MILONE & MACBROOM

June 7, 2019

Mr. James Nardozzi
Interim CEO
Waterbury Development Corporation
83 Bank Street, 3rd Floor
Waterbury, CT 06702

**RE: Geotechnical Engineering Report
Naugatuck-Waterbury Industrial Park
Waterbury, Connecticut
MMI #1014-66**

Dear Mr. Nardozzi:

Milone & MacBroom, Inc. (MMI) is pleased to submit our geotechnical engineering report for the proposed Naugatuck-Waterbury Industrial Park. The site is located at Waterbury's southern border with the borough of Naugatuck, which is accessible from Great Hill Road in Naugatuck, Connecticut. Refer to Figure 1 – Locus Plan in Appendix 1 for the general location of the project.

Recommendations for the proposed building are based in part on guidance from the 2018 Connecticut State Building Code, which includes the 2015 International Building Code (IBC) and the 2018 Connecticut Amendments. Design recommendations are based on Allowable Stress Design Methods.

Pavement recommendations are based in part on our interpretation of the subsurface conditions and traffic volumes in the project areas and guidance from the publication *AASHTO Guide for Design of Pavement Structures*.

PURPOSE AND SCOPE

MMI performed borings and a geotechnical engineering evaluation for the proposed building and surrounding pavements. Our scope of services included characterizing the subsurface conditions at the site, performing geotechnical engineering analyses, and providing geotechnical design and construction recommendations for the project.

SITE DESCRIPTION AND PROPOSED CONSTRUCTION

The site is currently undeveloped and wooded with site grades ranging from approximately El. 480 on the north to El. 550 on the south. The site is located northeast of an industrial property at 322 Great Hill Road; north, west, and south of residential properties; and east of additional undeveloped and wooded area that is east of South Main Street and the Naugatuck River.

A conceptual site plan has been prepared, which includes a building with a rectangular footprint of approximately 800,000 square feet (640 feet by 1,250 feet). The conceptual location of the building was used as a basis for determining the approximate location of site borings. It is understood that the final size and location of a building and other site improvements may differ from the locations shown on the plan. The finished floor of the conceptual building will be at approximately El. 515, which will require up to 35 feet of cutting in the southwest and up to 35 feet of filling in the northeast areas of the site to achieve proposed site grades.

REGIONAL GEOLOGY

According to published geologic data (1:125,000 scale, Surficial Material Map of Connecticut, Janet Radway Stone, 1992; and Bedrock Geological Map of Connecticut, John Rodgers, 1985), the subsurface materials are mapped as glacial till over "gray to dark-gray, fine to medium grained schist or gneiss."

SUBSURFACE EXPLORATIONS

MMI observed 15 borings (MM-1 through MM-15) that were performed by SITE, LLC of Beacon Falls, Connecticut, between May 20 and May 23, 2019. The borings were performed to explore the subsurface conditions within the proposed building footprint and for paved parking and drive aisles. The borings were located using Global Positioning System (GPS), and approximate locations are shown on Figure 2 – Subsurface Exploration Plan contained in Appendix 1. Logs of the borings are included in Appendix 2.

Hollow-stem auger drilling methods were used to advance the borings to depths ranging between approximately 5.5 and 26.2 feet below existing site grades. Representative soil samples were obtained by split-barrel sampling procedures in general accordance with American Society for Testing and Materials (ASTM) Specification D-1586, and representative bedrock samples were obtained by coring in general accordance with ASTM Specification D-2113.

The split-barrel sampling procedure utilizes a standard 2-inch-outside-diameter (O.D.) split-barrel sampler that is driven into the bottom of the boring with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler the middle 12 inches of a normal 24-inch penetration is recorded as the Standard Penetration Resistance Value (N). The blows are indicated on the boring logs at their depth of occurrence and provide an indication of the relative density of the material.

Groundwater levels were measured using a weighted tape in the open drill holes or inferred from the soil samples during drilling.

