous archaeological investigation completed in 2001 were presented.

Further to HCD's structural report, the following geotechnical related items are noted:

- Settlement of the foundation is considered to be the predominant cause of the observed leaning of the warehouse and can be attributed to three major factors:
  - the foundation bears on varying thickness of soil above bedrock resulting in differential settlement;
  - the foundations are very shallow and the soil is frost susceptible; and,
  - the dry laid stone construction of the foundation is highly susceptible to localized settlements.
- The settlement of the foundation is not a recent development and the warehouse is not considered to be at risk of collapse.
- The rate of settlement of the foundation is unknown and it is recommended that monitoring be initiated to establish the rate of settlement occurring. This foundation monitoring must occur prior to the development of any treatment options.
- It is recommended that archaeological and geological investigations be carried out to help decide on the possible foundation treatment options.

As shown in the attached photographs taken by Stantec and the findings presented in HCD's structural report, it is evident that the structure is leaning significantly. It is understood that leaning of the structure has been documented as far back as the 1970s; however, there is no data currently available to indicate that the structure lean is worsening.

Based on our understanding of the site and observations during our site visit, we provide the following geotechnical related comments and recommendations:

- Results of the test pitting indicate that the foundation walls were likely placed directly on the ground surface (i.e., on top of sod) or in the natural undisturbed sandy soils. The natural undisturbed sands encountered are typically suitable for lightly loaded structures such as the Provisions House. It is expected that the sod layer would have a negligible effect on the longer term performance of the foundations.
- From a bearing capacity (ultimate limit states) perspective, the natural sands encountered at the site appear to have performed satisfactorily and there is no evidence of bearing capacity failure.
- From a settlement (serviceability limit states) perspective, it is evident that the structure is not performing satisfactory. From a geotechnical perspective, the settlement may be attributed to differential settlements related to the varying soil thickness (i.e., sloping bedrock) beneath the structure. However, frost heave may also have been a contributing factor.
- Boreholes completed by Stantec for NG in 2015 show that discontinuous clay layers exist in the areas around the Mission. Clayey type soils can experience long term consolidation and secondary settlements. However, loose sands with organics can also contribute to the long term settlements, but would be less of a contributing factor at this site.
- It is anticipated that any further settlements would be small; however, further monitoring would be required to confirm this assumption. In order to fully understand the subsurface soil conditions and complete a detailed settlement analysis, a borehole investigation with a subsequent laboratory testing program would be necessary. This program would allow the assessment of the existence of clay within the building footprint.
- The foundation walls are not sufficiently deep to protect from frost penetration and potential frost heave. Historically, residential structures in Hopedale have had significant issues with frost heave. If frost heave was to occur, it would be expected that it would be more pronounced the west side, where the overburden layer is thicker.
- The laboratory testing indicates that, the sandy soils encountered on site are frost susceptible. Based on the Canadian Foundation Engineering Manual (2006), the soils can be classified as Frost Group F2 to F3 (i.e., low to medium frost susceptibility). There are three basic conditions required for frost heave (or frost action) to occur, which include: a frost-susceptible soil; a supply of water; and soil temperatures sufficiently low to cause some pore water to freeze. Typically soils that have relatively high fines content have a high frost-susceptibility (i.e., silts, clayey silts, silty sands). Clean sands and gravels are typically considered to have a very low frost-susceptibility. The frost-susceptibility of clays can vary significantly depending on the silt content and permeability.
- From a geotechnical perspective, it is expected that rehabilitation of the existing foundations or a new shallow foundation system consisting of concrete footings would be feasible. It is anticipated that any additional loading from a new foundation system or rehabilitation would be minimal and therefore, any additional settlements could be negligible. We recommend a borehole investigation program be carried out so that geotechnical input of ultimate limit states and serviceability limit states analysis of new foundations can be provided,
- The installation of piles end-bearing on bedrock is also an option for structure rehabilitation. In order to complete the pile design, a geotechnical borehole investigation and laboratory testing program is required.

- In general, there are three practical options to protect footings from frost heave,
  - Construct a new foundation system extending footings to bedrock or to 3.0 m below the ground surface.
  - Construct a new foundation system at the current foundation depths and installed rigid insulation beneath the footing a minimum of 2.44 m extending both to the exterior and interior of the footings.
  - Installation of piles end-bearing on bedrock. Piles would be protected or coated to resist frost heave forces.

7.2 Structural Foundation Discussion

There are several options that could be explored as a part of the structural stabilization of the Provisions House. As per the standards and guidelines of the conservation of historic places, considerable effort has been undertaken to apply the least intervention required to ensure a safe and stable historic and cultural resource. It is believed that attempts at stone infilling and grouting would have little positive effect to the structure while it would have a negative effect by altering the historical character.

We have focused on options to attempt to retain the structure while providing a stable resource for the future. A combination or alteration of the below options may prove to be the best solution, and actual geotechnical features such as depth to bedrock could change the approach.

A determination of leveling the existing building was not considered in this phase of the report however it could be incorporated into both Options 2 and 3 presented below. Additionally, the condition or the supporting system for the exterior floor sill beam could not be seen and assessed during the time of the site visit.

7.2.1 Option 1 – Minor Repairs and Site Work

The current dry stack stone foundation has undergone differential settlement. The PCA reports suggests that immediate failure is unlikely to occur therefore minor work and site work is a short term repair option. Minor repairs consist of localized efforts to provide sound support for the building structure including probing for loose stack stone and adding injection grouting in deteriorated areas to establish an improved load transfer. Similar previous repairs have been completed on the foundation but have since deteriorated and therefore most repairs must be redone. This repair scenario would affect the historical character of the support structure by changing the look and functionality of the dry stack stone. It is recommended that along with localized repairs, insulation and a proper drainage system be provided around the perimeter of the entire structure to reduce the presence of water and reduce risk of movement due to frost. This recommendation is common for all further options discussed in this report.

It is important to note that this is a short term repair option only and not a permanent solution, as it is unknown whether the building has finished settling.

The opinion of probable cost for this system is $50,000.

7.2.2 Option 2 – Helical Pile Foundations

The current foundation arrangement is shallow and susceptible to frost heave and possible additional settlement. To overcome these issues a foundation system supported below the frost line or on bedrock is recommended. Geotechnical helical piling is a technique that could preserve the original structure as much as possible and leave much of the existing foundation system in place. Conceptually, a helical pile would be installed just outside the existing building columns in 8 locations on both the east and west sides and 2 locations on both the north and south sides and would extend to bedrock or dense/hard bearing soils. The dry stack stone would then be removed in the immediate vicinity of the pile and load transferring concrete pier or encased steel be installed to transfer the building load to the piles. The removal of the stone and load transfer connection at each column location should be completed before the next column is undermined. The stacked stone between the subsequent new support systems could be left in place for historical significance.

