EXHIBIT V
GEOTECH REPORT BY TERRACON, DATED AUGUST 18, 2014
Geotechnical Engineering Report

Proposed Cellular Tower
ATC #281865
AT&T #SN4931
75th Street SW & 46th Avenue W
2605 Mukilteo Speedway
Mukilteo, Washington
August 18, 2014
Terracon Project No. 81145034

Prepared for:
American Tower Corporation
Portland, Oregon

Prepared by:
Terracon Consultants, Inc.
Mountlake Terrace, Washington
August 18, 2014

American Tower Corporation
12830 SW Park Way
Portland, Oregon 97225

Attn: Kevin Arnold
P: (503) 708-1072
E: Kevin.Arnold@AmericanTower.com

Re: Geotechnical Engineering Report
Proposed Cellular Tower
ATC #281865, AT&T #SN4931
75th Street SW & 46th Avenue W
2605 Mukilteo Speedway
Mukilteo, Washington 98275
Terracon Project Number: 81145034

Dear Mr. Arnold:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above-referenced project. This study was performed in general accordance with our proposal number P82140143, dated July 17, 2014 and authorized by your Purchase Order No. 338822, dated July 21, 2014. This report presents the findings of the subsurface explorations and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed tower.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

Ryan M. Scheffler, P.E.
Senior Staff Engineer

David A. Baska, P.E., PhD
Geotechnical Department Manager
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>i</td>
</tr>
<tr>
<td>1.0 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2.0 PROJECT INFORMATION</td>
<td>1</td>
</tr>
<tr>
<td>2.1 Project Description</td>
<td>1</td>
</tr>
<tr>
<td>2.2 Site Location and Description</td>
<td>2</td>
</tr>
<tr>
<td>3.0 SUBSURFACE CONDITIONS</td>
<td>2</td>
</tr>
<tr>
<td>3.1 Site Geology</td>
<td>2</td>
</tr>
<tr>
<td>3.2 Typical Profile</td>
<td>3</td>
</tr>
<tr>
<td>3.3 Groundwater</td>
<td>3</td>
</tr>
<tr>
<td>4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION</td>
<td>3</td>
</tr>
<tr>
<td>4.1 Geotechnical Considerations</td>
<td>3</td>
</tr>
<tr>
<td>4.2 Earthwork</td>
<td>4</td>
</tr>
<tr>
<td>4.2.1 Site Preparation</td>
<td>4</td>
</tr>
<tr>
<td>4.2.2 Subgrade Preparations</td>
<td>4</td>
</tr>
<tr>
<td>4.2.3 Fill Material Requirements</td>
<td>4</td>
</tr>
<tr>
<td>4.2.4 Compaction Requirements</td>
<td>5</td>
</tr>
<tr>
<td>4.2.5 Grading and Drainage</td>
<td>5</td>
</tr>
<tr>
<td>4.2.6 Earthwork Construction Considerations</td>
<td>6</td>
</tr>
<tr>
<td>4.3 Foundation Recommendations</td>
<td>6</td>
</tr>
<tr>
<td>4.3.1 Drilled Shaft Foundations</td>
<td>6</td>
</tr>
<tr>
<td>4.3.2 Drilled Shaft Construction Considerations</td>
<td>7</td>
</tr>
<tr>
<td>4.3.3 Engineered Mat Foundation</td>
<td>8</td>
</tr>
<tr>
<td>4.3.4 Construction Considerations</td>
<td>9</td>
</tr>
<tr>
<td>4.4 Equipment Shelter and Generator Slabs</td>
<td>10</td>
</tr>
<tr>
<td>4.5 Seismic Considerations</td>
<td>10</td>
</tr>
<tr>
<td>4.5.1 Fault Zones</td>
<td>11</td>
</tr>
<tr>
<td>4.5.2 Liquefaction</td>
<td>11</td>
</tr>
<tr>
<td>4.6 Field Resistivity Testing</td>
<td>11</td>
</tr>
<tr>
<td>5.0 GENERAL COMMENTS</td>
<td>12</td>
</tr>
</tbody>
</table>

## APPENDIX A – FIELD EXPLORATION
- Exhibit A-1 Site Location Map
- Exhibit A-2 Site & Exploration Plan
- Exhibit A-3 Field Exploration Description
- Exhibit A-4 Boring Log B-1

## APPENDIX B – LABORATORY TESTING
- Exhibit B-1 Laboratory Testing
- Exhibit B-2 Grain Size Distribution Results

## APPENDIX C – SUPPORTING DOCUMENTS
- Exhibit C-1 General Notes
- Exhibit C-2 Unified Soil Classification System
- Exhibit C-3 USGS Seismic Design Maps Summary Report
EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the ATC #281865 tower site to be constructed at 2605 Mukilteo Speedway in Mukilteo, Washington. Terracon's geotechnical scope of work included the advancement of one test boring to an approximate depth of 33 feet below the existing ground surface (bgs).

