Ward Geotechnical
Consulting, PLLC

October 4, 2017
Project 17200

Mr. Michael S. Vignale, P.E.
KV Partners, LLC
P.O. Box 432
New Boston, New Hampshire 03070

Subject: Foundation Investigation
Proposed Town Offices Building Additions
Bristol, New Hampshire

Dear Mr. Vignale:

Ward Geotechnical Consulting, PLLC (WGC) has prepared this letter report to summarize the results of the foundation investigation conducted for the proposed additions to the Bristol Town Offices in Bristol, New Hampshire. Our work on the project was authorized by your acceptance of our proposal dated May 25, 2017. You also provided verbal authorization to expand the boring program from one to two days because two different building addition options were still being considered.

PROJECT AND SITE DESCRIPTION

The project involves the construction of additional office space for the town offices complex in Bristol, New Hampshire. The location of the site is shown on Figure 1.

The existing building on the site houses the police department and town offices. The existing building is a two story wood and brick structure including a walk-out basement level. The top of the floor slab in the walk-out basement level is at approximately elevation 472.4 feet (project datum).

Preliminary plans for additional space are shown on Figure 2 and briefly described below:

- A new sally port addition is to be constructed along the south end of the existing structure. The sally port addition will be a drive-through structure with a concrete floor slab-on-grade but will include access to the below grade basement level (top of floor slab at about elevation 472.4 feet) of the existing building via a stairway and ramps. The plan dimensions of the proposed sally port are approximately 36 feet by 40 feet.

- Additional office space will be provided by one of the following two options:

  Option 1:

  This option includes the construction of a separate two story structure on an adjacent lot located to the north of the existing town office building lot. The proposed structure would have plan dimensions of approximately 60 feet by 70 feet. A basement level for this proposed structure is being considered.

  We understand that the adjacent lot on which the structure would be built was previously occupied by one or more residential structures that have been demolished. Information concerning the locations of these structures was not provided. We understand that at least one the structures had a basement, but the depth of the old basement floor below the existing grade is not known.

  Option 2:

  This option includes the construction of a two story addition that would wrap around the northern approximately 30 feet of the north end of the existing town office building. The addition would have plan dimensions of approximately 75 feet by 80 feet. The upper and lower levels of the addition would match those of the existing town office building.

- Regardless of the option selected for the additional office space, additional parking will be provided on the adjacent lot to the north of the lot containing the existing town office building. We understand that "buried ground water mitigation tanks" will be constructed beneath the proposed parking lot. These tanks are intended to prevent an increase in peak off-site surface water runoff from the site.

The town office complex is located along the east side of Lake Street in an area of primarily commercial development. The site, which gradually slopes downward towards Lake Street, is at the base of steep wooded slope located to the east. Soil mapping provided on the Natural Resources Conservation Service (NRCS) website indicates that the site is underlain by glacial outwash deposits comprised primarily of silty sand and sand.

SUBSURFACE INVESTIGATIONS

WGC engaged New England Boring Contractors, Inc. to conduct at two-day boring program at the site. Eight borings were drilled at the locations shown on Figure 2 on August 30 and 31, 2017, under the observation of WGC.

The boring location plan on Figure 2 was developed using a topographic site plan provided in AutoCAD format by KV Partners, LLC (KV). The boring locations were measured relative to existing site features shown on the site plan. Elevations at the boring locations were estimated based on topographic contours shown on the site plan. The elevations are referenced to the project datum (benchmark HPC-63 disc on the bridge over the Newfound River).

The borings were advanced to depths ranging from 8 to 20.3 feet below the existing ground surface using hollow stem augers. Split spoon soil sampling with standard penetration tests (SPTs) was typically conducted at intervals of about 5 feet in the borings. However, no sampling was conducted in boring B8, which was drilled for the installation of an observation well. The original subsurface exploration program was planned to provide subsurface information for the design of foundations for the proposed sally port and both options for additional office space.

On the second day of the drilling program (after completing borings B1 through B5 and installing an observation well in B3), the project architect (Ward D'Elia of Samyn-D'Elia Architects) informed WGC of changes to the project that impact the subsurface exploration program. Mr. D'Elia indicated that Option 1 had been selected and that the proposed sally port will be constructed along the east side of the north end of the existing building, rather than at the south end of the existing building as originally planned. As a result, WGC moved boring B6 from its originally planned location (at the southeast corner of the originally planned sally port footprint) to the southeast corner of the newly proposed sally port footprint (the location of B6 shown on Figure 2). We also removed the PVC well that had been installed in B3 for reinstallation within the Option 1 building footprint. To allow reinstallation of the well within the Option 1 footprint, we added boring B7 to the program. However, B7 became unstable after drilling to a depth of about 14 feet (sand was "blowing" into the bottom of the augers) and was abandoned. B8 was then drilled to a depth of 8 feet (without sampling) for the reinstallation of the well.

After the subsurface exploration program was completed, we were informed that the proposed sally port will be constructed in its originally planned location, at the south end of the existing building.

Boring logs are provided in Appendix A.

SUBSURFACE CONDITIONS

The subsurface conditions encountered in the borings are described below, from the ground surface down. Subsurface conditions are known only at the boring locations, and conditions at other locations may differ.

> Pavement – Asphalt pavement was encountered in borings B3 through B6, which were drilled in the paved access and parking areas. The thickness of the asphalt pavement at the boring locations ranges from approximately 4 to 5 inches.
>
> Fill – Fill was encountered in all of the borings to depths ranging from about 0.7 feet (B4) to about 6 feet (B1) below the existing ground surface.
>
> At B1, B2, and B7, which were drilled in the Option 1 building area, fill extends to a depth about 4 feet (B2 and B7) and about 6 feet (B1) below the existing grade. As previously discussed, this lot used to contain one or more buildings (at least one with a basement to unknown depth) that have been demolished. Much of this lot has been graded flat with sand and gravel fill. The fill encountered in B1, B2, and B7 consists primarily of sand with gravel and sand with silt and gravel. Several obstructions were encountered in these borings indicating the presence of cobbles and boulders and, possibly, construction debris (although

not directly observed). SPT N-values in the fill at these locations ranged from 7 to 20 blows per foot, indicating that the fill is loose to medium dense.