It is important to note that information is required to determine if the surrounding earth would heave due to frost to ensure that the new supports are designed for uplift. This information would be gained as a part of a monitoring program in Section 7.3.

A conceptual representation for this option is included in Attachment E identified as option 2. The opinion of probable cost for this system is $330,000.

7.2.3 Option 3 – Micro Pile/Pile Cap Foundations

The third option for consideration is a new foundation system that would extend around the entire perimeter of the building. Similar to Option 2, it brings the base of the new foundation below the frost line or to bedrock, whichever is closer. Small, approximately 1 m, segments of the building would be undermined to remove the existing stacked stone foundation and subsurface. Micro pile groups would be drilled, up to a depth of 6 m, installed and grouted, and a concrete pile cap would be placed on top of the micro pile group. Once adequate concrete strength has been achieved the pile cap would be stripped and backfilled. The adjacent section would then have the process repeated until the entire structure has been completed.

This option will provide the required structural stabilization however it is intrusive and dry stacked stone would be removed reducing some of the historical characteristics of the site. It is important to note that information is required to determine if the surrounding earth would heave due to frost to ensure that the new supports are designed for uplift. This information would be gained as a part of a monitoring program in Section 7.3.

A conceptual representation for this option is include in Attachment E identified as Option 3. The opinion of probable cost for this system is $470,000. This assumes an arrangement of two micro piles at 1 m intervals around the perimeter of the building and a continuous pile cap. If the piles were found to be able to be spaced further apart the cost would be reduced.

7.2.4 Option 4 – Shallow Foundation

The fourth option for consideration is a new foundation system that would extend around the entire perimeter of the building. Similar to Option 3, it brings the base of the new foundation below the frost line or to bedrock, whichever is closer. Small, approximately 1 m, segments of the building would be undermined to remove the existing stacked stone foundation and subsurface. New jack posts are installed and then encased in concrete with the traditional strap footing style for the excavated area. Once adequate concrete strength has been achieved the foundation would then be stripped and backfilled. The adjacent section would then have the process repeated until the entire structure has been completed. This would provide the required structural stabilization however it is the most intrusive and all the dry stacked stone would be removed reducing some of the historical characteristics of the site. A further understanding of the potential for frost heave would be required before implementation.

A conceptual representation for this option is include in Attachment E identified as Option 4. The opinion of probable cost for this system is $475,000.

7.3 Other Recommendations

Stantec recommends that movement of the structure be continually monitored from hence forth, until an action plan has been decided upon. The PCA report states that the exact reason for settlement is undetermined. Monitoring of movement and accessing the patterns is an integral part in developing a reliable solution for the foundation, as it will provide information about frost heave and further settlement. To our current knowledge, the recommendations for this program from the 2010 report have not been implemented. The suggested program would provide valuable information to ensure that any planned alterations are minimal and best preserve the historical character of the site. Details of the program are presented in Attachment F of the 2010 report. Adjusting the presented cost by 6 years at 4% inflation the opinion of probable cost for a 5-year assessment is estimated at $105,000.

Stantec also recommends that all options to support the building frame bear on the wooden columns or sills. The dry stack stone has undergone deferential settlement and the bearing surfaces are uneven and difficult to predict. There is a high potential to damage the structure if point loads and uneven transfer of loads are induced to the building frame when attempting to underpin the existing dry stack stone.

During the site visit some items were noted for recommendation outside of the current scope of work but that could affect the overall building structure. The recommendations are as follows:

- The deck on the east of the existing building should be cut back / trimmed to prevent contact with building. Wear marks on exterior face of building indicate that contact has occurred.

- Stored materials should be removed from the second and third floor to reduce weight.
- Changes to the building occupancy that have the potential to increase the load seen by the foundations should be avoided until foundation repair have been implemented.

8.0 CLOSURE

Use of this report is subject to the Statement of General Conditions attached. It is the responsibility of the Nunatsiavut Government, who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these not be satisfied. The Statement of General Conditions addresses the following: use of the report; basis of the report; standard of care; interpretation of site conditions; varying or unexpected site conditions; and planning, design, or construction.

Should any additional information be required, please do not hesitate to contact our office at your convenience.

Best Regards,

STANTEC CONSULTING LTD.

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This Permit Allows
STANTEC CONSULTING LTD.
To practice Professional Engineering in Newfoundland and Labrador.
Permit No. as issued by PEGNL J0291
which is valid for the year 2017

9.0 REFERENCES

[1] Moravian Mission, Structural Investigation, Heritage Conservation Directorate Professional and Technical Service Management, Real Property Branch of Public Works and Government Services Canada, HCD Project Number: R.011094.084, 2010.

ATTACHMENT A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

ATTACHMENT B

Symbol and Terms Used on Borehole and Test Pit Records
Test Pit Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

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TEST PIT RECORD

CLIENT: Nunatsiavut Government
PROJECT: Geotechnical and Structural Assessment - Hopedale Mission Provisions House
LOCATION: Hopedale, NL
DATES (mm-dd-yy): DUG 9-27-16
WATER LEVEL 1.09m 9-27-16

TEST PIT No. TP-01
PROJECT No. 121619875
DATUM See Notes

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES OTHER TESTS
		Measurements taken from top of floor					
0		VOID: Gap from floor to top of soil					
		Loose to compact, poorly graded SAND with silt (SP) to silty SAND (SM) with seams of organics: FILL - High moisture content of 38.1% likely due to organic content is soil			BS	1	S
1		REBAR (BEDROCK) PROBE: Inferred, loose to compact, SAND - Advanced rebar from 0.79 to 1.40 m depth, moderate to difficult driving		∇			
		End of Test Pit - Bedrock not encountered. - Foundation exposed along north wall. Wall consists of stacked rock and appears to be founded on sod, then native soil at a depth of approximately 0.8 m. - Rebar wet at approximately 1.09 m depth.					
2							

UNDRAINED SHEAR STRENGTH - kPa ★ 20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

10 20 30 40 50 60 70 80

TEST PIT RECORD

Stantec

CLIENT Nunatsiavut Government
PROJECT Geotechnical and Structural Assessment - Hopedale Mission Provisions House
LOCATION Hopedale, NL
DATES (mm-dd-yy): DUG 9-27-16 WATER LEVEL N/A

TEST PIT No. TP-02
PROJECT No. 121619875
DATUM See Notes

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80) / WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
		Measurements taken from top of floor						
0		VOID: Gap from floor to top of soil						
		Brown to black, sandy Organic Soil - Soil appears to be nutrient rich with organic content of 19.7% at 0.45m depth - Occasional cobbles (possibly part of wall)			BS	1		
		End of Test Pit - Bedrock encountered at 0.48 m depth. - Foundation wall consists of stacked rock. Sod layer (50-75mm) between underside of wall and bedrock at a depth of approximately 0.5 m. - No signs of groundwater observed.						
1								
2								

