

# Preliminary Geotechnical Engineering Report

**Jericho Rise Wind**  
**Franklin County, New York**  
July 20, 2015  
Terracon Project No. J5155113

DRAFT

**Prepared for:**  
EDP Renewables  
Houston, Texas

**Prepared by:**  
Terracon Consultants-NY, Inc.  
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**Terracon**

Environmental



Facilities



Geotechnical



Materials

July 20, 2015



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Attn: Ms. Evelyn Zapata, P.E.  
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Re: Preliminary Geotechnical Engineering Report  
Jericho Rise Wind  
Franklin County, New York  
Terracon Project No. J5155113

Dear Ms. Zapata:

Terracon Consultants-NY, Inc. (Terracon) has completed preliminary geotechnical engineering services for the above-referenced project. This study was performed in general accordance with our Engineering Services Agreement, effective date April 15, 2015. This report presents the findings of the subsurface exploration and preliminary geotechnical recommendations concerning the design and construction of foundations, earthwork, and other geotechnical related aspects of the proposed project.

We appreciate the opportunity to be of service on this project. If you have questions concerning this report, please contact us.

Sincerely,  
**Terracon Consultants-NY, Inc.**

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Sr. Project Manager  
/cwt

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Principal



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## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1</b>
<b>2.0</b>	<b>PROJECT INFORMATION .....</b>	<b>1</b>
2.1	Site Location .....	1
2.2	Project Description.....	2
<b>3.0</b>	<b>SUBSURFACE CONDITIONS .....</b>	<b>3</b>
3.1	Desktop Review and Site Geology .....	3
3.2	Mapped Soil Associations .....	3
3.3	Geologic Hazards .....	4
3.3.1	Flooding .....	4
3.3.2	Slope Failure/Landslides .....	4
3.3.3	Mining .....	5
3.3.4	Earthquakes/Seismicity .....	5
3.3.5	Sinkholes and Expansive Soils.....	6
3.3.6	Geologic Hazard Summary .....	6
3.4	Subsurface Profile.....	7
3.4.1	Soil and Rock Conditions .....	7
3.4.2	Groundwater .....	7
3.5	Surface Water .....	8
3.6	Laboratory Testing .....	8
<b>4.0</b>	<b>PRELIMINARY RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION.....</b>	<b>9</b>
4.1	Geotechnical Considerations .....	9
4.2	Earthwork .....	10
4.2.1	Stripping.....	11
4.2.2	Subgrade Preparation .....	11
4.2.3	Structural and General Site Fill.....	13
4.2.4	Utility Trenches and Poles.....	16
4.2.5	Grading, Drainage, and Land Use Restrictions .....	17
4.2.6	Construction Considerations .....	17
4.3	Wind Turbine Foundations .....	18
4.3.1	Net Allowable Bearing Pressures .....	18
4.3.2	Foundation Settlement .....	19
4.3.3	Buoyancy .....	19
4.3.4	Lateral and Uplift Loading .....	20
4.3.5	Foundation Subgrade Stiffness .....	21
4.3.6	Rock Anchors.....	21
4.3.7	Construction Recommendations – Turbine Foundations .....	22
4.4	Access Roadways and Crane Pads .....	24
4.4.1	Access Roadway Design Recommendations .....	24
4.4.2	Access Roadway Construction Recommendations .....	25
4.4.3	Crane Pad Design Recommendations .....	26

4.4.4	Crane Pad Construction Recommendations.....	27
4.5	Temporary Slopes.....	28
4.6	Frost Depth.....	28
4.7	IBC Site Class.....	28
4.8	Final Design Phase Investigations .....	29
5.0	<b>GENERAL COMMENTS .....</b>	<b>29</b>

## **APPENDIX A – FIELD EXPLORATION**

Exhibit A-1	Site Location Plan
Exhibit A-2	Site Map and Boring Locations
Exhibit A-3	Bedrock Geology
Exhibit A-4	Surficial Geology
Exhibit A-5	Field Exploration Description
Exhibit A-6 to A-22	Boring Logs
Exhibit A-23 to A-32	Geophysical Exploration Reports

## **APPENDIX B – LABORATORY TESTING**

Exhibit B-1	Laboratory Testing
Exhibit B-2 to B-18	Grain Size Analysis
Exhibit B-19 to B-24	Bulk Density and Unconfined Compressive Strength Tests

## **APPENDIX C – SUPPORTING DOCUMENTS**

Exhibit C-1	General Notes
Exhibit C-2	Unified Soil Classification
Exhibit C-3	General Notes – Description of Rock Properties
Exhibit C-4	Foundation Calculation Methodology

## **APPENDIX D – ROCK CORE PHOTOS**

Exhibit D-1 to D6	Rock Core Photos
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## **EXECUTIVE SUMMARY**

Terracon has completed test borings at 17 of the proposed 37 wind turbine locations, along with geophysical testing and associated laboratory testing for the proposed Jericho Rise Wind Project in Franklin County, New York. It should be understood the explorations and testing were completed at select locations as part of a preliminary investigation to evaluate the site. The preliminary recommendations presented in this report are based on a limited data set and may need to be revised when additional information becomes available. The general findings and recommendations generated from this study are summarized below:

**Subsurface Profile:** Based on the preliminary explorations and desktop review of available geological data, subsurface conditions generally consist of cultivated agricultural topsoil or forest mat underlain by alluvial deposits or glacial till which are underlain by bedrock. Seventeen test borings were advanced at proposed WTG locations as part of this preliminary geotechnical investigation. The overburden thickness ranged from 5.8 (WTG A4) to greater than 60 feet (WTGs, 4 and 12). Alluvium was encountered in the borings drilled for WTGs A4 and A9, which is consistent with mapped surficial geology. Explorations will be conducted at the remaining turbine locations during the final phase investigations to confirm the bearing conditions and evaluate the applicability of the preliminary recommendations presented in this report.

- **Wind Turbine Foundations:** Rock anchor foundations are feasible for support of the proposed WTGs where bedrock is relatively shallow. Where bedrock was encountered at greater depth, gravity mat foundations are feasible for support.
- **Access Roadways:** With proper subgrade preparation, the near surface soils appear suitable for support of crushed stone surfaced roadway sections. As with all roadway designs, the crushed stone surfaced roadways will require on-going maintenance throughout the life of the project.

### Summary of Recommended Design Parameters

Description	Value		
<b>Suitable Bearing Material</b>	Alluvium	Glacial Till	Bedrock
<b>Maximum Net Allowable Bearing Pressure (psf)</b>	4,000	6,000	20,000
<b>Estimated Total Settlement (inch)</b>	< 1 to 1-1/2 inch	< 1 to 1-1/2	< ½ inch
<b>Estimated Differential Settlement (inch)</b>	< ¾ inch	< ¾ inch	< ½ inch
<b>Passive Earth Pressure Coefficient, Kp (ultimate)</b>			
Soil backfill	3.5		
Bedrock	4.6		
<b>Coefficient of Sliding Friction (ultimate)</b> (soil-concrete or bedrock-concrete)	0.5 (ultimate)	0.5 (ultimate)	0.7 (ultimate)
<b>Design Shear Wave Velocity, V<sub>s</sub> (ft/s)</b>	900	1,500	3,200
<b>Small Strain Shear Modulus, G<sub>o</sub> (ksf)</b>	3,270	9,080	59,000
<b>Small Strain Elastic Modulus, E<sub>o</sub> (ksf)</b>	8,500	23,600	141,500
<b>Large Strain or Corrected Shear Modulus, G (ksf)</b>	1,750	5,700	53,500
<b>Large Strain or Corrected Elastic Modulus, E (ksf)</b>	4,560	9,070	128,400
<b>Estimated Poisson's Ratio, μ</b>	0.2	0.3	0.2
<b>Moist Unit Weight (pcf)</b>	120	130	152
<b>Dry Unit Weight (pcf)</b>	115	120	152
<b>Angle of Internal Friction (degrees)</b>	32	34	---
<b>Cohesion (psf)</b>	0	0	---
<b>Unconfined Compressive Strength of Rock (psi) <sup>1</sup></b>			
Low	---		
High	---		
Recommended for Design	---		
<b>Ultimate Bond Strength (Grout to Rock) (psi)</b>	---		
	450		

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

DRAFT

**PRELIMINARY GEOTECHNICAL ENGINEERING REPORT**  
**JERICO RISE WIND**  
**FRANKLIN COUNTY, NEW YORK**  
**Terracon Project No. J5155113**  
**July 20, 2015**

## **1.0 INTRODUCTION**

Terracon has completed borings at 17 of the 37 proposed wind turbine locations, along with geophysical testing and associated laboratory testing for the Jericho Rise Wind project located in Franklin County, New York. The exploration logs and exploration location plans are included in Appendix A and results of the laboratory testing are presented in Appendix B. The purpose of these services is to provide information and preliminary geotechnical engineering recommendations relative to:

- Subsurface soil and bedrock conditions
- Groundwater conditions
- Crane pads and access roads
- Turbine foundation design
- Earthwork and structural fill

## **2.0 PROJECT INFORMATION**

### **2.1 Site Location**

Item	Description
Location	The project site is located in the Townships of Chateaugay and Bellmont, New York, east of Malone, in Franklin County.
Existing Improvements	Undeveloped pasture and wooded property with a network of existing private trails and public roads
Current Ground Cover	Wooded with light underbrush to open pasture
Existing Topography	The general site terrain consists of upland with gradual grades and some locally rolling terrain near local streams.



## 2.2 Project Description

Item	Description
<b>Proposed Construction</b>	<p>77.7 MW wind farm facility consisting of the following:</p> <ul style="list-style-type: none"> <li>■ 37 wind turbine generators (WTG) with 7 alternates</li> <li>■ 4 Met tower locations – 1 permanent, 3 calibration</li> <li>■ Substation &amp; Interconnect Switchyard</li> <li>■ O&amp;M Building and Laydown Yard</li> <li>■ Public and county road evaluations (20± miles)</li> <li>■ Proposed access roads (12± miles)</li> <li>■ Collector lines (20± miles)</li> </ul>
<b>Structure Details (Based Upon Similar Projects and to be Confirmed)</b>	<p>Gamesa G114 2.1 MW turbines. Hub Height: 93 meters (305 feet)  Rotor diameter: 114 meters (374 feet)  Total height: 150 meters (492 feet).</p> <p>WTG's anticipated to be supported on octagon-shaped reinforced concrete gravity base foundations or rock-anchored foundations. Foundations are expected to bear about 7 to 10 feet below grade and have widths of approximately 50 to 60 feet.</p> <p>Substations are anticipated to consist of various equipment pads, equipment shelters, a control building, and dead-end structures supported on shallow mat or drilled shaft foundations.</p>
<b>Maximum Loads (Provided by Gamesa)</b>	<p>Tower and turbine dead weight: 750 to 810 kips  Maximum horizontal base shear: 75 to 220 kips  Maximum base overturning moment: 19,000 to 69,000 ft-kips</p>
<b>Finished Grade Elevation of Structures</b>	Unknown at this time; expected to be near existing grade with less than 3 feet of cut or fill required (to be confirmed).
<b>Truck Loading (Provided)</b>	<p>Single-axle – 26,500 lbs.  2-axle – 53,000 lbs.  3-axle – 74,500 lbs.</p>
<b>Erection Crane Loading (Provided)</b>	5,000 lbs./square foot

If any of the information regarding foundation loading outlined in this report is incorrect or changes occur during design, Terracon should be contacted so that modifications to our analysis can be made, as appropriate.

## **3.0 SUBSURFACE CONDITIONS**

### **3.1 Desktop Review and Site Geology**

The project site is located east of the Town of Malone, New York, in the Townships of Chateaugay and Bellmont, in Franklin County. The 37 proposed turbines, four proposed meteorological towers, and associated support structures are to be situated in currently undeveloped pasture and wooded areas, along a network of existing private trails and public roads. The geology of the project area is described below based on our review of the following publications:

- Muller, Earnest H. and Caldwell, Donald H., 1986. Surficial Geologic Map of New York, Adirondack Sheet: New York State Geological Survey, State Education Department, scale 1:250,000.
- Isachsen, Yngvar W. and Fisher, Donald W., 1970, Geologic Map of New York, Adirondack Sheet: New York State Museum and Science Service, Geologic Survey, scale 1:250,000.
- United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey, [<http://websoilsurvey.sc.egov.usda.gov>], viewed June 2015.
- USGS Mineral Resources On-Line Spatial Data [<http://mrdata.usgs.gov/geology/state/state.php?state=NY>], viewed June 2015.
- FEMA Effective Flood Insurance Maps [<https://msc.fema.gov/portal>]
- USGS Geologic Names Lexicon (GEOLEX), [<http://ngmdb.usgs.gov/Geolex/>].

Widespread surficial deposits across the project area are generally mapped as sand-rich till. There are numerous linear deposits of alluvium, consisting of permeable sand and gravel, deposited by west-to-east trending stream features across the area. Surficial geologic maps indicate significant bedrock outcrops immediately to the south of the project area, suggesting thin surficial deposits in the south end of the project.

Mapped bedrock in the area of the project consists primarily of the Cambrian-age Potsdam Sandstone, a well-cemented sandstone of nearly pure quartz. In the extreme southeast portion of the project area, there are older metamorphic rocks consisting primarily of gneiss, with biotite, hornblende, amphiboles, and quartz.

### **3.2 Mapped Soil Associations**

Terracon reviewed available soil resource data from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) to identify the major soil associations present within the project area. Over 20 soil horizons are identified in the project area, the majority

consisting of stony to very stony sand and fine sandy loam. The following table lists the three major soil associations present, their general parent materials, general depth to a restrictive feature, and general topographic locations. These three associations comprise approximately 65 percent of the total deposits in the project area.

Association	Parent Material	Depth to Restrictive Feature	General Topographic Location
<b>Empeyville Stony Very Fine Sandy Loam</b>	Glacial till from acid sandstone	>60 inches to bedrock	Drumloid ridges and till plains
<b>Tughill and Dannemora Stony Very Fine Sandy Loam</b>	Glacial till from acid siliceous rocks and scoured by glacial meltwater	17 to 30 inches to bedrock	Depressions
<b>Westbury and Dannemora Very Stony Fine Sandy Loam</b>	Glacial till from acid sandstone and siltstone	>60 inches to bedrock	Drumloid ridges and till plains

### 3.3 Geologic Hazards

#### 3.3.1 Flooding

Flooding may be a potential hazard wherever the project area coincides with rivers, streams, ponds, and drainages. According to FEMA, the project area has not been mapped as part of the Flood Insurance Rate Mapping program. Therefore, no 100-year or 500-year flood elevation data are available. WTG setbacks and pedestal elevations should be established during civil site design to prevent citing WTGs in flood prone areas.

#### 3.3.2 Slope Failure/Landslides

Review of USGS topographic maps and available aerial photographs suggest much of the project area consists of gentle and moderate slopes with less than 500 feet of relief across the site. Topographically, the site is highest in the southeast (approximately elevation 1,500 feet) and slopes downward to the northwest (approximate elevation 1,000 feet). Local areas of moderate slopes associated with surface water features are located across the project area. Obvious indications of steep, unstable slopes or cliffs were not noted. However, localized erosion undercutting may exist leading to slope instability.

The *2014 New York State Hazard Mitigation Plan*, indicates the majority of Franklin County's population is at Low Incidence for landslide risk, including the project area. It indicates that most soil consists of dense glacial till that stands up well to landslide tendency. It also states there has been \$0 in loss in Franklin County as a result of landslide events from 1960 to 2012.

### 3.3.3 Mining

Terracon reviewed the USGS Mineral Resources On-Line Spatial Data [<http://mrdata.usgs.gov/mineral-resources/mrds-us.html>]. There are two active sand and gravel pits in the vicinity of the project area; Lawrence Pit and Willis Pit. There are also three surface sandstone quarries west of the project area; Northern Adirondack Quarry, Franklin-Clinton Sandstone Quarry, and Adirondack Stone Inc Quarry. The locations of these surface mines are not anticipated to impact activities within the project area.

### 3.3.4 Earthquakes/Seismicity

Terracon reviewed the *2014 New York State Hazard Mitigation Plan*, which indicates that the north and northeast third of New York State, including the project area, has a higher risk of exceeding the peak ground acceleration than the rest of the state in the next 50 years. Soils in the project area are primarily classified as Site Class B or C by the National Earthquake Hazard Reductions Program (NEHRP), indicating rock or firm ground. This limits the impact of ground movement in the project area. However, the Hazard Mitigation Plan indicates Northern Franklin County as an area that may experience an amplification of ground motion during seismic activity.

The Hazard Mitigation Plan summarizes previous occurrences of earthquakes and associated magnitudes. From 1973 to 2012, there were eight events of Richter Scale magnitude 4 or higher. The greatest event was a magnitude 5.2 that occurred in April 2002 in nearby Clinton County, approximately 50 miles southeast of the project area. Several events between magnitude 2.0 and 4.0 have occurred near the project area.

Terracon utilized the USGS online *2009 Earthquake Probability Mapping* application available through the USGS *Geologic Hazards Science Center* website to compute estimated probabilities of an earthquake with Richter Scale magnitude greater than 5.0 occurring within an approximate 50-mile radius of the center of the site over different time intervals. The computed probabilities returned by the application are summarized in the following table:

Search Radius (miles)	Time Period (years)	Cumulative Poisson Earthquake Probability
50	50	0.01-0.02
50	100	0.15-0.20
100	50	0.10-0.12
100	100	0.15-0.20

As indicated in the table, the computed probabilities of earthquakes with a magnitude greater than 5.0 occurring within 100 miles of the center of the project over the next century is low to moderate.

### 3.3.5 Sinkholes and Expansive Soils

The 2014 New York State Hazard Mitigation Plan utilizes the USGS fact sheet from 2000 indicates the project area is not in an area of known land subsidence in the United States. Further, the area is underlain by sandstone and metamorphic rocks, which are not known to cause solution cavities and sinkholes. Sinkhole development due to natural solution of the underlying bedrock formations is not anticipated to be a concern in the project area.

The Mitigation Plan also indicates the project area where little to no clays are present, minimizing the potential for impacts from expansive soils. The presence of glacial till at the site, along with sand and gravel alluvium deposits, supports this conclusion.

### 3.3.6 Geologic Hazard Summary

Description	Present at Site?	Comment / Risk
<b>Flooding</b>	Yes	Localized flooding may be a potential hazard wherever the project area coincides with rivers, streams, ponds, and drainages. The project area is generally well drained except in low areas of surface water features.
<b>Slope Failure/ Landslides</b>	Possible	Areas of the site have low to moderately sloping topography; however, areas of unstable cliffs or slopes were not noted. Localized erosion could affect slope stability.
<b>Mining</b>	No	Current sand and gravel and sandstone surface mining are reportedly near the project area. However, there is no documented mining within the boundaries of the project area.
<b>Earthquake / Seismicity</b>	Yes	A magnitude 5.2 earthquake occurred in April 2002 in nearby Clinton County, approximately 50 miles southeast of the project area. Several events between magnitude 2.0 and 4.0 have occurred near the project area.
<b>Sinkholes/Karst</b>	No	The project area is underlain primarily by sandstone and metamorphic rocks, which are not known to cause solution cavities and sinkholes. Sinkhole development due to natural solution of the underlying bedrock formations is not anticipated to be a concern in the project area.
<b>Swelling/ Shrinking Soil</b>	No	Thin soils at the site consist of glacial till with little clay present. The granular or over-consolidated nature of the soils does not indicate a potential for swelling or shrinking.
<b>Corrosive Soil</b>	Unlikely	Soil survey descriptions indicate soils which are generally noncorrosive.
<b>Made Ground</b>	No	The undeveloped nature of the project area indicates a low risk.
<b>Collapsible Soil</b>	No	Relatively thin soil overburden present at the site, and the soil types present are not prone to collapse.
<b>Volcanic Action</b>	No	No current volcanic activity exists in the region.
<b>Quick Clay</b>	No	Based on the geological history and till deposits, quick clays are not present.

### **3.4 Subsurface Profile**

#### **3.4.1 Soil and Rock Conditions**

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in situ, the transition between native soil types and weathering/hardness changes of the rock may be gradual. Subsurface conditions are generalized below; the boring logs provide a detailed description of the subsurface conditions encountered at the individual boring locations.

Wind Turbine Generators: Seventeen test borings were advanced at proposed WTG locations as part of the preliminary geotechnical investigation. In general, borings encountered a surficial layer of cultivated agricultural topsoil or forest mat underlain by alluvium or glacial till which is underlain by bedrock. The overburden thickness ranged from 5.8 (WTG A4) to greater than 60 feet (WTGs, 4 and 12). Alluvium was encountered in the borings drilled for WTGs A4 and A9, which is consistent with Exhibit A-5 Surficial Geology. The alluvium is described as poorly graded sand (SP) to silt (ML). Bedrock was encountered at a depth of 5.8 feet in WTG A4. Glacial till was encountered below the alluvium in A9 at a depth of 15 feet below existing grade. The overburden type encountered in the remainder of the borings was glacial till, which is consistent with Exhibit A-5. The glacial till is generally described as silty sand with gravel. Boulders were encountered within the glacial till in several of the borings.

Rock core samples of the bedrock are generally described as moderately hard to hard, very slightly weathered light yellow brown, medium grained sandstone, very thinly bedded, non-foliated, with closely spaced horizontal joints, which is consistent with the bedrock geologic maps.

The Rock Quality Designation (RQD) values ranged from 22 to 93 percent, and were generally greater than 80 percent. The Rock Mass Rating (RMR) for foundations generally ranged from 61 to 71, resulting in a description of good rock except at WTG A4 which exhibited RMR of 47, which is fair quality rock mass.

Access Roads and Utility Installation (Trenching and Overhead Lines): Based on the desktop review and observed site conditions, subsurface conditions along access roads and utility corridors are anticipated to consist of alluvium and glacial till in the mapped areas shown in the Surficial Geologic map shown in Exhibit A-5. In general, the overburden thickness increases from south to north.

#### **3.4.2 Groundwater**

Groundwater levels were estimated during or immediately following drilling based on the moisture content of the recovered soils and/or a visual review, and after a minimum 24 hour



period. Additionally, piezometers were installed for longer term groundwater observation. Monthly groundwater level measurements will be taken for a period of six months at each WTG. The first round of groundwater level readings is scheduled for late July, 2015. Long-term equilibrated groundwater level readings will be presented in the final geotechnical engineering report.

Fluctuations of the groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the explorations were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be different than the levels indicated on the exploration logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

### **3.5 Surface Water**

Numerous drainages and seasonal streams are present throughout the project area in addition to several named and unnamed ponds and streams in the vicinity of the project. Drainages and streams on steeper terrain may be prone to erosion and scour; and lower areas may be prone to flooding during seasonal runoff and large storm events.

### **3.6 Laboratory Testing**

Laboratory testing was performed on soil and rock samples recovered from the explorations. Analytical laboratory test results are summarized below; the laboratory test reports are included in Appendix B

<b>Soil Gradation</b>						
<b>Sample Location</b>	<b>Depth (feet)</b>	<b>USCS</b>	<b>Gravel (%)</b>	<b>Sand (%)</b>	<b>Silt (%)</b>	<b>Moisture Content (%)</b>
<b>WTG-1, S-7</b>	15 to 17	SM	3	61	36	11.4
<b>WTG-4, S-5</b>	8 to 10	SM	10	49	41	17.8
<b>WTG-A4, S-3</b>	4 to 5.7	SM	10	62	28	9.8
<b>WTG-5, S-6</b>	10 to 12	ML	6	46	48	11.2
<b>WTG-7, S-6</b>	11 to 12.9	SM	6	60	34	8.4
<b>WTG-8, S-6</b>	10 to 12	SM	9	57	34	10.1
<b>WTG-A9, S-6</b>	10 to 12	SM	21	39	40	10.6
<b>WTG-12, S-5</b>	10 to 12	SM	8	64	28	12.0

<b>Soil Gradation</b>						
<b>Sample Location</b>	<b>Depth (feet)</b>	<b>USCS</b>	<b>Gravel (%)</b>	<b>Sand (%)</b>	<b>Silt (%)</b>	<b>Moisture Content (%)</b>
<b>WTG-13, S-6</b>	10 to 12	SM	22	59	18	6.7
<b>WTG-21, S-6</b>	10 to 12	SM	8	62	30	16.8
<b>WTG-23, S-6</b>	10 to 12	SM	7	61	32	9.4
<b>WTG-24, S-6</b>	10 to 12	SM	6	64	30	12.7
<b>WTG-26/Met 26C, S-5</b>	8 to 10	SM	4	66	30	8.6
<b>WTG-28, S-7</b>	15 to 17	SM	34	50	16	7.9
<b>WTG-29, S-5</b>	8 to 10	SM	12	63	25	7.4
<b>WTG-31/Met 31C, S-5</b>	8 to 9.8	SM	36	50	14	6.8
<b>WTG-36, S-6</b>	10 to 12	SM	32	52	16	9.0

<b>Bedrock (Density and Compressive Strength)</b>				
<b>Sample Location</b>	<b>Depth (feet)</b>	<b>Bulk Density (pcf)</b>	<b>Compressive Strength (psi)</b>	<b>Modulus of Elasticity (psi)</b>
<b>WTG-A4</b>	11 to 16	152.9	7,777	3,738,165
<b>WTG-13</b>	33 to 38	150.2	19,011	7,272,392
<b>WTG-23</b>	30 to 34	143.0	12,101	4,405,449
<b>WTG-26</b>	20 to 25	153.0	8,368	2,326,817
<b>WTG-31</b>	24.5 to 29.5	154.2	8,998	3,011,069
<b>WTG-36</b>	19 to 24	154.0	6,730	2,478,566

## **4.0 PRELIMINARY RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION**

### **4.1 Geotechnical Considerations**

Subsurface conditions are considered suitable for supporting the proposed WTGs on shallow foundations bearing on native soil deposits, bedrock, or compacted structural fill placed on the native soil or bedrock. Based on the explorations completed for this preliminary investigation, foundations bearing on bedrock are anticipated for WTGs A4, 26, and 36. Note that these WTGs are located in the southern portion of the project. WTG A9 is expected to bear on alluvium. The remainder of the WTGs drilled for the preliminary investigation are expected to bear on glacial till.



Explorations will be conducted at the remaining turbine locations during the final phase investigations to confirm the bearing conditions and evaluate the applicability of the preliminary recommendations presented in this report.

With proper subgrade preparation, the near surface soils appear suitable for support of gravel-covered roadway sections and for re-use as compacted fill to achieve design grades; however, as with all gravel-covered roadways, on-going maintenance throughout the life of the project will be required to maintain roadway performance.

Excavated soil will generally consist of silty sand and silty sand with gravel. These soils will be sensitive to moisture and difficult to compact when above the optimum moisture content. As such, re-using the on-site fine-grained soils may be difficult during seasonally wet periods, as discussed in the **Earthwork** subsection, below.

Relatively shallow bedrock, less than 8 feet below existing grade, was encountered in the southern portion of the project at A4. Additionally, rock outcrops are present south of the project. Rock excavation using hydraulic rams or blasting will likely be required to remove bedrock to achieve design elevations in the southernmost WTGs. We understand rock anchor foundations will likely be used where bedrock is within 10 feet of grade to provide additional resistance to uplift and overturning and to decrease the footprint of the foundation. Recommendations for rock anchors are provided in **4.3.6 Rock Anchors**.

## **4.2 Earthwork**

Stripping, excavation, grading, and subgrade preparation should be performed in a manner and sequence that will provide positive drainage throughout construction and provide proper control of erosion. The planned site work areas should be graded to prevent water from ponding in construction areas and/or flowing into exposed subgrade areas. Exposed soils should be crowned, sloped, and smooth-drum rolled at the end of each day to facilitate drainage if inclement weather is forecasted. Accumulated water should be removed from subgrades and work areas immediately prior to performing further work in the area. Soils that become disturbed or weakened from accumulated water should be improved by aeration and re-compaction, chemical treatment, or removal and replacement with new compacted fill.

The near surface soils are anticipated to be relatively stable upon initial exposure, but can be easily disturbed by inclement weather and/or construction traffic. This could limit equipment access, greatly increase the amount of soil determined unfit for use as structural fill, or increase the amount of required stabilization. When subgrade instability becomes apparent, reduced construction traffic or use of low ground pressure construction equipment in these areas can reduce the amount of stabilization required.

#### 4.2.1 Stripping

We recommend that earthwork begin with stripping of forest mat soils, organic-rich topsoil (soil with 5 percent or more organic content), vegetation, and soft or otherwise unsuitable materials from the surface of the proposed construction areas. Based on the visual classification of the near-surface soils, typical forest mat and agricultural root zone stripping depths, where encountered, vary from about 4 to 12 inches. Stripping depths between our boring locations and across the site could vary. We recommend actual stripping depths be evaluated by a qualified geotechnical engineer during construction. The stripped materials should be stockpiled for placement on the completed grade and should not be used as foundation backfill or structural fill.