Based on the information obtained from our subsurface exploration, the site is suitable for the proposed project. The following geotechnical considerations were identified:

- **Subsurface Conditions**: Soils encountered generally consisted of approximately 12 feet of hard / very dense silty sand / sandy silt, underlain with 21 feet of very dense silty sand. Groundwater was not encountered during drilling.

- **Foundations**: The proposed monopole tower may be supported on either a reinforced concrete mat foundation bearing on the native very dense silty sand soils, or a drilled shaft foundation with a minimum of 15 feet of embedment. Based on mapped geologic conditions and our field observations, the presence of scattered large cobbles or boulders could potentially cause difficulty during construction of a drilled shaft foundation.

Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that Terracon be retained to monitor this portion of the work.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.
1.0 INTRODUCTION

A geotechnical exploration has been performed for the proposed cellular tower to be constructed at 2605 Mukilteo Speedway in Mukilteo, Washington. One boring, designated B-1, was drilled to a depth of approximately 33 feet below the existing ground surface (bgs). This report presents our geotechnical recommendations for design and construction of the foundations for the proposed tower and equipment shelter slab. A log of the boring along with a Site Location Map and a Site and Exploration Plan are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- field resistivity testing
- foundation design and construction
- slab design and construction
- seismic considerations

2.0 PROJECT INFORMATION

2.1 Project Description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site layout</td>
<td>See Appendix A, Exhibit A-2: Site and Exploration Plan.</td>
</tr>
<tr>
<td>Structure</td>
<td>Proposed 120-foot tall Above Ground Level (AGL) monopine tower with an 80KW diesel generator and a 12-foot by 20-foot equipment shelter.</td>
</tr>
</tbody>
</table>
| Maximum tower loads| Vertical: 30 kips (assumed)  
                 | Shear: 35 kips (assumed)  
                 | Moment: 3,000 kip-ft (assumed)                                                                                                            |
2.2 Site Location and Description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>The proposed tower is located at 2605 Mukilteo Speedway in Mukilteo, Washington. The proposed tower coordinates are Latitude N 47.929414° and Longitude W 122.302964°.</td>
</tr>
<tr>
<td>Existing improvements</td>
<td>The future lease portion of the site is currently undeveloped and shares a gravel access driveway from Mukilteo Speedway (WA-525) with a single-family residence.</td>
</tr>
<tr>
<td>Current ground cover</td>
<td>Current ground cover was observed to be thick ivy with scattered 5 to 30 inch diameter trees. A dirt and moss path extends to the edge of the lease area from the nearby home and gravel driveway.</td>
</tr>
<tr>
<td>Existing topography</td>
<td>Based on the Existing Site Survey provided by the client, USGS contour maps, and field observations, the proposed lease site is gently sloped down to the southeast, while the adjacent hillside slopes steeply down to the west with a total relief on the order of 350 to 400 feet.</td>
</tr>
</tbody>
</table>

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

According to the USGS Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington (Minard 1982), the geology underlying the site is mapped as Qvt - Vashon Till (Fraser Glaciation). Various units are exposed as the slope descends to the west, including Qva – Advanced Outwash (Fraser Glaciation), Qtb – Transitional Beds (fraser Glaciation to pre-Fraser time), Qtu – Till, Undivided (Fraser and pre-Fraser Glaciation) and Qw – Whidbey Formation (pre-Fraser Glaciation). Subsurface conditions encountered in our boring are consistent with these glacial deposits.
3.2 Typical Profile

Based on the results of the boring, subsurface conditions on the project site can be generalized as follows:

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Approximate Depth to Bottom of Stratum (feet)</th>
<th>Material Description</th>
<th>Consistency/Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>Silty Sand to Sandy Silt</td>
<td>Hard / Very Dense</td>
</tr>
<tr>
<td>2</td>
<td>Full depth of exploration¹</td>
<td>Silty Sand</td>
<td>Very Dense</td>
</tr>
</tbody>
</table>

1. Auger refusal was met in this stratum; final depth of this stratum is undetermined.

Conditions encountered at the boring location are indicated on the boring log in Appendix A. Stratification boundaries on the boring log represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual.