TEST PIT RECORD

Stantec

CLIENT	Nunatsiavut Government	TEST PIT No.	TP-03
PROJECT	Geotechnical and Structural Assessment - Hopedale Mission Provisions House	PROJECT No.	121619875
LOCATION	Hopedale, NL		
DATES (mm-dd-yy): DUG	9-27-16 WATER LEVEL 0.79m 9-27-16	DATUM	See Notes

Measurements taken from top of floor

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	OTHER TESTS
0		VOID: Gap from floor to top of soil					
		Loose, SAND (SP) with seams of organics: FILL					
		Loose to compact, brown, poorly graded sand with silt (SP) to a silty sand (SM)			BS	1	S
		REBAR (BEDROCK) PROBE: Inferred, loose to compact, SAND - Advanced rebar from 0.71 to 0.94 m depth, moderate resistance during driving		∇			
1		End of Test Pit - Inferred bedrock at 0.94 m depth based on rebar refusal. - Foundation wall consists of stacked rock with some concrete, appears to be founded on sod, then native soil. - Rebar wet at approximately 0.79 m depth.					
2							

UNDRAINED SHEAR STRENGTH - kPa ★ 20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

10 20 30 40 50 60 70 80

TEST PIT RECORD

Stantec

CLIENT	Nunatsiavut Government	TEST PIT No.	TP-04
PROJECT	Geotechnical and Structural Assessment - Hopedale Mission Provisions House	PROJECT No.	121619875
LOCATION	Hopedale, NL	DATUM	See Notes
DATES (mm-dd-yy): DUG	9-27-16	WATER LEVEL	0.91m 9-27-16

Measurements taken from base of 6"x6" perimeter brown lumber

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	OTHER TESTS
0		VOID: Gap from 6"x6" lumber to top of soil					
		Loose, SAND (SP) with seams of organics: FILL					
		Loose to compact, brown, poorly graded sand with (SP) to a silty sand (SM)			BS	1	
		REBAR (BEDROCK) PROBE: Inferred, loose to compact, SAND - Advanced rebar from 0.61 to 1.14 m depth, difficult driving		∇			
1							
		End of Test Pit - Inferred bedrock at 1.14 m depth based on rebar refusal. - Foundation wall consists of stacked rock and appears to be founded on sod, then native soil at a depth of 0.6 m. - Rebar wet at approximately 0.91 m depth					
2							

UNDRAINED SHEAR STRENGTH - kPa ★

20 40 60 80

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

10 20 30 40 50 60 70 80

Stantec

TEST PIT RECORD

CLIENT Nunatsiavut Government
PROJECT Geotechnical and Structural Assessment - Hopedale Mission Provisions House
LOCATION Hopedale, NL
DATES (mm-dd-yy): DUG 9-27-16 WATER LEVEL N/A

TEST PIT No. TP-05
PROJECT No. 121619875
DATUM See Notes

UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80)
WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)

Measurements taken from base of clapboard and 0.9 m from the exterior wall

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	OTHER TESTS
0		VOID: Gap from base of clapboard to top of soil					
		SOD					
		Loose, brown, poorly graded sand with silt (SP) interbedded with sod layers: FILL					
		Loose to compact, brown, poorly graded sand with silt (SP) to a silty sand (SM)			BS	1	
1		REBAR (BEDROCK) PROBE: Inferred, loose to compact, SAND - Advanced rebar from 0.63 to 1.07 m depth, moderate resistance during driving					
2		End of Test Pit - Inferred bedrock at 1.07 m depth based on rebar refusal. - Foundation wall consists of stacked rock with concrete and appears to be founded on sod, then native soil at a depth of 0.6 m. - No signs of groundwater observed.					

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TEST PIT RECORD

CLIENT: **Nunatsiavut Government**
PROJECT: **Geotechnical and Structural Assessment - Hopedale Mission Provisions House**
LOCATION: **Hopedale, NL**
DATES (mm-dd-yy): DUG **9-27-16**
WATER LEVEL: **N/A**

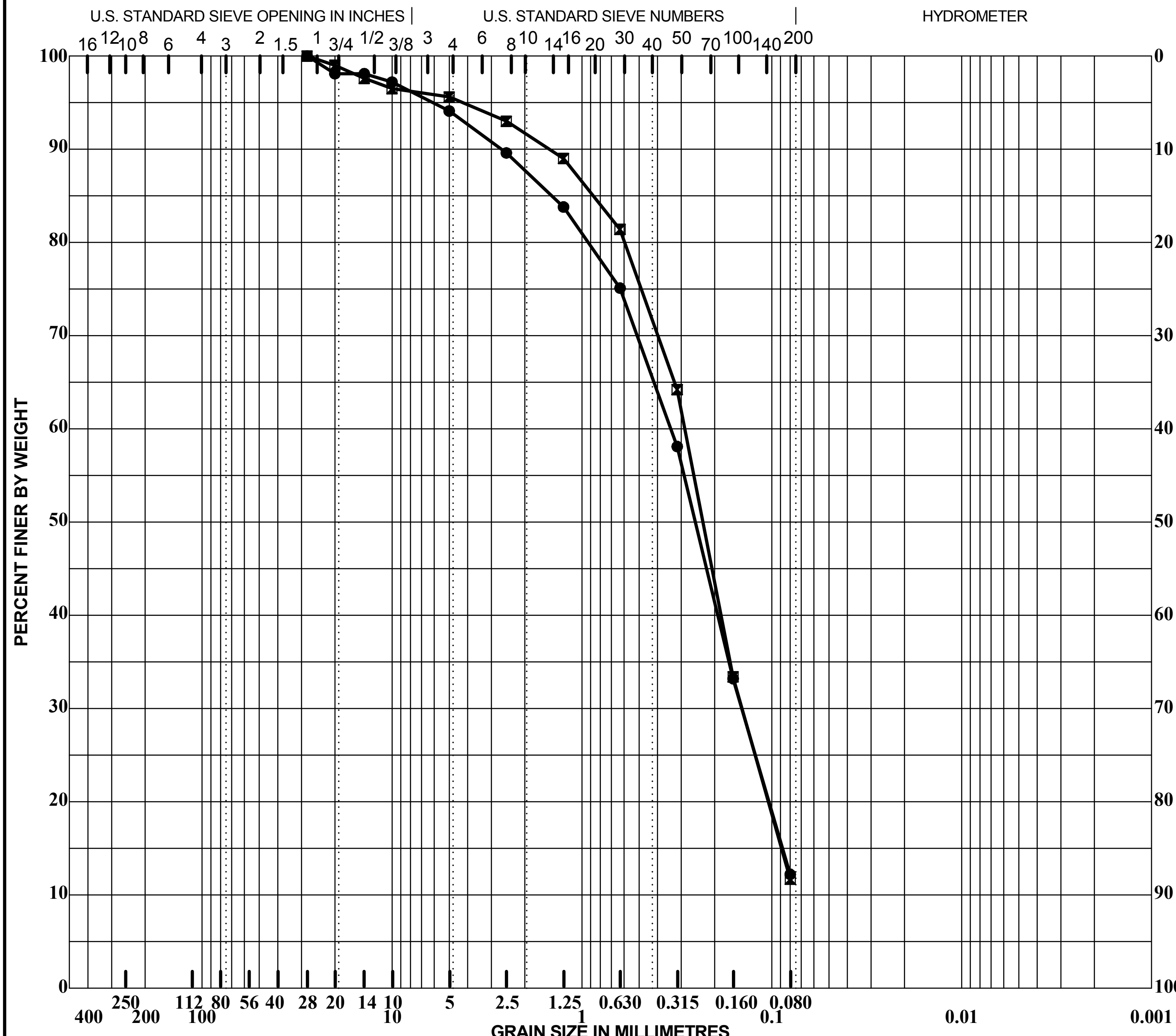
TEST PIT No. **TP-06**
PROJECT No. **121619875**
DATUM **See Notes**