In 2015, MMI observed seven borings (B-1 through B-7) that were performed by Soil Testing, Inc. of Oxford, Connecticut, between May 26 and May 27, 2015. These borings have been used for reference during our recent planning and design efforts. Their locations are also shown on Figure 2, and the logs are included in Appendix 3.

SUBSURFACE CONDITIONS

The generalized subsurface profile at the site as interpreted from the subsurface exploration data is generally consistent with published geologic information. The encountered subsurface materials are summarized as follows:

- Topsoil – 2 to 12 inches thick (where encountered), over
- Subsoil – 1.5 to 4.2 feet thick, over
- Glacial Till – 2.9 to 23.8 feet thick, over
- Inferred Bedrock – 2.9 to 23.8 feet below existing grades (where encountered).

A more detailed description of the subsurface materials encountered is provided below:

Topsoil was encountered at the surface in Borings MM-3 through MM-15 and generally consists of very loose to medium dense, dark brown, fine to medium sand, some to and silt, trace to some fine to coarse gravel, trace roots.

Subsoil was encountered in each boring and generally consists of very loose to medium dense, light brown to brown, fine to coarse sand, some to and silt, trace to some fine to coarse gravel, trace roots or soft, light brown, silt and clay, little fine to medium sand, trace roots.

Glacial Till was encountered below the subsoil in each boring and generally consists of medium dense to very dense, gray/gray-brown/brown, fine to coarse sand, little to and fine to coarse gravel, little to silt or fine to coarse gravel, little to and fine to coarse sand, little to some silt.

Bedrock was cored in Boring MM-3 and inferred in the other borings based on spoon and/or auger refusals. Refusal depths ranged from 5.5 to 26.1 feet below existing grades. In general, the bedrock surface slopes down from the southwest to the northeast. The cored bedrock consists of poor to fair quality, moderately hard, slightly weathered, slightly fractured to sound, gray, fine to coarse-grained gneiss. It appears the quality of the bedrock improves with depth.

Groundwater was encountered in Borings MM-3 through MM-6, MM-8, and MM-11 through MM-14 at depths from 2 to 16 feet below existing grades, or approximately El. 547 on the southwest side of the site to approximately El. 497 on the east side and El. 485 on the north side. The groundwater generally follows the topography and is likely perched atop the shallow bedrock in the southwest area of the site. Groundwater levels will vary depending on factors such as temperature, season, precipitation, construction activity, and other conditions that may be different from those at the time of these observations.

GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

Building Foundations and Slabs

We recommend supporting the proposed building on conventional shallow spread footing foundations that bear on undisturbed glacial till, bedrock, or compacted granular fill (CGF) or crushed stone over these materials. We recommend a maximum net allowable bearing pressure of 6 kips per square foot (e.g., 3 tons per square foot) for footings bearing on above-described subgrade.

Where CGF or crushed stone is used beneath the footings, we recommend that it be placed 1 foot beyond the edge of the footings and at a one horizontal to one vertical (1H:1V) slope away and down from the footings.

Exterior footings should be constructed at a minimum depth of 42 inches below final grades to protect against frost unless bearing directly on bedrock. We recommend a minimum depth of 12 inches be maintained below the proposed bottom of concrete floor slab and the top of footings. The minimum isolated footing size should be 3.0 feet, and the minimum wall footing width should be 24 inches.

Bedrock was encountered in the southwest building area between approximately 6 and 10 feet above the proposed finished floor level, requiring a significant amount of bedrock removal to achieve proposed site grades. Where footings bear on dissimilar materials of soil to rock, we recommend a transition strip to avoid abrupt transitions and minimize differential settlements. The transition strip should extend for 10 feet where bedrock is overexcavated by 12 inches and replaced with CGF. On either side of the 10-foot strip, the continuous footing would bear on bedrock and glacial till.

We anticipate that the footings will experience up to approximately 1 inch of total settlement and up to approximately ½ inch of differential settlement. Settlements should occur as the loads are applied and will be complete at the end of construction. We recommend a maximum coefficient of friction of 0.45 between foundations and CGF and 0.55 between foundations and bedrock.