The existing fill layer was less thick at the locations of most of the borings drilled in the paved areas (B3, B4, and B6). At B3, B4, and B6, the fill extends to depths of about 0.7 feet (B4) to about 2 feet (B3) below the existing pavement surface and consists of sand and sand with gravel (some of which was probably placed as pavement base soil). SPT N-values in the fill at B3, B4, and B6 ranged from 10 to 12 blows per foot, indicating that the fill is medium dense.

At B5, we expect that the existing fill extends to a depth of about 5 feet below the existing pavement surface because a peat layer was encountered from a depth of 5 to about 6.5 feet. The fill at B5 consists of sand with gravel, silty sand, and silty sand with gravel. SPT N-values in the fill at B5 ranged from about 5 to 16 blows per foot, indicating that it is loose to medium dense.

Peat (OL) – a layer of dark brown peat was encountered beneath the fill at B5. The peat layer extends from a depth of 5 feet to about 6.5 feet below the existing pavement surface. The peat is fine grained but fibrous and contains at least one thin (1/2-inch-thick) sand lens. Based on 6-inch blow counts (a full, 12-inch SPT N-value was not obtained within the peat layer), we expect that the peat is very loose.

Glacial Outwash Deposit – A deposit of glacial outwash soils was encountered beneath the fill and/or peat layers at the boring locations. At the boring locations, the glacial outwash deposit consists primarily of sand with silt and gravel (SP-SM and SW-SM)), but also contains sand (SP), sand with gravel (SW), silty sand (SM), silty sand with gravel (SM) and at least one lens of sandy silt (ML). Several cobbles and/or boulders were also encountered in the deposit. The layer also contains several cobbles and boulders. SPT N-values in the outwash deposit ranged from 9 to greater than 100 blows per foot, indicating that the soil is loose to very dense (relative density generally increasing with depth). At the boring locations, the depth to the top of the deposit ranges from about 0.7 feet to 6.5 feet below the existing ground surface. At the boring locations, the deposit extends to depths of at least 14 to 20.3 feet below the existing ground surface, where the borings were terminated.

SPT or auger refusals were encountered in several of the borings (B1, B2, B4, B5, and B6) at depths ranging from 14.1 feet (B6) to 20.3 feet (B1 and B2) below the existing ground surface. Rock coring was not performed to determine whether the refusals were encountered on boulders in the outwash deposit or on bedrock.

Groundwater – The groundwater level in the temporary well installed in B3 was approximately 4.0 feet below the existing pavement surface (corresponding to an approximate groundwater elevation of 469.5 feet) when measured on October 31, 2017, about 1 day after well installation. The well was then removed from B3 and the well materials were later used to install a well in B8W.

The groundwater level in the well installed in B8W was 4.0 feet below the existing ground surface (corresponding to an approximate groundwater elevation of 469 feet) when measured on September 13, 2017, about 13 days after well installation.

Groundwater observation wells for the measurement of stabilized groundwater levels were not installed in the other borings. However, based on soil sample moisture conditions, we expect that the groundwater levels at the boring locations (at the time of drilling) typically ranged from about 4 to 8 feet below the existing ground surface, generally increasing in depth from east to west. These groundwater levels correspond to elevations ranging from about 473 feet (B6) to about 465 feet (B4).

Note that groundwater levels fluctuate with seasonal variations in precipitation, and groundwater levels at the time of construction may differ from those measured in the wells (on August 31 and September 13, 2017) and estimated based on soil moisture conditions during the boring program (August 30 and 31, 2017).

FOUNDATION DESIGN AND CONSTRUCTION RECOMMENDATIONS

Introduction

The existing fill and peat layers are not suitable for support of foundations or floor slabs. Footings and slabs should bear on the underlying glacial outwash deposit, or on compacted granular fill placed directly on the outwash deposit or glacial till layer.

The top of the suitable outwash bearing layer was encountered at the following depths in the borings:

- Option 1 Building Area: The top of the glacial outwash bearing layer was encountered at depths of about 4 feet in B2 and B7 and at a depth of about 6 feet in B1. The top of the outwash bearing layer was encountered at shallower depths in B3 and B4 (located near the Option 1 building area), but these borings were not drilled in area of the adjacent lot that had been disturbed by the presence of the buildings on the adjacent lot that had been demolished.

  The thickness of the existing fill at other locations in the Option 1 building area is not known. The thickness of the existing fill might be deeper in some areas than was observed in the borings. We recommend that old drawings and photographs (if available) be reviewed to determine the locations of the old structures relative to the Option 1 building footprint. In addition, it might be necessary to excavate test pits in the Option 1 building area to better define the extent of the existing fill. The test pits could be excavated during design or construction.

- Sally Port Building Area: At B5, the top of the outwash deposit was encountered beneath the existing fill and peat layers at a depth of about 6.5 feet below the existing ground surface. The thickness of the unsuitable soils (existing fill and peat) at other locations within the Sally Port building area could vary. Note that only one boring was drilled in the Sally Port footprint because it was thought at the time of the drilling program that the Sally Port

location was to be changed. We recommend that additional subsurface explorations (borings and/or test pits) be conducted in the area of the Sally Port to better define the thickness of the unsuitable soils. The additional explorations could be done during design or construction.

It is possible that existing fill or other unsuitable soils extend deeper in some areas than were observed in the borings. If unsuitable soils are encountered below the planned footing or slab subgrade elevation, the unsuitable soils must be overexcavated to the top of the outwash and be replaced with compacted granular fill.

Footing Design

The proposed buildings should be supported on spread footing foundations bearing on the outwash deposit, or on compacted granular fill placed directly on the outwash deposit. The footings must bear at least 5 feet below the finished exterior grade to protect the footing subgrade from freezing temperatures. The bottoms of footings should bear at least 2 feet below the top of adjacent concrete floor slabs-on-grade. The footings may be underlain by a minimum 8-inch-thick layer of compacted structural fill.

The footings should be designed for an allowable bearing pressure of 2 tons per square foot (tsf). The allowable bearing pressure may be increased by 33% to 2.7 tsf for transient conditions such as wind and earthquake loads. Strip footings should be at least 2 feet wide and column footings should be at least 3 feet wide, even if this results in bearing pressures that are less 2 tsf.

For footings constructed according to the recommendations in this report, we estimate that total settlements will be less than one inch, with corresponding differential settlements less than ½ inch. Most of the settlement is expected to occur during construction.