#### 4.2.2 Subgrade Preparation

##### 4.2.2.1 Soil Subgrades

After stripping and cutting to design subgrade elevation, and prior to placement of new fill, we recommend the exposed subgrades be observed by a qualified geotechnical engineer and evaluated for the presence of soft, loose or unsuitable materials. We recommend proofrolling the exposed subgrades for roadways, and pavements (if any), prior to placing site fill in areas below design grade, and after rough grading is completed in other areas. Soil subgrades steeper than 4H:1V should be benched prior to proofrolling and fill placement. A minimum bench width of 5 feet is recommended. Proofrolling should be performed using a minimum 10-ton roller or heavy rubber-tired equipment, such as a loaded dump truck, having a minimum gross weight of about 25 tons.

Proofrolling aids in providing a firm base for compaction of fill and delineating soft or disturbed areas that may exist at or near the exposed subgrade level. Proofrolling should be performed in the presence of a qualified geotechnical engineer. **Proofrolling should not be performed on soft and loose soils that do not appear to be able to support rubber-tired vehicles.** These areas should be corrected before unnecessary additional disturbance is imposed. Unsuitable areas observed following proofrolling should be improved by scarification, adjusting to recommended moisture content, and recompaction or by undercutting and replacement with suitable compacted fill (with or without geosynthetics). The most suitable method of stabilization, if required, will be dependent upon factors such as construction schedule, weather, the size of area to be stabilized and the nature of the instability.

**Winter Considerations:** Subgrades should be protected from the effects of frost if earthwork takes place during freezing conditions. No fill should be placed over frozen subgrades. Frozen subgrades should be completely removed to reveal unfrozen soil prior to placing subsequent lifts of fill or foundation components. Frozen soil should not be used as fill until thawed and adjusted to the proper moisture content, which may not be possible during winter months. The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center

(NCDC) reports the monthly average low temperature is below freezing between November and April based on weather data at Albany, New York dating back to 1939.

**Spring Considerations:** Seasonally wet conditions should be anticipated during melting of winter snowpack and rain events. The on-site silty soil will be sensitive to moisture and difficult to compact when above the optimum moisture content. Similarly, silty soil subgrades will be easily disturbed and become unstable if exposed subgrades are allowed to become wet. The NCDC reports the period when monthly average high temperatures are above freezing coincide with monthly average low temperatures below freezing for Franklin County, New York is from February to April.

#### **4.2.2.2 Bedrock Subgrades**

Foundation subgrades should be observed for open joints, loose rock, and uneven surfaces. Bedrock subgrades steeper than 4H:1V should be benched. If required, the bedrock surface can be leveled to grade by placing lean concrete or by removing isolated higher areas of the bedrock.

Rock excavation, where required, will likely require blasting. Controlled blasting methods should be specified to reduce overbreak below foundations and at the excavation perimeter along final open slopes. The peak particle velocity should be limited to a maximum of 2.0 inches per second at the nearest adjacent structures. Blasting mats should also be used to control flyrock. The contractor should perform a preblast survey at structures, utilities, and groundwater wells within a minimum distance of 500 feet of the blasting, or as required by local and state agencies. If controlled blasting is used to excavate bedrock, care should be taken to limit the depth of overblast in order to minimize the subgrade preparation efforts. Alternative methods of rock removal, including expansive agents or mechanical methods such as a backhoe-mounted ram, may be employed if blasting is not permissible. We recommend that the contractor familiarize her/himself with the anticipated bedrock conditions before construction.

We recommend designing a blasting program to yield fragments with a nominal maximum dimension of 12 inches for crushing or use as rock fill. A sufficient amount of soil should be placed with the blast rock to create a well-graded choked matrix. A choke layer may be required between rock fill and material placed above the rock fill depending on the gradation of the fill materials.

We recommend a qualified geotechnical engineer be present during site preparation operations to observe stripping and grubbing depths, observe the removal of unsuitable soils, observe the preparation of the subgrade, and to observe the exposed subgrade has been prepared in accordance with the project plans and specifications.

### 4.2.3 Structural and General Site Fill

Structural fill includes material placed for support of foundations. Fill used to establish roadway subgrade elevations, trench backfill, and fill placed adjacent to and on top of turbine foundations can be considered as general site fill. Structural fill typically consists of various mixtures of sand, non-plastic silt, and gravel; crushed rock; or on-site soil free of organic materials. All fill materials (structural and general) should be free of deleterious, organic, or frozen matter.

The suitability of soils used for fill depends primarily on the gradation and moisture content of the soil when placed. As the fines content (percentage by weight passing the U.S. No. 200 sieve) of a soil increases, it becomes increasingly sensitive to changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Soils containing more than about 10 percent fines by weight, such as the native soils, cannot be consistently compacted to the recommended degree when the moisture content is more than about 4 percent above or below optimum.

The native on-site soils are considered suitable for general site fill. Selective use and placement as general fill will be required for portions of the glacial till with high fines content. The contractor should expect to perform some moisture conditioning of on-site soils in order to achieve adequate compaction. Scarifying and watering or drying of the soils will likely be required for filling with the on-site soils during favorable weather conditions.

The following specifications are recommended for structural and general fill:

Fill Type <sup>1</sup>	USCS Classification or NYDOT Specification	Acceptable Location for Placement
<b>Access Roadway Surfacing</b>	NYDOT Item 733-04A, Type 2 Subbase	<ul style="list-style-type: none"> <li>■ Beneath all foundations</li> <li>■ Access roadway subgrade fill and/or surfacing</li> </ul>
<b>Structural Fill</b>	NYDOT Item 733-09A Select Borrow	<ul style="list-style-type: none"> <li>■ Beneath all foundations</li> <li>■ Foundation backfill</li> <li>■ Trench backfill<sup>2</sup></li> <li>■ Access roadway subgrade fill</li> </ul>
<b>Rock Fill (Blast Rock) <sup>3</sup></b>	GW, GP, GW-GM, GP-GM	<ul style="list-style-type: none"> <li>■ Access roadway subgrade fill</li> </ul>
<b>Lean Concrete (min. 2,000 psi)</b>	--	<ul style="list-style-type: none"> <li>■ Beneath foundations</li> <li>■ Foundation backfill</li> </ul>
<b>Low Plastic Fine-grained Soils</b>	CL, ML, CL-ML (LL<40, PI<20)	<ul style="list-style-type: none"> <li>■ Foundation backfill</li> <li>■ Trench backfill<sup>2</sup></li> <li>■ Access roadway subgrade fill</li> </ul>

Fill Type <sup>1</sup>	USCS Classification or NYDOT Specification	Acceptable Location for Placement
<ol style="list-style-type: none"> <li>Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used. Fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.</li> <li>Suitable from a geotechnical and construction standpoint. For collection line trenches, the thermal properties of the backfill should be evaluated by the electrical engineer.</li> <li>12 inch maximum particle size.</li> </ol>		

The following gradation specifications are recommended for structural and general fill:

Access Roadway Surfacing NYDOT Item 733-04A, Type 2 – Subbase Gradation Specification	
Sieve Size	Percent Passing by Weight
2-inch	100
¾-inch	25 – 60
No. 40	5 – 40
No. 200	0 – 10

Structural Fill NYDOT Item 733-09A – Select Borrow Gradation Specification	
Sieve Size	Percent Passing by Weight
4-inch	100 <sup>1</sup>
No. 40	0 – 70
No. 200	0 – 15
<ol style="list-style-type: none"> <li>3-inch-maximum particle size within 12 inches of slab or footing grade.</li> </ol>	

### Rock Fill (Blast Rock)

Rock Fill Gradation Specification	
Sieve Size	Percent by Volume
12-inch	100
6-inch	25 - 100
¾-inch	10 - 60

The following compaction requirements are recommended for the prepared subgrade, general fill, and structural:

Item	Description
<b>Maximum Loose Fill Lift Thickness</b>	<ul style="list-style-type: none"> <li>Crushed Stone and Granular Material – 9 inches when heavy compaction equipment (minimum 10 ton vibratory roller) is used</li> <li>Rock Fill (Blast Rock) – 18 inches, compacted with heavy compaction (minimum 10 ton vibratory roller) equipment.</li> <li>Low Plastic Fine-grained Materials – 9 inches when heavy compaction equipment (minimum 10 ton vibratory roller) is used</li> <li>All Materials – 6 inches when hand-guided equipment (jumping jack or plate compactor) is used</li> </ul>
<b>Compaction Requirements <sup>1</sup></b>	<ul style="list-style-type: none"> <li>All Structural Fill (below foundations and slabs) - at least 95 percent of the material's maximum modified Proctor dry density</li> <li>General Site Fill - trench backfill, access roadway subgrade fill – at least 92 percent of maximum dry density</li> <li>Foundation Backfill - at least 95 percent of the material's maximum dry density</li> <li>Rock Fill (Blast Rock) - Minimum 8 passes with heavy compaction (minimum 10 ton vibratory roller) equipment; compact to firm, unyielding condition</li> <li>Compact all surfaces to firm, unyielding condition</li> </ul>
<b>Moisture Content</b>	<ul style="list-style-type: none"> <li>Granular Material – within ±3 percent of optimum moisture content as determined by ASTM D 1557</li> <li>Fine-grained Materials – within -1 to +3 percent of optimum moisture content as determined by ASTM D 1557</li> </ul>
<b>Minimum Compaction Testing Frequency <sup>2</sup></b>	<ul style="list-style-type: none"> <li>Embankment/Slope Fill – 1 test per 1,000 cubic yards of material</li> <li>General Site Fill – 1 test per 1,000 cubic yards of material</li> <li>Structural Fill – 1 test per 3,000 square feet, except under WTG foundations. Minimum 3 tests per lift under WTG foundations.</li> <li>Foundation Backfill – 1 test per 3,000 square feet</li> <li>Crane Pads – 1 test per 3,000 square feet</li> <li>Access Road Surfacing/Crane Pads – 1 test per 500 linear feet</li> </ul>

Item	Description
<b>Maximum Dry Density Determination and Compaction Testing</b>	<ul style="list-style-type: none"> <li>■ Materials maximum dry density should be determined by the Modified Proctor Method (ASTM D 1557)</li> <li>■ In-place density should be determined by ASTM D 1556 (Sand Cone Method) or ASTM D 6938 (Nuclear Method).</li> <li>■ Material that cannot be tested for in-place density (i.e.: rock fill) should be systematically compacted to a firm, unyielding condition. It should be understood that if it is possible to conduct a test then a test should be run.</li> </ul>
<ol style="list-style-type: none"> <li>1. We recommend that fill be tested 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 retested as required until the specified moisture and compaction requirements are achieved.</li> <li>2. Testing frequencies presented above are considered minimum requirements, project conditions normally require more frequent testing for proper control. In addition, each lift must meet compaction requirements prior to placement of subsequent lifts.</li> </ol>	

Samples of each material type to be used as structural fill or general site fill should be submitted to a qualified geotechnical engineer for evaluation during construction. As a minimum, moisture-density (Modified Proctor) tests should be performed. Atterberg limits and gradation tests should also be performed to evaluate the material's suitability for a particular application.

#### **4.2.4 Utility Trenches and Poles**

Based on the preliminary explorations and desktop review of available geological data, subsurface conditions along ridges generally consist of forest mat underlain by relatively shallow bedrock. Lower elevations are anticipated to consist of glacial till of varying thickness overlying bedrock. Utility installation will likely require excavation in soil and bedrock for trenches and utility poles. Limits of areas that may require rock excavation should be evaluated during the final geotechnical investigation.

Utility trenches are a common source of water infiltration and migration. All utility trenches that extend near foundations, slabs or other settlement sensitive improvements, such as crane pads, should be effectively sealed to restrict water intrusion and flow through the trenches that could impact the improvement. We recommend constructing an effective "trench plug" that extends at least 5 feet out from the face of the improvement to be protected. The plug material should consist of clay compacted at a water content at or above the soil's optimum water content or cementitious flowable fill with a minimum 28-day compressive strength of 300 psi. The clay or flowable fill should be placed to completely surround the utility line. Clay fill should be compacted in accordance with recommendations in this report. Where natural drainage exists, or trench or subdrains are constructed, as described in **Section 4.3.3**, construction of a trench plug may not be necessary provided the utility trench slopes away from the improvement.



#### **4.2.5 Grading, Drainage, and Land Use Restrictions**

Proper grading, drainage, and land use restrictions will be necessary for the successful performance of WTG, substation, and O&M foundations. Grading measures should be taken such that depressions or low points are not present on the surface of the foundation backfill and adjacent grades. Positive grading sloping away from the completed structures should be established and maintained to direct surface water away from the foundations. We recommend that site grades be constructed at a minimum gradient of 5 percent sloped away from the center of the turbines, and other structures. Although not anticipated, irrigation of any kind should be prohibited within 50 feet from the perimeter of each WTG foundation.

Groundwater may seep from cut slopes during seasonally wet periods. Groundwater seepage at the face of the soil slopes may result in surface sloughs and erosion if not controlled. Seepage, if encountered at cut slopes during construction, should be evaluated and engineered controls incorporated if applicable. Engineered controls may include drainage blankets or sand layers, riprap armoring, and inclusion of drainage swales at the slope toe. Gradation compatibility of drainage filter and base materials should also be evaluated and incorporation or geotextiles considered, where appropriate.

Construction activities are anticipated adjacent to streams and drainages. Erosion and sediment controls should be installed and maintained in accordance with construction documents and permits.

The native soils encountered are susceptible to erosion. These soils should be protected from erosion over the life of the project.

#### **4.2.6 Construction Considerations**

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to further construction. Construction traffic over completed subgrades should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become saturated, frozen, desiccated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompact prior to the construction of other site improvements.

We recommended that a qualified geotechnical engineer be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction/ installation of foundations.



### **4.3 Wind Turbine Foundations**

Based on our understanding of the project and encountered subsurface conditions, turbines are anticipated to be supported on rock anchored mat foundations where rock is within approximately 10 feet of design grade. Where soil is greater than approximately 10 feet of design grade, gravity base foundations bearing on alluvium or glacial till are feasible for support. Preliminary design parameters presented in the following paragraphs were developed using subsurface information collected during our preliminary site investigation, in-situ and laboratory testing, and anticipated foundation loading presented in **Section 2.1**. The following considerations and parameters were used to develop these recommendations:

- The bases of the octagonal-shaped, gravity mat foundations are to bear about 7 feet below grade and have widths of about 50 to 60 feet.
- Rock anchored foundations bearing on intact bedrock are anticipated to have widths on the order of 26 to 30 feet.
- The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at footing base elevation.
- The maximum net allowable bearing pressure would result in a factor of safety of at least 3 against bearing capacity failure for the mean operating conditions for the above foundation sizes and bearing depth.
- The recommended maximum net allowable bearing pressure may be increased by 30 percent (resulting in a factor of safety of at least 2.5 against bearing capacity failure) for short-term or transient live loading, conditions such as the extreme wind event or seismic activity.

#### **4.3.1 Net Allowable Bearing Pressures**

Net allowable bearing pressures for gravity mat foundations were evaluated by estimating the effective bearing area and average contact stress under the extreme load case for the 93m (305 feet) tower and the assumed foundation size, and determining the required shear strength for adequate bearing under this loading condition and geometry. Bearing pressures were evaluated based upon these shear strength criteria and evaluation of the shear strength at the individual turbine locations, as well as the depth and quality of underlying soil and bedrock. We based the shear strength on laboratory test results on samples from the borings.

Based upon this analysis, we recommend gravity wind turbine foundations bearing on glacial till be designed using a maximum net allowable bearing pressure of 6,000 psf. Foundations bearing on alluvium should be designed using a net allowable bearing pressure of 4,000 psf. For gravity mat foundations on bedrock, or rock anchored foundations bearing on the relatively sound bedrock, a maximum net allowable bearing pressure of 20,000 psf may be used for

design. Foundation and slope stability should be evaluated if foundations are planned above slopes.

#### **4.3.2 Foundation Settlement**

Settlement estimates for gravity base foundations bearing on soil were made based upon the assumed foundation widths and extreme loads, and resulting estimates of effective foundation areas and average contact stresses, coupled with the boring and laboratory data. Based on our estimates using the aforementioned assumptions for generalized and specific soil profiles, we estimate that gravity foundations bearing on soil would experience total settlements of less than 1 to 1.5 inches under the normal operating loads. Settlement of gravity mat turbine foundations, if utilized, and rock anchored foundations bearing on bedrock is estimated to be less than 0.5 inch.

Differential settlement of a gravity foundation is based on soil-structure interaction that not only depends upon the bearing conditions and potential variation of soil conditions across the foundation area, but also on the rigidity of the foundation, the actual stress distribution on the foundation, subsequent redistribution of stresses upon movement, and the quality of construction performed. Based upon our experience, differential settlement can typically be estimated at about one half of the total settlement.

#### **4.3.3 Buoyancy**

Based upon the water levels encountered in our preliminary borings, buoyancy may impact design of foundations at WTGs 4, 8, A9, 13, 23, 24, 26, and 29, where groundwater was measured at 10 feet or less immediately after drilling. Temporary piezometers were installed at all WTGs, and groundwater levels will be monitored for a period of 6 months. At the time of this preliminary report, the first round of long-term groundwater levels have not yet been gauged.

Where shallow groundwater is expected and/or encountered and where bedrock excavations for foundations are depressed below the adjacent rock surface, water may accumulate and pond in the excavation resulting in buoyant forces acting on the foundation. Surface and groundwater conditions should be evaluated by the geotechnical engineer at the time of construction for the need for foundation drainage. Where foundation drainage is warranted, drainage trenches (i.e: French drains) or subdrains should be designed to facilitate drainage of water out of the excavation. Where drains cannot be constructed or are obstructed due to topographic or hydraulic features, foundations should be designed to resist buoyant forces.

Trench drains, in general, should be installed from the downslope side of the foundation to daylight at the ground surface. Trench drains should consist of a minimum 3 foot wide trench sloped to provide positive gravity drainage (i.e. 0.5 percent or more) and filled with free-draining (less than 5 percent passing the No. 200 sieve) granular material graded to prevent the intrusion

of fines, or an alternative non-graded free-draining granular material encapsulated with suitable filter fabric.

In general, where subdrains are required they should be installed around the entire perimeter of the WTG foundation, about 2 feet laterally from the edge of the foundation. The invert of the subdrains should be at foundation base level. The drain line should be sloped to provide positive gravity drainage (i.e. 0.5% or more) and should be surrounded by free-draining (less than 5 percent passing the No. 200 sieve) granular material graded to prevent the intrusion of fines, or an alternative non-graded free-draining granular material encapsulated with suitable filter fabric. At least a 2-foot wide section of free-draining granular fill should be used for backfill above the drain line. Subdrains should discharge to daylight or a suitable, frost-free outlet. Periodic maintenance of the drains would be required to maintain their proper operation.

#### **4.3.4 Lateral and Uplift Loading**

Lateral loads transmitted to spread footings can be resisted by a combination of soil-concrete friction on the base of the footings and passive pressure on the sides of the footings. The friction between the base of the footings and bearing soils (or lean concrete or granular structural fill) may be computed using an ultimate friction coefficient of 0.5. An internal friction angle of 32 and 36 degrees may be used for alluvium and glacial till, respectively. The friction between the base of the foundation and bedrock may be computed using an ultimate friction coefficient of 0.7.

Passive pressure coefficient of 3.5 (ultimate) may be used for onsite soil used as backfill over foundations and 4.6 (ultimate) for concrete poured directly against rock provided passive pressures calculated are reduced by at least a factor of safety of 3, to reflect the amount of movement required to mobilize the passive resistance. Additionally, the upper 4 feet of the soil profile should be neglected in the calculation, due to freeze thaw effects.

The ultimate uplift capacity of a spread footing due to deadweight forces is limited to the effective weight of the foundation plus the effective weight of soil directly above the foundation. The ultimate uplift capacity should be divided by an appropriate factor of safety in design. For backfill compacted to at least 95 percent of the Modified Proctor maximum dry density (ASTM D 1557), a total unit weight of 120 pounds per cubic foot may be used for design. This unit weight includes no factor of safety. Soil weight should be ignored in potential zones of disturbance, such as utility excavations. We recommend the excavated material be tested to evaluate if materials will meet the minimum design backfill density criterion. Provisions should be made for some potential sorting, mixing or selective use of excavated materials. In addition, density testing of the backfill materials should be performed to evaluate the unit weight criterion is achieved.

#### 4.3.5 Foundation Subgrade Stiffness

Foundation soil stiffness was evaluated based on our geotechnical exploration and laboratory testing. Geotechnical Parameters to evaluate overall foundation system stiffness are as follows:

Parameter Description	Alluvium	Glacial Till	Bedrock
<b>Design Shear Wave Velocity, <math>V_s</math> (ft/s)<sup>1</sup></b>	900	1,500	3,200
<b>Small Strain Shear Modulus, <math>G_o</math> (ksf)</b>	3,270	9,080	59,000
<b>Small Strain Elastic Modulus, <math>E_o</math> (ksf)</b>	8,500	23,600	141,500
<b>Large Strain or Corrected Shear Modulus, <math>G</math> (ksf)<sup>2</sup></b>	1,750	5,700	53,500
<b>Large Strain or Corrected Elastic Modulus, <math>E</math> (ksf)<sup>2</sup></b>	4,560	9,070	128,400
<b>Estimated Poisson's Ratio, <math>\mu</math></b>	0.2	0.3	0.2

1. Based upon a weighted average of shear wave velocities measured at ten locations by performing geophysical tests.
2. Reduced from small strain values based on an assumed strain level of  $10^{-3}$ , following the method from "Guidelines for Design of Wind Turbines", Riso, 2nd Edition, 2002 - pages 201-202, and using a modulus degradation value of 0.35 for soil.

The geotechnical parameters outlined above are based upon generalized soil profiles and material values obtained from the exploration data and our interpretation of the variability of the data. As such, variations of the soils and their engineering properties are likely to occur across the site. The above soil stiffness values have no factor of safety included.

#### 4.3.6 Rock Anchors

Rock anchors are anticipated in the foundation design to resist overturning. Anchors installed into bedrock will provide overturning resistance in addition to the dead weight of the foundations, structure and backfill. Anchors should be grouted and prestressed. Capacity of grouted rock anchors should be estimated using the following formula:

$$P = L_b \times \pi \times d \times T_w$$

$P$  = Design load

$L_b$  = Anchor bond length

$d$  = Diameter of drill hole

$T_w$  = Allowable bond stress between grout and rock surface

For the above equation, the allowable bond stress ( $T_w$ ) may be calculated using an appropriate factor of safety and the estimated ultimate bond stress for fair to good quality rock mass sandstone of 450 psf.

Estimated bond stress values are consistent with published data and take into account the RQD at each WTG location within the anticipated bond zone and the unconfined compression test results. Anchors should be installed with a minimum 10-foot long unbonded zone (free length) in order to engage higher quality rock and avoid excessive creep and reduction in tensioning as bonds weaken in upper rock zones. Rock anchors may extend beyond the maximum depth of the borings.

The weight of rock engaged to resist overturning should be taken as the volume of a truncated cone extending from the midpoint of the anchor bond zone to the surface of the rock at an angle of 45 degrees from vertical multiplied by the unit weight or effective unit weight of rock, as applicable. A minimum factor of safety of 1.5 with respect to rock mass engaged versus overturning load is recommended. Where the rock mass is highly fractured, a higher factor of safety may be required, along with a smaller cone of influence angle.

At least 10 percent of the anchors should be performance tested at each turbine location before production installation of anchors. Pending satisfactory results of performance tests, all anchors need to be proof-tested and locked off to at least the design load. Performance testing will help evaluate load and unload behavior, and creep potential. Proof testing will effectively load test the remaining anchors and verify the capacity of each anchor prior to casting the foundations. If performance testing field capacities do not meet design capacities, anchor lengths and/or drill hole diameters may need to be increased.

Spacing of rock anchors should be such that imaginary lines extending from the top of the grout bonds of adjacent anchors, at an angle of 20 degrees from the perpendicular intersection of the bedrock, to the ground surface do not intersect. Rock anchors should be designed, installed, and tested in accordance with the manufacturer's recommendations and guidelines by the Post-Tensioning Institute (PTI) *Recommendations for Prestressed Rock and Soil Anchors, 2004* including requirements for water pressure testing and pre-grouting.

### **4.3.7 Construction Recommendations – Turbine Foundations**

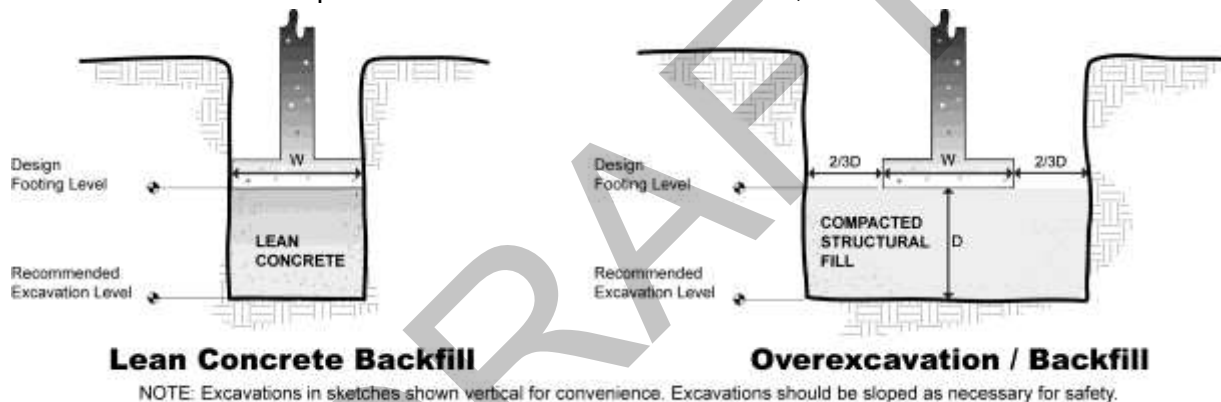
#### **4.3.7.1 Foundation Excavations**

Due to the size of the turbine foundations relative to our boring test areas, variations in bearing conditions (including possible unsuitable soils) may potentially be present in portions of foundation areas that were not explored.

After completing the foundation excavation, if the exposed bearing surface consists of granular soil, it should be proofrolled with a heavy (at least 10 tons static weight) vibratory roller to densify the exposed subgrade. Bedrock subgrades will not require proofrolling; however if loose or highly weathered rock is exposed, it should be replaced with concrete. To provide evaluation

of bearing conditions, we recommend a qualified geotechnical engineer observe foundation excavations prior to placement of working mats (typically 3-inch thick “mud slabs” of minimum 2,000-psi lean concrete) or reinforcing steel.

If unsuitable soils are encountered at bearing level, the geotechnical engineer may recommend the foundation subgrade be improved by overexcavation and backfilling as discussed herein. For foundations bearing on soil, overexcavation for structural fill placement below foundations should extend laterally beyond all edges of the foundation at least 8 inches per foot of overexcavation depth below footing base elevation, as illustrated below. The overexcavation should then be backfilled up to the footing base elevation with structural fill placed in accordance with the recommendations of **Section 4.2.3**. As an alternative, lean concrete could be used to backfill over-excavations to footing base elevation. No widening of the footing excavation would be required if lean concrete backfill is used, as illustrated below.



Observations in the borings suggest that water should generally not be encountered within the anticipated foundation excavations for most of the wind turbines. However, borings indicated relatively shallow groundwater at: WTGs 4, 8, A9, 13, 23, 24, 26, and 29. Furthermore, water commonly becomes trapped or perched in sand or silt seams or layers above the “normal” water level after periods of heavy or prolonged precipitation. Surface water can collect in excavations during rainfall events. Therefore, the contractor should be prepared to temporarily dewater excavations, as necessary. We anticipate water can be collected in a series of sump pits, or a shallow ditch or trench system around the perimeter of the excavations, and removed with adequately sized pumps with filters.

#### **4.3.7.2 Foundation Backfill & Compaction – Wind Turbines**

Backfill soils placed alongside or above foundation elements should consist of approved materials, free of organic matter and debris. Backfill soils should satisfy the requirements of **Section 4.2** of this report. Excluding the topsoil/forest mat and organic portions of the subsoil, the explorations generally encountered materials that should meet the criteria for WTG foundation backfill.



A qualified geotechnical engineer should be retained to observe and test each lift of fill placement. If the results of the in-place density tests indicate that the recommended compaction has not been achieved, the area represented by the test(s) should be reworked and retested as required until the specified compaction is achieved.

#### **4.4 Access Roadways and Crane Pads**

Our access road and crane pad recommendations should be considered minimum recommendations based on the conditions observed during our preliminary exploration program. Conditions during construction may differ, particularly during periods of increased precipitation; therefore, we recommend that a qualified geotechnical engineer be retained to observe the construction and subgrade preparation of the roadways and crane pads to confirm that assumed conditions are achieved or to provide alternative recommendations if necessary.