3.3 Groundwater

Groundwater was not encountered at the time of drilling. It should be recognized that fluctuations of the groundwater table may occur due to seasonal and longer term variations in the amount of precipitation and runoff, future construction and other factors not evident at the time the boring was drilled. Evaluation of these factors is beyond the scope of this exploration.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of the subsurface exploration, laboratory testing, and our analyses, it is our opinion that the site is suitable for the proposed construction. The tower may be supported on either a reinforced concrete mat foundation bearing on native very dense silty sand to sandy silt soils or a drilled shaft foundation with a minimum embedment of 15 feet bgs. Based on mapped geologic conditions and our field observations, the presence of scattered large cobbles or boulders could potentially cause difficulty during construction of a drilled shaft foundation.

Geotechnical engineering recommendations for design and construction of foundation systems and other earthwork phases of the project are outlined below. The recommendations contained in this report are based upon engineering analyses, and our current understanding of the proposed project.
4.2 Earthwork

Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, observation of drilled shaft construction, and other geotechnical elements involved with construction of the project.

4.2.1 Site Preparation

We understand the extent of clearing and grading on the site may be limited by Fish and Wildlife regulations. All existing vegetation, including grass, roots, loose or soft soil/rock and other unsuitable materials should be removed from beneath proposed structural slabs and the tower foundation. After removal of unsuitable materials and prior to placing fill, soft or disturbed areas encountered during subgrade preparation should be removed and replaced with suitable structural fill as described below. Pumping or unstable soils are not suitable for supporting structure foundations and should be removed and replaced with structural fill.

The design recommendations presented in this report are based on the observed soil/rock conditions at the specific exploration location.

4.2.2 Subgrade Preparations

If a concrete mat foundation is selected to support the tower, the tower foundation area should be excavated to the minimum depth of 4 feet. Once the excavation is completed, we recommend that the exposed subgrades be evaluated by a qualified geotechnical engineer to identify remaining soft or disturbed soils.

For the equipment shelter subgrades, we recommend that the subgrades be stripped of unsuitable materials, and overexcavated to allow at least 4 inches of granular fill to be placed beneath the slab. To provide a capillary break, the granular fill should consist of clean, free-draining, uniformly graded gravel, containing less than 5 percent fines, based on that soil fraction passing the US No. 4 sieve. In addition, the subgrades for the equipment shelter should be evaluated by a qualified geotechnical engineer to identify any unsuitable areas. Unsuitable areas identified by visual observation and/or probing should be removed and replaced with compacted structural fill.

4.2.3 Fill Material Requirements

All fill materials should be inorganic soils free of vegetation, debris, and particles larger than three inches in size. Pea gravel or other similar non-cementitious, poorly-graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer.

Approved imported materials or onsite fill materials may be used as fill material for the following:

- general site grading
- foundation and slab areas
- foundation backfill
- trench backfill
<table>
<thead>
<tr>
<th>Fill Type</th>
<th>Specification</th>
<th>Acceptable for Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Fill</td>
<td>WSDOT(^3) Section 9-03.14(3) for Common Borrow</td>
<td>All locations across the site, with the exception of foundation base materials (Dry Weather only).</td>
</tr>
<tr>
<td>Select Fill</td>
<td>WSDOT(^3) Section 9-03.14(1) for Gravel Borrow</td>
<td>All locations across the site, Wet Weather and Dry Weather acceptable.</td>
</tr>
<tr>
<td>Crushed Aggregate Base (CAB)</td>
<td>WSDOT(^3) Section 9-03.9(3) for Crushed Surfacing (Base Course and Top Course sizes)</td>
<td>All locations across the site. Recommended for finished base course materials for foundations and slabs.</td>
</tr>
</tbody>
</table>

1. Controlled, compacted fill should consist of approved materials that are free (free = less than 3% by weight) of organic matter and debris (i.e. wood sticks greater than ½-inch in diameter). Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

2. Materials within 1-foot of footings should have a maximum particle size of 3 inches.


If open-graded materials with large void spaces, such as quarry spalls, are used over fine-grained soils, we recommend that the materials be placed over a geotextile fabric separator to prevent fines migration as well as to stabilize the subgrade. The geotextile fabric should be a woven product (Mirafi HP370 or equivalent).

### 4.2.4 Compaction Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill Lift Thickness</td>
<td>8 inches or less in loose thickness</td>
</tr>
<tr>
<td>Compaction(^1)</td>
<td>95% of the material's modified Proctor maximum dry density (ASTM D 1557) in foundation areas and 92% elsewhere.</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>Within two percent of the optimum moisture content as determined by the modified Proctor test at the time of placement and compaction</td>
</tr>
</tbody>
</table>

1. Fill should be tested frequently for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met; the area represented by the test should be reworked and restested as required until the specified compaction is achieved. This may require adjustment of the moisture content.

### 4.2.5 Grading and Drainage

Positive drainage away from the proposed structure should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into excavations should be prevented during construction. All grades should provide effective drainage away from all structures during and after construction.
4.2.6 Earthwork Construction Considerations
The site should be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to footing or floor slab construction.

Temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions, and comply with applicable local, state and federal safety regulations. The grading contractor is responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom.

4.3 Foundation Recommendations

Based on the results of this exploration, it is our opinion that the site is suitable for the proposed construction using a drilled shaft foundation or a concrete mat foundation.

4.3.1 Drilled Shaft Foundations
Recommended soil properties and design parameters to be used in the design of the drilled shaft foundations are included in the following tables. The values included in the tables were estimated based on the observed subsurface conditions during our field exploration, visual classifications, and presumptive values for similar materials. Note that the soil parameters are not intrinsic values of the soil, and depend on the state of the soil (density, depositional history, water content, etc.) and the loading conditions, among other factors. The soil parameters presented in the tables are intended to be used in the design of drilled shaft foundations at the site assuming soil and groundwater conditions are similar to those encountered during our field exploration. The applicability of these soil parameters for other uses should be discussed with Terracon.

<table>
<thead>
<tr>
<th>Layer Depth (ft)</th>
<th>Layer Thickness (ft)</th>
<th>Recommended Soil Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Approx. Effective Unit Weight of Soil (pcf)</td>
</tr>
<tr>
<td>0 to 12</td>
<td>12</td>
<td>125</td>
</tr>
<tr>
<td>12 to 33</td>
<td>21</td>
<td>130</td>
</tr>
</tbody>
</table>

The allowable end bearing pressure, skin friction, and constant of horizontal subgrade reaction \( n_h \) for granular soils) values are summarized in the following table. The allowable end bearing pressure and compressive skin friction values presented in the table are based on a factor of safety of 2.0. The allowable skin friction uplift values presented in the table are based on a factor of safety of 2.5. Also, the allowable skin friction to resist both vertical downward loads and...
uplift forces assumes bored shafts having concrete cast in direct contact with adjacent soil (uncased). The contribution of the upper 18 inches of the soil profile to shaft capacities should be neglected due to the potential freeze-thaw, wet-dry cycles and other disturbance in this zone that could further loosen the soil around the foundation.

<table>
<thead>
<tr>
<th>Layer Depth (ft)</th>
<th>Net Allowable End Bearing Pressure (Q_e), (psf)</th>
<th>Allowable Skin Friction; Compression (s_u), (psf)</th>
<th>Allowable Skin Friction; Uplift (s_u), (psf)</th>
<th>Ultimate Equivalent Fluid Passive Pressure* (p_{pass}), (pcf)</th>
<th>LPILE (k) value for sands, (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 12</td>
<td>18,500</td>
<td>435</td>
<td>350</td>
<td>481</td>
<td>225</td>
</tr>
<tr>
<td>12 to 33</td>
<td>26,500</td>
<td>1,250</td>
<td>1,000</td>
<td>546</td>
<td>225</td>
</tr>
</tbody>
</table>

a) \(N/R = \) not recommended. Minimum embedment depth is 15 feet.
b) End bearing with tip elevation at noted depth below existing ground surface.
c) For shaft diameters greater than 4 feet, reduce \(Q\) by a factor of 1.27/\(B_b\) where \(B_b\) is the shaft diameter in meters.
d) Neglect soil resistance for the upper 18 inches due to frost action and other disturbance.
e) The equivalent fluid passive pressures provided are for the individual layer, and assumes that there are no limitations on lateral deflection. The pressures should be applied as a triangular distribution over one shaft diameter. These are ultimate values with no safety factor applied.
f) Based on typical values from Table 3-6 of the LPILE 2012 Technical Manual.

The horizontal subgrade reaction values presented in the table above are applicable to static loads up to one-third of the ultimate lateral capacity of the shaft. For cyclic loads induced by wind or seismic forces, we recommend that 25 percent of the constant of horizontal subgrade reaction or coefficient of horizontal subgrade reaction be used to calculate lateral deflections to depths of 20 feet bgs. We recommend that 50 percent of the constant of horizontal subgrade reaction or coefficient of horizontal subgrade reaction be used to calculate lateral deflections below depths of 20 feet bgs. We recommend that the ultimate lateral resistance of the soils be evaluated as part of the drilled shaft design, in addition to deflection. The constants of horizontal subgrade reaction are based on a 1 foot square loaded area; reduction of these values for wider loaded areas may be appropriate.