Possible Basement for Option 1 Building

As previously indicated, the construction of a basement for the Option 1 building is being considered. Based on the groundwater measurements in the wells installed in B3 (temporarily) and B8W and groundwater levels roughly approximated based on sample moisture conditions in the other borings, we expect that groundwater levels ranged from about 4 to 7 feet below the existing ground surface at the time of the drilling program. The drilling program was conducted during a relatively dry time of the year and we expect that at other times of the year the groundwater levels could be significantly higher. Therefore, construction of a basement with a slab-on-grade below about elevation 471 feet would require the installation of an extensive foundation drainage system. Based on the existing topography of the site, it appears that a foundation drainage system could not flow by gravity to an outlet on the ground surface. Unless the foundation drainage system could be discharged by gravity to a culvert or manhole in the surface water drainage system, it would have to flow by gravity to a wet well or vault and be pumped to a suitable outlet. The pump system would have to be designed with a backup power supply and redundancies (such as a backup pump) so that it would remain operational in the event of equipment or power failures. Failure of the foundation drainage system could cause basement flooding, overstressing and instability of the foundation walls, and possibly heaving of the floor slab.

The construction of a basement for the Option 1 building would also require extensive temporary excavation dewatering. Excavation for a basement floor slab level more than about 4 feet below the existing grade (with footings at least 6 feet below grade) could probably require the use of special dewatering methods such as well points or deep wells, which could significantly increase construction costs.

Therefore, due to the relatively high groundwater levels in the Option 1 building area, we do not recommend the construction of a basement.

Concrete Floor Slab-on-Grade

Concrete floor slabs-on-grade should be underlain by a minimum 8-inch-thick layer of compacted structural fill placed on the outwash deposit or on compacted granular fill placed directly on the outwash deposit. A subgrade modulus of 150 pounds per cubic inch (pci) may be used for the design of floor slabs.

A vapor barrier should be placed beneath the floor slabs. The vapor barrier should consist of polyethylene sheeting with a minimum thickness of 6 mil. Adjacent sheets of the polyethylene should be overlapped by at least 6 inches. To protect the vapor barrier and allow proper curing of the concrete slab-on-grade, a 3-inch-thick layer of sand containing less than 5% fines and no gravel exceeding ¾ inch in diameter should be placed between the vapor barrier and the floor slab. Prior to placing the reinforcing steel for the floor slab, the sand should be moistened and compacted using a vibratory plate compactor.

Seismic Design

Seismic design parameters required by the International Building Code (IBC) are as follows:

- Based on the results of the borings, the site is considered to be within Site Class D.
- The 5% damped design spectral response acceleration at short periods (S_{DS}) is approximately 0.305g.
- The 5% damped spectral response acceleration at 1-second period (S_{D1}) is approximately 0.142g.

Based on the results of the borings, the soils that underlie the Option 1 building area and the sally port building area are not susceptible to liquefaction under design earthquake conditions.

Seismic earth pressures should be used for design of foundation walls that will act as retaining walls. The seismic earth pressure increment is discussed in a subsequent section of this report.

Foundation Drains

Unless the Option 1 building will have a floor slab-on-grade below elevation 472 feet (note that a basement for this building is not recommended, as previously discussed), we expect that foundation drains will be not be required.

Foundation drains will probably not be required for the stairwell/ramps in the sally port building, which will have a slab-on-grade matching the elevation of the existing slab-on-grade in the existing town office building (elevation 472.4 feet). The groundwater level roughly estimated based on soil sample moisture content in B5 (nearest boring) appears to at least 5 feet below the proposed slab-on-grade elevation. Also, there have been no indications of flooding or moisture problems in the walk-out basement level in the existing town office building. However, if groundwater is encountered in the excavation for construction of the stairwell/ramps, WGC should be notified to determine if a foundation drainage system should be installed.

Earth Pressures

Foundation walls that act as retaining walls, such as basement walls in the Option 1 building (not recommended) and the foundation walls for the stairwell/ramps in the sally port, should be designed for earth and surcharge pressures.

We assume that the foundation walls will be braced by the concrete floor slabs-on-grade and the main level structural floors prior to backfilling. These floors will restrain the foundation walls from rotation and displacement. Therefore, an “at rest” earth pressure with an equivalent fluid pressure of 60 pounds per square foot per vertical foot of wall height (psf/ft) should be used for design. A uniform (rectangular pressure distribution) vehicle surcharge of 120 pounds per square foot (psf) should be included in the design if vehicular traffic can pass within a distance from the back of a wall equal to half of the wall’s height.

For design earthquake conditions, a seismic pressure increment should also be included in the design. The seismic earth pressure increment, estimated using the Mononobe-Okabe method for a peak ground acceleration of 0.122g ($S_{DS}/2.5$), should be calculated as follows:

$F = 8.5H^2/2$ applied at a distance of 0.6H from the bottom of the footing

Where:

F = seismic force per foot of wall in pounds
H = overall wall height in feet

Friction along the bottoms of the footings should be calculated using a friction coefficient (Tanδ) of 0.45 for footings cast directly on the natural outwash soils, and 0.55 for footings cast on compacted structural fill. If the friction along the bottoms of the footings (as well as the restraint provided by the concrete floor slabs-on-grade) is not sufficient to resist the lateral loads, small movement will mobilize a portion of the passive earth pressure at the toes of footings and foundation walls. An earth pressure with an equivalent fluid pressure of 200 pounds per square foot per foot depth (psf/ft) may be assumed for this purpose.

Excavation and Dewatering

Based on the groundwater levels measured and/or estimated (based on sample moisture conditions) during the drilling program, we expect that groundwater will be encountered in excavations for the Option 1 building foundations extending below about elevation 470 feet. Based on sample moisture conditions in the one boring (B5) drilling in the sally port building area, we expect that groundwater will not be encountered in the excavations for the sally port and its stairwell/ramps.

However, it should be noted that groundwater levels at the time of construction might be higher than they were at the time of the boring program. If groundwater levels during construction are less than about 2 feet above the bottom of an excavation, we expect that dewatering can be accomplished by pumping from sumps. If groundwater levels are more than about 2 feet above the bottom of the excavation, it might be necessary to use special dewatering methods, such as deep wells or well points, to reduce upward seepage pressures that could disturb the subgrade soils.

All water pumped from the excavation must be discharged in accordance with local, state, and federal requirements.