The ultimate bearing capacities presented below are for a load the width of the crane tracks at the ground surface and correspond to a Factor of Safety of 1.0. The contractor or designer should consider an appropriate factor of safety for operation of the crane over the prepared surfaces. This ultimate bearing pressure is without regard for settlement and/or deflection of the prepared subgrade. We recommend establishing deflection criteria based on equipment tolerance for verification of the subgrade performance before mobilization of the crane.

We consider the movement and operation of the erection cranes part of the contractor's "means and methods" of construction, and, as such, the contractor has sole responsibility in these operations, including the subgrade preparation of crane travel areas and crane pads. The following comments are based upon our experience and are provided as information only.

##### **4.4.1 Access Roadway Design Recommendations**

Design of the access roadway section thicknesses for the project has been based on the procedures outlined in the 1993 *Guideline for Design of Pavement Structures* by the American Association of State Highway and Transportation Officials (AASHTO) for low volume design along with our experience. A CBR value of 10 was assumed for our analysis based on the soils encountered.

EDP provided component delivery truck load information. We estimated the number of trucks for component delivery, concrete, and reinforcing steel based on our experience with similar projects. The estimated Equivalent 18-kip Single Axle Loads (ESALs) are presented in the table below. Loads do not include those associated with periodic farming and logging activities. If shared roadways are planned, loads will increase. Higher traffic loadings would require thicker sections. Where bedrock is present at access road subgrade elevation, the crushed stone surfacing can be reduced to 6 inches.

Item	Assumed Traffic Loadings		
	Access Roads For 1 Turbine	Access Roads For 5 Turbines	Collector roads for >10 Turbines
<b>Total Truck Counts</b>	125	625	1,250
<b>ESALs (Equivalent 18-kip Single Axle Loads)</b>	387	1,934	3,870

A summary of the roadway sections is presented below.

Option	Thickness of Crushed Stone (inches) <sup>1</sup>		
	Access Roads For 1 Turbine	Access Roads For 5 Turbines	Collector roads for >10 Turbines
<b>Crushed Stone Surfacing over Prepared Subgrade<sup>2,3</sup></b>	8	10	12

Notes:

1. Assumes about a 3-inch rut depth.
2. Crushed stone surfacing should consist of material meeting NYDOT Item 733-04A, Type 2 Subbase. The material should be moisture conditioned to within 3% of optimum moisture content and compacted to at least 92 percent of the Modified Proctor maximum dry density.
3. Native subgrade should be prepared as outlined in **Section 4.2** of this report.

#### **4.4.2 Access Roadway Construction Recommendations**

Prepared soil subgrades should be proofrolled prior to placement of aggregate surfacing. Proofrolling should be performed using a loaded tandem-axle dump truck weighing at least 25 tons. Proofrolling the prepared subgrade is important in helping to identify unstable near surface subgrade materials that may require remediation. Visually unstable areas or unstable areas identified by proofrolling should be improved, as recommended by the geotechnical engineer.

In order for the above recommendations to be valid and to maintain roadway performance, surface drainage of the roadway and subgrade should be provided and maintained. Where subgrade soils are allowed to become wet, the subgrade resilient modulus may become less than the value used to develop these sections. Reduced performance, increased maintenance, and possible repair should be expected if this occurs. The roadway surface and subgrade should be sloped to provide positive drainage at all times. Water should not be allowed to remain on the subgrade soils within the roadway section.



The following recommendations should be considered minimum measures relative to drainage of the roadway:

- Slope the finished ground surface adjacent to the roads at a minimum 2% grade away from the roadways.
- The subgrade and roadway surfaces should be constructed and maintained with a minimum 2% cross slope (crown) to promote proper surface drainage.
- Consider appropriate edge drainage and open ditches/culverts.

We emphasize that crushed stone surfaced roadways, regardless of the section thickness or subgrade preparation measures, will require on-going maintenance and repairs to keep them in a serviceable condition. It is not practical to design a gravel section of sufficient thickness that on-going maintenance will not be required. This is due to the porous nature of the gravel that will allow precipitation and surface water to infiltrate and soften the subgrade soils, and the limited near surface strength of unconfined gravel that makes it susceptible to rutting. When potholes, ruts, depressions or yielding subgrades develop, they must be addressed as soon as possible in order to avoid major repairs.

Maintenance should consist of periodic grading with a road grader. Typical repairs could consist of placing additional gravel in ruts or depressed areas. In some cases, complete removal of distressed portions of the existing section will be required along with replacement of the roadway section. Potholes and depressions should not be filled by blading adjacent ridges or high areas into the depressed areas. New material should be added to depressed areas as they develop. Failure to make timely repairs will result in more rapid deterioration of the roadways, making more extensive repairs necessary.

#### **4.4.3 Crane Pad Design Recommendations**

Preliminary crane loading provided by EDP indicates a maximum track contact pressure of approximately 56.7 psi (8,165 psf). Based on subsurface conditions at the preliminary boring locations and the recommended subgrade preparation, we estimate an ultimate bearing capacity of the subgrade prepared and surfaced with compacted aggregate as described below to be about 10,000 psf for a track width of 3.4 feet. Based on the above assumptions, we have provided the following minimum aggregate thickness for the crane pads. Heavier crane loads may require a thicker section. Where bedrock is present at crane pad subgrade elevation, the processed gravel thickness may be reduced to the minimum thickness necessary to level the pad area; a minimum thickness of 6 inches is recommended to facilitate grading and compaction efforts.

Minimum Recommended Aggregate Thickness	
Material Type	Thickness (in)
Access Roadway Surfacing NYDOT Item 733-04A Subbase	18

Our recommendations should be considered minimum recommendations based on the conditions observed during our explorations. Conditions during construction may differ, particularly during periods of increased precipitation; therefore, we recommend that a qualified geotechnical engineer be retained to observe the construction and subgrade preparation of the crane pads to confirm that assumed conditions are achieved or to provide alternative recommendations if necessary.

#### **4.4.4 Crane Pad Construction Recommendations**

In order for the above recommendations to be valid, surface drainage of the subgrade should be provided and maintained. Where subgrade conditions are allowed to become wet, the subgrade resilient modulus would be less than the estimated value and reduced performance and possible repair should be expected. Water should not be allowed to remain on the subgrade soils within the crane pad. In addition, the subgrade soils should be prepared in accordance with the **Section 4.2**.

Often, a portion of the crane pad footprint will be located above the foundation backfill, and the remaining portion will be supported by the native soils beyond the foundation backfill. This can create two differing bearing surfaces, resulting in differential movement. Therefore, it is critical that foundation backfill be properly compacted and the native subgrade is stable, properly prepared and evaluated.

The condition of the near surface soils across a given site can be highly variable and are subject to significant changes in shear strength and bearing capacity over very short periods of time, due to rainfall, construction traffic disturbance, utility installation, or other factors. As a result, completed crane pads and crane travel areas that were previously deemed suitable, may not be suitable at a later time. Therefore, it is imperative the condition of crane travel areas and crane pads be evaluated immediately prior to moving or operating cranes. This is typically accomplished by proofrolling and subgrade correction, as described above. Particular attention and evaluation should be provided after rainfall events or after construction events in the crane areas.

Our recommendations for testing and proofrolling to be conducted before the crane setup follow:

- Proofroll each crane pad one day before the crane operation with a heavily-loaded truck to locate zones that are soft or unstable. The proofrolling should be in accordance with the specifications stated in **Section 4.2**.
- The subgrade in areas where rutting or pumping occurs during proofrolling should be replaced with suitable granular structural fill. The replacement fill should be constructed in accordance with the recommendations of this report including field moisture/density testing and proofrolling.
- If rainfall occurs at the site in the time between proofrolling and crane operation, the crane pad should be proofrolled again to determine whether the underlying materials would deflect excessively.

#### **4.5 Temporary Slopes**

As a minimum, all excavations should be sloped or braced as required by OSHA regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The grading contractor, by his contract, is usually 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. All excavations should comply with applicable local, State and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards.

#### **4.6 Frost Depth**

Minimum foundation embedment for frost protection is 60 inches.

#### **4.7 IBC Site Class**

The results of the geophysical testing for the determination of the shear wave velocity profile at four locations at the project site are included in Appendix A. The International Building Code (IBC) requires structural design to be in accordance with the appropriate Site Class definition for soil profile type. Based upon the Site Class definitions in Table 1613.5.2 of the 2009 International Building Code, and the average shear wave velocities determined, Terracon recommends the following seismic site classification for design.

Description	Value
<b>Code Used</b>	2010 Building code of New York State
<b>Seismic Site Class</b>	B <sup>2</sup> – Foundations on bedrock
	C <sup>2</sup> – Foundations on soil
<b>Maximum Considered Earthquake Ground Motions (5 percent damping)</b>	0.548g (S <sub>s</sub> - 0.2 second spectral response acceleration)
	0.139g (S <sub>1</sub> - 1.0 second spectral response acceleration)
<b>Liquefaction Potential</b>	Not considered susceptible

1. In general accordance with the 2009 *International Building Code*, Table 1613.5.2.
2. The 2010 Building code of New York State is based on the International Building Code (IBC) which requires a site soil profile determination extending to a depth of 100 feet. The geophysical testing was interpolated to a depth of about 100 feet bgs; borings for the turbines extended to a maximum depth of approximately 62 feet bgs. The site classes were determined using both the shear wave velocities estimated from the geophysical testing and the results of the borings.

The average shear wave velocity analysis and recommendations presented in this report are based upon the data obtained from the MASW survey performed in the vicinity of selected WTG locations. This analysis does not reflect variations that may exist between individual sites.

#### **4.8 Final Design Phase Investigations**

The explorations and testing for this report were completed at select locations as part of a preliminary investigation to evaluate the site. The preliminary recommendations presented in this report are based on a limited data set and may need to be revised when additional information becomes available. We recommend completing explorations at each turbine location and areas of roadway cuts and fills as part of the final design phase to confirm the bearing conditions and evaluate the applicability of the preliminary recommendations presented in this report.

### **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. A qualified geotechnical engineering testing firm 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 explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between explorations, 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.

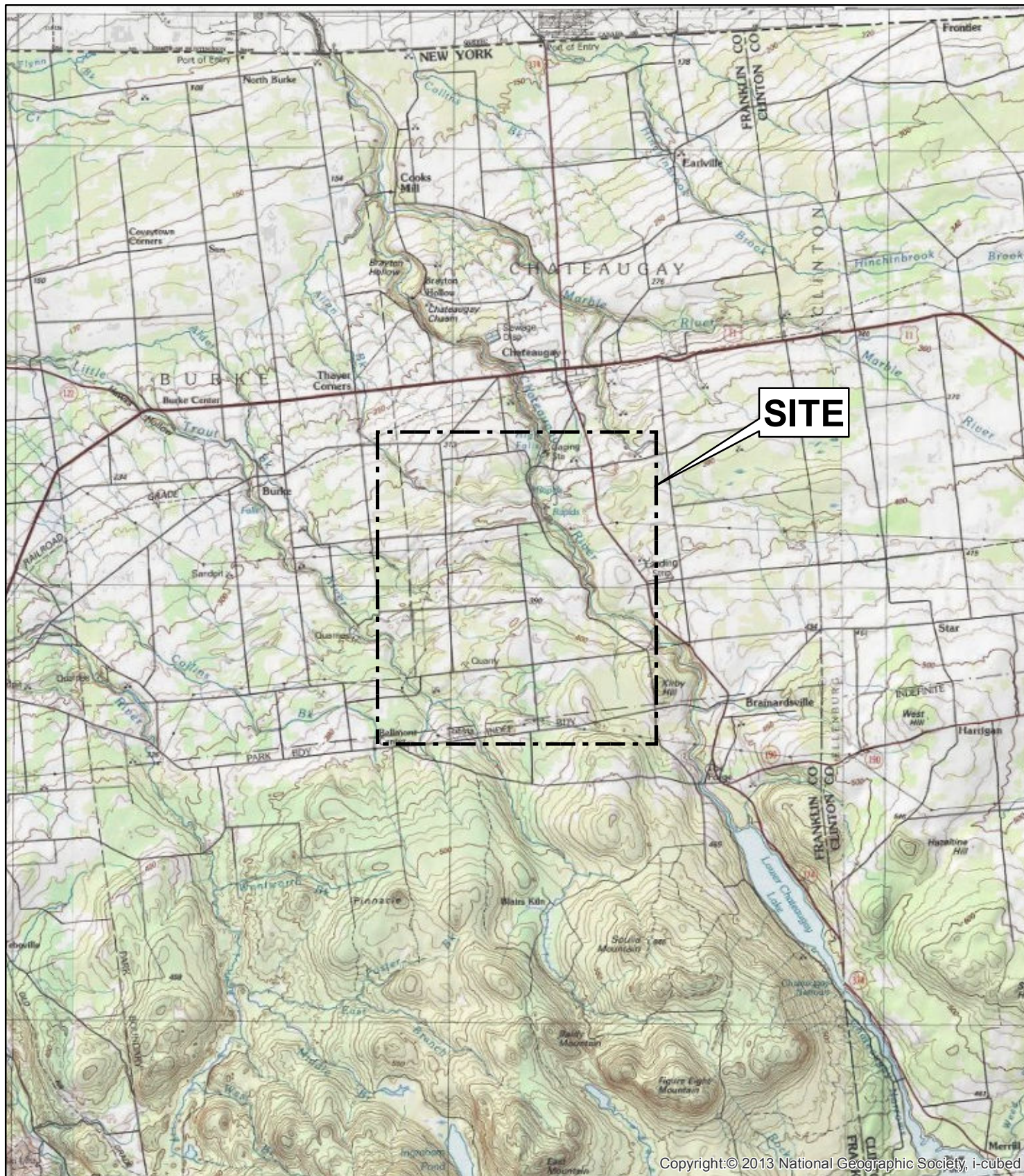
This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, 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.

DRAFT

**APPENDIX A**  
**FIELD EXPLORATION**

DRAFT





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1:120,000

SITE CENTER COORDINATES: 74°5'55.482"W 44°52'43.87"N

Data Source:  
USGS Chateaugay Quadrangle,  
1993, 7.5-Minute Series



Project No.: J5155113

Drawn By: JDF

Reviewed By: CWT

Date: July 2015

**Terracon**  
Consulting Engineers & Scientists

77 Sundial Ave., St. 401W Manchester, NH  
PH. (603) 647 9700 terracon.com

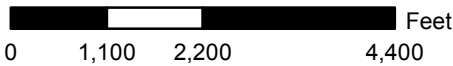
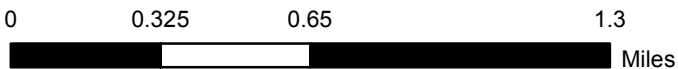
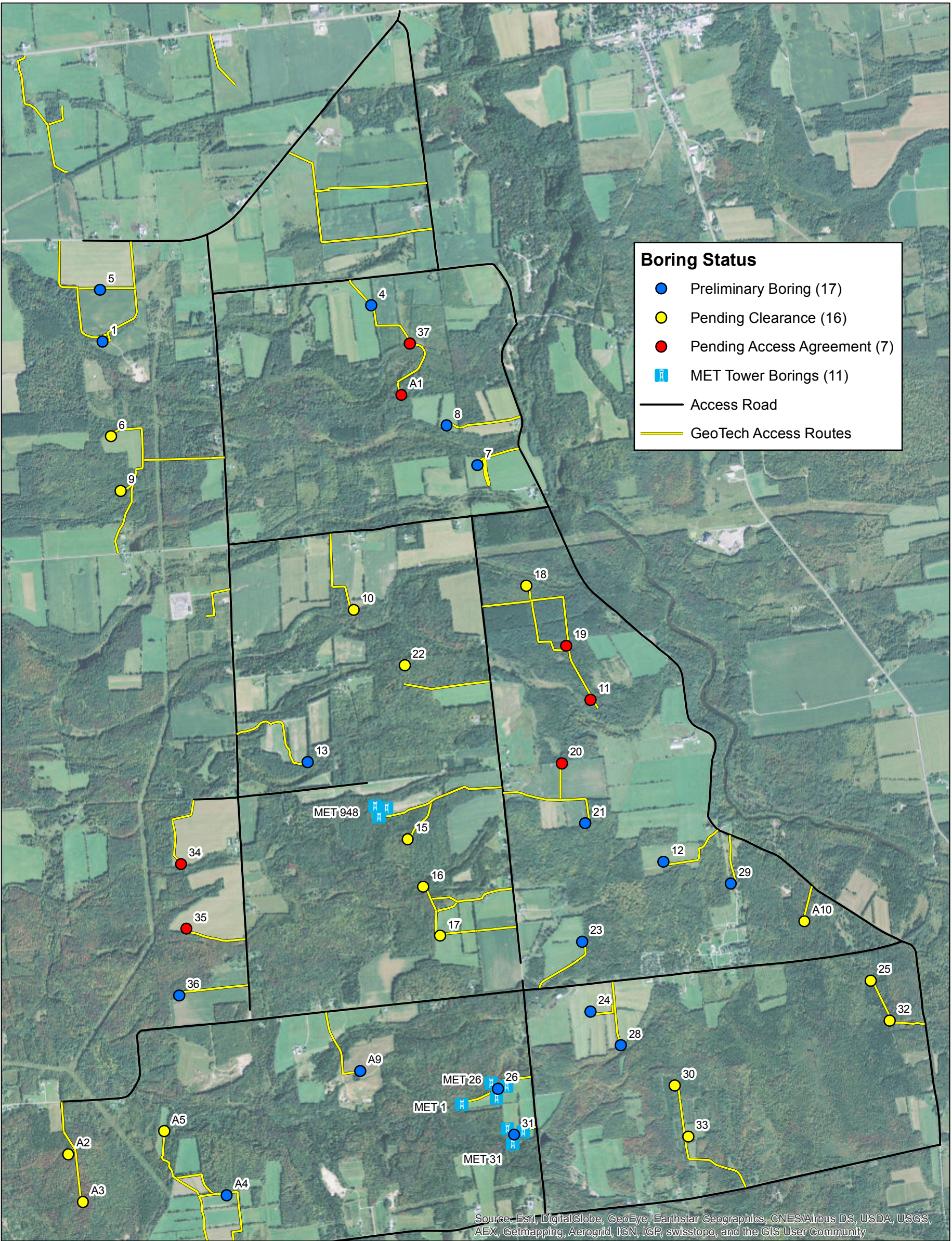
SITE LOCUS MAP

JERICO RISE WIND FARM  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

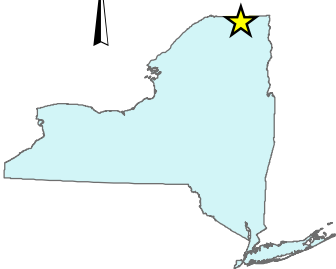
A-1





1:26,400

SITE CENTER COORDINATES: -74.100000 W, 44.884467 N



Project No.	J5155113
Drawn By:	JDF
Reviewed By:	CWT
Date:	July 20, 2015

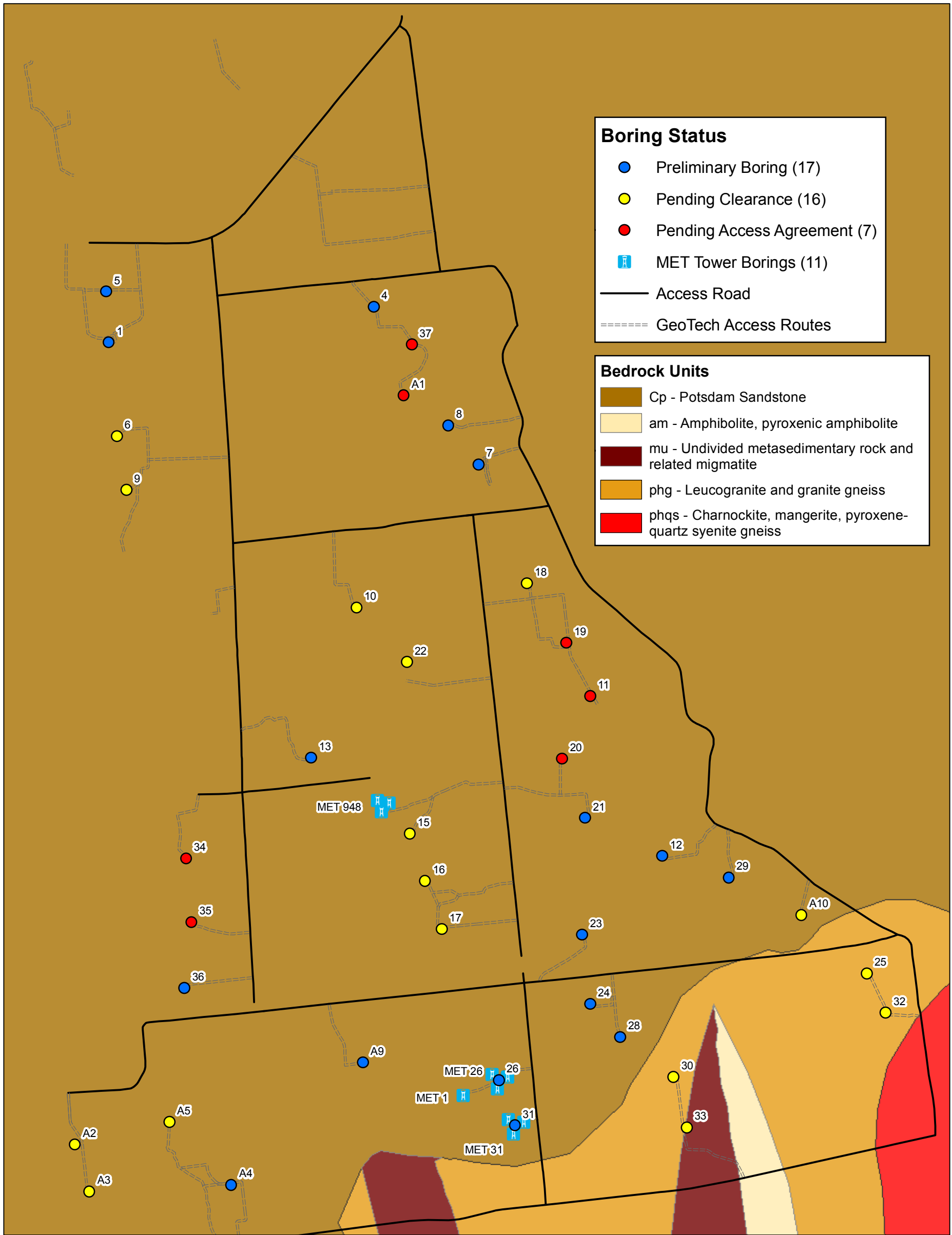
**Terracon**

77 Sundial Ave, Ste 401W    Manchester, NH 03103  
Phone: (603) 647 9700    terracon.com

SITE MAP AND BORING LOCATIONS
JERICO RISE WIND FARM FRANKLIN COUNTY, NEW YORK

EXHIBIT
A-2





**Boring Status**

Preliminary Boring (17)

Pending Clearance (16)

Pending Access Agreement (7)

MET Tower Borings (11)

Access Road

GeoTech Access Routes

**Bedrock Units**

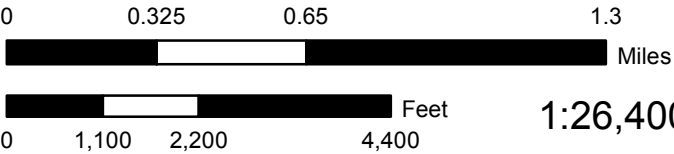
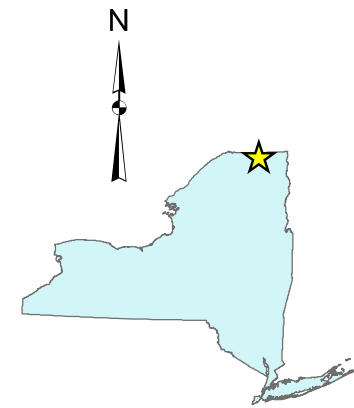
Cp - Potsdam Sandstone

am - Amphibolite, pyroxenic amphibolite

mu - Undivided metasedimentary rock and related migmatite

phg - Leucogranite and granite gneiss

phqs - Charnockite, mangerite, pyroxene-quartz syenite gneiss



SITE CENTER COORDINATES: -74.100000 W, 44.884467 N

Data Sources:  
- Bedrock Units: New York State Museum GIS Datasets  
- Borings & Site Features: EDP Renewables

Project No.	J5155113
Drawn By:	JDF
Reviewed By:	CWT
Date:	July 20, 2015

**Terracon**

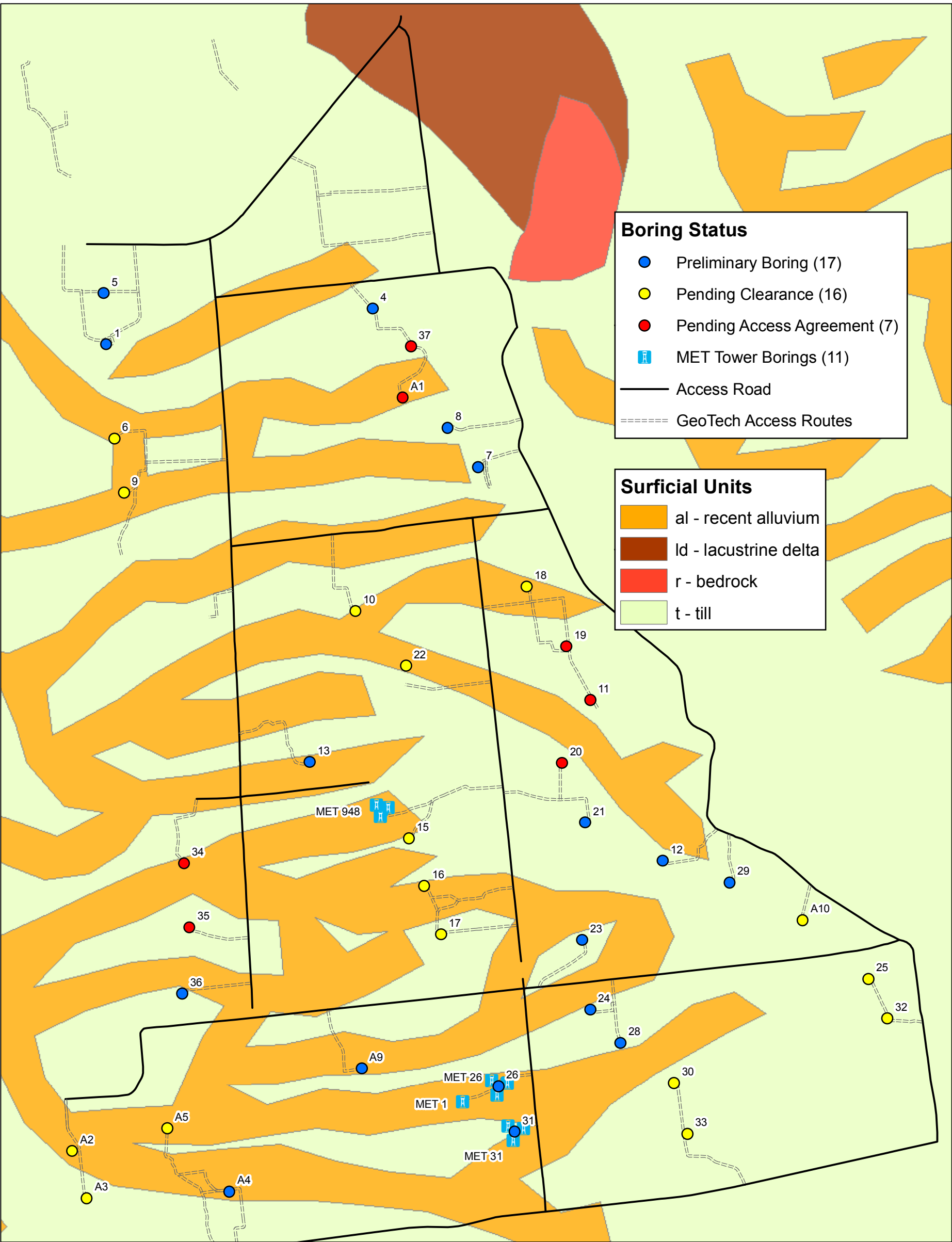
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BEDROCK GEOLOGY

JERICO RISE WIND FARM  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-3

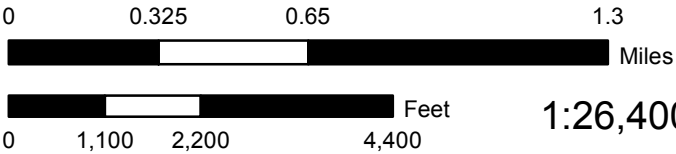
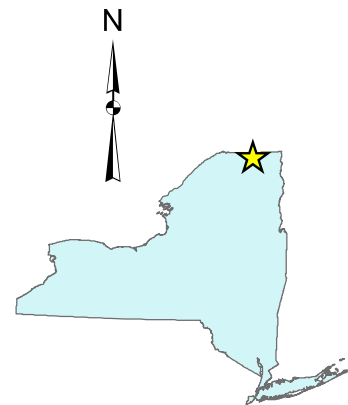


**Boring Status**

- Preliminary Boring (17)
- Pending Clearance (16)
- Pending Access Agreement (7)
- MET Tower Borings (11)
- Access Road
- GeoTech Access Routes

**Surficial Units**

- al - recent alluvium
- ld - lacustrine delta
- r - bedrock
- t - till



SITE CENTER COORDINATES: -74.100000 W, 44.884467 N

Data Sources:  
- Surficial Units: New York State Museum GIS Datasets  
- Borings & Site Features: EDP Renewables

Project No.	J5155113
Drawn By:	JDF
Reviewed By:	CWT
Date:	July 20, 2015

**Terracon**

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Phone: (603) 647 9700 terracon.com

SURFICIAL GEOLOGY
JERICO RISE WIND FARM FRANKLIN COUNTY, NEW YORK

EXHIBIT
A-4

## **Field Exploration Description – Borings and Probes**

The boring locations were laid out in the field by a licensed land surveyor under separate contract with EDPR. In general, the borings were completed either directly at the stake or within about 5 feet of the staked locations. Coordinates of drilled locations are reported on the boring logs in NY State Plane coordinates. The approximate boring and probe locations are indicated on Exhibit A-2, Site and Boring Locations.