We recommend placing the concrete floor slab over a minimum 6-inch-thick base course layer of compacted sand and gravel over undisturbed glacial till, bedrock, or CGF or crushed stone over these materials. The subgrade modulus for the recommended subgrade and base course is 250 pounds per cubic inch.

Lateral Earth Pressures

We are not aware of any changes in grade where site or foundation walls will be required. However, for cantilevered walls that are free to rotate at the top and are not braced should be designed to resist an equivalent active static horizontal fluid pressure equal to 38 pounds per square foot (psf) (based on $\phi = 34°$, $c = 0$ psf, $K_a = 0.29$, and $\Upsilon = 130$ pounds per cubic foot [pcf]). Braced walls should be designed to resist an equivalent at-rest static horizontal fluid pressure equal to 57 psf (based on $\phi = 34°$, $c = 0$ psf, $K_o = 0.44$, and $\Upsilon = 130$ pcf). This assumes no unbalanced hydrostatic pressures (free-draining backfill), seismic forces, or traffic surcharge loads. We recommend using a traffic surcharge load of 250 psf.

Foundation Drainage and Dampproofing

In the southwest area of the site, groundwater was observed between El. 547 and El. 527, placing the finished floor at least 12 feet below observed groundwater levels.

We recommend a subslab vapor barrier over the entire building area to protect against capillary moisture impact to the concrete and to limit the transmission of moisture into the floor slab. We recommend foundation drains along the bottom of the exterior shallow foundations that consist of 4-inch perforated drainpipe, surrounded by 4 inches of crushed stone and filter fabric on all sides, gravity fed to daylight or site drainage.

In the southwest quarter of the building footprint, we recommend a subslab drainage system consisting of 12 inches of crushed stone with 4-inch-diameter perforated drainpipes, surrounded by 4 inches of crushed stone, located 25 feet on center and underlain by filter fabric. Subslab drains should be gravity fed and tied into the foundation drains.

Rock Slopes

A slope up to approximately 35 feet tall consisting of a mixed face of approximately 15 feet of soil over approximately 20 feet of rock will be constructed along the southwest side of the site. We recommend the final slope configuration of the rock be no steeper than 1H:6V and the overburden soils no steeper than 2.5H:1V, which blends into the existing grades. Where blending of the overburden soils cannot take place, a site retaining wall or erosion control measures may be required.

A catchment area at least 8 feet wide should be provided at the base of the slope along its entire length to provide an area for which fallen rock or other materials can be contained. Where there is insufficient space to provide the minimum recommended catchment area, a rock catchment fence should be installed. The design of the rock catchment fence should consider the available catchment area and the above slope geometry. The rock catchment fence, if required, should be specified by the manufacturer and installed by the contractor.

Seismic Site Class and Liquefaction Potential

The average Standard Penetration Test "N" value over a 100-foot depth below the building is between 15 and 50 blows per foot. Thus, the site class for the proposed structure is "D" (very dense soil and soft rock) profile per the IBC. According to the 2018 Connecticut Building Code for Naugatuck, Connecticut, S_S is 0.190g, and S_1 is 0.064g. We calculated S_{MS} as 0.228, S_{M1} as 0.109g, S_{DS} as 0.152g, and S_{D1} as 0.073g.

Based on the standard penetration test results, estimated depth to groundwater, soil classifications, and expected peak ground acceleration at this locale, it is our opinion that site soils are not prone to liquefaction.

Asphalt Pavement

Pavement sections should be constructed on a prepared subgrade of proof-compacted glacial till, weathered bedrock, bedrock, or CGF over these materials. Where pavement sections are constructed atop bedrock, we recommend a minimum total pavement section thickness of 12 inches, thickening the processed aggregate base as necessary. The following pavement section recommendations depend largely on the loading anticipated for a given area.