We expect that excavations could be open cut on a slope no steeper than 1.5H:1V slope (assuming the excavation is properly dewatered, if necessary). Excavations must not extend below a 2H:1V plane sloping downward from the edges of new or existing footings or slabs. All excavations should comply with OSHA regulations.

Preparation and Maintenance of Footing and Slab Subgrades

All unsuitable soils (existing fill and peat) that overlie the outwash deposit within the area of the proposed building footprints must be removed. Based on the results of the borings B1, B2, and B7, we expect that depth of these unsuitable existing fill soils within the proposed Option 1 building footprint typically range from about 4 to 6 below the existing ground surface. Based on the results of B5, it appears that the unsuitable soils (peat and existing fill) extend to a depth of about 6.5 feet below the existing ground surface. However, it is likely that these unsuitable soils vary in thickness, and might extend deeper in some areas. Where the bottom of the unsuitable soils extend below the subgrade for the structural fill to be placed beneath the footings and floor slabs, the unsuitable soils must be overexcavated and replaced with compacted granular fill.

Where unsuitable soils are to be excavated below footings and replaced by compacted granular soil, the width of the footing excavation should be at least equal to the footing width and increase by 2 feet for every foot that the excavation extends below the footing subgrade elevation (with the footing centered on the replacement fill).

The final 2 feet of soil above excavation subgrades below footings should be excavated using a smooth-edged bucket to reduce subgrade disturbance. All loose, soft, or disturbed soils should be removed from excavation subgrades beneath footings and slabs. Proof rolling of excavation subgrades with a vibratory compactor should be performed unless it causes “pumping” and disturbance. The period of time that the excavation subgrades are left exposed should be minimized to reduce the risk of subgrade softening and disturbance. If overexcavation of the subgrade is

necessary to remove disturbed soils, the overexcavation should be backfilled with compacted granular fill.

Excavation subgrades should be free of standing water, frost, and loose soil before placement of foundations or backfill.

Backfill and Compaction

The layer of structural fill to be placed beneath footings and floor slabs should be meet the requirements for crushed gravel, item 304.3 of the New Hampshire Department of Transportation Standard Specifications for Road and Bridge Construction, 2010 (NHDOT Specifications). Granular fill to be used as fill below the subgrade for the structural fill to replace unsuitable soils should meet the requirements for gravel, item 304.2 of the NHDOT Specifications. Much of the sand and gravel excavated from the existing fill layer may be used as granular fill provided cobbles and boulders greater than 6 inches in size, construction debris, organic soils or debris, and other deleterious materials are removed. All fill below footings and slabs should be placed in lifts and be compacted to at least 95% of maximum dry density as determined in accordance with ASTM D 1557.

All fill placed behind the foundation walls should be a granular soil consisting of sand or sand with gravel containing no more than 8% fines. Much of the sand with gravel excavated from the existing fill layer might be suitable for this purpose, provided cobbles and boulders exceeding 6 inches in size, construction debris, organic soils or debris, and other deleterious materials are removed, and the fines content does not exceed 8%. The backfill should be placed in lifts and be compacted to at least 90% of maximum dry density as determined in accordance with ASTM D 1557. In areas where the backfill will be below pavements or structures, the compacted density should be increased to at least 95% of maximum dry density.

The thickness of fill lifts required to achieve adequate and uniform compaction will vary depending on fill gradation and moisture content and the compaction equipment used. Typically, fill compacted using a large vibratory roller compactor should be placed and compacted in maximum 9-inch-thick loose lifts. Smaller lift thicknesses (about 5 to 6 inches) will be necessary for adequate fill compaction using vibratory plate compactors or tampers. In no case should the loose lift thickness exceed 9 inches.

Heavy vibratory roller compactors should not be used to compact fill placed within a distance from the backs of retaining walls equal to half of the overall wall height. In these areas, vibratory plate or tamper compactors should be used. Backfill should be placed in such a manner as to minimize differential loading on the walls. Walls should be braced at bottom by the concrete floor slabs-on-grade and near the top by the main level structural floors before backfill is placed, unless the walls are designed to support active earth pressures without being braced by the floors.

Special Inspections

In accordance with the IBC, special inspections are necessary during subgrade preparation and placement of fill within the building area. We recommend that a local soil testing company be retained to conduct grain size, moisture-density relationship (a.k.a., Proctor testing), and field

density testing of fill materials. We recommend that WGC be engaged to make at least three site visits during excavation and subgrade preparation to check that our assumptions regarding subsurface conditions (which were based on a limited number of borings and test pits) were reasonably representative, and that our recommendations are properly interpreted and followed. Note that if subsurface conditions differ from those assumed in developing our recommendations, our recommendations may need to be modified.

Freezing Conditions

During freezing conditions, additional care must be exercised during construction to prevent disturbance of the soil subgrades and to achieve the required degree of fill compaction. The subgrades and each lift of backfill must be compacted before the water in the subgrade or backfill can freeze.

Frozen material should not be placed as backfill, nor should backfill, foundations, pavements, or slabs be placed on frozen soil. If, during construction, the top layer of soil becomes frozen, the frozen soil should be removed before backfill, foundations, pavements, or slabs are placed on it. When the air temperature is below 25° F the contractor should not be allowed to place fill or expose final subgrades unless special procedures, approved by the geotechnical engineer, are used to prevent freezing. If footings are built and left exposed during the winter season, precautions should be implemented to prevent damage due to frost heave.

LIMITATIONS

Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed structure. We cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. We, therefore, recommend that WGC be engaged to make site visits during construction to:

1. Check that the subsurface conditions exposed during construction are in general conformance with our design assumptions.

2. Ascertain that, in general, the work is being performed in compliance with the contract documents and our recommendations.

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, express or implied, is made.

We appreciate the opportunity to work with you on this project. Please call if you have any questions.