The borings were drilled with an all-terrain vehicle (ATV) mounted rotary drill rig using rotary wash boring techniques to advance the boreholes. Soil samples were generally obtained nearly continuously from the ground surface to a depth of 20 feet, and at 5-foot intervals thereafter using a standard 2-inch-outside-diameter split-barrel sampler. Standard Penetration Tests (SPTs) were performed in general accordance with industry standards. Density of soil samples are based on N-values, which is determined by the number of hammer blows required to drive the sampler from 6 to 18 inches. A roller bit was used to advance the borings between the sampling intervals. The sampling depths and penetration distance, plus the standard penetration resistance values are shown on the boring logs.

Rock coring was generally completed at locations where spoon refusal, defined as 50 blows of the 140 pound hammer with less than 1 inch penetration, was encountered. Bedrock core samples were obtained using an NX-sized double tube core barrel.

Samples were placed in appropriate containers and transported to our laboratory for further examination, testing, and classification.

## **Seismic Refraction Data**

A multichannel analysis of surface waves (MASW) was obtained at ten locations in the project area. Surface elastic waves were created using a sledgehammer striking a plate. Velocity data was collected using a 24-channel 4.5 mHz geophone setup with a 5-foot array. A computer was used to collect and process the data.

The processed data is presented in this Appendix. Subsurface conditions interpreted from geophysical testing are subject to possible anomalies creating variations from actual conditions. The boring logs should also be reviewed in conjunction with these interpreted subsurface conditions.

# BORING LOG NO. WTG-1

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2212586.3317 Easting: 589234.5004  DEPTH 0.5 6-inches sandy topsoil, cornfield <b>POORLY GRADED SAND WITH SILT (SP-SM)</b> , trace gravel, dark brown, very loose to medium dense, (GLACIAL TILL) 6.0 <b>SILTY SAND (SM)</b> , trace gravel, brown, loose 8.0 <b>GRAVELLY SILT (ML)</b> , brown, loose to medium dense, (GLACIAL TILL) 15.0 <b>SILTY SAND (SM)</b> , trace gravel, dark brown, medium dense to dense, (GLACIAL TILL) Similar, gray-brown, dense Similar, with gravel, very dense 39.1 <b>Roller bit refusal at 39.1 Feet</b>							
						12	1-2-2-2 N=4	
						14	2-2-3-3 N=5	
		5				18	4-4-6-4 N=10	
						16	4-2-4-3 N=6	
		10				18	3-4-2-3 N=6	
						18	5-10-19-5 N=29	
		15				14	8-6-5-8 N=11	
		20				18	4-6-9-15 N=15	
		25				18	21-23-24-17 N=47	
		30					25-40-50/1"	
		35					50-50/2"	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

6' WD  
13.7' after 18 hrs

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 5/27/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 5/27/2015

Driller: ATL/Josh

Exhibit: A-6

# BORING LOG NO. WTG-4

Page 1 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC



SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2213382.648 Easting: 595147.1203						
	DEPTH ELEVATION (Ft.)						
	0.8 Topsoil				10	1-2-3-3 N=5	
	<b>SILTY SAND (SM)</b> , brown, loose to very dense, (GLACIAL TILL)				20	5-8-4-5 N=12	
		5			12	3-5-5-6 N=10	
					2	6-4-4-3 N=8	
		10			12	4-4-7-5 N=11	
					24	4-4-3-4 N=7	
		15			0	12-8-19-31 N=27	
		20			14	17-20-29-50/5"	
		25			24	22-47-31-28 N=78	
	27.5						
	Boulder encountered, roller bit to 29 feet						
	29.0						
	<b>SILTY SAND WITH GRAVEL</b> , brown, very dense to dense, (GLACIAL TILL)				24	18-29-37-33 N=66	
		35			24	20-27-33-41 N=60	
		40			18	14-25-41-38	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method: 4-inch casing	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any).	Notes:	
Abandonment Method:	See Appendix C for explanation of symbols and abbreviations.		
<b>WATER LEVEL OBSERVATIONS</b>	 <p>15 Marway Circle, Suite 2B Rochester, New York</p>	Boring Started: 6/17/2015	Boring Completed: 6/18/2015
 5.5' WD		Drill Rig: CME-75	Driller: ATL/Josh
		Project No.: J5155113	Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

# BORING LOG NO. WTG-4

Page 2 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2213382.648    Easting: 595147.1203  DEPTH ELEVATION (Ft.)						
	<b>SILTY SAND WITH GRAVEL</b> , brown, very dense to dense, (GLACIAL TILL) <i>(continued)</i> Cobbles at 40.5 feet			X	18	N=66	
		45		X	7	26-50/1"	
		50		X	20	20-17-17-17 N=34	
		55		X	22	18-19-23-22 N=42	
		60		X		18-18-30-34 N=48	
	61.0 <b>Boring Terminated at 61 Feet</b> Monitoring well set at 15 feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

5.5' WD

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/17/2015

Boring Completed: 6/18/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-7

# BORING LOG NO. WTG-A4

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC


SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2193770.6831 Easting: 591968.4285						
	DEPTH ELEVATION (Ft.)						
1.2	TOPSOIL				16	1-3-4-7 N=7	
2.0	<b>SILTY SAND (SM)</b> , trace gravel, dark brown, loose						
4.0	<b>SILTY SAND WITH GRAVEL (SM)</b> , brown/gray, dense, (ALLUVIUM)				13	14-25-20-10 N=45	
5.8	<b>SILTY SAND (SM)</b> , trace gravel, brown, very dense, rock fragments				15	6-14-12-50/1"	
6.0	Roller bit from 5.75 to 6 feet, begin rock core at 6 feet						
	Run 1 Moderately hard, very slightly weathered, light yellow brown, medium grained SANDSTONE, very thinly bedded, non-foliated, with closely spaced horizontal joints, very poor RQD	5			50.5		0
	Run 2 Similar to Run 1, very poor RQD	10			52		22
	Run 3 Similar to Run 2, very poor RQD	15			49.5		22
21.0	<b>Boring Terminated at 21 Feet</b>	20					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method: 4-inch casing	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any).	Notes:	
Abandonment Method:	See Appendix C for explanation of symbols and abbreviations.		
<b>WATER LEVEL OBSERVATIONS</b> No free water observed	 <p>15 Marway Circle, Suite 2B Rochester, New York</p>	Boring Started: 6/4/2015	Boring Completed: 6/4/2015
		Drill Rig: CME-75	Driller: ATL/Josh
		Project No.: J5155113	Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON 2015\_MASTER GDT 7/20/15



# BORING LOG NO. WTG-5

Page 1 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2213724.0361 Easting: 589175.9761						
	DEPTH ELEVATION (Ft.)						
	0.3 4-inches sandy topsoil, cornfield				12	woh-2-3-4 N=5	
	POORLY GRADED SAND WITH SILT (SP-SM), dark brown, loose to medium dense				16	4-5-7-6 N=12	
	4.0 SILTY SAND (SM), dark brown, medium dense, (GLACIAL TILL)	5			18	3-3-3-2 N=6	
	Similar, trace gravel				12	2-7-9-12 N=16	
	10.0 SILT WITH SAND (ML), dark brown, very dense, (GLACIAL TILL)	10			18	8-10-17-17 N=27	
	Similar, rock fragments in tip of sampler				12	13-10-12-18 N=22	
		15			7	49-50/2"	
		20			9	33-50/4"	
		25			18	19-32-52 N=84	
	29.0 Boulder encountered, roller bit to 31 feet	30			18	11-17-21-34 N=38	
	31.0 SILTY SAND (SM), gray-brown, dense to very dense	35			16	17-22-27-50/3" N=49	
		40					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method: 3-inch casing	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any).	Notes:	
Abandonment Method:	See Appendix C for explanation of symbols and abbreviations.		
WATER LEVEL OBSERVATIONS		Boring Started: 5/26/2015	Boring Completed: 5/27/2015
15.7' after 12 hrs		Drill Rig: CME-75	Driller: ATL/Josh
		Project No.: J5155113	Exhibit: A-9

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

## Page 2 of 2

**CLIENT: Jericho Rise Wind Farm, LLC**

## Franklin County, New York

### ***Roller bit refusal at 55.3 Feet***

Hammer Type: Hydraulic

Notes:

Exhibit: A-9

# BORING LOG NO. WTG-7

Page 1 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:


Franklin County, New York

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2209860.0458 Easting: 597492.3162						
	DEPTH ELEVATION (Ft.)						
	0.7 8-inches topsoil				8	woh-1-3-5-8	
	1.0 <b>SANDY SILT (ML)</b> , trace gravel, brown, soft				20	7-8-8-7 N=16	
	<b>SILTY SAND (SM)</b> , trace gravel, brown, medium dense to dense						
		5			15	7-9-7-7 N=16	
					20	4-7-9-12 N=16	
	8.0 <b>SILTY SAND WITH GRAVEL (SM)</b> , brown to light red, dense, (GLACIAL TILL)				14	8-12-19-50/5" N=31	
	11.0 Note: Roller bit through cobble from 9.9 to 10.5 feet	10					
	<b>SILTY SAND (SM)</b> , trace gravel, brown, medium dense, Rock in tip of sampler (GLACIAL TILL)				16	9-11-14-50/2" N=25	
	13.0 Note: Cored through boulder from 13 to 15 feet						
	15.0 <b>SILTY SAND WITH GRAVEL (SM)</b> , brown, medium dense to very dense, (GLACIAL TILL)	15			15	12-13-16-18 N=29	
		20			16	8-32-34-48 N=66	
		25			3	50/5"	
		30			18	22-18-23-39 N=41	
		35			18	26-31-32-50/5" N=63	
		40					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method: 3-inch casing	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any).	Notes:	
Abandonment Method:	See Appendix C for explanation of symbols and abbreviations.		
<b>WATER LEVEL OBSERVATIONS</b> No free water observed	 <p>15 Marway Circle, Suite 2B Rochester, New York</p>	Boring Started: 6/17/2015	Boring Completed: 6/17/2015
		Drill Rig: CME-75	Driller: ATL/Josh
		Project No.: J5155113	Exhibit: A-10

# BORING LOG NO. WTG-7


Page 2 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC


SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
	See Exhibit A-2 Northing: 2209860.0458    Easting: 597492.3162						
DEPTH	ELEVATION (Ft.)						
	<b>SILTY SAND WITH GRAVEL (SM)</b> , brown, medium dense to very dense, (GLACIAL TILL) ( <i>continued</i> )				15	26-33-31-50/4" N=64	
42.8							
43.5	Bedrock inferred at 43 feet due to refusal on roller bit from 42.8 to 43.5 feet						
	<b>Boring Terminated at 43.5 Feet</b>						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method: 3-inch casing	See Exhibit A-3 for description of field procedures. See Appendix B for description of laboratory procedures and additional data (if any). See Appendix C for explanation of symbols and abbreviations.	Notes:	
Abandonment Method:			
<b>WATER LEVEL OBSERVATIONS</b> No free water observed	 15 Marway Circle, Suite 2B Rochester, New York	Boring Started: 6/17/2015	Boring Completed: 6/17/2015
		Drill Rig: CME-75	Driller: ATL/Josh
		Project No.: J5155113	Exhibit: A-10

# BORING LOG NO. WTG-8

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	0.7 8-inches topsoil						8	1-4-5-5 N=9	
	2.0 <b>SANDY SILT (ML)</b> , trace gravel, brown, loose						15	9-3-4-5 N=7	
	<b>SILTY SAND (SM)</b> , trace gravel, brown, loose to very dense, (GLACIAL TILL)						24	3-2-3-4 N=5	
							24	3-2-3-5 N=5	
							14	11-11-8-8 N=19	
							13	6-7-8-10 N=15	
							20	17-23-19-31 N=42	
							15	26-37-43-40 N=80	
							21	17-21-23-36 N=44	
								33-50/3"	
	30.8 Roller bit from 30.75 to 36 feet, bedrock inferred at 30.8 feet								
	36.0 <b>Roller bit refusal at 36 Feet</b> Monitoring well set at 20 feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

4.7' WD

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/17/2015

Boring Completed: 6/18/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

## Page 1 of 1

**CLIENT: Jericho Rise Wind Farm, LLC**

## Franklin County, New York

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL J5155113.GPJ TERRACON 2015\_MASTER.GDT 7/20/15

Hammer Type: Hydraulic

Notes:

Exhibit: A-12

# BORING LOG NO. WTG-12

Page 1 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	<p>16-inches topsoil</p> <p>1.3</p> <p><b>SILTY SAND (SM)</b>, trace gravel, brown to light brown, loose to very loose, (ALLUVIUM)</p> <p>8.0</p> <p>Roller bit and core through boulders from 8 to 15 feet (GLACIAL TILL)</p> <p>15.0</p> <p><b>SILTY SAND (SM)</b>, trace gravel, brown to light brown, loose to medium dense, (GLACIAL TILL)</p> <p>25.0</p> <p><b>SANDY SILT (ML)</b>, trace gravel, light brown, dense, (GLACIAL TILL)</p> <p>30.0</p> <p><b>SILTY SAND WITH GRAVEL (SM)</b>, dark gray, very dense, (GLACIAL TILL)</p>							
						18	woh-1-2-2 N=3	
						15	2-3-3-2 N=6	
		5				14	2-1-1-1 N=2	
						16	1-1-1-2 N=2	
		10						
		15				18	1-2-3-2 N=5	
		20				14	6-6-11-18 N=17	
		25				7	11-12-20-26 N=32	
		30				20	23-26-26-44 N=52	
		35				18	35-36-49-50/1"	
		40						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

0' WD

13.4 AB

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/12/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/15/2015

Driller: ATL/Josh

Exhibit: A-13

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15



# BORING LOG NO. WTG-12

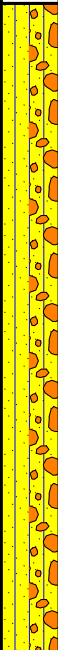
Page 2 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2 Northing: 2201118.4476 Easting: 601589.2922	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
DEPTH	ELEVATION (Ft.)						
	<b>SILTY SAND WITH GRAVEL (SM)</b> , dark gray, very dense, (GLACIAL TILL) (continued)				4	50/4"	
	Similar, less gravel, dense to medium dense	45		8		13-13-20-20 N=33	
		50		18		14-11-16-15 N=27	
	Similar, trace gravel	55		18		11-11-16-15 N=27	
		60		20		7-7-13-32 N=20	
62.0	<b>Boring Terminated at 62 Feet</b> Temporary well set at 20 feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

0' WD

13.4 AB

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/12/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/15/2015

Driller: ATL/Josh

Exhibit: A-13

# BORING LOG NO. WTG-13

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2203312.8967 Easting: 593751.0333							
	DEPTH							
	Topsoil	1.3				16	1-6-5-5 N=11	
	<b>SILTY SAND</b> , olive brown, medium dense					14	5-9-17-11 N=26	
						16	5-5-5-20 N=10	
		7.0				18	14-8-10-21 N=18	
	<b>SILTY SAND WITH GRAVEL</b> , brown, medium dense to very dense, (GLACIAL TILL)					16	19-37-47-40 N=84	
						10	31-34-50/5"	
						12	21-28-33-31 N=61	
						10	25-40-40-34 N=80	
						14	25-50-37-41 N=87	
		27.0						
	Roller bit to 28 feet	28.0						
	Run 1 Moderately hard, very slightly weathered, light brown and pink, medium grained SANDSTONE, very thinly bedded, non-foliated, with closely spaced horizontal joints, good RQD					60		86
	Run 2 Similar to Run 1, excellent RQD					60		93
		33.0						
		38.0						
	<b>Boring Terminated at 38 Feet</b> Monitoring well installed at 20 feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

5' WD

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/16/2015

Boring Completed: 6/15/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-14

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

# BORING LOG NO. WTG-21

Page 1 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2201968.4458 Easting: 599866.0978						
	DEPTH ELEVATION (Ft.)						
	0.6 7-inches topsoil				14	woh-2-1-3	
	2.0 <b>SILTY SAND (SM)</b> , trace gravel, brown, loose				16	5-5-7-6 N=12	
	<b>SANDY SILT WITH GRAVEL (ML)</b> , brown, medium dense				16	1-1-1-1 N=2	
	4.0 <b>SILTY SAND</b> , trace gravel, brown, very loose to loose, (ALLUVIUM)	5			14	4-3-3-3 N=6	
					14	8-3-3-2 N=6	
		10			18	2-1-1-1 N=2	
	15.0 <b>POORLY GRADED GRAVEL (GP)</b> , light brown, very dense, (GLACIAL TILL)	15			3	10-19-50-50/1" N=69	
	17.0 Cored through boulders and cobbles from 17 to 27 feet						
		20					
		25					
	27.0 <b>SILTY SAND WITH GRAVEL (SM)</b> , light brown to gray, very dense, (GLACIAL TILL)				18	30-38-41-50/2" N=79	
	28.0 Boulders and cobbles						
		30			20	23-36-41-50/3" N=77	
	31.0 <b>SILTY SAND WITH GRAVEL (SM)</b> , light brown to gray, very dense, (GLACIAL TILL)				18	48-49-39-40 N=88	
		35					
		40					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

No free water observed

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/17/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/17/2015

Driller: ATL/Josh

Exhibit: A-15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL J5155113.GPJ TERRACON 2015 MASTER GDT 7/20/15

# BORING LOG NO. WTG-21

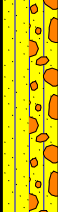
Page 2 of 2

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
	See Exhibit A-2 Northing: 2201968.4458    Easting: 599866.0978						
DEPTH	ELEVATION (Ft.)						
	<b>SILTY SAND WITH GRAVEL (SM)</b> , light brown to gray, very dense, (GLACIAL TILL) (continued)			X	16	16-41-37-50/3" N=78	
47.5		45		X	18	10-12-13-25 N=25	
49.3	Bedrock inferred at 47.5 feet, roller bit to 49.3 feet with refusal						
	<b>Boring Terminated at 49.3 Feet</b> Temporary well set at 20 feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

No free water observed

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/17/2015

Boring Completed: 6/17/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-15

# BORING LOG NO. WTG-23

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2199357.0116 Easting: 599802.5904							
	DEPTH							
	0.8 10-inches topsoil					14	1-1-1-2 N=2	
	<b>SANDY SILT WITH GRAVEL (ML)</b> , brown, loose to medium dense					14	8-10-15-18 N=25	
		5				9	9-14-7-11 N=21	
						18	15-9-4-4 N=13	
	8.0 <b>SILTY SAND (SM)</b> , trace gravel, brown, loose to medium dense, (GLACIAL TILL)	10				16	6-4-4-5 N=8	
						16	6-6-14-47 N=20	
	Similar, rock in sampler	15				6	5-9-20-19 N=29	
	18.0 Roller bit to 20 feet, begin rock core at 20 feet	20						
	20.0 Run 1 Moderately hard, very slightly weathered, dark gray with pink, medium grained SANDSTONE, very thinly bedded, non-foliated, with closely spaced horizontal joints, poor RQD					38		43
	25.0 Similar to Run 1, fair RQD	25				56		58
	30.0 Similar to Run 2, fair RQD	30				43		69
	34.0 <b>Boring Terminated at 34 Feet</b>							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

9.8 WD  
8.9' after 18 hrs

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/8/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/10/2015

Driller: ATL/Josh

Exhibit: A-16

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON 2015\_MASTER.GDT 7/20/15

# BORING LOG NO. WTG-24

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	1.0 12-inches topsoil					15	1-2-3-8 N=5	
	2.0 <b>SANDY SILT (ML)</b> , trace gravel, dark brown, loose					20	8-7-4-5 N=11	
	<b>SILTY SAND (SM)</b> , dark brown to brown, medium dense to very dense, (GLACIAL TILL)					9	4-12-8-7 N=20	
		5				18	7-15-10-11 N=25	
						16	7-2-5-5 N=7	
		10				16	6-9-5-4 N=14	
		15				16	7-6-8-9 N=14	
	20.0	20						
	Roller bit through boulders from 20 to 22 feet							
	22.0							
	<b>SILTY SAND (SM)</b> , dark brown to brown, medium dense to very dense, (GLACIAL TILL)					0	10-14-18-15 N=32	
						14	16-44-16-20 N=60	
		25						
	30.0	30				14	24-39-40-48 N=79	
	<b>SILTY SAND WITH GRAVEL (SM)</b> , dark brown, very dense, (GLACIAL TILL)							
	34.0							
	35.0 Roller bit from 34 feet to refusal at 35 feet	35						
	<b>Roller bit refusal at 35 Feet</b>							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

9.8 WD  
8.9' after 18 hrs

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/8/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/10/2015

Driller: ATL/Josh

Exhibit: A-17

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

# BORING LOG NO. WTG-26/MET-26C

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	<p>Northings: 2196114.2228 Easting: 597942.3563</p> <p>DEPTH</p>							
	0.5 Topsoil					16	1-4-2-9 N=6	
	<b>SILTY SAND (SM)</b> , trace gravel, dark brown to brown, loose to medium dense, (GLACIAL TILL)					16	9-6-4-4 N=10	
	Similar, sandstone rock in tip of split spoon sampler					22	4-5-6-25 N=11	
		5				10	7-10-9-11 N=19	
						8	7-11-7-5 N=18	
	10.0 <b>SILTY SAND WITH GRAVEL (SM)</b> , brown/purple, medium dense, sandstone rock in tip of split spoon sampler (GLACIAL TILL)	10				10	6-9-35-24 N=44	
	13.0 Bedrock at 13 feet, roller bit to 15 feet, begin rock core							
	15.0 Run1 Moderately hard, slightly weathered, light brown with pink, medium grained SANDSTONE, very thinly bedded, non-foliated with closely spaced horizontal joints, good RQD	15				58	Run 1	87
	20.0 Run 2 Similar to Run 1, good RQD	20				56	Run 2	89
	25.0 Run 3 Similar to Run 2, excellent RQD	25				56	Run 3	90
	30.0 <b>Boring Terminated at 30 Feet</b>	30						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:  
Boring backfilled with soil cuttings upon completion.

## WATER LEVEL OBSERVATIONS

2.5'WD  
4' 24 hrs

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/2/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/2/2015

Driller: ATL/Josh

Exhibit: A-18

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON 2015 MASTER GDT 7/20/15



# BORING LOG NO. WTG-28

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2 Northing: 2197073.1295 Easting: 600652.1547	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
DEPTH	ELEVATION (Ft.)						
1.2	14-inches topsoil				14	1-2-1-6 N=3	
	<b>SILTY SAND (SM)</b> , trace gravel, medium dense, (GLACIAL TILL)				20	6-10-8-9 N=18	
	Similar, sandstone rock within sample	5			8	9-8-11-16 N=19	
8.0					13	23-13-5-4 N=18	
8.5	<b>SILTY SAND WITH GRAVEL (SM)</b> , light brown, very dense					50/5"	
	Roller bit through boulders from 9 to 14 feet	10			5	23-17-11-15 N=28	
14.0							
	<b>SILTY SAND WITH GRAVEL (SM)</b> , light brown, medium dense to very dense, (GLACIAL TILL)	15			5	5-6-8-10 N=14	
	Similar, sandstone rock in sampler, light brown, medium dense. Could not advance casing beyond boulders at 14 feet, no rock core possible at this location	20			1	50/1"	
22.0	<b>Roller bit refusal at 22 Feet</b>						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

No free water observed

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/8/2015

Drill Rig: CME-75

Project No.: J5155113

Boring Completed: 6/10/2015

Driller: ATL/Josh

Exhibit: A-19

# BORING LOG NO. WTG-29

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	<p>0.8 10-inches topsoil</p> <p><b>SILTY SAND (SM)</b>, trace gravel, dark brown, loose to dense, (GLACIAL TILL)</p>						15	woh-1-3-6 N=4	
							20	3-2-3-4 N=5	
				5			16	3-4-3-3 N=7	
							13	5-6-7-8 N=13	
				10			12	8-8-12-21 N=20	
							4	18-18-13-10 N=31	
				15			16	11-20-24-26 N=44	
				20			15	19-36-26-27 N=62	
				25			15	15-21-15-24 N=36	
				30					
	<p>30.8 Bedrock inferred at 30.3 feet due to very slow advancement by roller bit from 30.1 to 30.7 feet.</p> <p>Temporary well set at 20 feet.</p> <p><b>Boring Terminated at 30.8 Feet</b></p> <p>Temporary well set at 20 feet</p>								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

4' WD  
2' after 72 hrs

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/12/2015

Boring Completed: 6/12/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-20

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J5155113.GPJ TERRACON\_2015\_MASTER.GDT 7/20/15

# BORING LOG NO. WTG-31/MET-31C

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
	<p>0.3 Topsoil</p> <p><b>SILTY SAND WITH GRAVEL (SM)</b>, light brown, very loose to medium dense</p> <p>6.0</p> <p><b>SILTY SAND WITH GRAVEL (SM)</b>, brown to white/brown, very dense, (GLACIAL TILL)</p> <p>15.0</p> <p><b>POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)</b>, with cobbles, light brown, very dense, (GLACIAL TILL)</p> <p>19.5</p> <p>Run1 Moderately hard, slightly weathered, light brown with pink, medium grained SANDSTONE, very thinly bedded, non-foliated with closely spaced horizontal joints, fair RQD</p> <p>24.5</p> <p>Run 2 Similar to Run 1, good RQD</p> <p>29.5</p> <p>Run 3 Similar to Run 2, excellent RQD</p> <p>34.5</p> <p><b>Boring Terminated at 34.5 Feet</b></p>							
						3	woh-1-1-1	
						21	3-5-5-10 N=10	
		5				18	8-9-10-9 N=19	
						9	7-50/4"	
						7	10-20-50/4"	
		10						
		15				9	29-21-46-20 N=67	
		20				50	Run 1	51
		25				59	Run 2	85
		30				60	Run 3	97

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
3-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:  
Boring backfilled with soil cuttings upon completion.

