April 25, 2022
Mr. Guy A. Flament
84 Lumber Company
1019 Route 519, Building 4
Eighty-Four, PA 15330

RE: Geotechnical Investigation & Summary
3 Sullivan Road
Hudson, New Hampshire **Project #22062**

Dear Mr. Flament:

The purpose of this report, as agreed, is to present the results, observations, and professional geotechnical engineering recommendations and conclusions from a subsurface investigation program that was completed on March 29, 2022, at the above referenced site.

This soil boring program, as requested, is intended to address the structural implications of the subsurface materials and groundwater conditions relative to the proposed 84 lumber facility on 3 Sullivan Road. The field data was utilized to draw the engineering conclusions and to formulate the professional engineering recommendations presented later in this document.

During the course of two weeks starting March 29, 2022, Mr. Mark St Fleur, an *Aardvark* Geotechnical engineer, visited the site and monitored a limited subsurface boring investigation consisting of twelve (12) soil borings (B-1 to B-12) across the footprint of the proposed building location.

It should also be noted that our boring elevations reflected the values shown on the original site plan regardless of the ongoing site operations and possible minor changes in contours/grade.

The borings were advanced using 3" casing, driven by an Geoprobe rig. Standard penetration resistance, at standard continuous increments, was measured using a 24 inch long 2" O.D. split spoon sampler driven by an automatic, pneumatic hammer delivering a force equal to a 140 lb weight falling 30 inches. The field values, commonly referred to as "blow counts," are listed on the individual soil boring logs which are attached. The recovered soil samples, visually classified in the field, were recorded and stored in the event that further review is requested. The boring locations shown in Figure 1, the Boring Location Plan, were adjusted by our field engineer during drilling in order to provide a cross section of the subsurface soils underlying the complex footprint.

B-1, showed 4'± of dry, brown, fine to medium sand, some coarse sand some coarse gravel, little cobbles(fill) over brown, dry to wet silty sand trace gravel which extended to the 12' termination depth. Evidence of the static ground water table was observed at 12'±.

Advancement of boring B-2, 15'± revealed dry, brown, medium to coarse sand, some gravel little fine sand, little cobbles continued to the 18'± termination with a trace gravel.

B-3 revealed 4'± dry, brown, medium to coarse sand, some gravel, little fine sand which extended to 7'± which showed dry, brown, medium to coarse sand. Trace gravel, trace fine sand.

B-4, discovered 3" '± of topsoil over 4'± of dry, brown, medium to coarse sand, some gravel, little fine sand(fill) over brown, dry, dense silty sand little gravel which extended to the 8'± termination depth on possible ledge/bedrock.

B-5, showed 1"± of topsoil over 4'± of dry brown, fine to medium sand, little coarse sand, trace gravel(fill) over 10'± of brown, dry to wet, dense silty sand some gravel which extended to the 17' termination depth. Evidence of the static groundwater table was observed at 11'±.

B-6, at 2'± topsoil revealed dry brown, fine to medium sand, little coarse sand, trace gravel over 4'± dry, brown medium to coarse sand, some gravel, little fine sand over dry, brown, medium to coarse sand, some fine sand trace gravel which extend to the 17'± termination depth. Evidence of the static groundwater table was observed at the 10'± depth.

B-7, discovered at 4'± dry, medium dense, brown, fine to coarse sand, some organic silt and fine to coarse gravel(Fill), 7'± showed dry, very dense, brown, fine to coarse sand, some fine to coarse gravel and inorganic silt.

B-8, showed 6.5'± of dry, dense to very dense, brown, fine to coarse sand and silty sand which extended to the 7'± refusal depth.

B-9, revealed 4'± of dry, medium dense, brown, fine to medium sand, some organic silt and fine to coarse gravel(fill) over 9'± of moist to wet, medium dense silty sand which extended to the 15' termination depth of possible ledge/bedrock. Evidence of the static groundwater table was observed at 13'±.

B-10 & B-10 showed 3.4'± dry medium dense, brown, silty sand some gravel.

B-11, revealed 4'± of dry, medium dense, brown, fine to medium sand(fill) over 5'± moist to wet, loose, brown, silty sand, over which extended to the 10'± termination depth on bedrock/ledge. Evidence of the static groundwater table was observed at the 8' depth.

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Offices in NH, MA, and RI
Phone: (978) 650-2990

B-12, showed 4'± of dry, medium dense, brown/black, fine to medium sand, some organic silt(fill) over 9'± of dry to wet, loose to medium dense, brown, silty sand which extended to the 17'± termination depth. Evidence of the static groundwater table was noted at the 8'± depth.