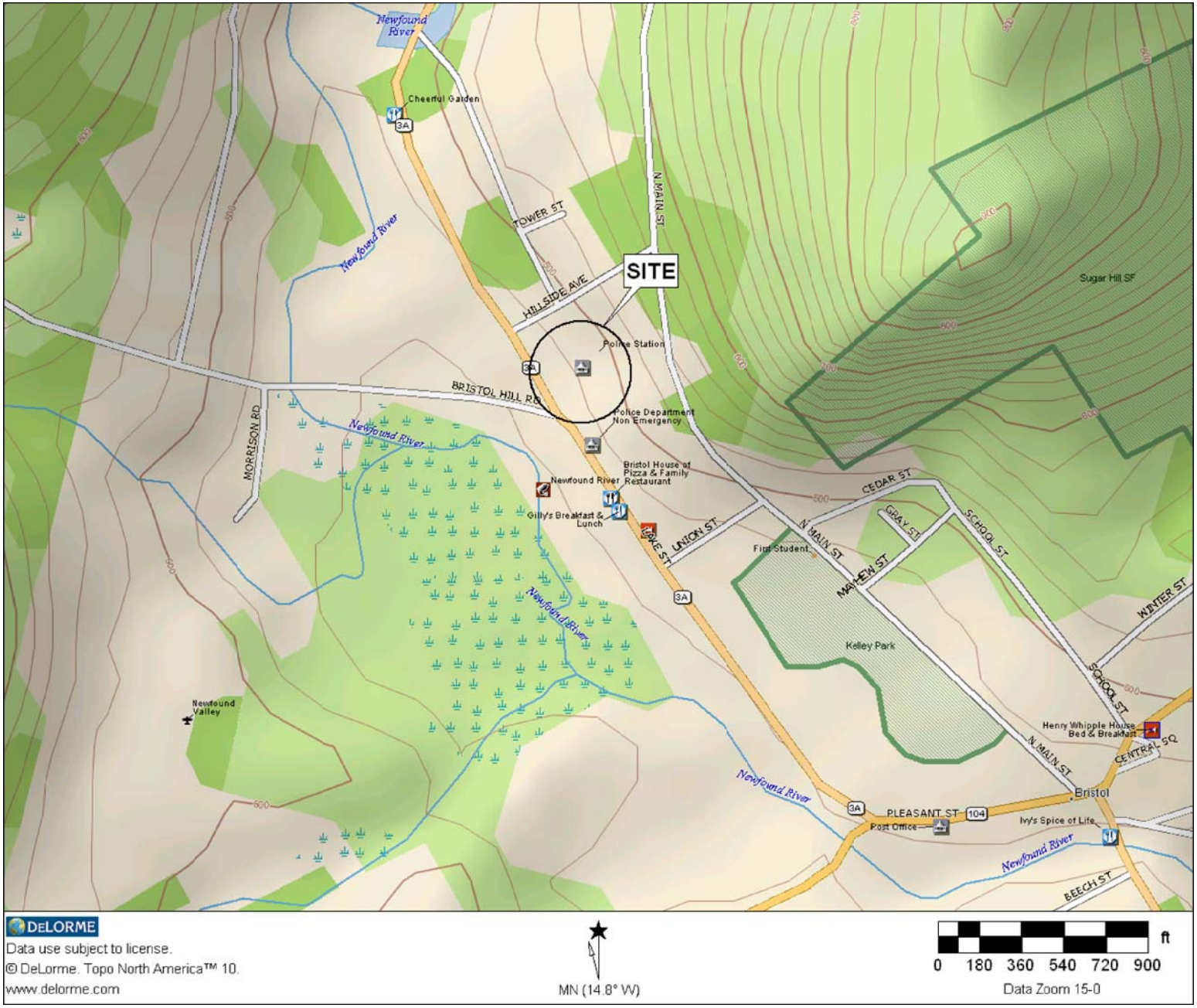
Sincerely,

Ward Geotechnical Consulting, PLLC

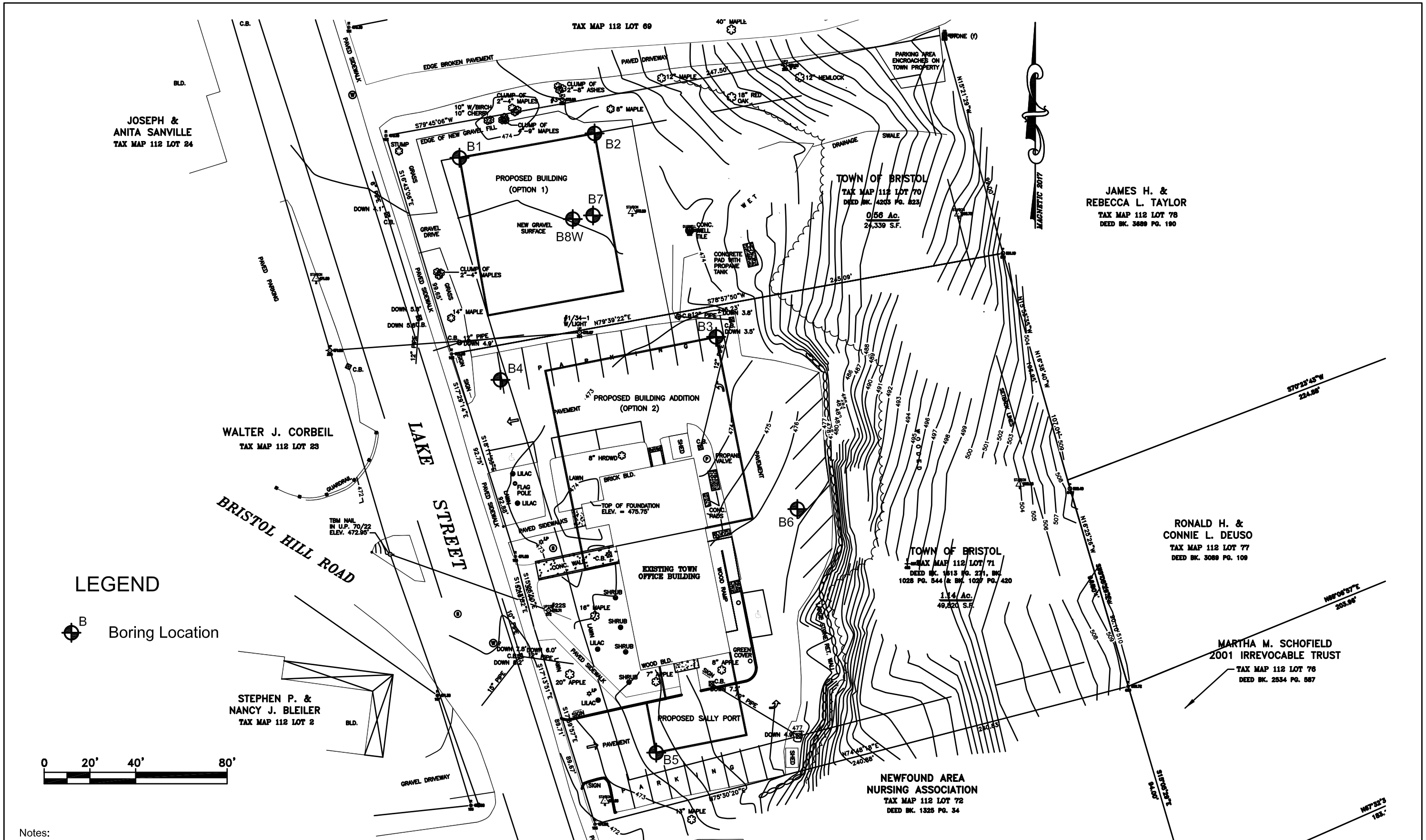
Craig F. Ward, P.E.
Principal

Figures 1 and 2
Appendix A

CFW



KV Partners, LLC New Boston, New Hampshire	TOWN OFFICES BRISTOL, NEW HAMPSHIRE	SITE LOCATION MAP
Ward Geotechnical Consulting, PLLC	WGC Project 17200	October 2017 Figure 1



Notes:

1. The borings were drilled by New England Boring Contractors, Inc. and observed by Ward Geotechnical Consulting, PLLC on August 30 and 31, 2017. B8W was drilled without sampling to install an observation well.

2. Base plan was provided by KV Partners, LLC in AutoCAD format for our use in preparing this boring location plan. Elevations are referenced to the project datum (benchmark HPC-63 disc on bridge over Newfound River).

KV Partners, LLC New Boston, New Hampshire	TOWN OFFICES BRISTOL, NEW HAMPSHIRE	BORING LOCATION PLAN
Ward Geotechnical Consulting, PLLC	WGC Project 17200	October 2017 Figure 2

Appendix A – Boring Logs

Ward Geotechnical Consulting, PLLC	Project: Bristol Town Offices Location: Bristol , New Hampshire Client: KV Partners, LLC Project No.: 17200	Boring Log **B1**

Contractor: NewEngland Boring Contractors Logged By: Craig Ward Drilling Dates: 8/30/2017 Drill Rig: Mobile B-48 Truck Rig	Groundwater Depth: not measured	Date:		Page 1 of 1
	GS Elevation: 473.5 +/- Datum: Project Datum	Boring Location: see Boring Location Plan		

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
	S1	2-4 13-1	24	8	2-1/4" Hollow Stem Augers Augered to 4'. Augers deflected by boulders & grinding on boulders.		S1: **Sand with Gravel (SP)** - fine to medium sand, 15%-25% subrounded gravel to 3/4", brown.	**Probably Fill**
5	S2	14-11 9-8	24	14			S2: **Sand with Gravel (SW)** - fine to coarse sand, 15%-25% subangular gravel to 3/4", dry, brown.	**~6'**
					Augered to 9'. Augers on boulders from 4' to 5' and at ~8'.			**Silty Sand with Gravel, Silty Sand, & Sand (with Cobbles & Boulders)**
10	S3	26-12 13-10	24	8	Spoon wet. Augered to 14'. Occasional grinding on gravel.		S3: **Silty Sand with Gravel (SM)** - fine to medium sand, 15%-25% nonplastic fines, 20%-30% angular gravel & rock fragments to 1", wet, light brown.	
15	S4	24-36 41-35	24	22	Augered to 19'. Occasional grinding on gravel.		S4: **Silty Sand with Gravel (SM)** - fine to medium (some coarse) sand, 15% to 25% nonplastic fines, 5%-15% subangular gravel to 1/2", olive.	