For the parking areas intended for passenger car use only, we recommend a finished course of 1.5 inches, over a binder course of 1.5 inches, over 4 inches of processed aggregate base. For roadways and parking areas used for passenger cars and routine delivery trucks, we recommend a finished course of 1.5 inches, over a binder course of 2 inches, over 8 inches of processed aggregate base. Finally, for the entrance and HS-20 truck aisles, we recommend a finished course of 2 inches, over a binder course of 3 inches, over 6 inches of processed aggregate base.

We recommend pavement drainage in the northwest area of the site where pavements will be below existing groundwater levels. The pavement drains could consist of trench drains along the edges of the pavement areas or a horizontal composite drain installed below the pavement section. The pavement drains should discharge by gravity to an appropriate location.

MATERIALS AND COMPACTION REQUIREMENTS

On-site Material Reuse

Excavated topsoil and subsoil should be stockpiled and used for the same in landscaped areas.

Based on the information contained on the boring logs, the natural glacial till may be suitable for reuse as CGF for below footings, slabs, and pavements and as backfilling around foundations, provided that required in-place density and optimum moisture contents (±2 percent) are met. Modified proctors and sieves should be obtained for differing materials to ensure proper in-place density requirements are being met.

Based on the information above, it is our opinion the bedrock does not contain large amounts of mica. Provided bedrock mass is the same, the excavated and/or blasted bedrock may be crushed and reused such that it meets the following requirements below for a given material type.

Material Specifications

CGF for use as structural fill should consist of inorganic soil that is free of clay, loam, ice and snow, tree stumps, roots, and other organic matter and graded within the following limits:

Sieve Size	Percent Finer by Weight
3 inches	100
No. 4	50 – 85
No. 10	25 – 50
No. 40	10 – 35
No. 100	10 – 25
No. 200	0 – 10

Sand and gravel for use as slab base course should consist of hard, durable sand and gravel that is free of clay, loam, ice and snow, tree stumps, roots, and other organic matter and graded within the following limits:

Sieve Size	Percent Finer by Weight
2 inches	100
1/2 inch	50 – 85
No. 4	40 – 75
No. 40	10 – 25
No. 200	0 – 10

Crushed stone for use around drains and below foundations and slabs should consist of sound, tough, durable rock that is graded within the following limits:

Sieve Size	Percent Finer by Weight
3/4 inch	100
1/2 inch	85 – 100
3/8 inch	15 – 45
No. 4	0 – 15
No. 8	0 – 5

Processed aggregate base should meet the requirements of Connecticut Department of Transportation Form 817 specification M.05 with the following gradation:

Sieve Size	Percent Finer by Weight
2-1/2 inches	100
2 inches	95 – 100
3/4 inch	50 – 75
1/4 inch	25 – 45
No. 40	5 – 20
No. 100	2 – 12

We recommend a minimum in-place dry density of 95 percent as per ASTM D1557 for material placed below foundations, floor slabs, and pavements. We recommend a minimum in-place dry density of 92 percent as per ASTM D1557 for material placed as backfill against structural walls. Materials should be placed within 2 percent of their optimum moisture content. We recommend a maximum loose lift thickness of 10 inches.

CONSTRUCTION CONSIDERATIONS

Site Preparation

We recommend the site be cleared of existing topsoil and subsoil. The exposed subgrades should be proof compacted prior to construction of the slabs and footings. On the southwest area of the site, groundwater is expected at or near the bottom of subsoil. Therefore, the contractor should be prepared to manage groundwater for the next stage of construction.

Bedrock Excavations

While mechanical excavation for rock removal may be used for the initial upper layers of bedrock, the effectiveness of such means may prove to be time consuming with depth as the quality of the bedrock improves. We recommend that excavation of the bedrock involve blasting. The primary requirement of the blasting is to control damage to the rock and minimize instability when excavating the final rock faces and subgrades. Another consideration of the blasting is producing a blast rock that is fragmented to suit the capacity of the excavating and hauling equipment.