## WATER LEVEL OBSERVATIONS

16' AB

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/3/2015

Boring Completed: 6/3/2015

Drill Rig: CME-75

Driller: ATL/Josh

Project No.: J5155113

Exhibit: A-21

# BORING LOG NO. WTG-36

Page 1 of 1

PROJECT: Jericho Rise

CLIENT: Jericho Rise Wind Farm, LLC

SITE:

Franklin County, New York

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)
	Northing: 2198168.9672 Easting: 590921.3847						
	DEPTH ELEVATION (Ft.)						
0.8	TOPSOIL				16	1-3-6-6 N=9	
	<b>SILTY SAND WITH GRAVEL (SM)</b> , brown to light brown, loose to dense, sandstone rock in bottom 4-inches (GLACIAL TILL)				20	6-6-38-28 N=44	
	Similar, sandstone rock in top 4-inches	5			16	8-9-12-14 N=21	
8.0					17	14-12-29-29 N=41	
10.0	<b>POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)</b> , light brown, very dense, rock in sampler (GLACIAL TILL)				5	18-39-23-16 N=62	
	<b>SILTY SAND WITH GRAVEL (SM)</b> , brown, very dense, (GLACIAL TILL)	10			4	25-50/3"	
13.0							
14.0	Roller bit from 13 to 14 feet, begin rock core at 14 feet						
	Run 1 Moderately hard, very slightly weathered, light yellow brown with pink, medium grained SANDSTONE, very thinly bedded, non-foliated, with closely spaced horizontal joints, good RQD	15			55		72
	Run 2 Similar to Run 1, excellent RQD	20			58		90
	Run 3 Similar to Run 2, fair RQD	25			39		60
29.0							
	<b>Boring Terminated at 29 Feet</b>						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Hydraulic

Advancement Method:  
4-inch casing

See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:

## WATER LEVEL OBSERVATIONS

No free water observed

**Terracon**  
15 Marway Circle, Suite 2B  
Rochester, New York

Boring Started: 6/8/2015

Drill Rig: CME-75

Project No.: J5155113

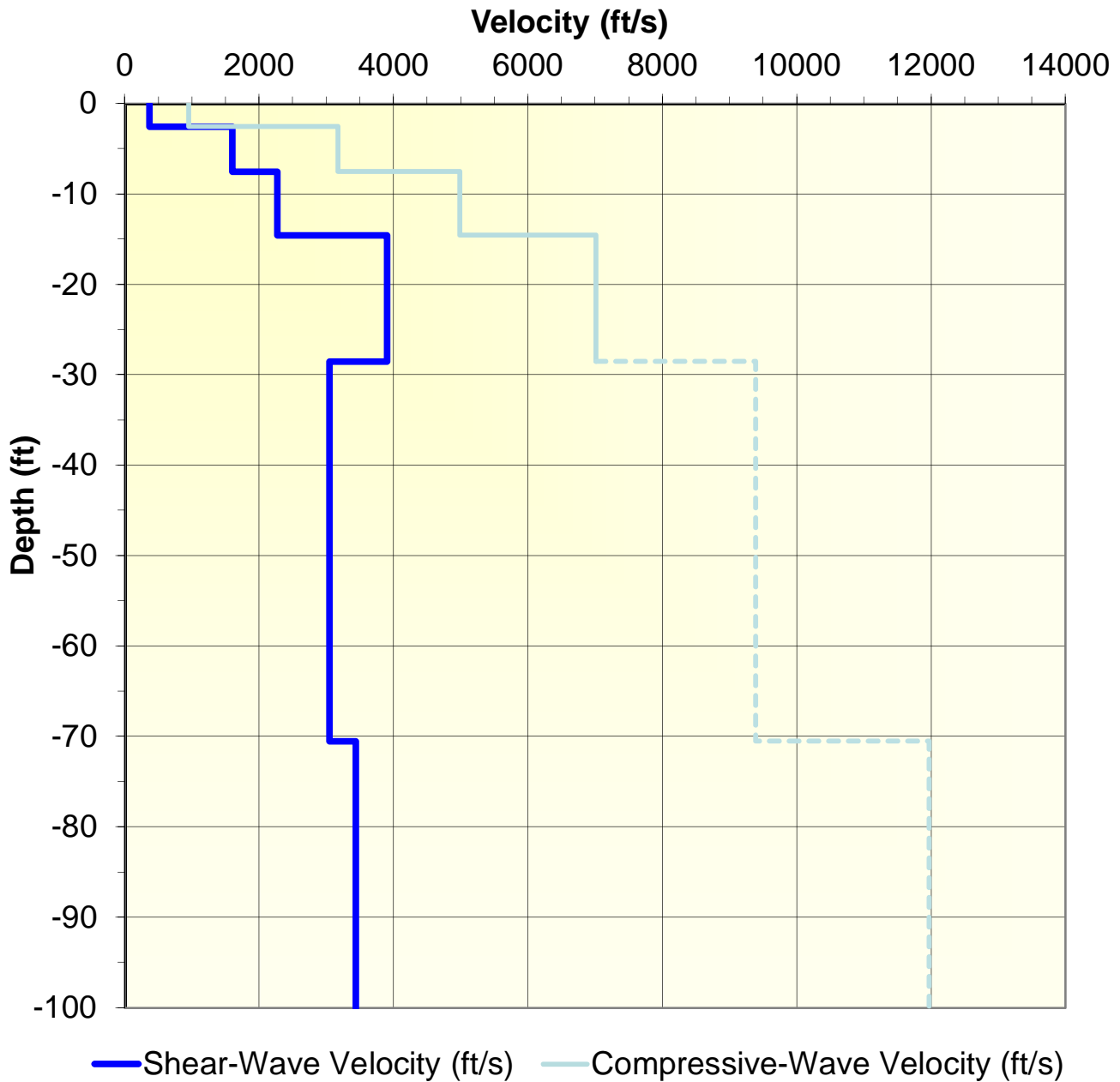
Boring Completed: 6/8/2015

Driller: ATL/Josh

Exhibit: A-22

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL J5155113.GPJ TERRACON 2015\_MASTER.GDT 7/20/15

# WTG A-4



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	367	950
-3	1601	3170
-8	2263	4990
-15	3900	7015
-29	3043	9390
-71	3437	11975

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model A4.xlsx
Approved by:	LJD	Date:	July 2015



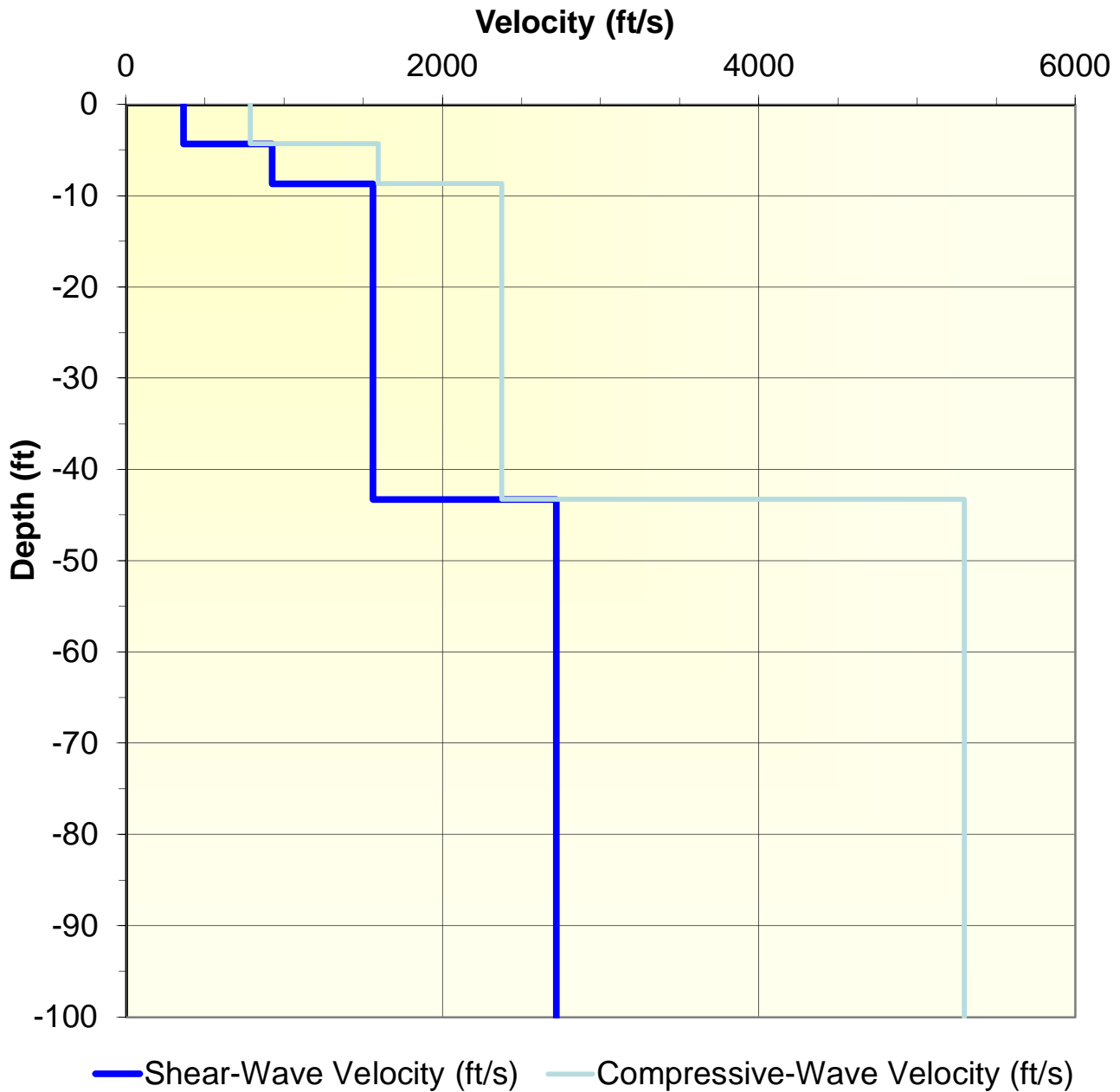
## SEISMIC VELOCITY PROFILE WTG A-4

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-23

# WTG 1



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	361	785
-4	923	1595
-9	1559	2375
-43	2717	5300

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model_WTG1.xlsx
Approved by:	LJD	Date:	July 2015

**Terracon**  
Consulting Engineers & Scientists

15 Marway Circle, Suite 2B      Rochester, New York 14624  
PH: (585) 247-3471

## SEISMIC VELOCITY PROFILE WTG 1

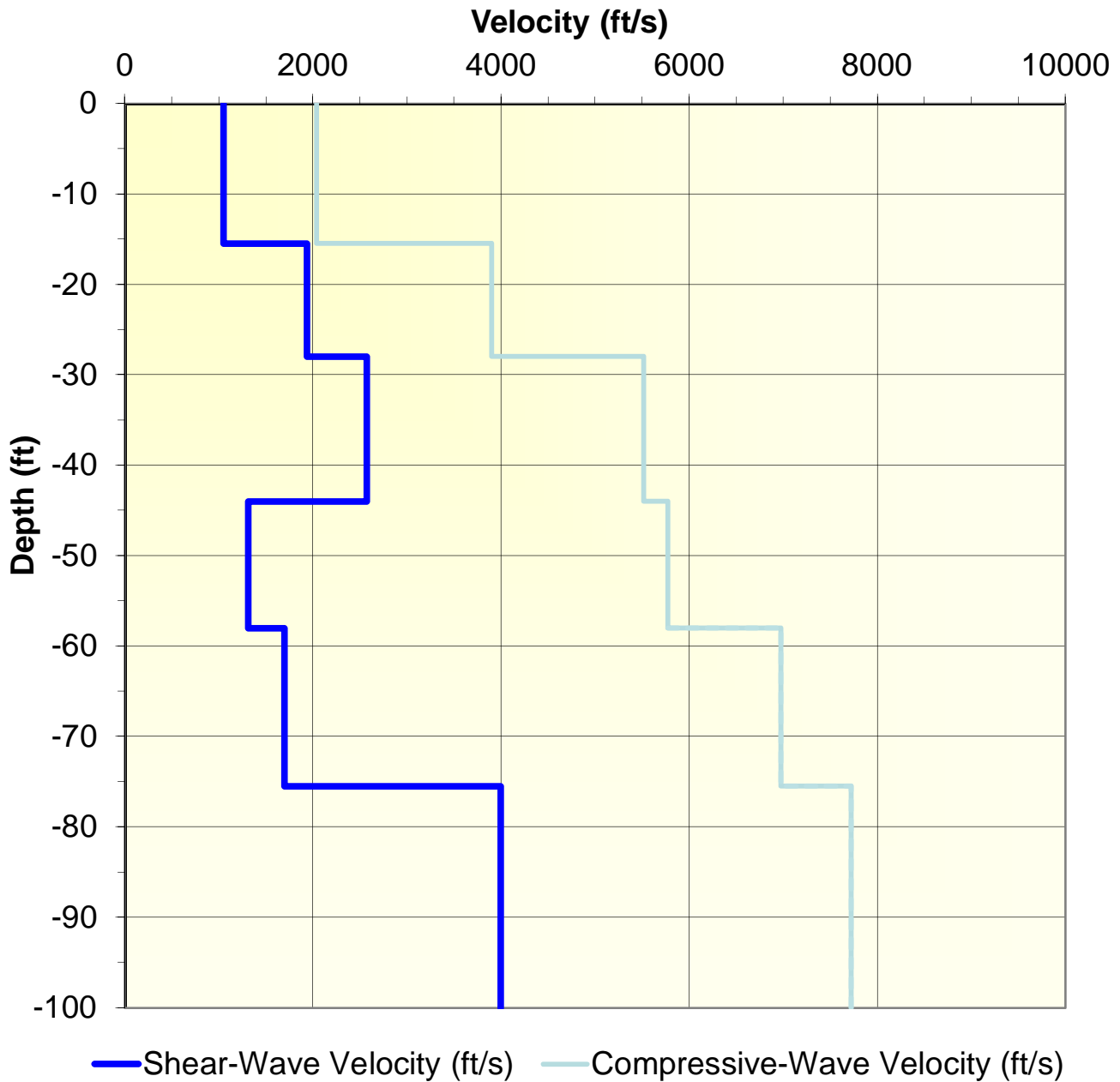
SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-24



# WTG 4



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	1045	2040
-16	1934	3900
-28	2573	5515
-44	1313	5775
-58	1695	6975
-76	3996	7725

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model_WTG4.xlsx
Approved by:	LJD	Date:	July 2015

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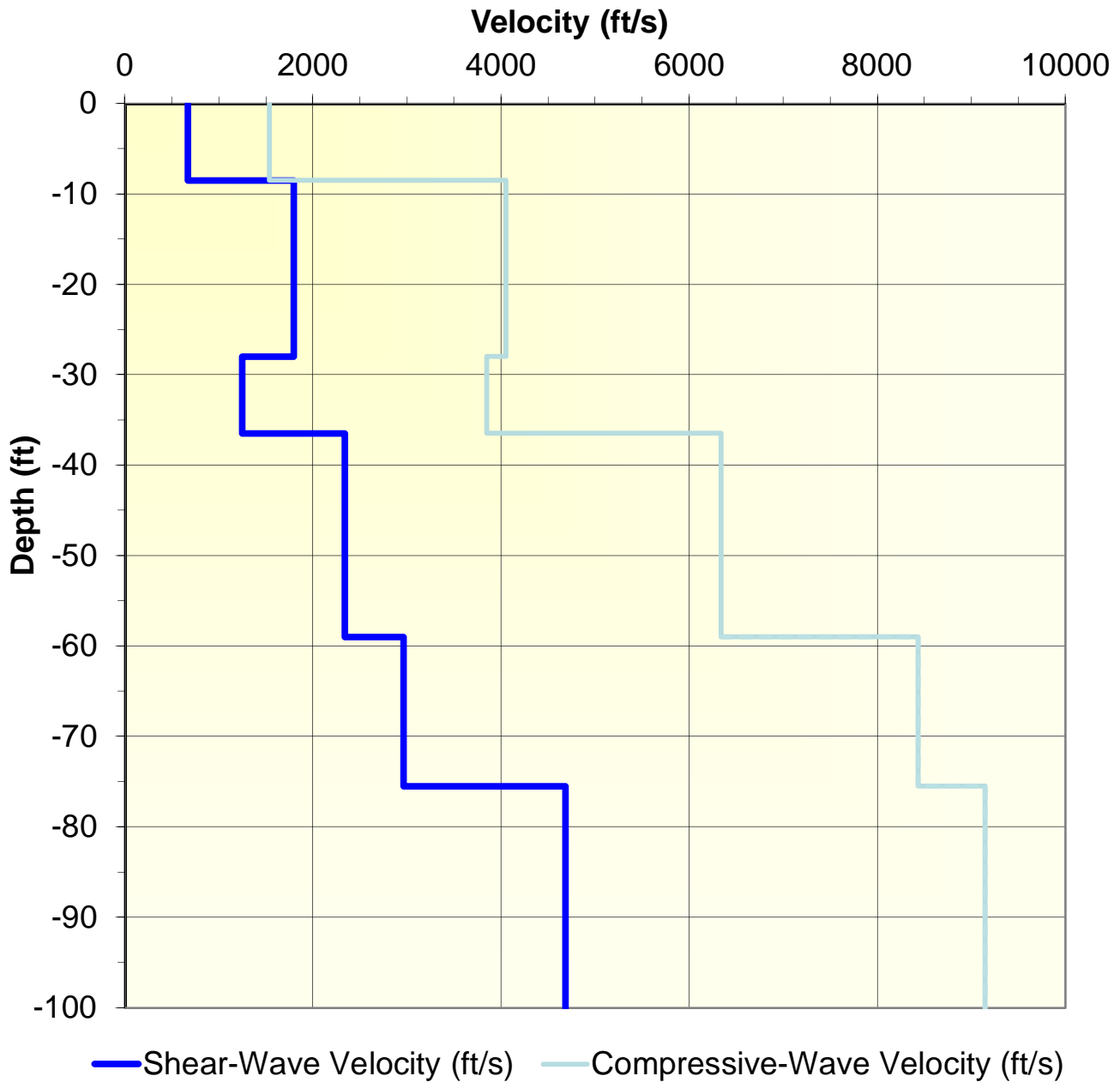
## SEISMIC VELOCITY PROFILE WTG 4

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-25

# WTG 8



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	670	1540
-9	1793	4050
-28	1244	3850
-37	2335	6340
-59	2960	8435
-76	4682	9145

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model_WTG8.xlsx
Approved by:	LJD	Date:	July 2015

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Consulting Engineers & Scientists

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PH: (585) 247-3471

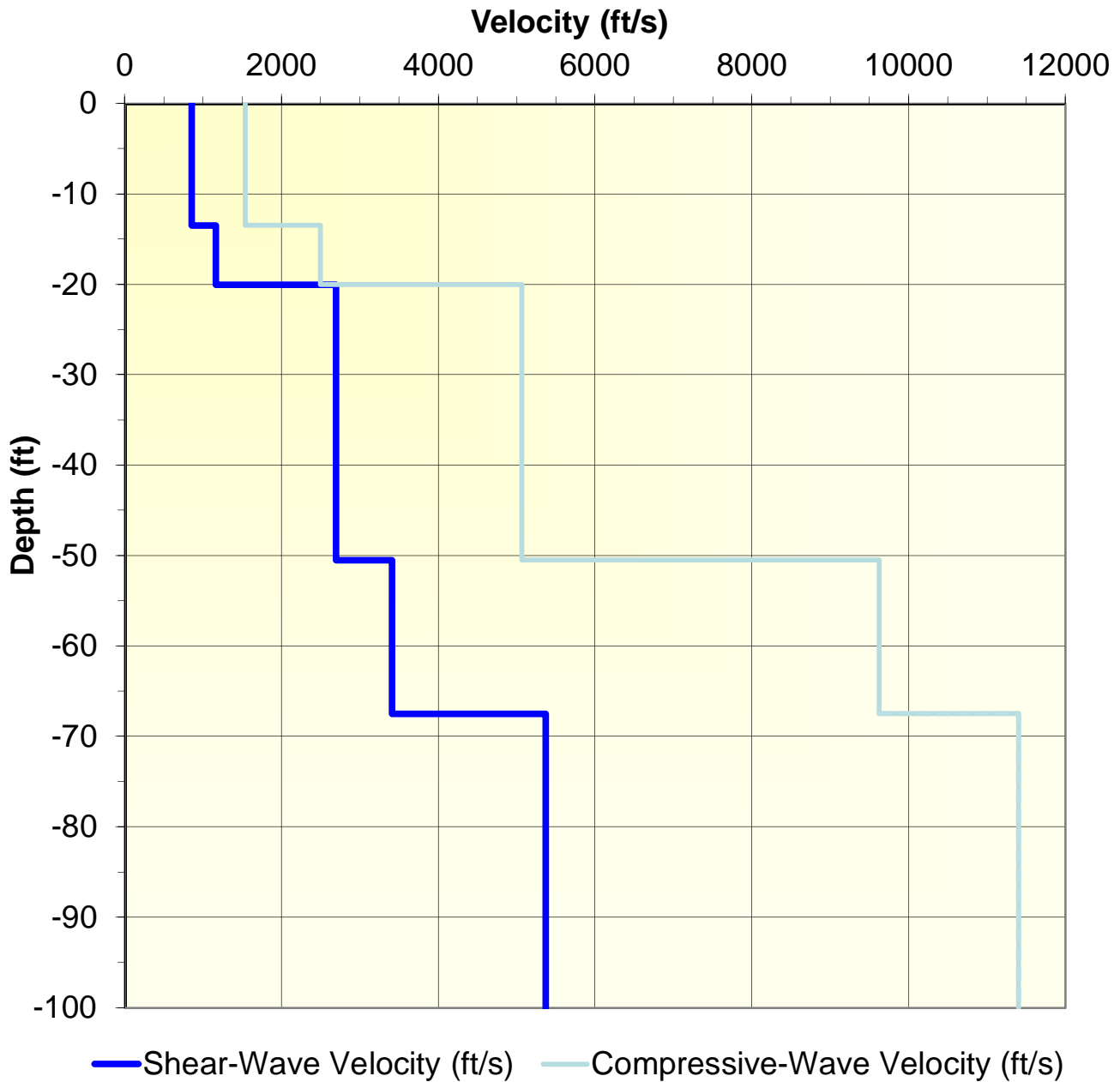
## SEISMIC VELOCITY PROFILE WTG 8

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-26

# WTG 13



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	854	1535
-14	1157	2500
-20	2692	5065
-51	3404	9625
-68	5367	11400

Project Manager:	CWT
Drawn by:	RAK
Checked by:	CWT
Approved by:	LJD

Project No.	J5155113
Scale:	N.T.S.
File Name:	Model_WTG13.xlsx
Date:	July 2015

**Terracon**  
Consulting Engineers & Scientists

15 Marway Circle, Suite 2B Rochester, New York 14624  
PH: (585) 247-3471

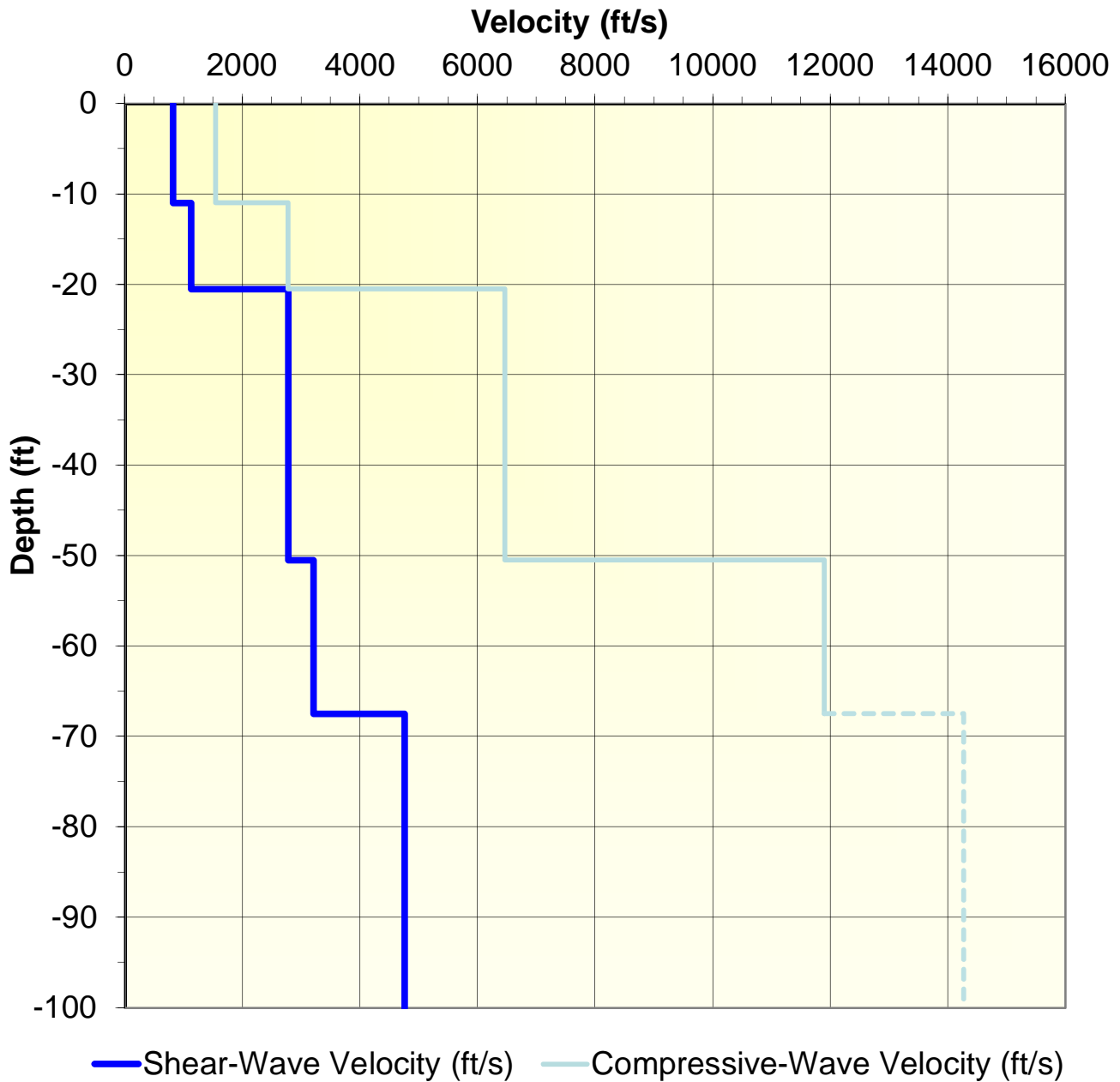
## SEISMIC VELOCITY PROFILE WTG 13

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-27

# WTG 22



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	813	1550
-11	1129	2775
-21	2774	6465
-51	3203	11900
-68	4757	14270

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model WTG22.xlsx
Approved by:	LJD	Date:	July 2015



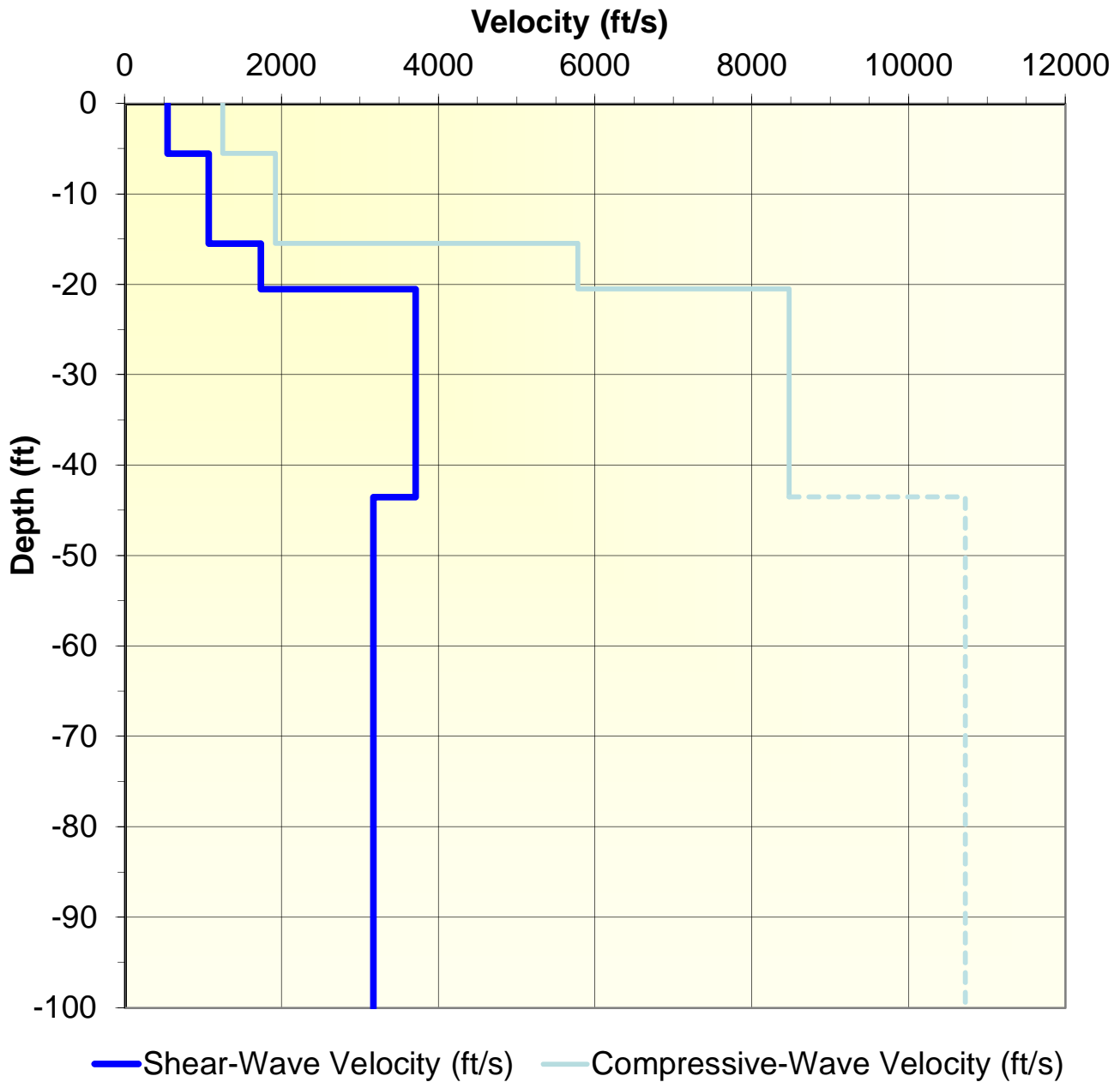
## SEISMIC VELOCITY PROFILE WTG 22

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-28

# WTG 28



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	545	1250
-6	1069	1920
-16	1731	5780
-21	3705	8475
-44	3168	10725