20 20.3	S5	20-46 54/4"	16	15	SPT Refusal at 20.3'.		S5: **Sand (SP) & Silty Sand (SM)** - fine to medium sand, some zones 15%-25% nonplastic fines, occasional subagular gravel to 3/4", wet, light brown. Weathered rock (probably schist) in tip of spoon.	
							Bottom of Boring at 20.3'	
25								

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical Consulting, PLLC	Project: Bristol Town Offices Location: Bristol , New Hampshire Client: KV Partners, LLC Project No.: 17200	Boring Log **B2**

Contractor: NewEngland Boring Contractors Logged By: Craig Ward Drilling Dates: 8/30/2017 Drill Rig: Mobile B-48 Truck Rig	Groundwater Depth: not measured	Date:		Page 1 of 1
	GS Elevation: 473.5 +/- Datum: Project Datum	Boring Location: see Boring Location Plan		

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
	S1	4-6 10-8	24	8	2-1/4" Hollow Stem Augers Augered to 4'. Occasional grinding on gravel.		S1: **Sand with Silt & Gravel (SP-SM)** - fine to meduim sand, 5%-20% (varies) nonplastic fines, 10%-20% subangular gravel to 3/4", occasional roots, light brown (upper 4") and dark brown (lower 4").	**Probably Fill** **~4'**
5	S2	15-14 15-14	24	9	Spoon wet. Augered to 9'. Occasional grinding on cobbles.		S2: **Sand with Silt & Gravel (SP-SM)** - fine to medium (some coarse) sand, 5%-15% nonplastic fines, 20%-30% subangular gravel to 3/4", wet, brown (upper 4") and light olive (lower 5").	**Sand with Silt & Gravel and Silty Sand**
10	S3	23-26 24-36	24	12	Augered to 14'. Occasional grinding on cobbles.		S3: **Sand with Silt & Gravel (SP-SM)** - fine to medium & fine to coarse sand, 5%-15% nonplastic fines, 30%-40% subangular gravel & rock fragments to 1", wet, light brown-olive.	
14.5 15	S4	88/6"	6	6	Augered to 19'. Occasional grinding on cobbles.		S4: **Silty Sand (SM)** - fine to medium sand, 15%-25% nonplastic fines, occasional subangular gravel to 3/8", wet, light olive.	
20 20.3	S5	13-31 69/3.5"	15.5	14.5	SPT Refusal at 20.3'.		**Silty Sand (SM)** - fine (some medium) sand, 25%-35% nonplastic fines, vague lamination, wet, olive. Weathered rock (probably schist) in tip of spoon.	
25							Bottom of Boring at 20.3'	

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical Consulting, PLLC	Project: Bristol Town Offices Location: Bristol , New Hampshire Client: KV Partners, LLC Project No.: 17200	Boring Log **B3**