4.3.2 Drilled Shaft Construction Considerations
We recommend that the foundation construction be observed on a full-time basis by a Terracon representative in order to verify that the soils encountered are consistent with the recommended design parameters. Drilling into the very dense silty sand soils may present difficult drilling conditions. Geologic mapping and field observations indicate the potential presence of scattered large cobbles or boulders and constructability of a drilled shaft foundation may be hindered if encountered during construction.
Based on the density and fines content of the soils observed in our exploration, in our opinion a drilled shaft foundation could likely be drilled without casing; however the contractor should be prepared to utilize means and methods of maintaining an open hole and stable shaft sidewalls during drilling and placement of reinforcing steel and concrete. The use of temporary casing and/or bentonite slurry may be required to maintain stability of the shaft sidewalls. Groundwater conditions encountered during construction may differ from those observed in our boring and may increase the chance of caving soils.

Construction of drilled shafts should only be performed by contractors experienced in construction of this type of foundation, and in the use of temporary casing and/or slurry. If casing is used, reinforcing steel should be placed inside the casing. The casing should be pulled as the concrete is placed to provide final contact between the soil and the concrete. A minimum head of 5 feet of concrete should be maintained above the lower edge of the casing as it is pulled to prevent intrusion of soil during extraction.

Following completion of drilling, soft, loose or disturbed soil should be removed from the bottom of the shaft prior to placement of concrete. We recommend that concrete be placed into the excavation through a tremie pipe extending to the bottom of the excavation. Concrete must not be allowed to free fall into the excavation or be placed through water or slurry without the use of a tremie if groundwater is present. An uninterrupted supply and placement of concrete should be performed to produce a monolithic pier/foundation. Use clean, watertight tremie pipes large enough in diameter to allow the free flow of concrete. The tremie pipes should be placed within one foot above the bottom of the excavation prior to the commencement of concrete placement. Maintain a minimum 5 feet embedment of the tremie pipe into the concrete during placement to displace drilling fluids or groundwater and prevent re-entry of bentonite slurry or groundwater into the tremie pipe.

4.3.3 Engineered Mat Foundation
The proposed tower may alternatively be supported on an engineered mat foundation bearing on native soils a minimum of 4 feet below ground surface. Design for uplift and overturning forces will be required. Thickening the mat or increasing embedment depths would provide additional weight to resist these forces.
Geotechnical Engineering Report
Proposed Cell Tower ■ Mukilteo, Washington
August 18, 2014 ■ Terracon Project No. 81145034

<table>
<thead>
<tr>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net allowable bearing pressure(^1)</td>
<td>4,000 psf</td>
</tr>
<tr>
<td>Foundation bearing directly on silty sand soils</td>
<td></td>
</tr>
<tr>
<td>Mat dimensions</td>
<td>Minimum 10 feet</td>
</tr>
<tr>
<td>Embedment below finished grade for frost protection(^2)</td>
<td>18 inches</td>
</tr>
<tr>
<td>Approximate total settlement(^3)</td>
<td>Less than 1 inch</td>
</tr>
<tr>
<td>Coefficient of sliding friction</td>
<td>0.4 (ultimate)</td>
</tr>
<tr>
<td>Coefficient of subgrade reactions “(k_i)”(^4)</td>
<td>150 pci</td>
</tr>
</tbody>
</table>

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes any unsuitable fill or soft silt soils, if encountered, will be undercut and replaced with Select structural fill.
2. To reduce the effects of seasonal moisture variations in the subgrade soils.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of any compacted fill, and the quality of the earthwork operations.
4. This value is representative of a 1 foot by 1 foot footing and should be scaled appropriately for a larger foundation. The coefficient decreases as the width of the foundation increases. The following equation by Das\(^2\) (1990) or other appropriate relationship may be used to scale the coefficient of subgrade reaction.

\[
k = k_i \left[ \frac{(B+1)}{(2B)} \right]^2
\]

\[
k_i = \text{coefficient of subgrade reaction (1 foot X 1 foot foundation)}
\]

\[
k = \text{scaled coefficient of subgrade reaction}
\]

\[
B = \text{foundation width}
\]

Compacted native soils or compacted select fill placed over the embedded mat are anticipated to have moist unit weights on the order of 110 to 120 pounds per cubic foot (pcf), respectively.

4.3.4 Construction Considerations

The base of all foundation excavations should be free of water and loose or soft soil or loose rock prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing material disturbance. If the material at bearing level becomes excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on this soil. Overexcavation for compacted structural fill placement below footings for support equipment should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with Select structural fill placed and compacted as specified in Compaction Requirements of this report. The overexcavation and backfill procedure is described in the following figure.

4.4 Equipment Shelter and Generator Slabs

The equipment shelter and generator slabs may be supported on 4 inches of structural fill prepared per the Site Preparation and Subgrade Preparation sections of this report. To provide a capillary break, the structural fill should consist of clean, free-draining, uniformly graded gravel, containing less than 5 percent fines, based on that soil fraction passing the US No. 4 sieve.