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model_WTG28.xlsx
Approved by:	LJD	Date:	July 2015



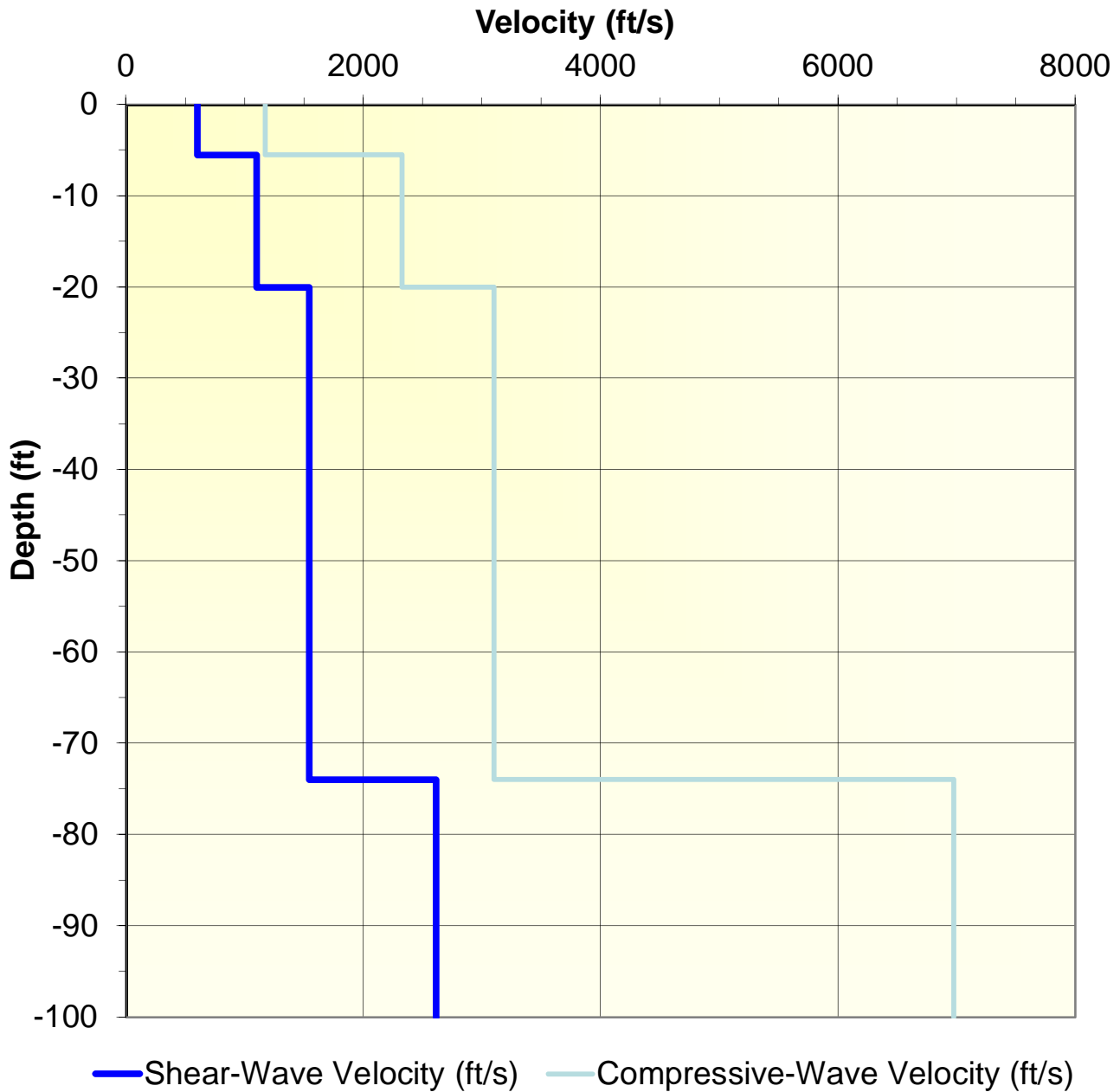
## SEISMIC VELOCITY PROFILE WTG 28

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-29

# WTG 29



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	601	1175
-6	1099	2325
-20	1545	3100
-74	2614	6975

Project Manager:	CWT	Project No.	J5155113
Drawn by:	RAK	Scale:	N.T.S.
Checked by:	CWT	File Name:	Model_WTG29.xlsx
Approved by:	LJD	Date:	July 2015

**Terracon**  
Consulting Engineers & Scientists

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PH: (585) 247-3471

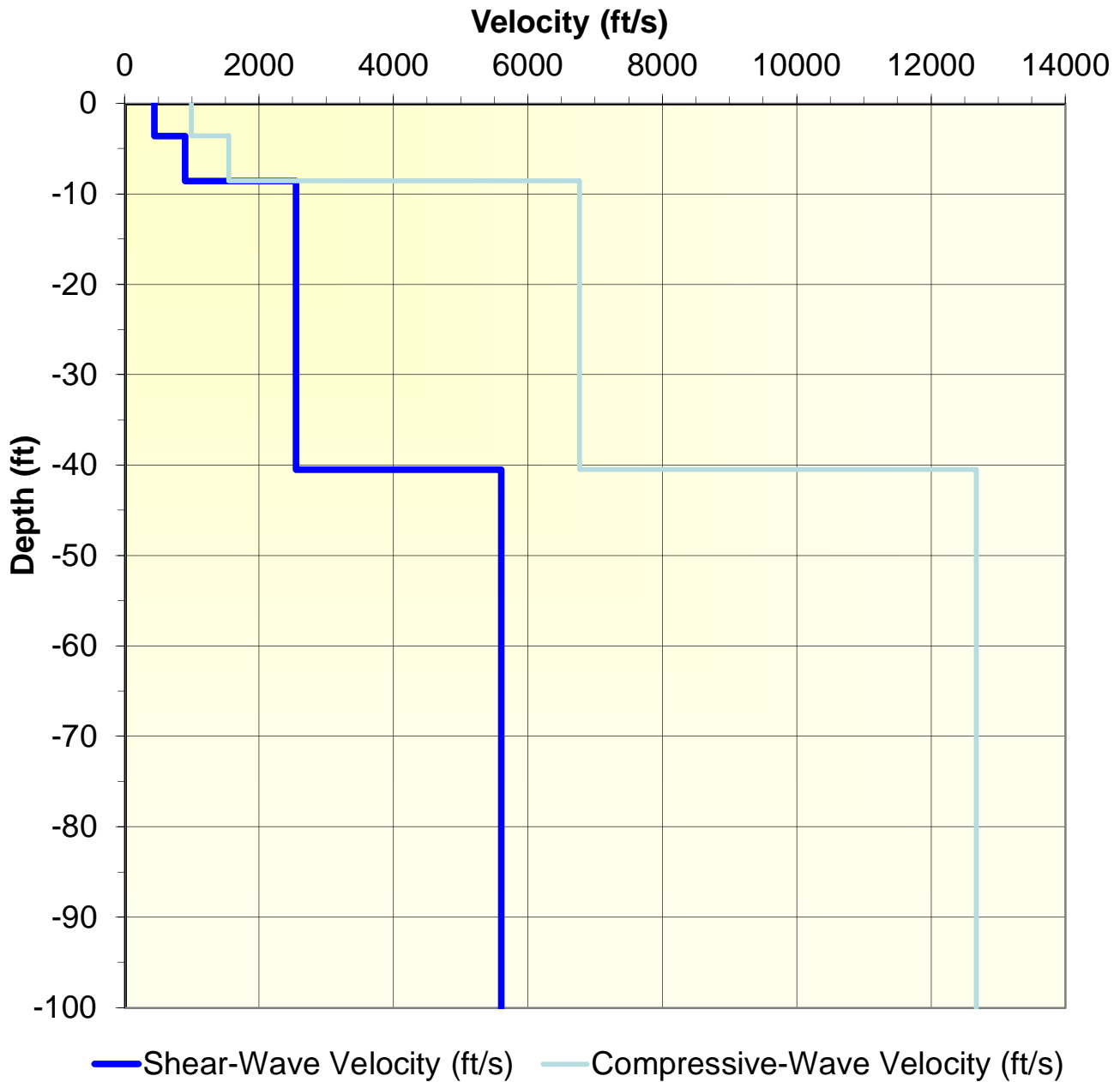
**SEISMIC VELOCITY PROFILE WTG 29**

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT
A-30



# WTG 31



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	437	995
-4	896	1550
-9	2549	6770
-41	5596	12675

Project Manager:	CWT
Drawn by:	RAK
Checked by:	CWT
Approved by:	LJD
Project No.	J5155113
Scale:	N.T.S.
File Name:	Model WTG31.xlsx
Date:	July 2015

**Terracon**  
Consulting Engineers & Scientists

15 Marway Circle, Suite 2B    Rochester, New York 14624  
PH: (585) 247-3471

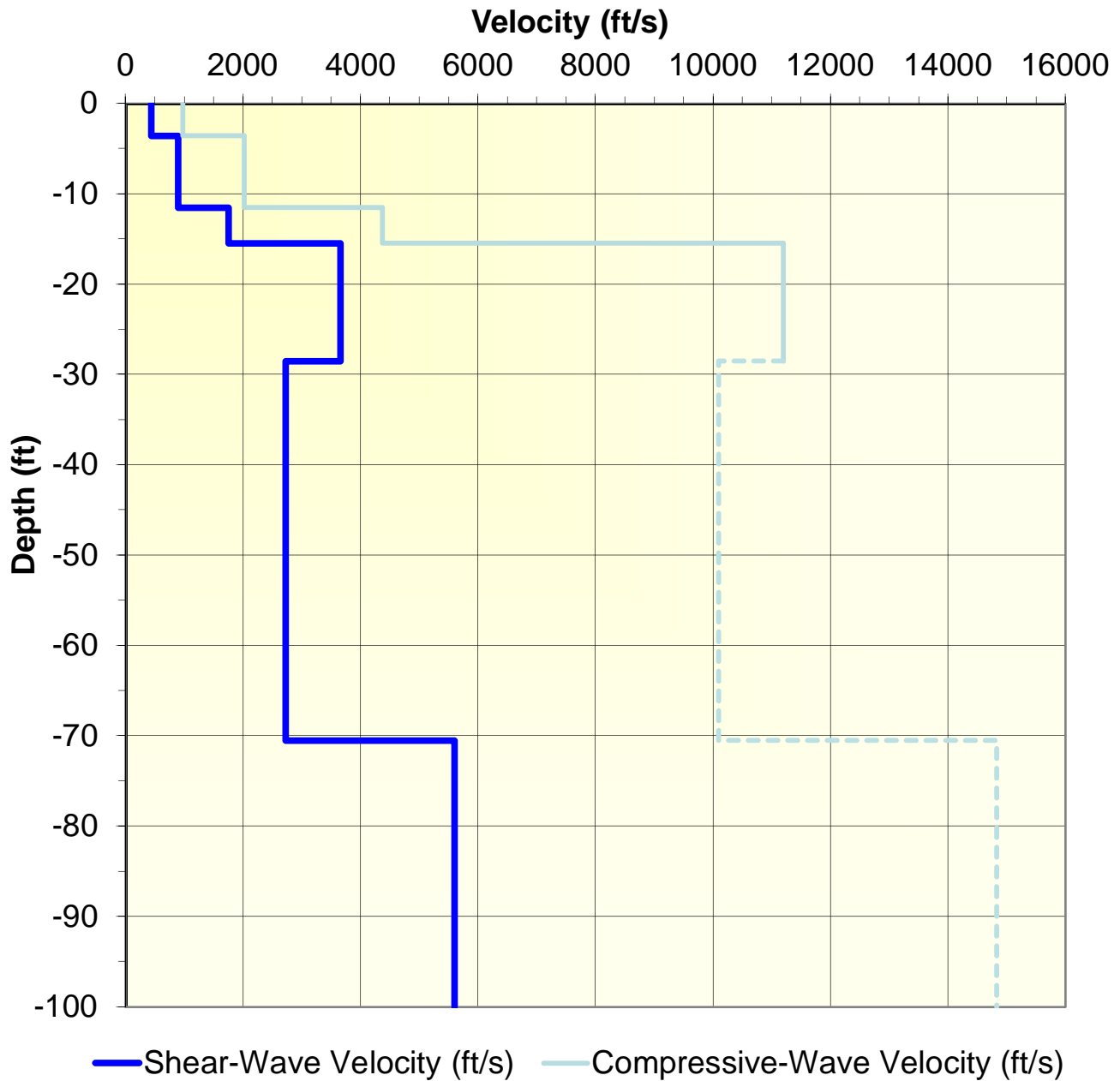
## SEISMIC VELOCITY PROFILE WTG 31

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-31

# WTG 36



Depth, ft	Shear-Wave Velocity (ft/s)	Compressive-Wave Velocity (ft/s)
0	437	975
-4	896	2025
-12	1753	4375
-16	3653	11200
-29	2722	10100
-71	5596	14830

Project Manager: CWT	Project No. J5155113
Drawn by: RAK	Scale: N.T.S.
Checked by: CWT	File Name: Model_WTG36.xlsx
Approved by: LJD	Date: July 2015



## SEISMIC VELOCITY PROFILE WTG 36

SEISMIC SURVEY  
JERICHO RISE WIND  
FRANKLIN COUNTY, NEW YORK

EXHIBIT

A-32

**APPENDIX B**  
**LABORATORY TESTING**

## **Laboratory Testing**

Disturbed SPT samples were obtained and sealed in the field to reduce moisture loss. Bedrock cores were obtained and stored in wooden core boxes. Soil and bedrock samples were then transported to our laboratory for examination and testing. Soil samples obtained during the field exploration were visually classified in the laboratory in general accordance with the Unified Soil Classification System (USCS). The USCS is described in Appendix C.

The following laboratory tests were performed on selected soil and bedrock samples collected from the explorations. The tests performed were in general accordance with the applicable ASTM, or other standards.

### **SOIL TESTING**

- Visual Classification
- Moisture Content
- Grain Size Analysis
- 

### **BEDROCK TESTING**

- Visual Classification
- 
- Unconfined Compression
- Bulk Density

The results of these tests are in this Appendix.

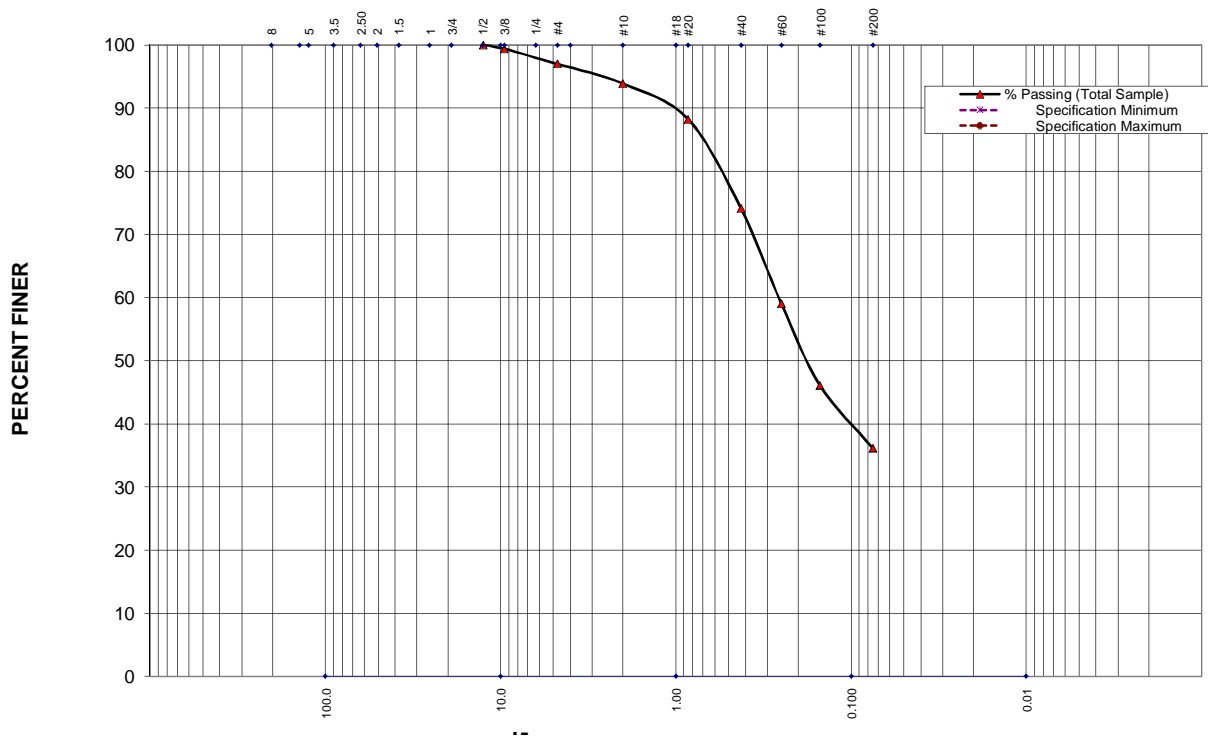
## Exhibit B-2

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	3	5	32	62	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		61	36.1	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"				
12.5	1/2"	0	100		
9.5	3/8"	1.20	99		
4.75	#4	5.90	97		
2.00	#10	12.00	94		
0.85	#20	23.10	88		
0.425	#40	50.80	74		
0.250	#60	80.50	59		
0.150	#100	106.10	46		
0.075	#200	125.60	36		

Total Dry Wt. 196.63 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0001</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-1, S-7	Sampled from: 15' to 17' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 11.4%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15

## Exhibit B-3

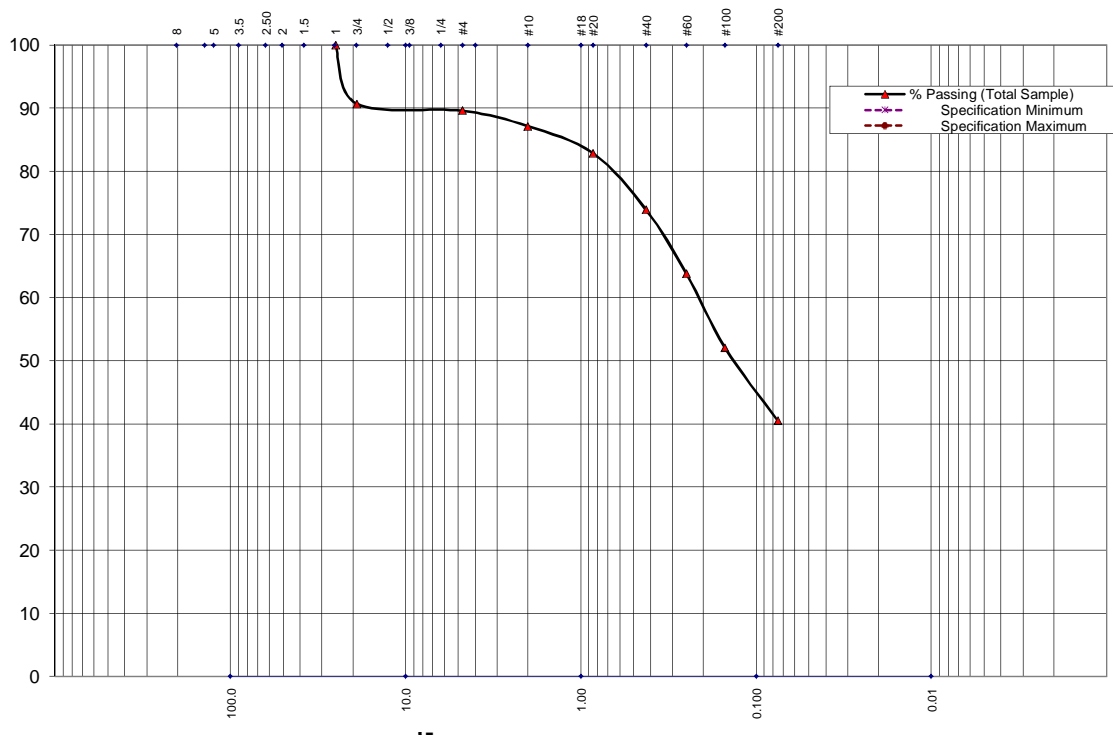
**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil; D422, D1140

Concrete Aggregate; C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	10	5	27	68	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		49	40.4	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"	0	100		
19.0	3/4"	21.30	91		
12.5	1/2"				
9.5	3/8"				
4.75	#4	23.80	90		
2.00	#10	29.40	87		
0.85	#20	39.20	83		
0.425	#40	59.60	74		
0.250	#60	82.70	64		
0.150	#100	109.70	52		
0.075	#200	136.20	40		

Total Dry Wt. 228.66 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0002</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-4, S-5	Sampled from: 8' to 10' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 17.8%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15



Exhibit B-4

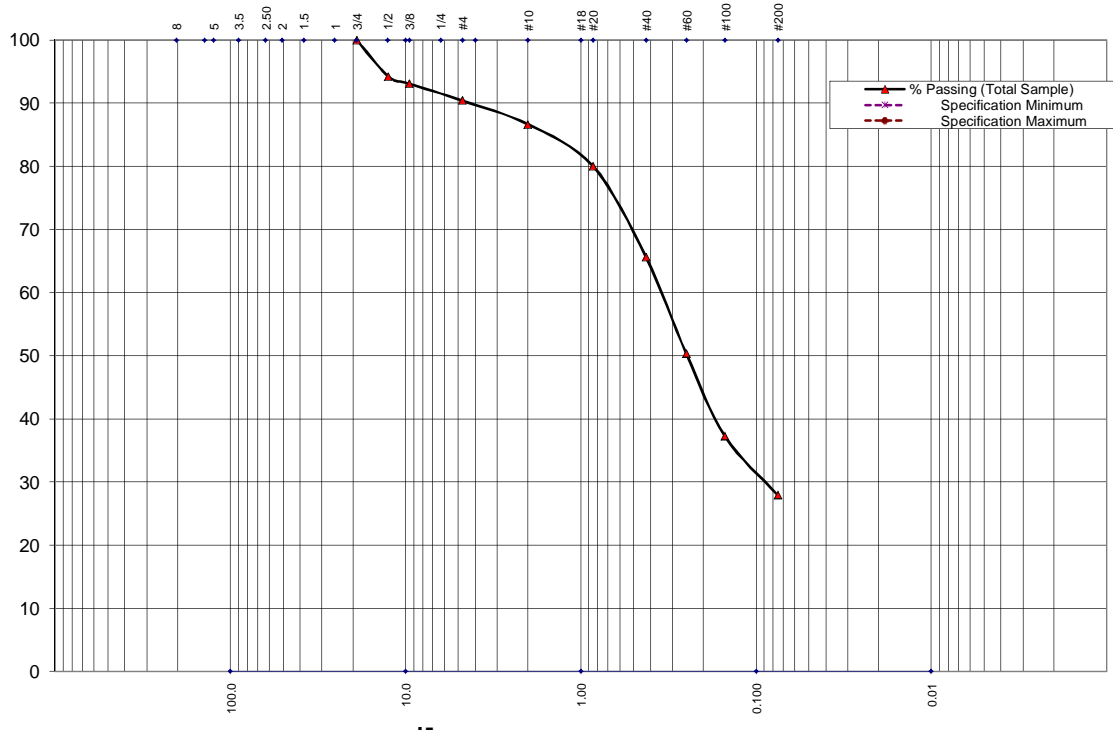
# GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	10	6	34	60	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		63	27.9	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	19.70	94		
9.5	3/8"	23.50	93		
4.75	#4	32.50	90		
2.00	#10	45.30	87		
0.85	#20	67.90	80		
0.425	#40	116.50	66		
0.250	#60	168.50	50		
0.150	#100	213.00	37		
0.075	#200	244.70	28		

Total Dry Wt. 339.26 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0003</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-A4, S-3	Sampled from: 4' to 5.7' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 9.8%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15

Exhibit B-5

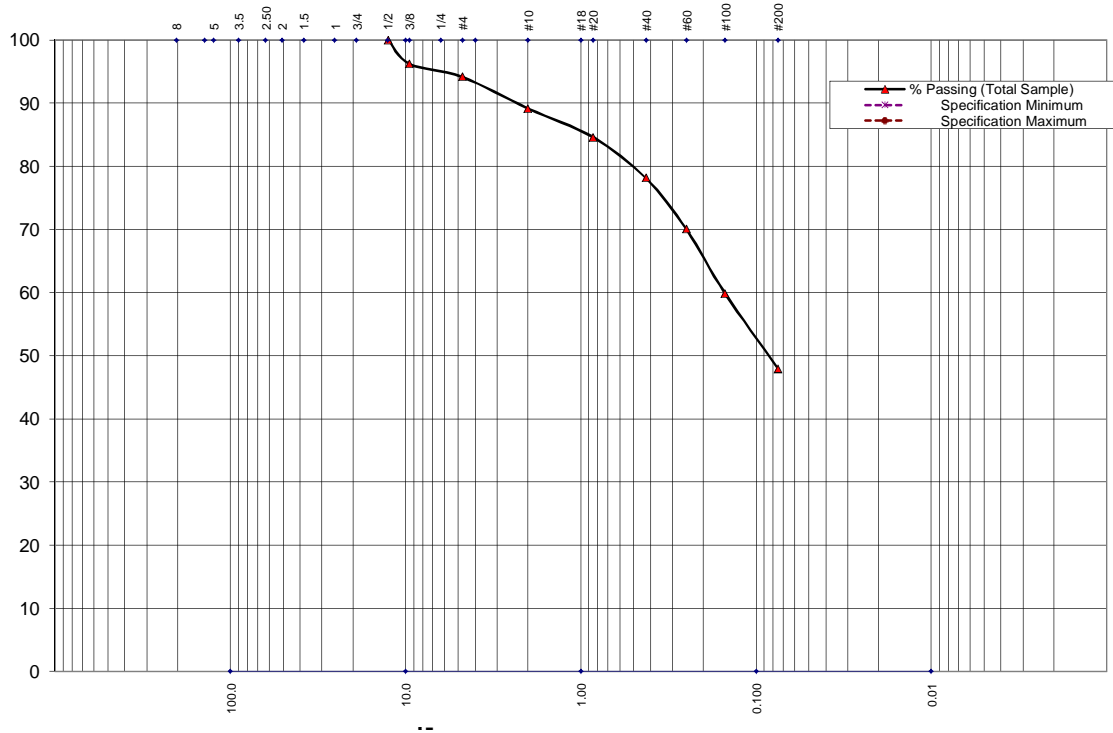
# GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	6	11	24	65	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		46	47.9	

USCS Classification: Silt with Sand (ML)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"				
12.5	1/2"	0	100		
9.5	3/8"	7.90	96		
4.75	#4	12.10	94		
2.00	#10	22.50	89		
0.85	#20	31.90	85		
0.425	#40	45.30	78		
0.250	#60	62.10	70		
0.150	#100	83.20	60		
0.075	#200	107.90	48		

Total Dry Wt. 207.20 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0004</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-5, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 11.2%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15