Contractor: NewEngland Boring Contractors Logged By: Craig Ward Drilling Dates: 8/30/2017 Drill Rig: Mobile B-48 Truck Rig	Groundwater Depth: 4.0' below existing pavement surface on 8/31/17 Date:		Page 1 of 1
	GS Elevation: 473.5 +/- Datum: Project Datum	Boring Location: see Boring Location Plan	

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
0.5	S1	4-5 5-5	24	16	4-1/4" Hollow Stem Augers		5" Ashpalt Pavment S1: 0-15": **Sand (SP)** - fine to medium (some coarse) sand, 5%-10% subangular gravel to 3/4", moist, light brown-tan.	**Fill** **~2'**
2.5					Augered to 4'. Aguers grinding on cobbles or boulders below 2'.		15"-16": **Silty Sand (SM)** - fine to medium sand, 15%-25% nonplastic fines, moist, dark gray.	**Silty Sand, Sand with Silt & Gravel, & Silty Sand with Gravel (with Cobbles & Boulders)**
5	S2	9-13 16-17	24	17	Spoon wet.		S2: **Sand with Silt & Gravel (SP-SM)** - fine to medium (some coarse) sand, 5%-15% nonplastic fines, 5%-15% subangular gravel to 3/4" (some weathered), wet, brown.	
					Augered to 9'. Occasional grinding on gravel			
10	S3	6-13 10-9	24	16			S3: **Sand with Silt & Gravel (SP-SM)** - similar to S2.	
					Augered with 4-1/4" augers to refusal at 13'. Continued to 14' with 2-1/4" augers.			
15 15.2	S4	29-52 48/3"	15	15			S2: **Silty Sand with Gravel (SM)** - fine to medium (some coarse) sand, 20%-30% nonplastic fines, 5%-15% subangular gravel to 1/2", wet, olive. Sample contains ~5" thick zone of sandy silt (nonplastic fines, 30%-40% fine sand, wet, dark olive).	
					Augered to 19' without encountering refusal.			
20							Bottom of Boring at 19' Installed 1" PVC observation well to depth of 18.1' below pavement surface: - 10' screen - 8.5' riser - backfilled with filter sand to ~0.4' below pavement - installed roadbox at pavement surface Groundwater level measured on 8/31/17 at 7:20am was 4.0' below the pavement surface.	
25							PVC screen & riser and roadbox were subsequently removed for use in a boring to be drilled in the proposed Option 1 building area B8W).	

Notes:

Abbreviations:

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C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical
Consulting, PLLC

Project:	Bristol Town Offices		Boring Log
Location:	Bristol , New Hampshire		**B4**
Client:	KV Partners, LLC		
Project No.:	17200		
Contractor: NewEngland Boring Contractors	Groundwater Depth: not measured	Date:	Page 1 of 1
Logged By: Craig Ward			
Drilling Dates: 8/31/2017	GS Elevation: 472.5 +/-	Boring Location: see Boring Location Plan	
Drill Rig: Mobile B-48 Truck Rig	Datum: Project Datum		

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
	S1	5-6 5-4	24	13	2-1/4" Hollow Stem Augers		5" Asphalt Pavement S1: 0-2": **Sand with Gravel (SW)** - fine to coarse sand, 20%-30% subangular gravel to 1/2", brown.	**Fill** **~0.7'**
					Augered to 4'. Occasional grinding on gravel.		2"-13": **Sand (SP) & Silty Sand (SM)** - approx 2" layers of fine to medium sand and fine to medium sand with 10%-20% nonplastic fines, occasional gravel to 1/2", light brown and brown. Possible fill.	**Sand, Silty Sand, Silt, Sand with Silt & Gravel, and Silty Sand with Gravel (with Cobbles & Boulders)**
5	S2	2-4 5-6	24	19			S2: **Sand (SP)** - fine to medium sand, vague stratification, moist, tan & light orange. Sample also contains 2" thick lens of silty fine sand (fine sand, 20%-30% nonplastic fines, light green/gray).	
					Augered to 9'. Occasional grinding on gravel.			
10	S3	4-5 6-5	24	16	Spoon wet.		S3: **Sandy Silt (ML)** - nonplastic fines, 20%-30% fine sand, vague lamination, wet, light olive.	
					Augered to 14'. Grinding on cobbles below 12'.			
15	S4	6-13 14-16	24	15			S4: **Sand with Silt & Gravel (SW-SM)** - fine to coarse sand, 5%-15% nonplastic fines, 25%-35% subangular gravel to 1", wet, light brown.	
					Augered to 19'. Occasional grinding on cobbles.			
20 20.2	S5	15-36 64/2.5"	14.5	14	SPT Refusal at 20.2'.		S5: **Silty Sand with Gravel (SM)** - fine to medium (some coarse) sand, 15%-25% nonplastic fines, 15%-25% subangular gravel to 3/4" (some weathered) wet, light olive.	
							Bottom ofBoring at 20.2'	
25								

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical Consulting, PLLC	Project: Bristol Town Offices Location: Bristol , New Hampshire Client: KV Partners, LLC Project No.: 17200	Boring Log **B5**

Contractor: NewEngland Boring Contractors Logged By: Craig Ward Drilling Dates: 8/31/2017 Drill Rig: Mobile B-48 Truck Rig	Groundwater Depth: not measured	Date:		Page 1 of 1
	GS Elevation: 474.5 +/- Datum: Project Datum	Boring Location: see Boring Location Plan		

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
	S1	9-9 7-5	24	16	2-1/4" Hollow Stem Augers Augered to 4'.		5" Asphalt Pavement S1: 0-6": **Sand with Gravel (SW)** - fine to coarse sand, 15%-25% subangular gravel to 3/8", light brown. 6"-16": **Silty Sand (SM)** - fine (some medium) sand, 15%-25% nonplastic fines, 5%-10% subangular gravel to 1/4", moist, light brown.	**Fill**
5	S2	2-3 2-1	24	13			S2: 0-8": **Silty Sand with Gravel (SM)** - fine to medium sand, 15%-25% nonplastic fines, 10%-20% subangular gravel to 3/4", light olive.	**~5'**
							8"-13": **Peat (OL)** - fibrous, fine grained, moist, dark brown & black. S3: 0-5": **Peat (OL)** - fibrous, fine grained, moist, dark brown & black, containing a 1/2" thick lens of fine to medium sand.	**Peat** **~6.5'**
	S3	3-14 16-14	24	16			5"-16": **Sand with Gravel (SW)** - fine to coarse sand, 30%-40% subang. gravel to 3/4", moist, light brown.	**Sand with Gravel and Silty Sand with Gravel (with Cobbles & Boulders)**
10	S4	13-16 16-18	24	16	Augered to 9'. Occasional grinding on gravel/cobbles.		S4: **Sand with Gravel (SW)** - fine to coarse sand, 20%-30% subangular & subrounded gravel to 3/4", wet, light brown.	
15	S5	11-12 16-19	24	17	Augered to 14'. Grinding on cobbles/boulders. Augered to refusal at 17.5'		S5: **Sand with Silt & Gravel (SW-SM)** - fine to coarse sand, 5%-15% nonplastic fines (siltier with depth), 20%-30% subangular gravel to 3/4", wet, brown.	
							Bottom of Boring at 17.5'	
20								
25								