4.5 Seismic Considerations

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 International Building Code Site Classification (IBC)</td>
<td>$C^2$</td>
</tr>
<tr>
<td>Site Latitude</td>
<td>N 47.929414°</td>
</tr>
<tr>
<td>Site Longitude</td>
<td>W 122.302964°</td>
</tr>
<tr>
<td>$S_s$ Spectral Acceleration for a Short Period</td>
<td>1.456g</td>
</tr>
<tr>
<td>$S_1$ Spectral Acceleration for a 1-Second Period</td>
<td>0.567g</td>
</tr>
<tr>
<td>$F_a$</td>
<td>1.000</td>
</tr>
<tr>
<td>$F_v$</td>
<td>1.300</td>
</tr>
</tbody>
</table>

1. In general accordance with the 2012 International Building Code, and Table 20.3-1 of ASCE 7 – Chapter 20. Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.

2. Note: The 2012 International Building Code (IBC) and ASCE Publication 7 requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100-foot soil profile determination. Our single boring extended to a maximum depth of 33.2 feet, and this seismic site class definition assumes that very dense glacially consolidated soils as noted on the published geologic mapping continue below the maximum depth of the boring.
4.5.1 Fault Zones
We reviewed the USGS Earthquake Hazards Program Quaternary Faults and Folds Database available online (http://earthquake.usgs.gov/hazards/gfaults/map). The project site is within the Southern Whidbey Island fault zone. According to this source, the fault age is less than 15,000 years, has been mapped with northwest striking features, and is in the slip rate category of between 0.2 and 1.0 mm/year. Based on the information described above, we estimate that the risk associated with surface rupture at the site is moderate.

4.5.2 Liquefaction
Liquefaction is the phenomenon where saturated soils develop high pore-water pressures during seismic shaking and lose their strength characteristics. This phenomenon generally occurs in areas of high seismicity, where groundwater is shallow and loose granular soils or relatively non-plastic fine grained soils are present. Based on the site geology and subsurface conditions, the risk of liquefaction of the site soils is negligible.

4.6 Field Resistivity Testing
Field measurements of soil resistivity using the Wenner Four-Electrode Method were performed in general accordance with ASTM G 57-78. A series of soil resistivity tests were performed within the site area along perpendicular lines. The soil resistivity measurements were performed using a meter manufactured by Advanced Geosciences, Inc. The Wenner arrangement (equal electrode spacing) was used with the "a" spacing incrementally increasing from 5 to 20 feet. Results of the soil resistivity measurements are presented in the table below. Interpretation of the data from this survey was not included in the requested scope of services for this project.

<table>
<thead>
<tr>
<th>Test Direction</th>
<th>a =</th>
<th>5 feet</th>
<th>10 feet</th>
<th>15 feet</th>
<th>20 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-South</td>
<td>ρ(OHM-FT)</td>
<td>1,545</td>
<td>362.7</td>
<td>377.3</td>
<td>380.4</td>
</tr>
<tr>
<td></td>
<td>(measured)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ρ(OHM-CM)</td>
<td>47,092</td>
<td>11,055</td>
<td>11,500</td>
<td>11,595</td>
</tr>
<tr>
<td>East-West</td>
<td>ρ(OHM-FT)</td>
<td>2,424</td>
<td>371.1</td>
<td>365.8</td>
<td>374.7</td>
</tr>
<tr>
<td></td>
<td>(measured)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ρ(OHM-CM)</td>
<td>73,883</td>
<td>11,311</td>
<td>11,150</td>
<td>11,421</td>
</tr>
</tbody>
</table>
5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the boring performed at the indicated location and from other information discussed in this report. This report does not reflect variations that may occur across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.
APPENDIX A
FIELD EXPLORATION
SITE


SITE LOCATION MAP
ATC #281865, AT&T #SN4931
2605 Mukilteo Speedway
Mukilteo, Snohomish County, Washington
Field Exploration Description

The proposed boring location was located in the field by Terracon personnel with a hand-held GPS unit with an accuracy of ±20 feet horizontal using the tower coordinates supplied in the Zoning Drawing, Sheet T-1, dated February 20, 2014. The approximate location of the boring is shown on the Site & Exploration Plan that is attached in Appendix A. The exploration was drilled as close to the planned tower center coordinate location as possible without disturbing vegetation. The boring was drilled with a track drill rig using hollow-stem augers. A cathead hammer was utilized for penetration testing and obtaining samples. The boring elevation was measured in the field relative to the ground surface elevation at the tower location.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The boring was backfilled with bentonite prior to the field engineer leaving the site.