It appears that native soil was removed used as back fill within the proposed Facility adjacent to the existing building to the depths of 7'±. Blow values soil to the depth of 5'+ indicate that the soil was placed in compacted lifts. The fill soil should be reviewed during excavation to determine if it's reusable if compacted in lifts to 95%.

It should be noted that the groundwater table fluctuates throughout the year due to precipitation, season, and other factors. As such, it is possible that, taken under different conditions, may vary from those presented in this report.

Three (3) laboratory soil gradation analyses, per ASTM D-422 washed sieve methods, representing the subsurface tan, silty, sand/gravel for geotechnical classification and evaluation. The individual composition results (gravel/sand/silt contents) are shown on the attached gradation curves and can be summarized as follows:

Boring ID	Sample No#	Depth	Gravel	Sand	Silt/Clay
B-1	S-4	7' – 9'	37.1%	41.1%	21.8%
B-8	S-3	5' – 7'	34.3%	48.6%	17.1%

As can be seen on the Table, the soil gradations showed an average of "good" gravel contents of around 20%; however, the soils also had moderately elevated "fine" (% passing #200) gravel contents of greater than 10%. Based on the results, the soils would be considered susceptible to moisture and/or vibration as well as exhibiting low drainage characteristics and frost heave potential. Thus, the onsite silty sands/gravels were judged to be generally unsuitable for reuse beneath structures or roadways.

Judging from the blow counts and soil types it is our professional opinion that, in accordance with Section 1804.3 of the Massachusetts State Building Code, the maximum allowable net soil bearing capacity of the medium dense to dense, silty sand/gravel (Class #7), at the expected footing elevation, could be up to 4 TSF (8000 PSF). However, as some interior footings may bear on prepared structural fill, we recommend that the design bearing value not exceed 2.5 TSF (5000 PSF).

SBC section 9.4.1.2.1 applies site classes "A/B/C/D/E" based on boring standard penetration numbers (SPN's or blow counts) for soil below the proposed footing elevation. Our evaluation, based on the measured 30^+ blows/foot (N) for the soil below a depth of 5', correlated to Site Class "D" as some of the blow counts didn't meet the required 50^+ blows/foot.

It should be noted that the soils underlying the building area were judged to be not susceptible to liquefaction (rapid settlement via vibration) due to their recorded boring blow counts (i.e. high relative density) and the soils were not classified as clean sands.

We recommended that the static lateral earth pressure (at rest = K_o) for any restrained foundation walls, which will effectively serve as retaining walls with more than 4' exposed, should be calculated using an equivalent fluid pressure of 60 pcf (pounds per cubic foot). This value is based on the backfill consisting of granular soils, having less than 10% silt (% < #200 sieve) being compacted to 95%+. It is calculated as Ko = 1-sin Ǿ where Ǿ is the soil shear angle (assumed to be 30º± for "granular" sand/gravel with a unit weight of 120± pcf). Thus, the at rest (no wall movement) soil "fluid" pressure is this: Ko x soil unit weight = 0.5± x 120± pcf = 60 pcf

The static lateral earth pressure (outward wall movement allowed "active" pressure = K_a) for "unrestrained" retaining walls is calculated as Ka = $\tan^2$ (45º -sin Ǿ/2) where Ǿ is the soil shear angle (assumed 30º± for granular soil). Thus the "active" soil pressure is Ka x soil unit weight (0.33± x 120± pcf) which yields an active equivalent fluid pressure of 40 pcf.

Footings should be designed in accordance with Section 1806 of the SBC. For footings smaller than 3' in least lateral dimension, the allowable bearing pressure should be reduced to one-third of the above value multiplied by the least lateral footing dimension in feet. We recommend that continuous wall footings be a minimum of 18" wide and isolated footings at least 24" wide. All exterior and interior footings in unheated areas should bear a minimum of 4' below exterior grade for protection from frost penetration. We suggest that interior footings, in heated areas, bear at least 18" below the underside of the floor slab. Further, any disturbed soil at the bottom of footing excavations should be proof rolled, prior to forming the footings to confirm the soil stability and achieve the required 95% compaction.

The existing native, tan, silty sands/gravels underlying the surficial topsoil were judged to be suitable to remain as subgrade beneath the structure and/or pavements. The soils should be reviewed by an engineer from this firm to determine if soils are suitable to remain prior to any backfill.

Unsuitable materials, including surficial topsoil, subsoil, and organics should be stripped down to the underlying native, tan, silty sands/gravels prior to commencing construction. The unsuitable materials should be removed to a distance of at least 5' beyond the structures. Also, the contractor should proof roll the exposed subgrade, under the supervision of an experienced *Aardvark* geotechnical engineer, and any observed weak/soft spots should be excavated and replaced with compacted Gravel Base or up to 1' of 1½" max crushed stone.