Measurements taken from base of clapboard and 0.3 m from the exterior wall

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa ★ (20, 40, 60, 80); WATER CONTENT & ATTERBERG LIMITS W_P W W_L (10, 20, 30, 40, 50, 60, 70, 80)
0		VOID: Gap from base of clapboard to top of soil						
		SOD						
		Loose, poorly graded SAND with silt (SP) with seams of organics: FILL						
		REBAR (BEDROCK) PROBE: Inferred, loose to compact, SAND - Advanced rebar from 0.63 to 1.07 m depth, moderate resistance during driving						
1								
		End of Test Pit - Bedrock not encountered. - Foundation wall consists of stacked rock with concrete and appears to be founded on sod, then native soil at a depth of approximately 0.6 m. - No signs of groundwater observed.						
2								

ATTACHMENT C

Laboratory Results



COBBLE	GRAVEL		SAND			SILT and CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (m)	Description	W%	W_L	W_P	I_P
●	TP-01 BS1	0.71	Silty SAND (SM)	38.1			
⊠	TP-03 BS1	0.69	Poorly graded SAND with silt (SP-SM)	13.5			

	Sample	Depth (m)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TP-01 BS1	0.71	28.00	0.34	0.144		5.9	81.9	12.2	
⊠	TP-03 BS1	0.69	28.00	0.29	0.144		4.4	83.9	11.7	

REMARKS:

Stantec

Client: **Nunatsiavut Government**

Project: **Geotechnical and Structural Assessment - Hopedale Mission Provisions House**

Project No.: **121619875**

Location: **Hopedale, NL**

FIGURE 1

GRADATION CURVES

ATTACHMENT D

Photographs

Photo 1a – TP1

Photo 1b – TP1

Photo 1c – TP1

Photo 2a – TP2

Photo 2b – TP2

Photo 2c – TP2

Photo 3a – TP3

Photo 3b – TP3

Photo 3c – TP3

Photo 4a – TP4

GEOTECHNICAL AND STRUCTURAL ASSESSMENT - HOPEDALE MISSION PROVISIONS HOUSE, HOPEDALE MISSION NATIONAL HISTORIC SITE, HOPEDALE, NL

Photo 4b – TP4

Photo 4c – TP4

Photo 5a – TP5

Photo 5b – TP5

Photo 5c – TP5

Photo 5d – TP5

Phot 6a – TP6

Photo 6b – TP6

Photo 6c – TP6

Photo 6d – TP6

Photo 7a – PB-02

Photo 7b – PB-02

Photo 8a – Looking at Southeast Corner

Photo 8b – Looking at Southeast Corner

Photo 9a – Looking at West Side of the Building

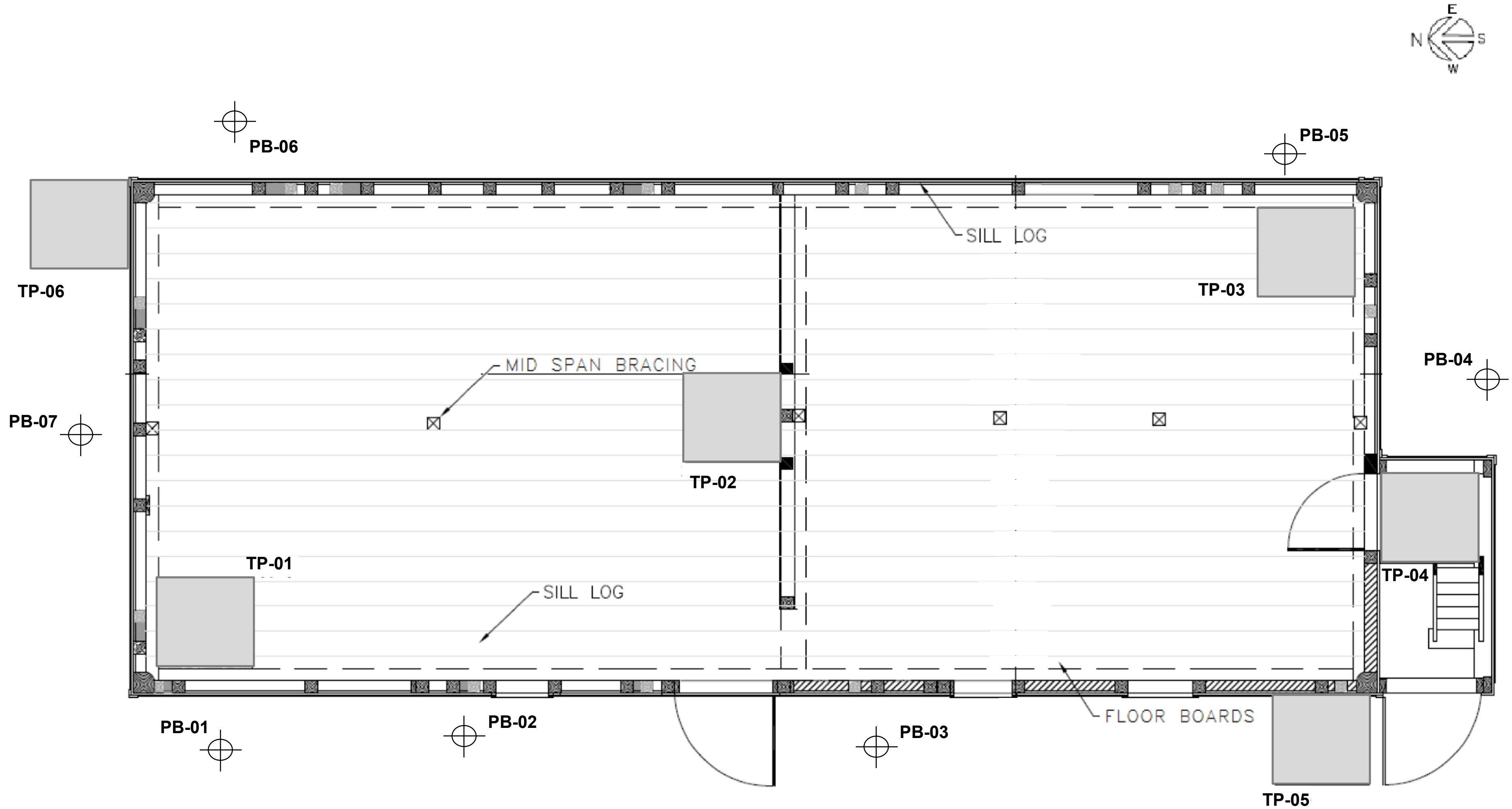
Photo 9b – Looking at West Side of the Building