A field log of the boring was prepared by the field engineer during the field exploration in general accordance with the Unified Soil Classification System (USCS). The USCS is described in Appendix B. Collected soil samples from the boring were packaged and transported to our laboratory for further observation and testing. The final boring log included with this report represents the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

Field measurements of soil resistivity using the Wenner Four-Electrode Method were performed in general accordance with ASTM G 57-78. A series of soil resistivity tests were performed adjacent to the boring location area along perpendicular lines.
BORING LOG NO. B-1

PROJECT: ATC Tower # 281865

SITE: 2605 Mukilteo Speedway
Mukilteo, Washington

CLIENT: American Tower Corporation
Portland, Oregon

LOCATION
See Exhibit A-2
Latitude: 47.929414° Longitude: -122.302064°

DEGREE ELEVATION (FT)
Approximate Surface Elev 410 (FT) +/-

DEPTH

SILTY SAND (SM) to SANDY SILT (ML), light brown, very dense, damp to moist, rock fragments in tip (overstated blowcounts)

70
403+L

8
40-45-46
N=91
S-2
6
41

17
17-29-50/5°
N=79/11°
S-3
9
45

5
50/5°
N=50/5°
S-4
7

11
20-50/6°
N=50/6°
S-5
5
20

1
50/4°
N=50/4°
S-6

Hammer Type: Rope & Crown

Stratification lines are approximate. In-situ, the transition may be gradual.
Elevation based on field measurements relative to ground surface elevation of lower location.

Notes:
Boring Started: 8/8/2014
Boring Completed: 8/9/2014

Abandonment Method:
Brothers backfilled with bentonite chips upon completion

Water Level Observations:
Groundwater not encountered

Drill Rig: Track
Driller: Boxtec

21905 64th Ave. W., Suite 100
Mountlake Terrace, Washington

Project No.: 81145034
Exhibit: A-4

244
# Boring Log No. B-1

**Project:** ATC Tower # 281865  
**Client:** American Tower Corporation  
**Site:** 2605 Mukilteo Speedway, Mukilteo, Washington

## Graphic Log

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Water Level Observations</th>
<th>Sample Type</th>
<th>Field Test Results</th>
<th>Sample Number</th>
<th>Water Content (%)</th>
<th>Percent Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.2</td>
<td>grades to damp, rock in sample tip</td>
<td>3</td>
<td>50/4&quot; N=50/4&quot;</td>
<td>S-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>3</td>
<td>50/6&quot; N=50/6&quot;</td>
<td>S-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Auger refusal at 33.2 Feet</td>
<td>2</td>
<td>100/2&quot; N=100/2&quot;</td>
<td>S-9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stratification lines are approximate, in-situ, the transition may be gradual.  
Elevation based on field measurements relative to ground surface elevation of tower location.

**Hammer Type:** Rope & Cathead

---

**Advance Method:** Hollow Stem Auger  
**Abandonment Method:** Borings backfilled with bentonite chips upon completion

**Notes:**

- Boring Started: 8/8/2014  
- Boring Completed: 8/8/2014
- Drill Rig: Track  
- Driller: Boretec
- Project No.: 81145034  
- Exhibit: A-1

---

**Terracon**  
21905 84th Ave W, Suite 100  
Mountlake Terrace, Washington
APPENDIX B
LABORATORY TESTING
Laboratory Testing

Laboratory tests were conducted on selected soil samples and the test results are presented on the soil boring log. The laboratory test results were used for the geotechnical engineering analyses and the development of foundation design and construction recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following index and engineering properties:

- Moisture Content Determinations
- Percent Fines Content
- Grain Size Distributions
APPENDIX C
SUPPORTING DOCUMENTS
## General Notes

### Description of Symbols and Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲</td>
<td>Water Initially Encountered</td>
</tr>
<tr>
<td>▼</td>
<td>Water Level After a Specified Period of Time</td>
</tr>
<tr>
<td>▼</td>
<td>Water Level After a Specified Period of Time</td>
</tr>
</tbody>
</table>

**FIELD TESTS**

- (HP) Hand Penetrometer
- (T) Torvane
- (b/f) Standard Penetration Test (blows per foot)
- (PID) Photo-Ionization Detector
- (OVA) Organic Vapor Analyzer

**Shelby Tube**
- **Macro Core**
- **Rock Core**
- **Grab Sample**
- **No Recovery**
- **Ring Sampler**
- **Split Spoon**
- **Auger**