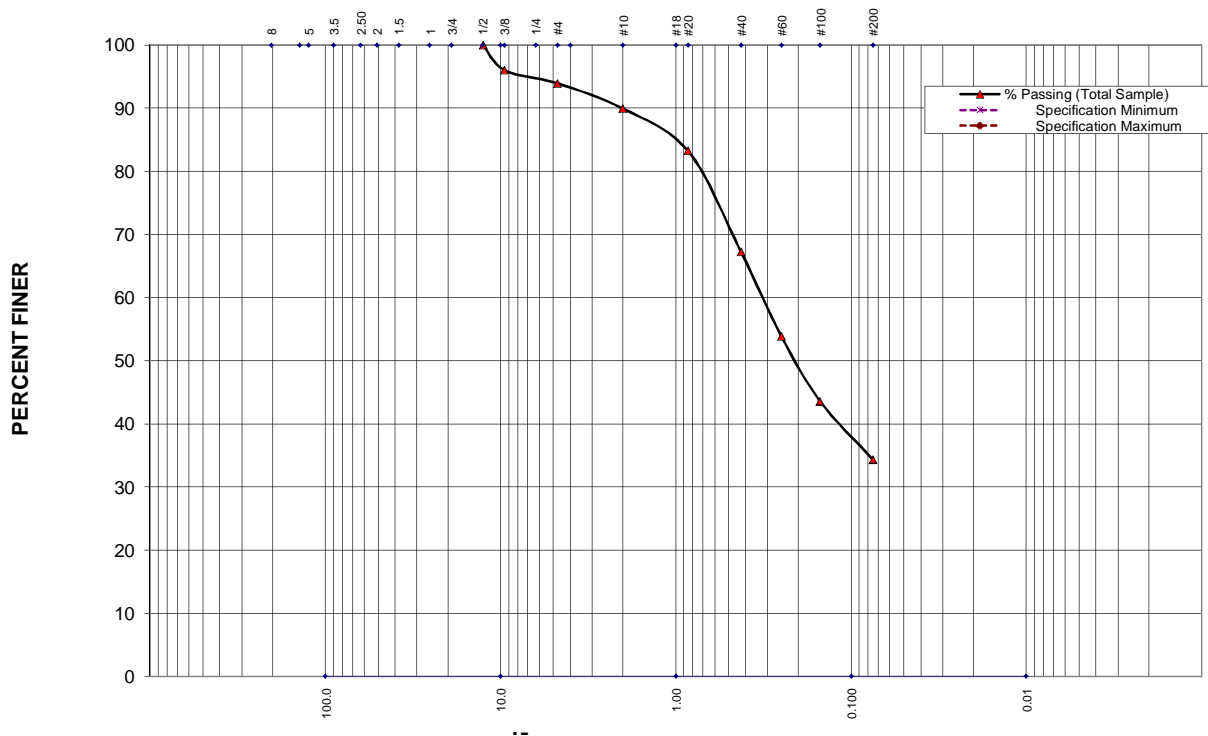
## Exhibit B-6

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil; D422, D1140

Concrete Aggregate; C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	6	7	38	55	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		60	34.3	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"				
12.5	1/2"	0	100		
9.5	3/8"	11.20	96		
4.75	#4	17.00	94		
2.00	#10	28.30	90		
0.85	#20	47.10	83		
0.425	#40	91.80	67		
0.250	#60	129.30	54		
0.150	#100	158.30	44		
0.075	#200	184.20	34		

Total Dry Wt. 280.52 g

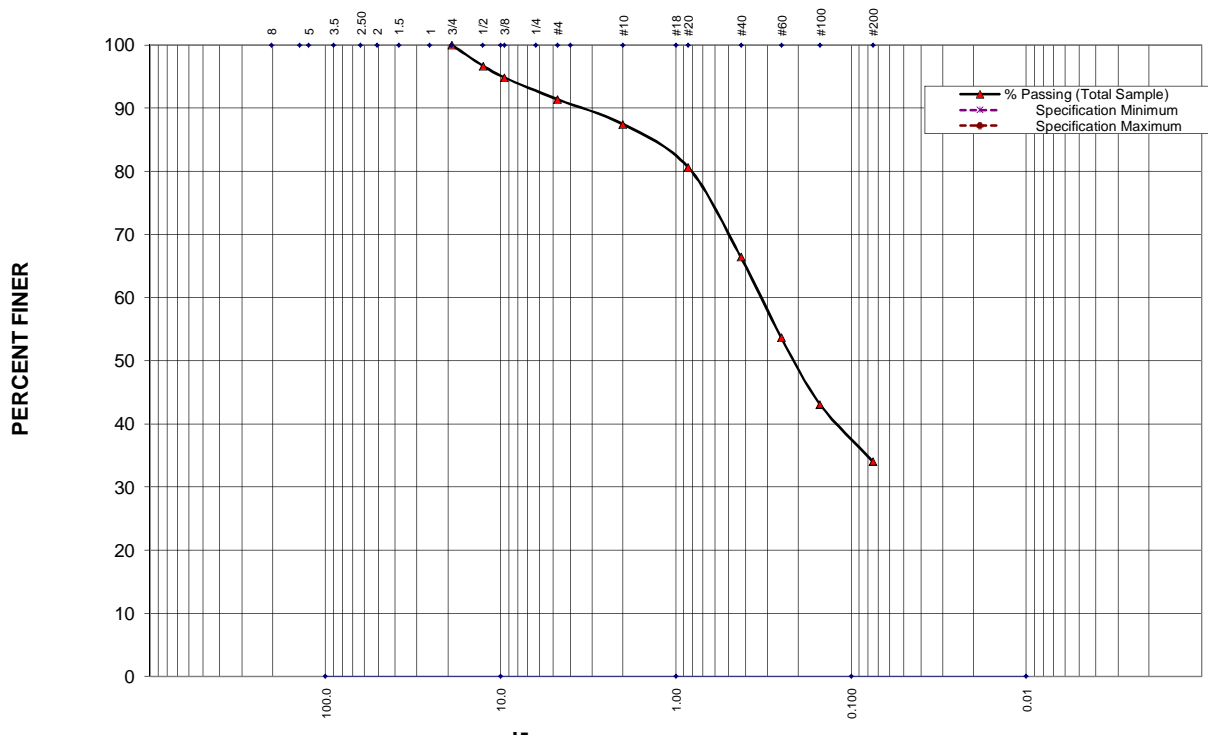
Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0005</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-7, S-6	Sampled from: 11' to 12.9' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 8.4%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	9	7	37	56	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		57	34.0	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	9.10	97		
9.5	3/8"	14.00	95		
4.75	#4	23.40	91		
2.00	#10	34.10	87		
0.85	#20	52.60	81		
0.425	#40	91.40	66		
0.250	#60	126.00	54		
0.150	#100	154.80	43		
0.075	#200	179.40	34		

Total Dry Wt. 271.88 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0006</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-8, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 10.1%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

## Exhibit B-8

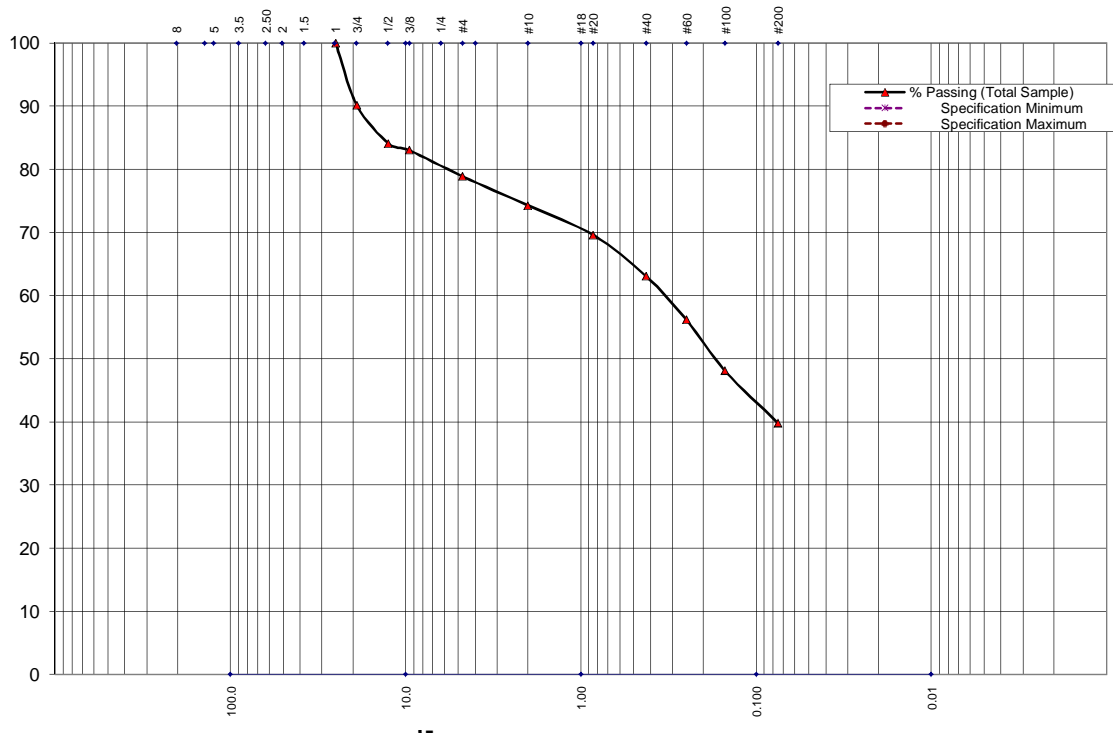
**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	21	12	29	60	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand			39.8	

USCS Classification: SILTY SAND with gravel (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"	0	100		
19.0	3/4"	31.90	90		
12.5	1/2"	51.80	84		
9.5	3/8"	55.20	83		
4.75	#4	68.60	79		
2.00	#10	83.60	74		
0.85	#20	98.80	70		
0.425	#40	119.90	63		
0.250	#60	142.40	56		
0.150	#100	168.90	48		
0.075	#200	195.70	40		

Total Dry Wt. 325.07 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0007</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-A9, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 10.6%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

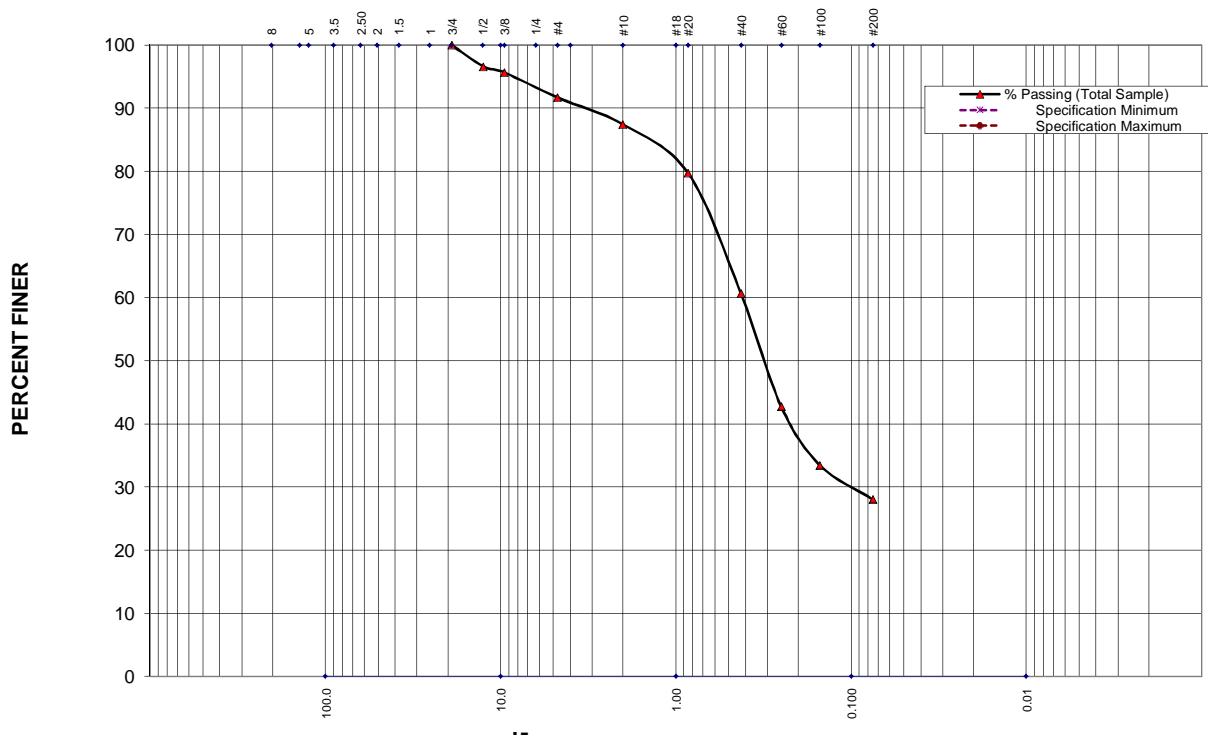
## Exhibit B-9

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	8	7	42	51	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		64	28.0	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	15.50	97		
9.5	3/8"	19.70	96		
4.75	#4	37.60	92		
2.00	#10	56.90	87		
0.85	#20	91.80	80		
0.425	#40	178.10	61		
0.250	#60	259.30	43		
0.150	#100	301.40	33		
0.075	#200	325.70	28		

Total Dry Wt. 452.58 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0008</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-12, S-5	Sampled from: 15' to 17' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 12.0%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15



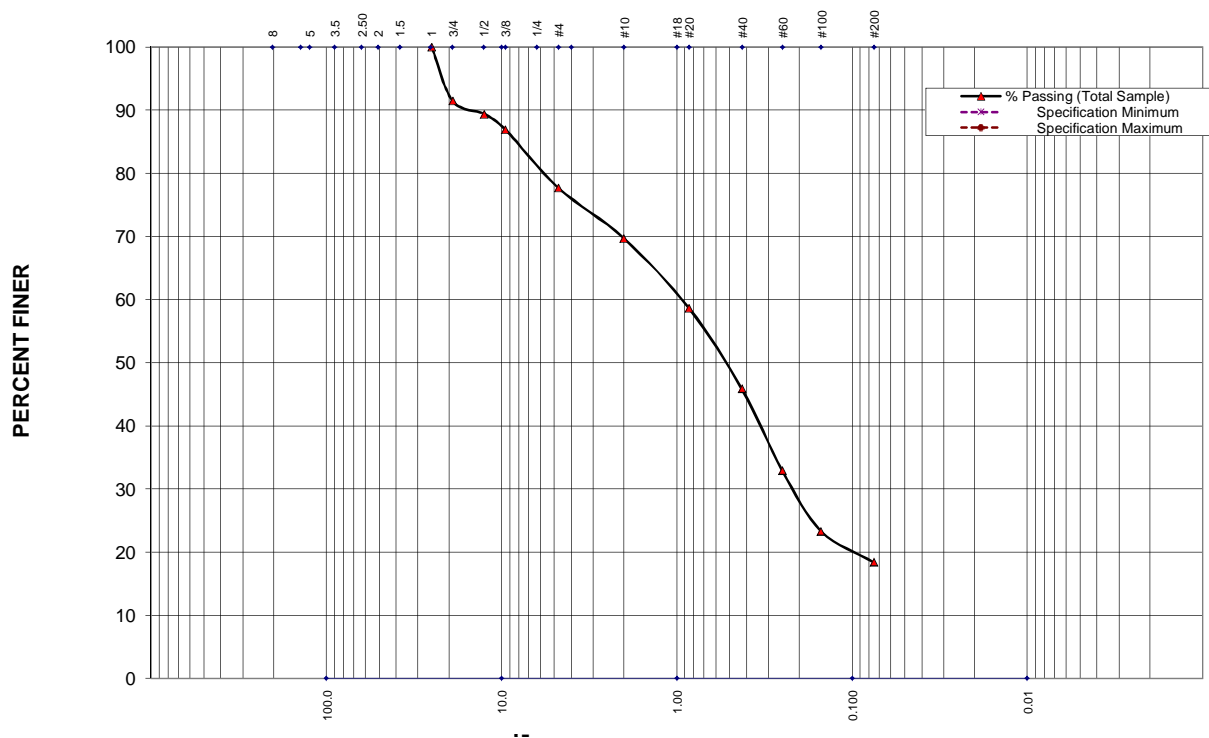
## Exhibit B-10

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	22	14	40	46	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand			18.4	

USCS Classification: SILTY SAND with gravel (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"	0	100		
19.0	3/4"	26.70	91		
12.5	1/2"	33.10	89		
9.5	3/8"	40.80	87		
4.75	#4	69.50	78		
2.00	#10	94.50	70		
0.85	#20	129.10	59		
0.425	#40	168.90	46		
0.250	#60	209.20	33		
0.150	#100	239.20	23		
0.075	#200	254.50	18		

Total Dry Wt. 311.84 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0009</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-13, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 6.7%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

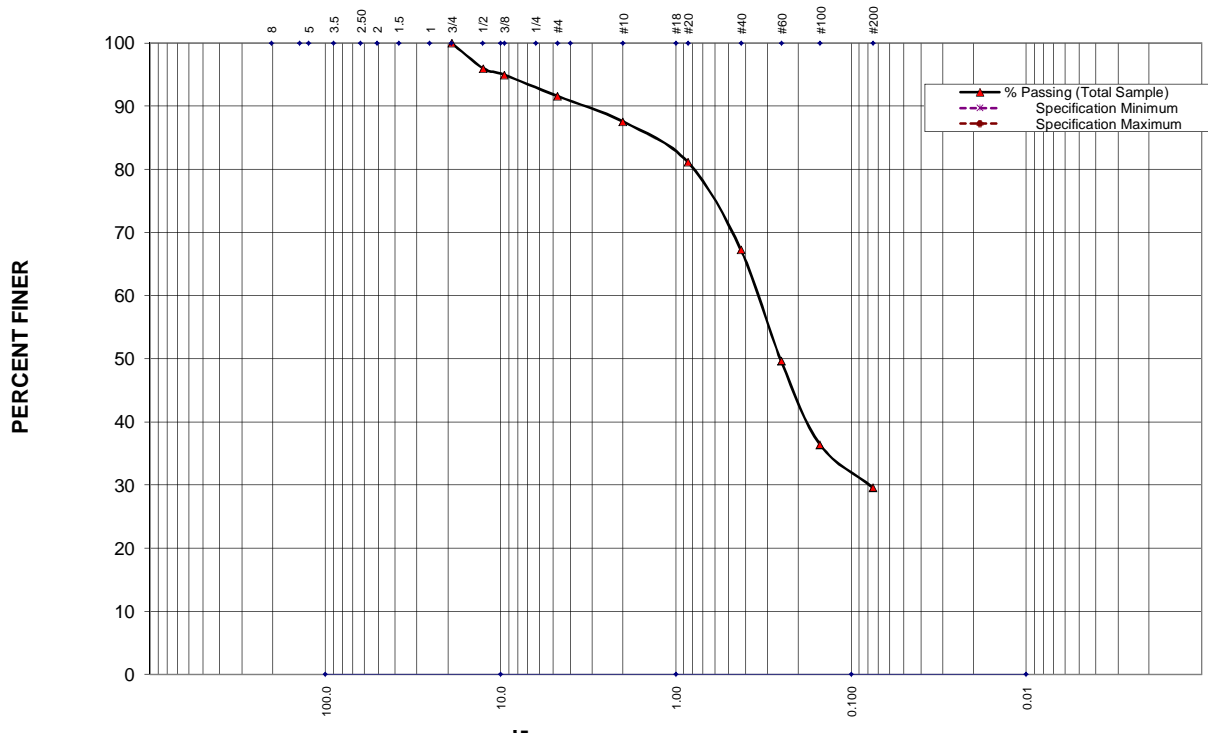
## Exhibit B-11

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	8	7	33	61	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		62	29.6	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	9.90	96		
9.5	3/8"	12.40	95		
4.75	#4	20.60	92		
2.00	#10	30.60	88		
0.85	#20	46.40	81		
0.425	#40	80.50	67		
0.250	#60	123.80	50		
0.150	#100	156.30	36		
0.075	#200	172.90	30		

Total Dry Wt. 245.56 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0010</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-21, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 16.8%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

Exhibit B-12

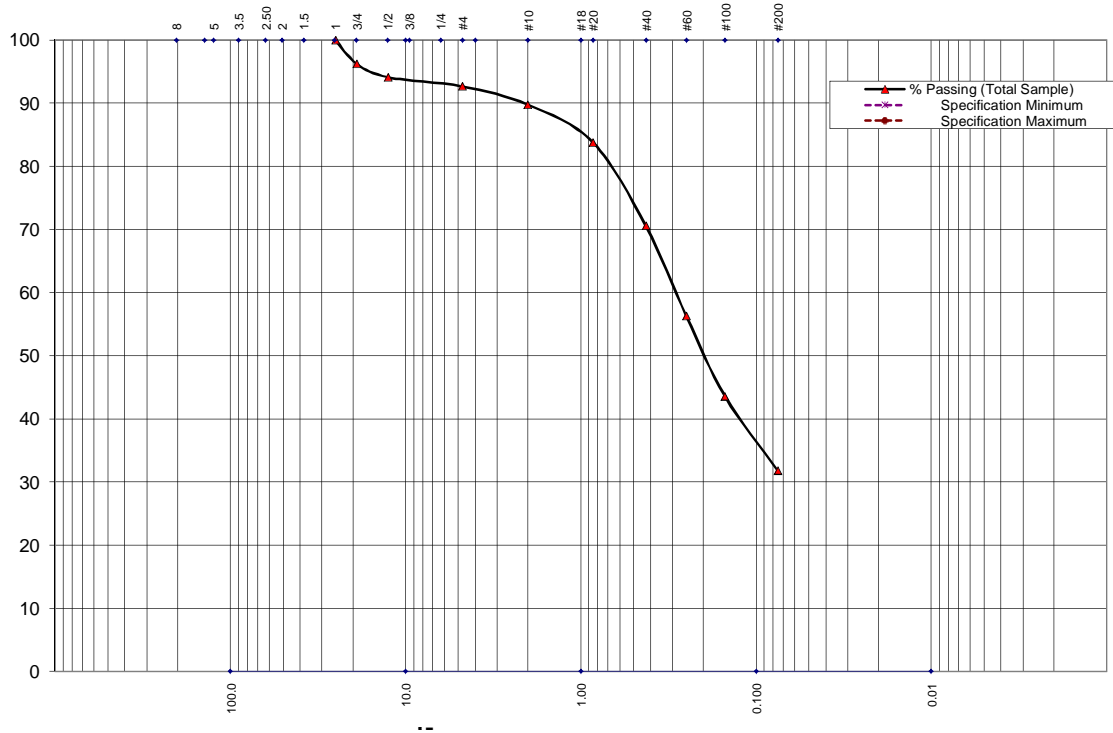
# GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	7	5	32	64	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		61	31.7	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"	0	100		
19.0	3/4"	10.90	96		
12.5	1/2"	16.90	94		
9.5	3/8"				
4.75	#4	21.00	93		
2.00	#10	29.30	90		
0.85	#20	46.40	84		
0.425	#40	84.20	71		
0.250	#60	124.90	56		
0.150	#100	161.40	44		
0.075	#200	195.10	32		

Total Dry Wt. 285.81 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0011</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-23, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 9.4%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

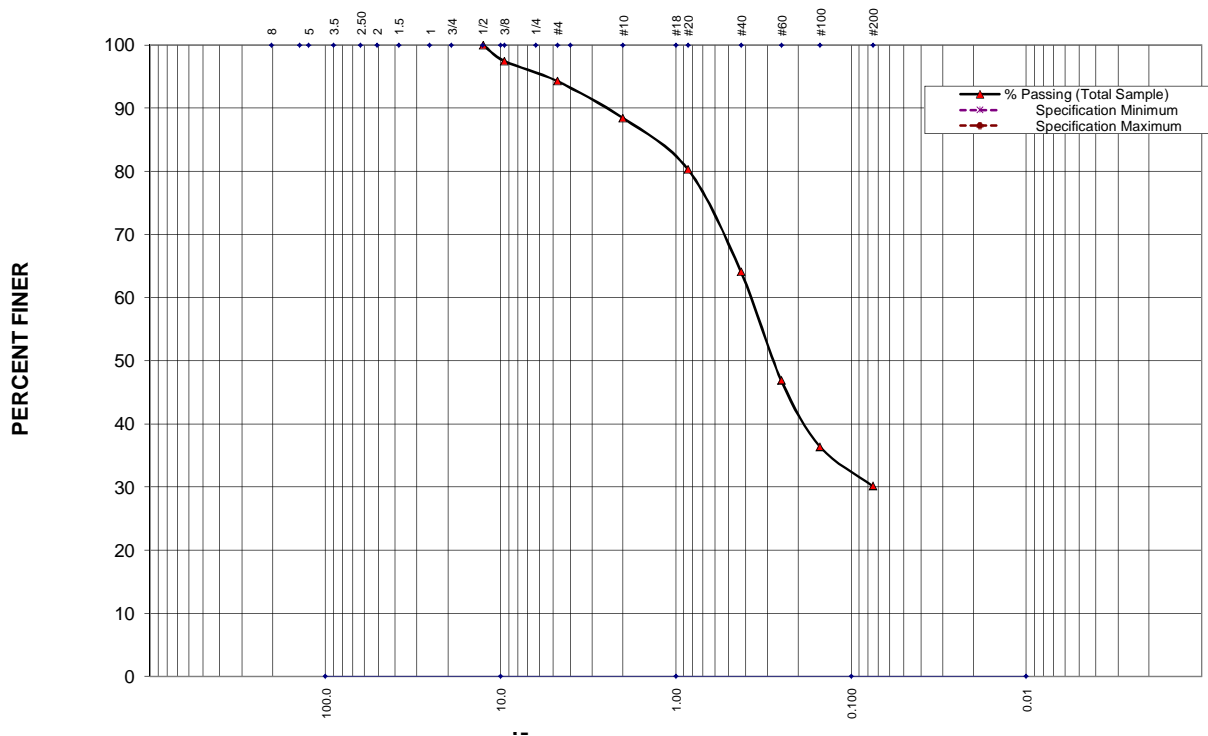
## Exhibit B-13

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil; D422, D1140

Concrete Aggregate; C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	6	9	38	53	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		64	30.1	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"				
12.5	1/2"	0	100		
9.5	3/8"	7.00	97		
4.75	#4	15.70	94		
2.00	#10	31.80	88		
0.85	#20	54.20	80		
0.425	#40	98.60	64		
0.250	#60	145.90	47		
0.150	#100	174.80	36		
0.075	#200	191.90	30		

Total Dry Wt. 274.66 g

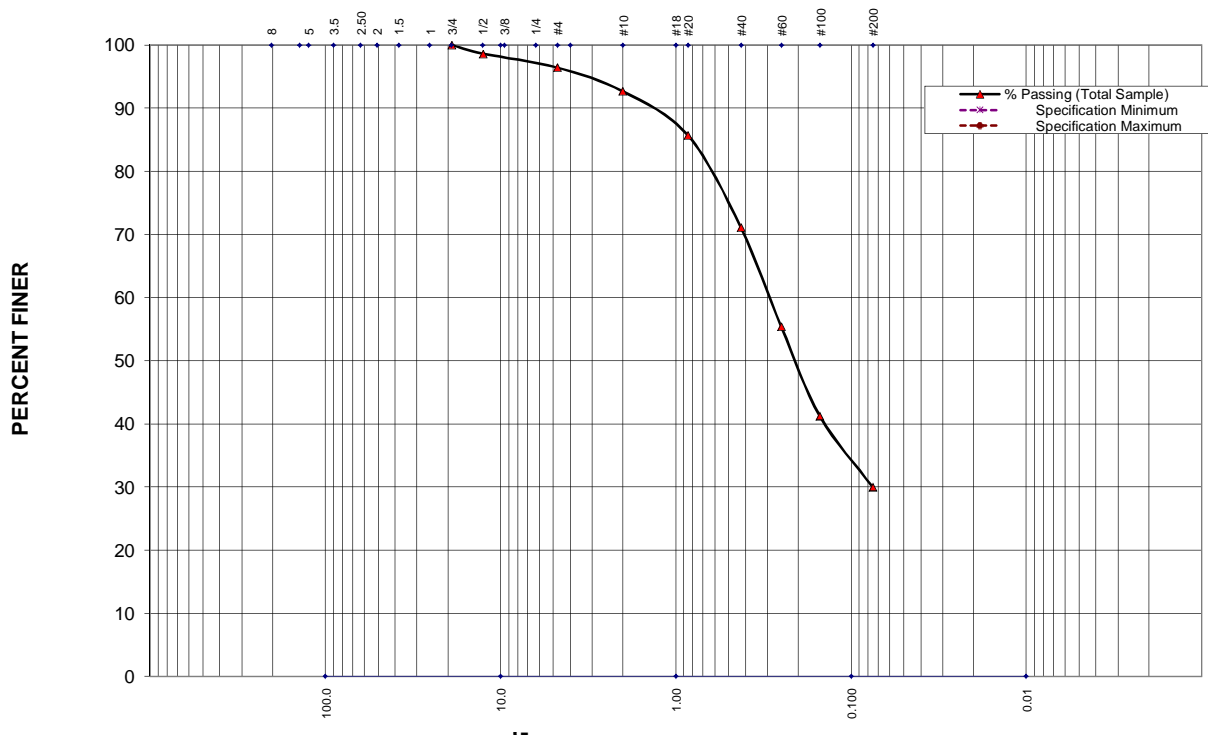
Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0012</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-24, S-6	Sampled from: 10' to 12' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		Remarks: Wn= 12.7%  Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15

**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	4	6	32	62	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		66	29.9	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	3.40	99		
9.5	3/8"				
4.75	#4	8.70	96		
2.00	#10	17.90	93		
0.85	#20	34.90	86		
0.425	#40	70.50	71		
0.250	#60	108.80	55		
0.150	#100	143.40	41		
0.075	#200	170.80	29.9		

Total Dry Wt. 243.76 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0013</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-26/Met 26C, S-5	Sampled from: 8' to 10' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 8.6%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