Photo 10a – Looking at Northeast Corner

Photo 11a – Looking at North Side leaning

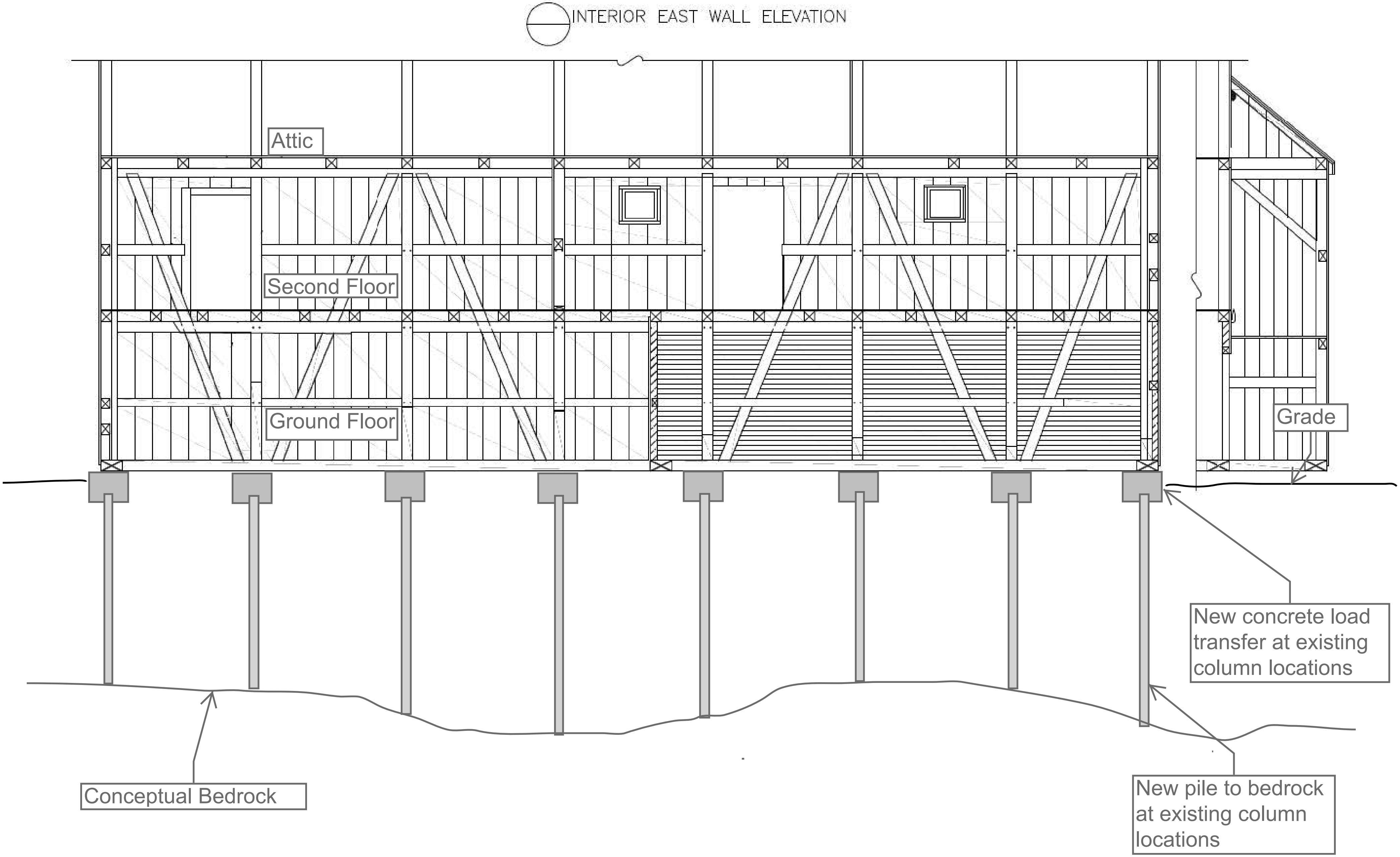
ATTACHMENT E

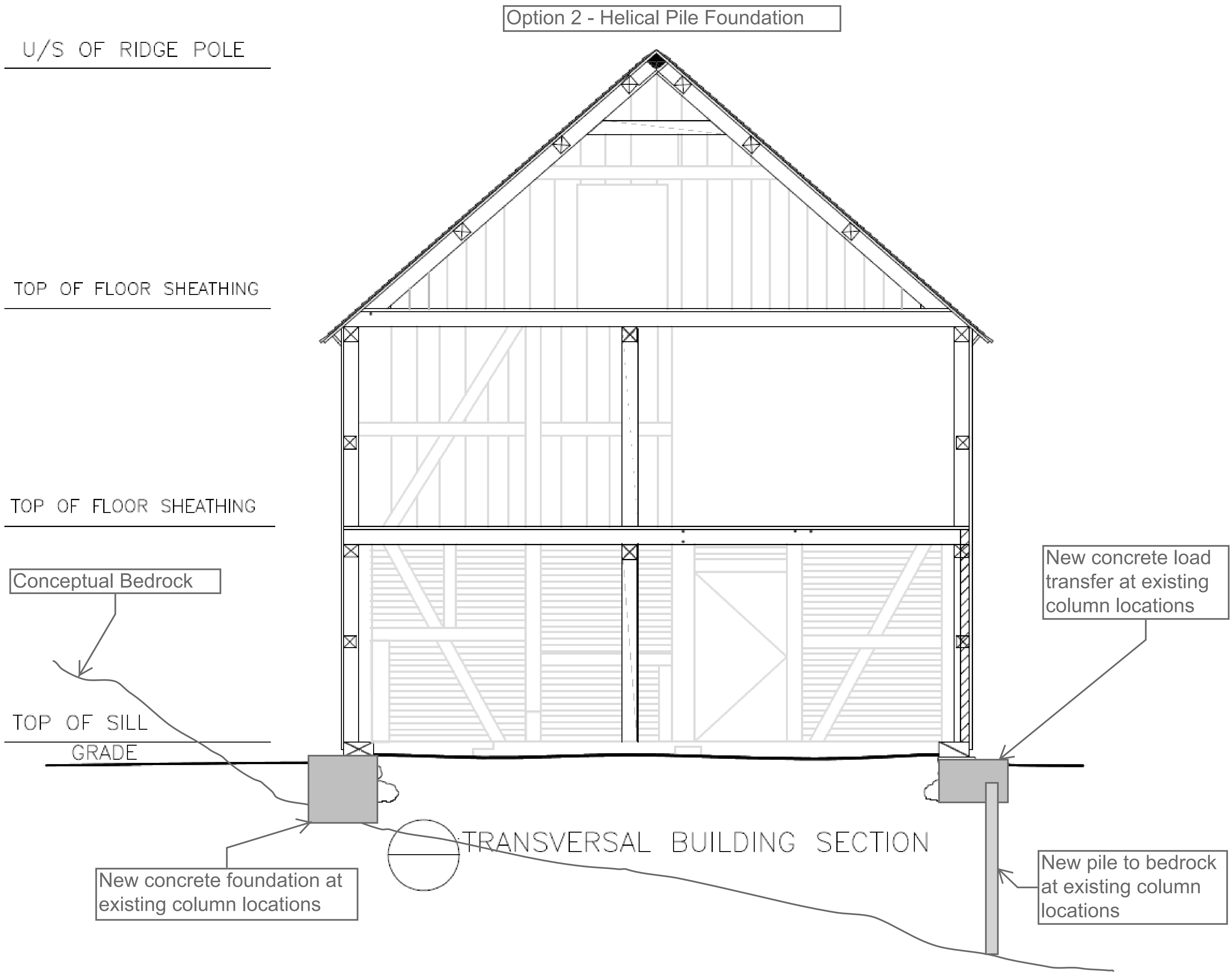
Drawings

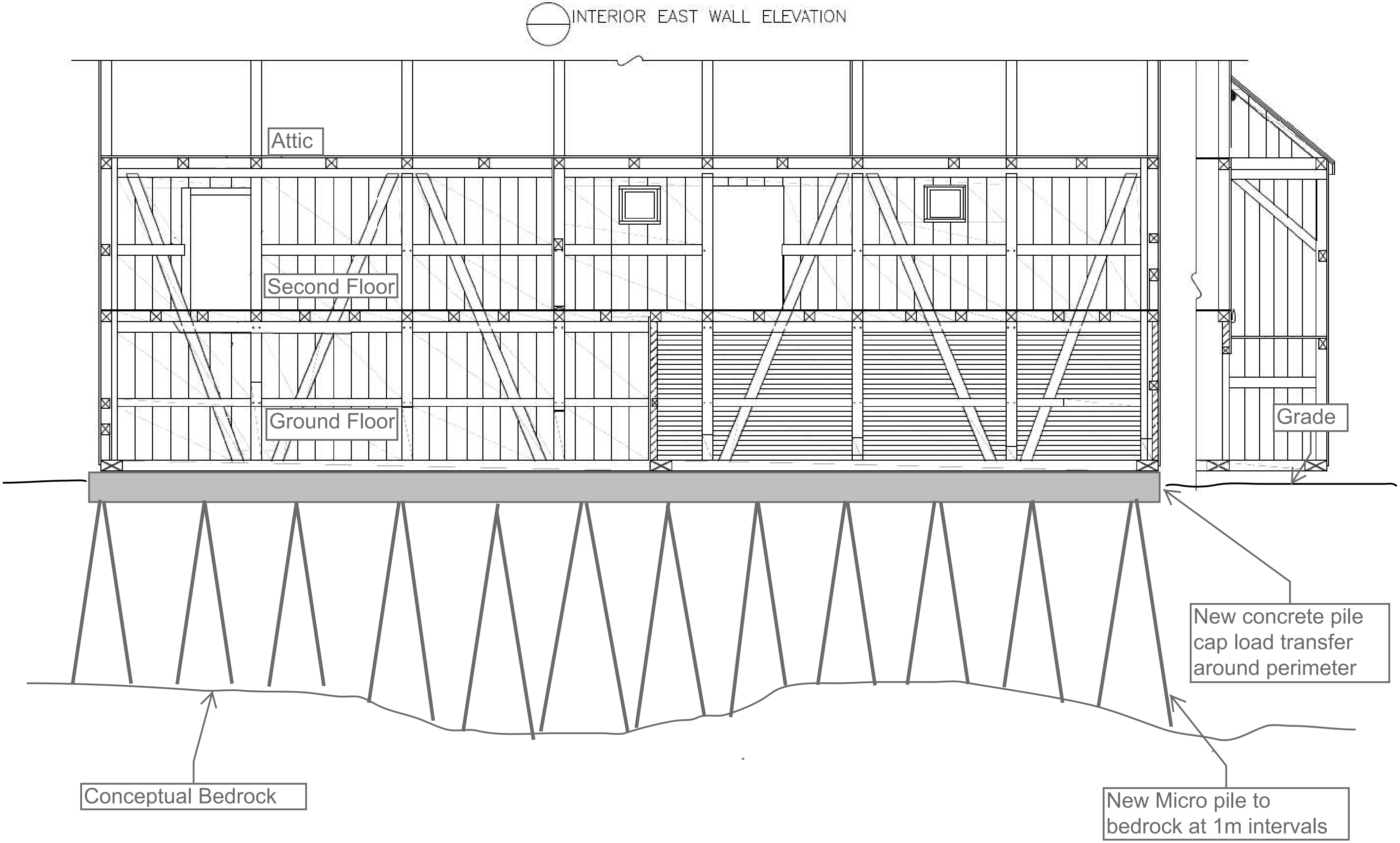