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
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U - Undisturbed Tube Sample

Ward Geotechnical
Consulting, PLLC

Project:	Bristol Town Offices		Boring Log
Location:	Bristol , New Hampshire		**B6**
Client:	KV Partners, LLC		
Project No.:	17200		
Contractor: NewEngland Boring Contractors	Groundwater Depth: not measured	Date:	Page 1 of 1
Logged By: Craig Ward			
Drilling Dates: 8/31/2017	GS Elevation: 477 +/-	Boring Location: see Boring Location Plan	
Drill Rig: Mobile B-48 Truck Rig	Datum: Project Datum		

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
0.5	S1	4-5 7-6	24	13	2-1/4" Hollow Stem Augers		4" Asphalt Pavement S1: 0-6": **Sand with Gravel (SP)** - fine to medium (some coarse) sand, 10%-20% subangular gravel to 3/4", moist, brown.	Fill ~1.5'
2.5					Augered to 4'. Grinding on cobbles/boulders.		6"-13": **Silty Sand with Gravel (SM)** - fine (some medium) sand, 10%-20% nonplastic fines, 10%-20% subangular gravel to 3/8", light brown-olive.	Sand with Silt & Gravel, Silty Sand with Gravel, and Sandy Silt (with Cobbles & Boulders)
5	S2	7-10 10-11	24	14	Spoon wet.		S2: **Sand with Silt & Gravel (SP-SM)** - fine to medium (some coarse) sand, 5%-15% nonplastic fines, 20%-30% subrounded & subangular gravel to 3/4", wet, brown.	
					Augered to 9'. Grinding on cobbles/boulders.			
10	S3	9-9 11-8	24	13			S3: **Sand with Silt & Gravel (SP-SM)** - similar to S2.	
					Augered to 14'. Grinding on cobbles/boulders			
14.0 14.1	S4	50/1.5"	1.5	1	SPT Refusal at 14.1'.		S4: **Sandy Silt (ML)** - nonplastic fines, 20%-30% fine sand, wet, olive. Weathered rock (probably schist) in tip of spoon.	
15							Bottom of Boring at 14.1'	
20								
25								

Notes:

Abbreviations:

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REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical Consulting, PLLC	Project: Bristol Town Offices Location: Bristol , New Hampshire Client: KV Partners, LLC Project No.: 17200	Boring Log **B7**

Contractor: NewEngland Boring Contractors Logged By: Craig Ward Drilling Dates: 8/31/2017 Drill Rig: Mobile B-48 Truck Rig	Groundwater Depth: not measured Date: GS Elevation: 473 +/- Datum: Project Datum	Boring Location: see Boring Location Plan	Page 1 of 1

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS	
	S1	2-4 5-8	24	15	2-1/4" Hollow Stem Augers Augered to 4'. Grinding on boulders.		S1: **Sand with Gravel (SW)** - fine to coarse sand, 20%-30% subangular gravel to 1/2", dry, light brown.	Probably Fill ~4'
5	S2	15-25 32-23	24	17	Aguered to 9'. Grinding on cobbles and boulders.		S2: **Sand with Silt & Gravel (SP-SM)** - fine to medium (some coarse) sand, 5%-15% nonplastic fines, 10%-20% subangular gravel to 3/4", wet, light olive.	Sand with Silt & Gravel, Silty Sand with Gravel, and SandySilt (with Cobbles and Boulers)
10	S3	3-5 7-8	24	16	Augered to 14'. Grinding on boulder at ~12'. ~3' of blow in of clean sands - couldn't take sample. Tried to auger back down - blew in again.		S3: **Silty Sand (SM)** - fine to medium sand, 10%-25% (varies) nonplastic fines, occasional subangular gravel to 3/8", wet, olive.	
15					Abandoned boring. Moved rig twice (4' and 6' south of B7) to attempt to auger down without sampling to install well. Both attempts encountered auger refusals on boulders at less than 3' depth and were abandoned.		Bottom of Boring at 14'	
20					Moved rig to about 9' south of B7 to location B8 to install well.			
25								

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample

Ward Geotechnical
Consulting, PLLC

Project:	Bristol Town Offices		Boring Log
Location:	Bristol , New Hampshire		**B8**
Client:	KV Partners, LLC		
Project No.:	17200		

Contractor:	NewEngland Boring Contractors	Groundwater Depth: 4.0' below existing ground surface on 9/13/17	Date:
Logged By:	Craig Ward		Page 1 of 1
Drilling Dates:	8/31/2017	GS Elevation: 473 +/-	Boring Location: see Boring Location Plan
Drill Rig:	Mobile B-48 Truck Rig	Datum: Project Datum	

DEPTH FT.	SAMPLE TYPE & NO.	BLOWS per 6 IN.	PEN. IN.	REC. IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS
					2-1/4" Hollow Stem Augers		Augered through granular soils containing several cobbles and boulders to refusal (probably on boulder) at 8' to install observation well.
5							
							Bottom of Boring at 8' Installed 1" PVC observation well to depth of 7.5' below ground surface: - 5' screen - 2.1' riser - backfilled with filter sand to ~0.6' below ground surface - installed roadbox at ground surface Groundwater level measured on 9/13/17 at ~4:30 pm was 4.0' below the existing ground surface.
10							
15							
20							
25							

Notes:

Abbreviations:

PEN - Penetration length of sampler or core barrel
REC - Recovery length of sample
S - Split Spoon Sample
C - Rock Core Sample
U - Undisturbed Tube Sample