**Water Levels**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

### Descriptive Soil Classification

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

### Location and Elevation Notes

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

<table>
<thead>
<tr>
<th>STRENGTH TERMS</th>
<th>RELATIVE DENSITY OF COARSE-GRAINED SOILS</th>
<th>CONSISTENCY OF FINE-GRAINED SOILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive Term (Density)</td>
<td>Standard Penetration or N-Value Blows/Ft.</td>
<td>Ring Sampler Blows/Ft.</td>
</tr>
<tr>
<td>Very Loose</td>
<td>0 - 3</td>
<td>0 - 6</td>
</tr>
<tr>
<td>Loose</td>
<td>4 - 9</td>
<td>7 - 18</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 - 29</td>
<td>19 - 58</td>
</tr>
<tr>
<td>Dense</td>
<td>30 - 50</td>
<td>59 - 98</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt; 50</td>
<td>&gt; 99</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt; 4.00</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

### Relative Proportions of Sand and Gravel

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 15</td>
</tr>
<tr>
<td>With</td>
<td>15 - 29</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

### Relative Proportions of Fines

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>With</td>
<td>5 - 12</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 12</td>
</tr>
</tbody>
</table>

### Grain Size Terminology

- **Major Component of Sample**
  - Boulders: Over 12 in. (300 mm)
  - Cobble: 12 in. to 3 in. (300mm to 75mm)
  - Gravel: 3 in. to #4 sieve (75mm to 4.75 mm)
  - Sand: #4 to #200 sieve (4.75mm to 0.075mm)
  - Silt or Clay: Passing #200 sieve (0.075mm)

### Plasticity Description

<table>
<thead>
<tr>
<th>Term</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

---

**Terracon**

Exhibit C-250
## UNIFIED SOIL CLASSIFICATION SYSTEM

### Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Soil Classification</th>
<th>Group Symbol</th>
<th>Group Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Cu ≥ 4 and 1 ≤ Cc ≤ 3</td>
<td>Well-graded gravel</td>
</tr>
<tr>
<td>GP</td>
<td>Cu &lt; 4 and/or 1 &gt; Cc &gt; 3</td>
<td>Poorly graded gravel</td>
</tr>
<tr>
<td>GM</td>
<td>Fines classify as ML or MH</td>
<td>Silty gravel</td>
</tr>
<tr>
<td>GC</td>
<td>Fines classify as CL or CH</td>
<td>Clayey gravel</td>
</tr>
<tr>
<td>SW</td>
<td>Cu &lt; 6 and/or 1 &gt; Cc &gt; 3</td>
<td>Well-graded sand</td>
</tr>
<tr>
<td>SP</td>
<td>Cu &lt; 6 and/or 1 ≤ Cc ≤ 3</td>
<td>Poorly graded sand</td>
</tr>
<tr>
<td>SM</td>
<td>Fines classify as CL or CH</td>
<td>Silty sand</td>
</tr>
<tr>
<td>SC</td>
<td>Fines classify as ML or MH</td>
<td>Clayey sand</td>
</tr>
</tbody>
</table>

### Coarse Grained Soils: More than 50% retained on No. 200 sieve

- **Gravels:** More than 50% of coarse fraction retained on No. 4 sieve
- **Clean Gravels:** Less than 5% fines
  - Cu ≥ 4 and 1 ≤ Cc ≤ 3
  - Cu < 4 and/or 1 > Cc > 3
- **Gravels with Fines:** More than 12% fines
  - Fines classify as ML or MH
  - Fines classify as CL or CH

### Sands: 50% or more of coarse fraction passes No. 4 sieve

- **Clean Sands:** Less than 5% fines
  - Cu ≥ 6 and 1 ≤ Cc ≤ 3
  - Cu < 6 and/or 1 > Cc > 3
- **Sands with Fines:** More than 12% fines
  - Fines classify as ML or MH
  - Fines classify as CL or CH

### Fine-Grained Soils: 50% or more passes the No. 200 sieve

- **Silt Clays:** Liquid limit less than 50
  - Inorganic: PI ≥ 7 and plots on or above “A” line
  - Organic: Liquid limit - oven dried
- **Silt Clays:** Liquid limit 50 or more
  - Inorganic: PI plots on or above “A” line
  - Organic: Liquid limit - oven dried

### Highly organic soils:

- Primarily organic matter, dark in color, and organic odor

---

\[ \text{Cu} = \frac{(D_{60})^2}{D_{10} \times D_{60}} \]

\[ \text{Cc} = \frac{(D_{60})}{D_{10}} \]

- If fines are organic, add "with organic fines" to group name.
- If soil contains ≥ 15% gravel, add "with gravel" to group name.
- If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
- If soil contains 15 to 25% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
- If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
- If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravely" to group name.

---

![Graph of For classification of fine-grained soils and fine-grained fraction of coarse-grained soils](graph.png)

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- Equation of "A" - line Horizontal at PI=4 to LL=25.5, then PI=0.73 (LL=20)
- Equation of "U" - line Vertical at LL=16 to PI=7, then PI=0.9 (LL=8)

---

Terracon

Exhibit C-2 251