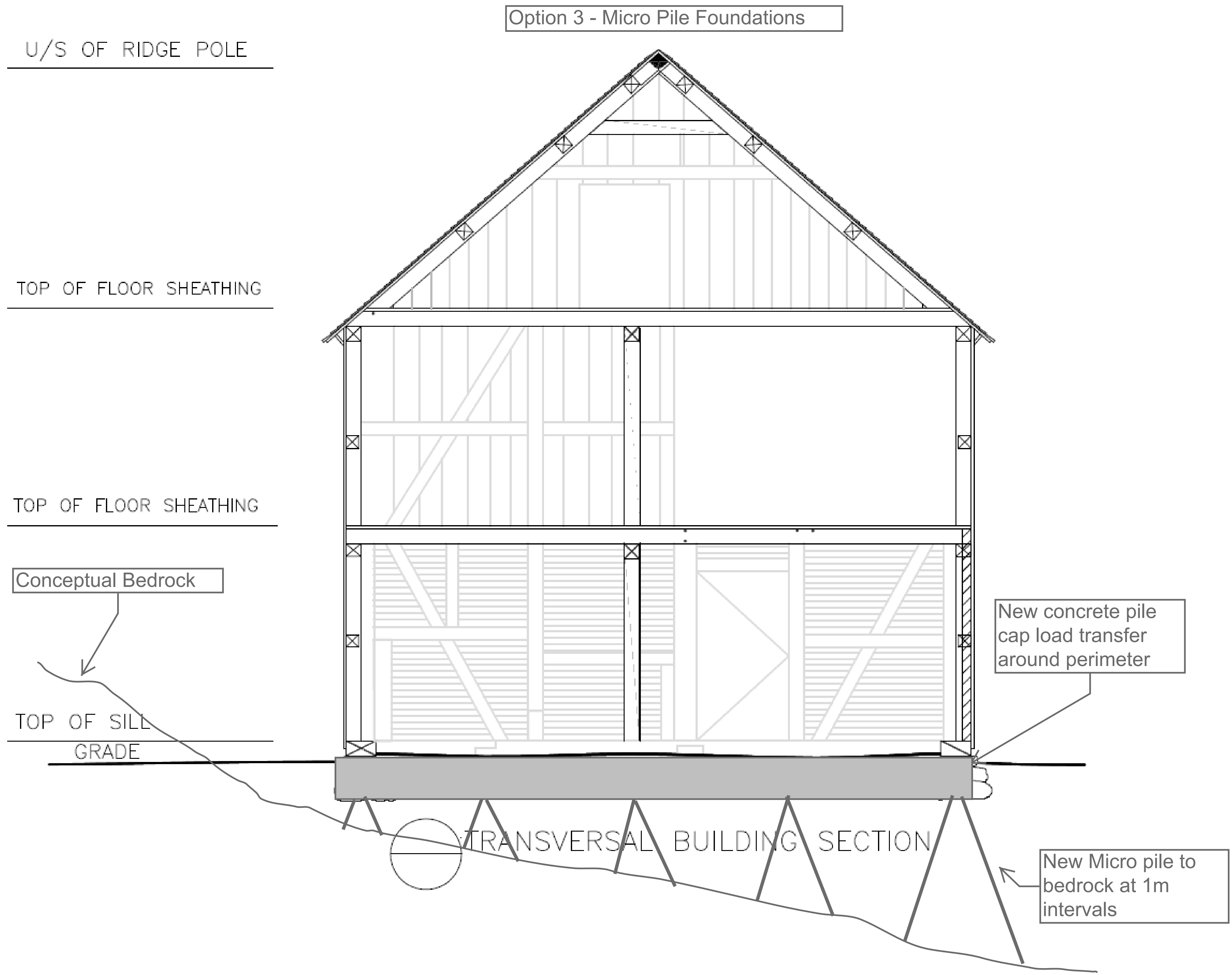
NOTES:
- Not to Scale. For illustration purposes only.
- All test hole locations and dimensions are approximate
- Site plan based on Parks Canada's SOW drawing

Project:	Geotechnical and Structural Consultation – Provisions Warehouse, Geotechnical and Archaeological Investigation, Hopedale, NL	**Drawn:**	SDP	**Drawing Title:** Test Hole Site Plan	Stantec
Client:	Nunatsiavut Government	**Date:**	11/22/2016		
Project #:	121619875	**Checked:**	JJ/SDP	**Drawing No.:** 01	