The silty, subgrade soils are moisture sensitive and may destabilize if exposed to excessive moisture and/or equipment traffic. Thus, the soils will require some protection during construction to maintain their suitable density and stability. If the soil becomes unstable, the contractor will likely have to over-excavate footing locations and prepare 1' of 1½" traprock. The purpose of the stone layer is to maintain subgrade stability and provide temporary drainage during construction. This stone layer should be placed after removing any soft/wet soils then tamped/seated by ramming with the excavator bucket. We recommend that an *Aardvark* technician be onsite for geotechnical guidance during the determination and confirmation of subgrade suitability.

The following soil gradation specifications are suggested for Granular Fill, Gravel Base, and Dense Graded crushed stone materials are recommended:

Sieve Size	Granular Fill	Gravel Base	Dense Grade
6"	100	100	100
3"	95-100	100	100
1/2"	60-95	50-85	50-80
#4	50-80	40-75	30-55
#10	30-70	30-60	n/a
#40	10-70	10-35	10-25
#100	0-25	0-15	n/a
#200	0-10	0-8	3-10

All backfill soils shall be free from snow, ice, roots, topsoil, and/or other deleterious materials.

All backfill within the additional footing "zone of influence" (1:1 slope from the outside face of the footing) should consist of Gravel Base. Backfill outside/beyond the structural zone of influence could consist of Granular Fill or possibly onsite "cut" soils (weather permitting) if approved in writing first by our firm. The recommended compaction based on the percentage of the soil's maximum dry density, according to ASTM D-1557 methods, is specified below:

General Back fill Areas	Minimum Compaction
Beneath Footings and for Pavement Gravel Base	95%
Below Pavement Base Course Material	92%
Beneath Landscaped Areas	90%

It is recommended that all backfill be compacted to a minimum of 95% of the soil's maximum dry density. Also, any controlled fill should be approved by Aardvark in writing or meet the MSH&B gravel borrow (sec. M1.03.0) specifications and be prepared in compacted lifts not exceeding 1'. Further, any controlled fill operations should be reviewed (and tested) by *Aardvark* to confirm the required 95% compaction.

The existing native, silty sand/gravel appears suitable to remain as subgrade material beneath pavements. However, they are moisture/traffic sensitive and will require some protection during construction to maintain their stability. We typically recommend a minimum 1' layer of Gravel

Base, topped by 4" of Dense Graded, directly beneath the pavement, for "light duty" traffic conditions. Our typically recommended pavement material cross sections are summarized in the Table below:

Pavement Courses	Heavy Duty Traffic	Light Duty Traffic
Bituminous Top Mix MHD M3.11.03 Table A	1 ½"	1"
Bituminous Binder Mix M3.11.03 Table A	2 ½ "	2"
Dense Graded Crushed Stone MHD M2.01.7	6"	4"
Gravel Borrow Subbase MHD M1.03.0	16"	12"

It should be noted that the onsite soils might be suitable (depending on the weather/season) for reuse as subgrade backfill beneath pavements. However, as mentioned previously, the soil is moderately silty and could present a moisture/frost concern. As such, an *Aardvark* technician should be onsite to monitor and confirm these conditions.

We recommend that Aardvark Geotechnical Engineering & Testing Inc. be retained to monitor aspects of the 84 Lumber construction operations which are listed below:

- Monitor the initial site work and confirm that the type(s) of subgrade soil is adequate.
- Review the proposed bearing surfaces to confirm that they have been properly prepared, and that they are satisfactory for the recommended bearing pressures.
- Observe the placement and compaction of structural fill within the building areas.
- Observe the placement and compaction of fill within the proposed pavement areas.
- Check the suitability, via project specifications, of soils for use as backfill.

By monitoring these aspects of the construction, we will be able to observe compliance with the geotechnical design concepts, assumptions, and specifications, and to facilitate the design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction. In addition, *Aardvark* could provide the SBC required field testing for the structural concrete/masonry and/or steel aspects during construction.

In summary, the property was classified as site Class D and the boring blow counts typically correlated to dense (Class #7) soil having a recommended maximum soil bearing capacity not exceeding 2.5 TSF (5000 psf). Should you have any questions, or wish to discuss the reported conditions, engineering recommendations, and geotechnical considerations contained herein and attached, please do not hesitate to contact me at our Somerville office at 978-650-2990.

Prepared By:

Mark St Fleur, PE
Director of Engineering Services

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