The contractor should develop a blasting plan and perform a test blast so that production blasting can be designed to limit rock fracturing behind the final rock face or below final rock subgrades. The design of the production blasting program should consider, among other parameters selected by the blasting subcontractor, the bench height and burden. The bench height may be dictated by the geometry of the site, and the burden distance should range between 0.25H to 0.33H, where H is the bench height. The effective burden distance will influence the efficiency of the blasting.

Preblasting and postblasting inspection and vibration monitoring of the nearby structures to the southwest is recommended before bedrock removal occurs.

Foundations and Slab-on-Grade Preparation

The base of footing excavations should be free of water, ice, frozen soil, and loose soils prior to placing concrete. We recommend the use of smooth-edged excavator buckets to make the final excavations in soil to help protect the subgrade, followed by proof compaction of the exposed subgrade. Concrete should be placed as soon as possible after excavation as to not disturb the bearing materials. Should the materials at bearing level become disturbed, the affected materials should be removed prior to placing concrete. A 4-inch-thick layer of crushed stone may be used to protect footing subgrades that are expected to be open for an extended period.

Where footings bear directly on bedrock, we recommend loose rock fragments be removed by hand so as to not further disturb the subgrade with the use of excavator buckets. A hoe ram should level bedrock fragments protruding into the bottom of footing footprint. Crushed stone may be placed to fill voids and provide a level bearing surface.

Temporary Excavation Support

All excavations should be sloped or shored in accordance with local, state, and federal regulations, including the Occupational Safety and Health Administration (OSHA) (29 CFR part 1926) excavation trench safety standards. Excess soils should be disposed of in accordance with federal, state, and local regulations.

The on-site material is classified as OSHA Class "C" soil and can be cut at a maximum one vertical to one and a half horizontal (1V:1.5H) slope up to a maximum excavation depth of 20 feet. These maximum slope and excavation depths assume no surcharge load (i.e., stockpiles, construction equipment, etc.) at the top of the excavations or seepage (e.g., cuts below the groundwater table).

Where excavations cannot be sloped in accordance with the above, a temporary excavation support system will be required. The temporary excavation support system should be selected by the contractor and designed by a professional engineer registered in the State of Connecticut.

Freezing Conditions

All foundation and slab-on-grade subgrades should be free of frost before placement of reinforcing steel and concrete and protected from freezing until they are backfilled. Subgrade soils that have frozen should be removed and replaced with compacted structural fill.

Dewatering

Based on Borings MM-3, MM-4, and MM-13, we expect groundwater and surface water runoff will need to be controlled from the southwest side of the site during construction. We anticipate the groundwater and surface water can be managed during construction with local sumps and positive grading. The contractor should prepare a dewatering plan in accordance with project requirements for approval by the engineer.

CONSTRUCTION DOCUMENTS AND PLANS

Project plans should be provided to MMI to review for conformance with the geotechnical recommendations contained herein. If changes are made to the location or type of structure, the recommendations in this report will need to be reviewed.

CONSTRUCTION QUALITY CONTROL

We recommend that MMI make field observations of excavations and foundation preparation to monitor actual conditions and compliance with our recommendations and the project specifications. Specifically, we recommend field observation of removal of unsuitable materials, blasting and vibrations, groundwater management, footing subgrades, fill placement, and compaction. We can also assist in classifying material on site for segregation and/or mixing for reuse on site.

LIMITATIONS

This report is subject to the limitations included in Appendix 4. Thank you for the opportunity to be of service. Please feel free to call either of the undersigned if you have any questions.

Very truly yours,

MILONE & MACBROOM, INC.

Marie G. Bartels, PE
Geotechnical Engineer

Joseph W. Kidd, PE
Senior Geotechnical Manager

Attachments: Appendix 1 – Figures
Appendix 2 – Test Boring Logs (MM-Series)
Appendix 3 – 2015 Test Boring Logs (B-Series)
Appendix 4 – Limitations

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