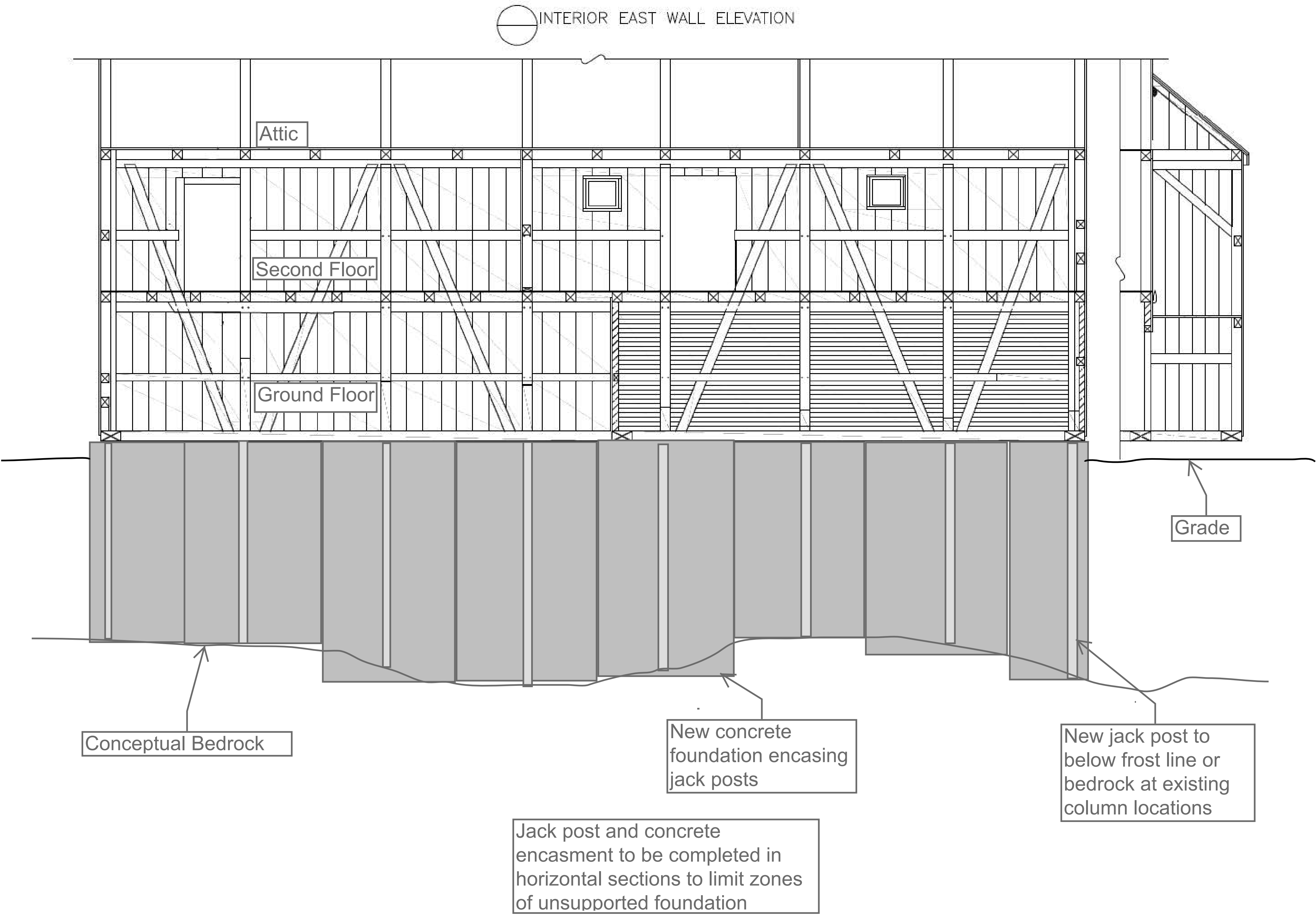

INTERIOR EAST WALL ELEVATION
Attic
Second Floor
Ground Floor
Grade
New concrete load transfer at existing column locations
New pile to bedrock at existing column locations
Conceptual Bedrock

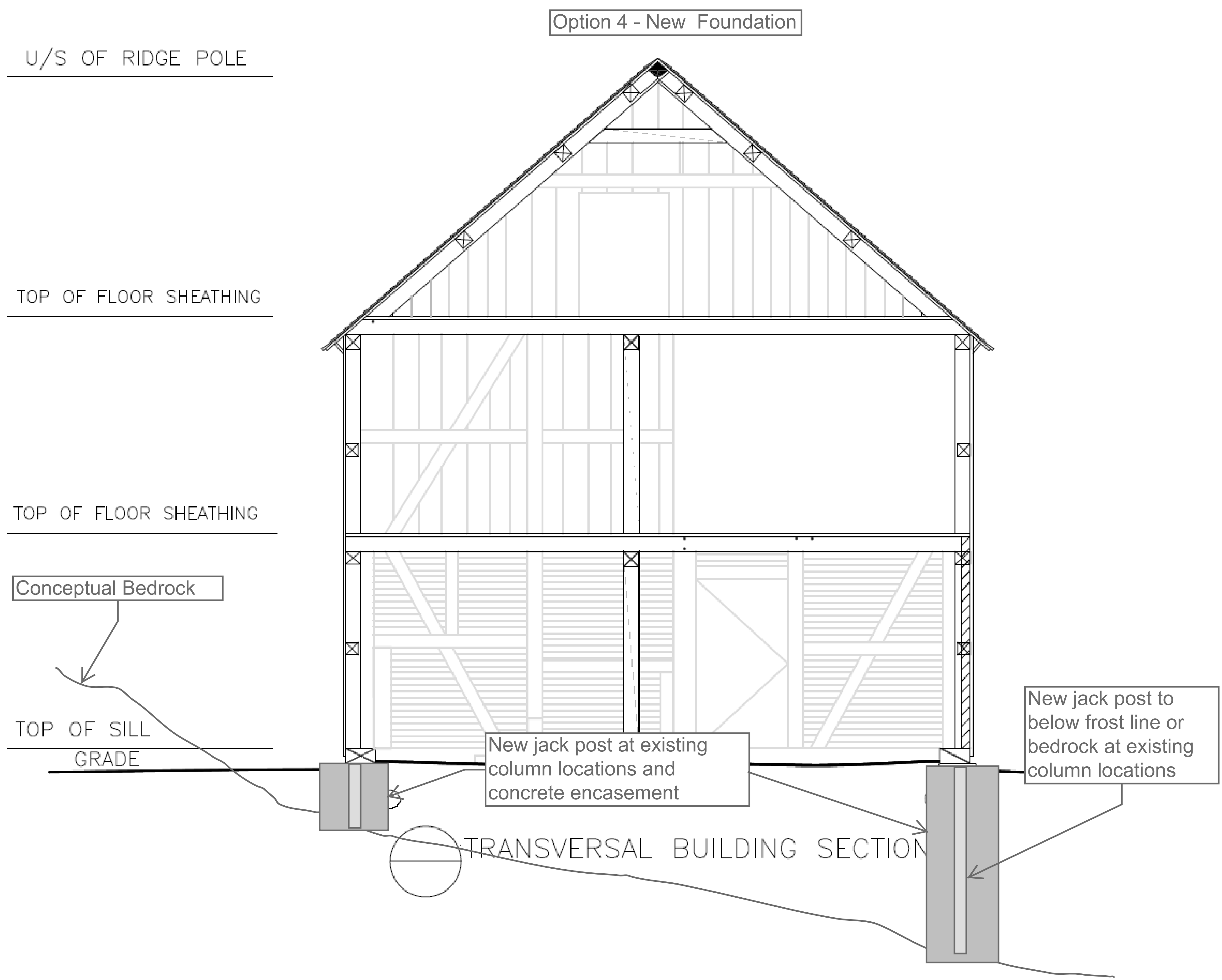

Option 2 - Helical Pile Foundation
U/S OF RIDGE POLE
TOP OF FLOOR SHEATHING
TOP OF FLOOR SHEATHING
Conceptual Bedrock
TOP OF SILL
GRADE
New concrete load transfer at existing column locations
New concrete foundation at existing column locations
TRANSVERSAL BUILDING SECTION
New pile to bedrock at existing column locations


INTERIOR EAST WALL ELEVATION
Attic
Second Floor
Ground Floor
Grade
New concrete pile cap load transfer around perimeter
Conceptual Bedrock
New Micro pile to bedrock at 1m intervals


Option 3 - Micro Pile Foundations
U/S OF RIDGE POLE
TOP OF FLOOR SHEATHING
TOP OF FLOOR SHEATHING
Conceptual Bedrock
TOP OF SILL
GRADE
New concrete pile cap load transfer around perimeter
TRANSVERSAL BUILDING SECTION
New Micro pile to bedrock at 1m intervals

Option 4 - New Foundation




Option 4 - New Foundation
U/S OF RIDGE POLE
TOP OF FLOOR SHEATHING
TOP OF FLOOR SHEATHING
Conceptual Bedrock
TOP OF SILL
GRADE
New jack post at existing column locations and concrete encasement
New jack post to below frost line or bedrock at existing column locations
TRANSVERSAL BUILDING SECTION