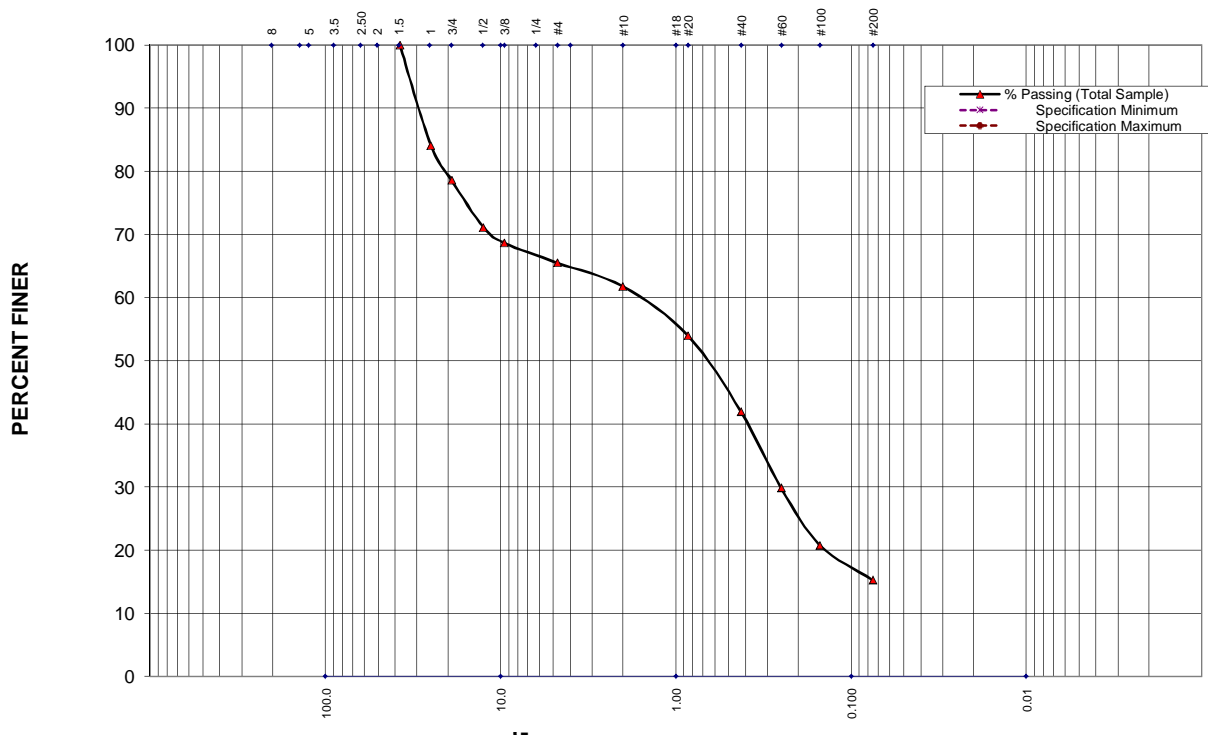
## Exhibit B-15

## GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	34	7	39	53	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand			15.2	

USCS Classification: SILTY SAND with gravel (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"	0	100		
25.0	1"	47.60	84		
19.0	3/4"	64.10	79		
12.5	1/2"	86.40	71		
9.5	3/8"	93.70	69		
4.75	#4	103.10	66		
2.00	#10	114.30	62		
0.85	#20	137.60	54		
0.425	#40	173.50	42		
0.250	#60	209.80	30		
0.150	#100	236.90	21		
0.075	#200	253.30	15		

Total Dry Wt. 298.87 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0014</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-28, S-7	Sampled from: 15' to 17' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>		
Remarks: Wn= 7.9% Tested By: Dan Savage Date: 07/15/15 Reviewed By: C. Thunberg Date: 07/17/15		

# Exhibit B-16

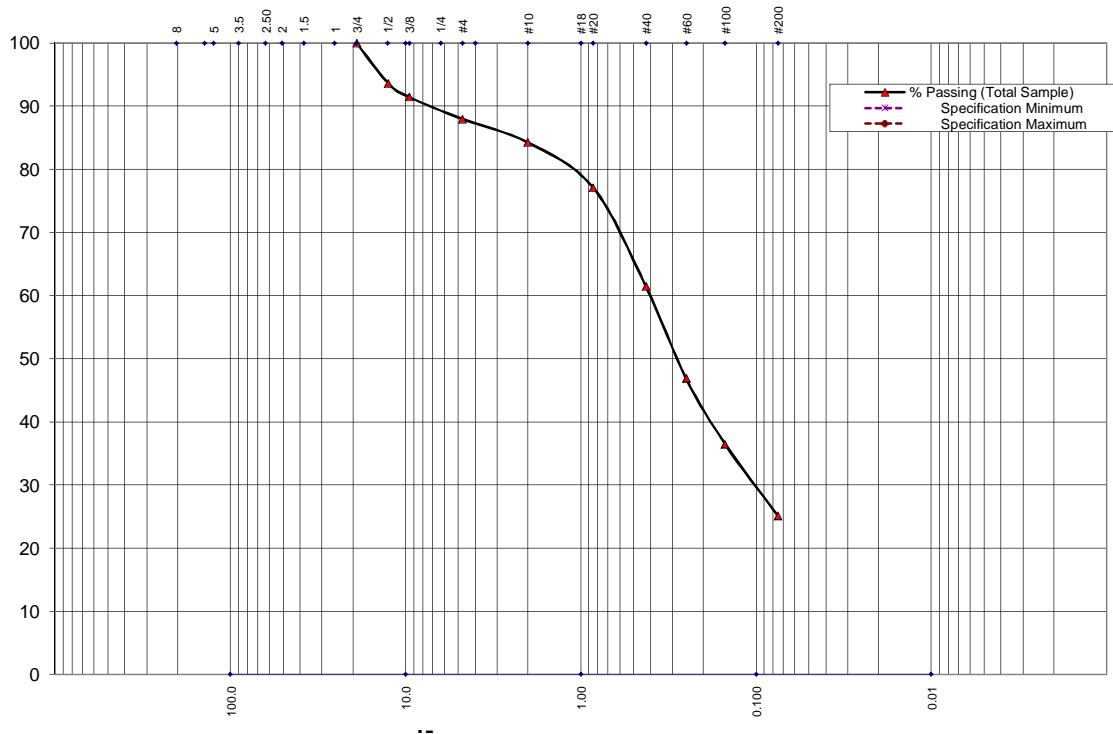
## GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil: D422, D1140

Concrete Aggregate: C136, C117

PERCENT FINER



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	12	6	36	58	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		63	25.1	

USCS Classification: SILTY SAND (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"				
25.0	1"				
19.0	3/4"	0	100		
12.5	1/2"	15.60	94		
9.5	3/8"	20.70	91		
4.75	#4	29.10	88		
2.00	#10	38.10	84		
0.85	#20	55.30	77		
0.425	#40	93.20	61		
0.250	#60	128.50	47		
0.150	#100	153.50	36		
0.075	#200	181.10	25		

Total Dry Wt. 241.66 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0015</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-29, S-5	Sampled from: 8' to 10' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 7.4%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

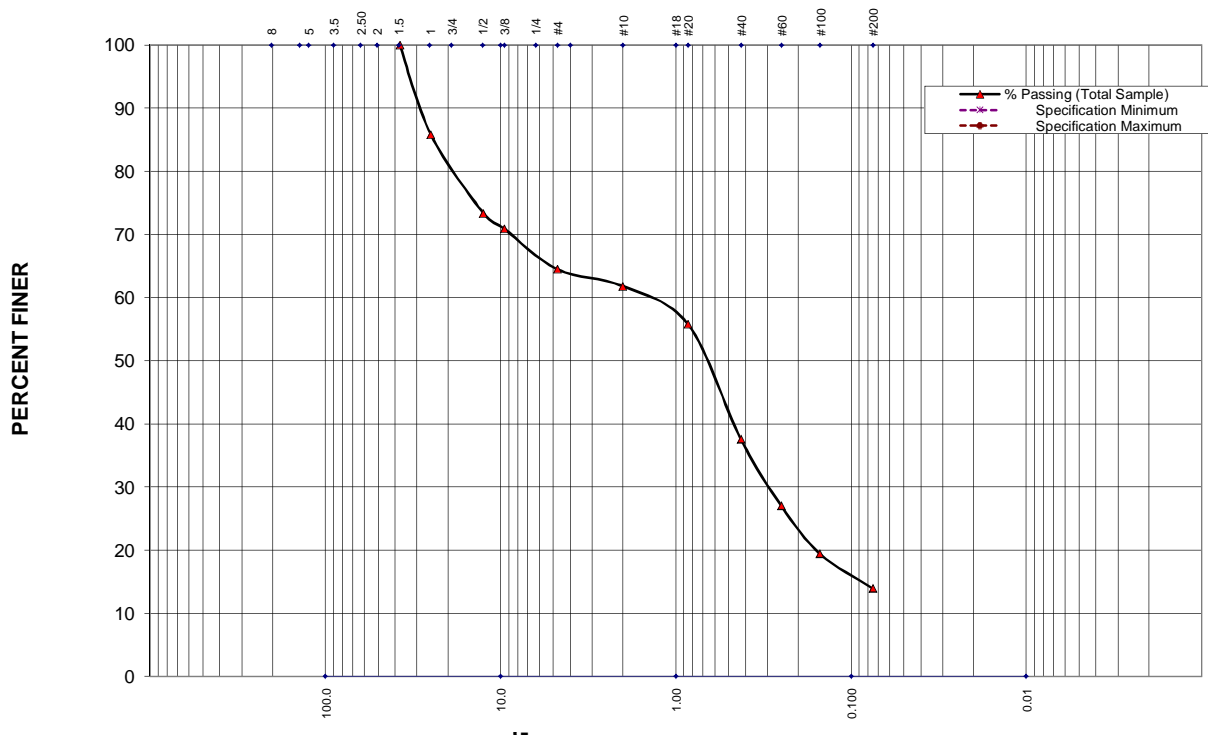


**GRAIN SIZE DISTRIBUTION TEST REPORT**

ASTM TEST METHODS:

Soil; D422, D1140

Concrete Aggregate; C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	36	5	48	47	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand		51	13.9	

USCS Classification: SILTY SAND with gravel (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"	0	100		
25.0	1"	35.40	86		
19.0	3/4"				
12.5	1/2"	66.50	73		
9.5	3/8"	72.70	71		
4.75	#4	88.60	64		
2.00	#10	95.30	62		
0.85	#20	110.40	56		
0.425	#40	155.80	38		
0.250	#60	182.10	27		
0.150	#100	201.10	19		
0.075	#200	214.70	14		

Total Dry Wt. 249.47 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0016</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-31/Met-31C, S-5	Sampled from: 8' to 9.8' BGS	
<b>Terracon</b> 77 Sundial Avenue Manchester, NH 03103 (603) 647-9700 fax: (603) 647-4432 <a href="http://www.terracon.com">www.terracon.com</a>	Remarks: Wn= 6.8%	
	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15

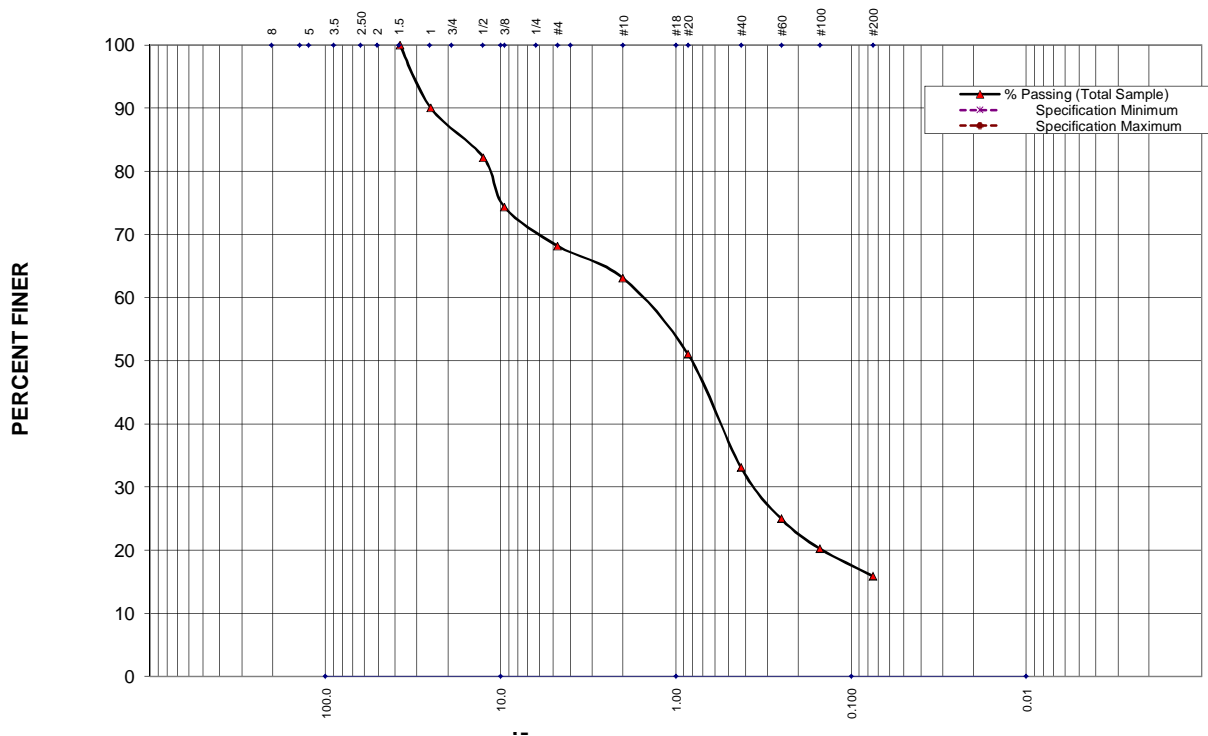
## Exhibit B-18

## GRAIN SIZE DISTRIBUTION TEST REPORT

ASTM TEST METHODS:

Soil; D422, D1140

Concrete Aggregate; C136, C117



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
0	32	10	57	33	Silt (>0.002mm)	Clay (<0.002mm)
		% Sand			15.9	

USCS Classification: SILTY SAND with gravel (SM)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Retained (g)	% Passing (Total Sample)	Specification Minimum Maximum	
200.0	8"				
152.4	6"				
90.0	3.5"				
76.2	3"				
63.0	2.5"				
50.0	2"				
37.5	1.5"	0	100		
25.0	1"	22.60	90		
19.0	3/4"				
12.5	1/2"	40.40	82		
9.5	3/8"	58.20	74		
4.75	#4	72.10	68		
2.00	#10	83.70	63		
0.85	#20	111.10	51		
0.425	#40	151.70	33		
0.250	#60	170.20	25		
0.150	#100	180.90	20		
0.075	#200	190.70	16		

Total Dry Wt. 226.75 g

Project: <b>Jericho Rise Wind Farm</b>	Project No.: <b>J5155113</b>	Report #: <b>J5155113.0017</b>
Location: Franklin Co., NY	Specification: NA	Date: 07/15/15
Source: WTG-36, S-6	Sampled from: 10' to 12' BGS	
<b>77 Sundial Avenue</b> <b>Manchester, NH 03103</b> <b>(603) 647-9700 fax: (603) 647-4432</b> <a href="http://www.terracon.com">www.terracon.com</a>		
<b>Terracon</b>		
Remarks: Wn= 9.0%	Tested By: Dan Savage	Date: 07/15/15
	Reviewed By: C. Thunberg	Date: 07/17/15



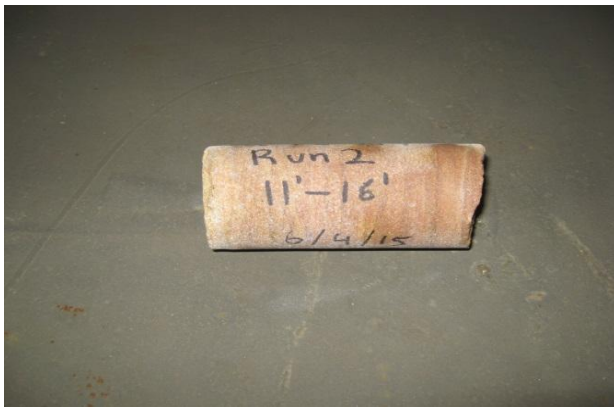
**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind Farm  
 Project No.: J5155113  
 \_\_\_\_\_

Date of testing: 6/29/15  
 Lab technician: DPS, A. Suprunenko

Boring No.: WTG-A4  
 Sample No.: Run 2  
 Sample depth: 11' to 16'  
 Sampling date: 6/4/15

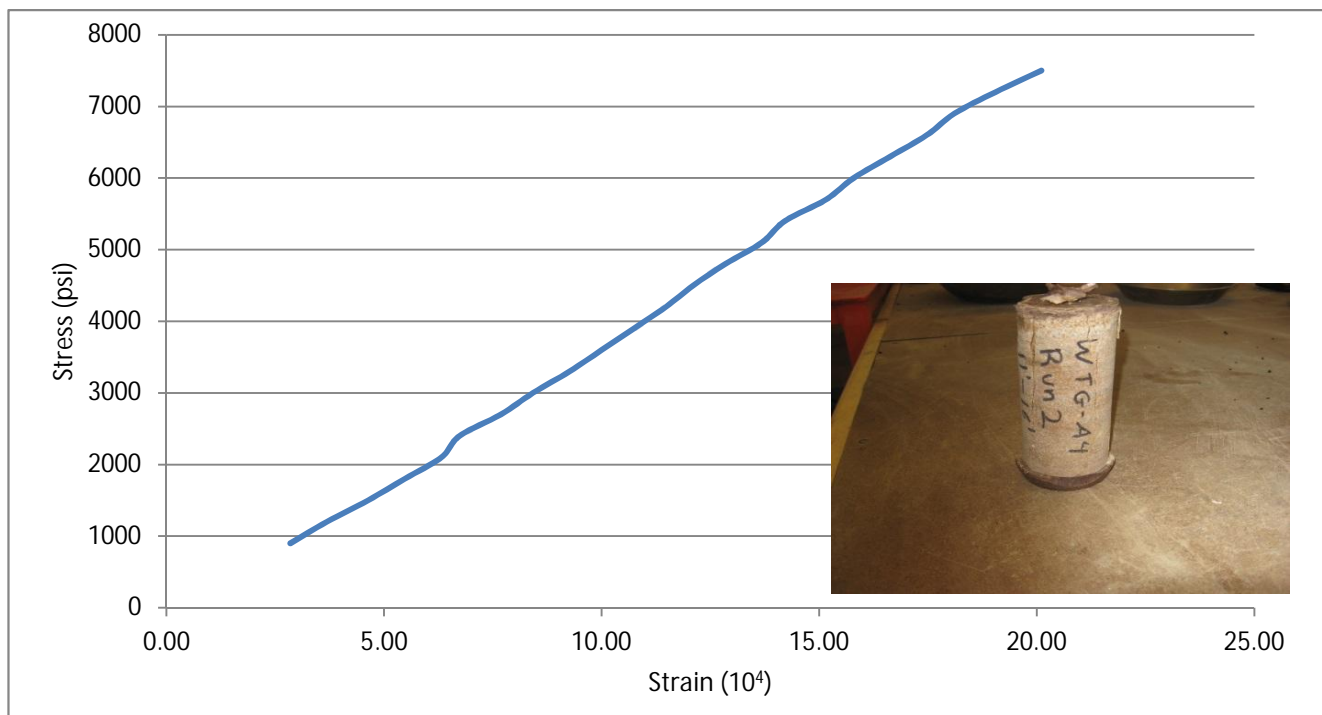
Diameter: 2.06 in  
 Length: 4.66 in  
 End area: 3.33 in<sup>2</sup>



Bulk Density 152.88 pcf

Compressive Strength: 7,777 psi

Modulus of Elasticity ( E ) 3,738,165 psi



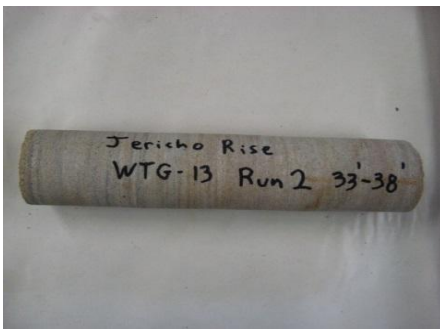
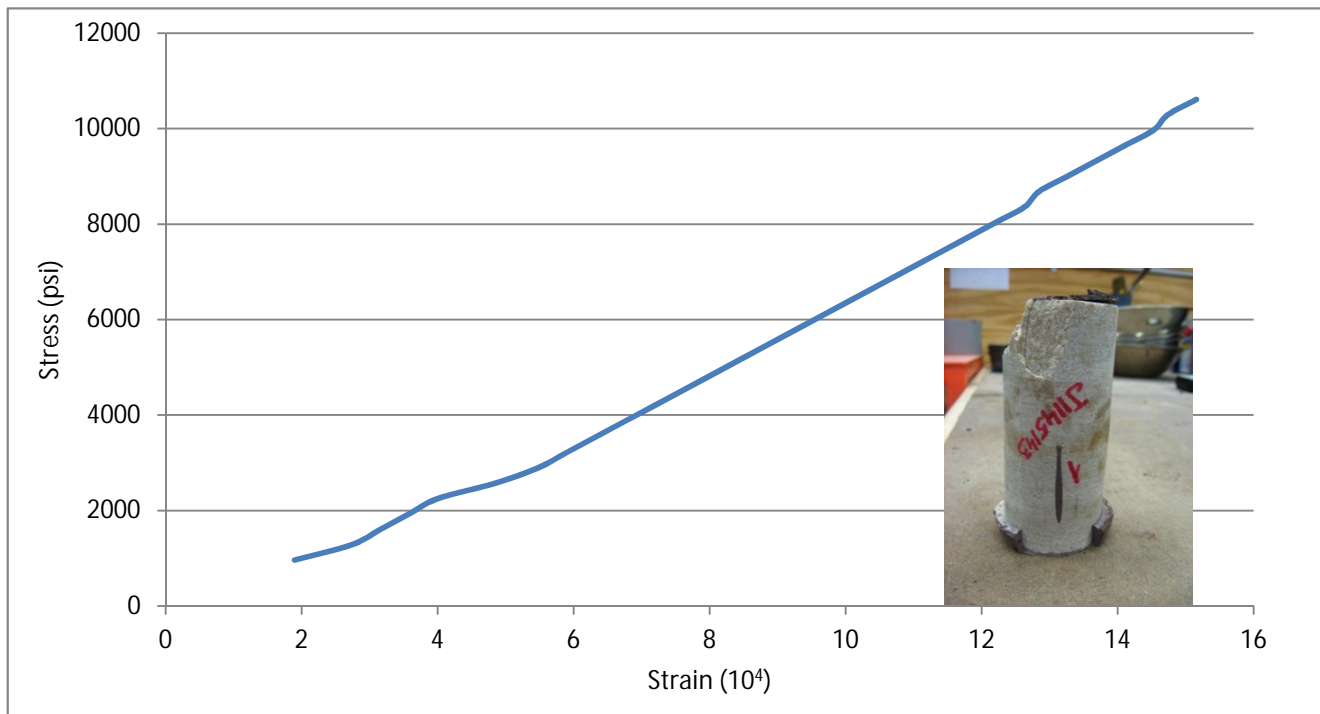
Checked By: C. Thunberg



**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind FarmProject No.: J5155113Date of testing: 7/16/15Lab technician: A. SuprunenkoBoring No.: WTG-13Sample No.: Run 2Sample depth: 33'-38'

Sampling date: \_\_\_\_\_

Diameter: 1.99 inLength: 4.36 inEnd area: 3.11 in<sup>2</sup>Bulk Density 150.26 pcfCompressive Strength: 19,011 psiModulus of Elasticity ( E ) 7,272,392 psiChecked By: C. Thunberg



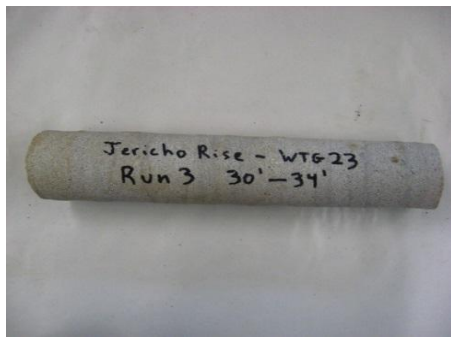
**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind Farm  
 Project No.: J5155113  
 PIN: \_\_\_\_\_

Date of testing: 7/16/15  
 Lab technician: A. Suprunenko

Boring No.: WTG23  
 Sample No.: Run3  
 Sample depth: 30'-34'  
 Sampling date: \_\_\_\_\_

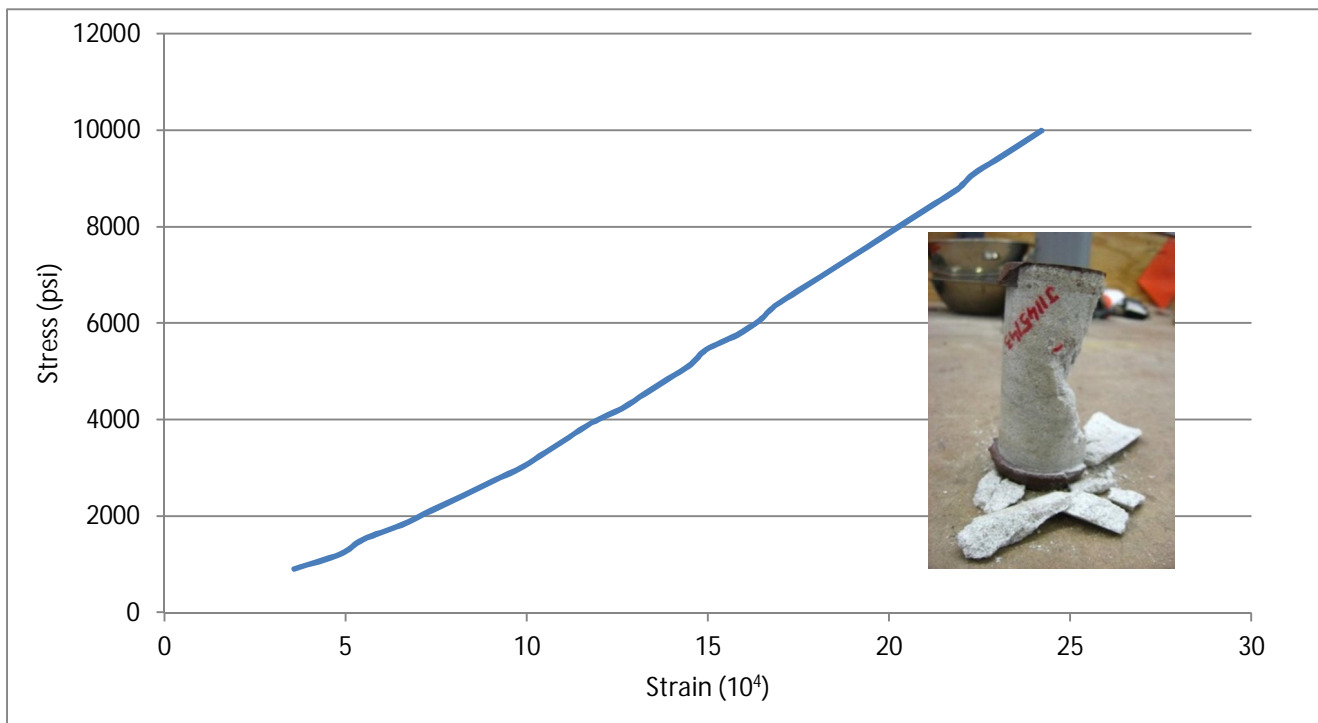
Diameter: 2.05 in  
 Length: 4.37 in  
 End area: 3.30 in<sup>2</sup>



Bulk Density 142.97 pcf

Compressive Strength: 12,101 psi

Modulus of Elasticity ( E ) 4,405,449 psi



Checked By: C. Thunberg



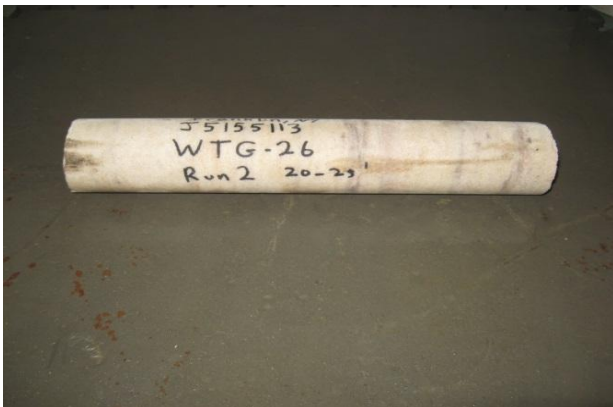
**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind Farm  
 Project No.: J5155113  
 \_\_\_\_\_

Date of testing: 6/29/15  
 Lab technician: DPS, A. Suprunenko

Boring No.: WTG-26  
 Sample No.: Run 2  
 Sample depth: 20' to 25'  
 Sampling date: \_\_\_\_\_

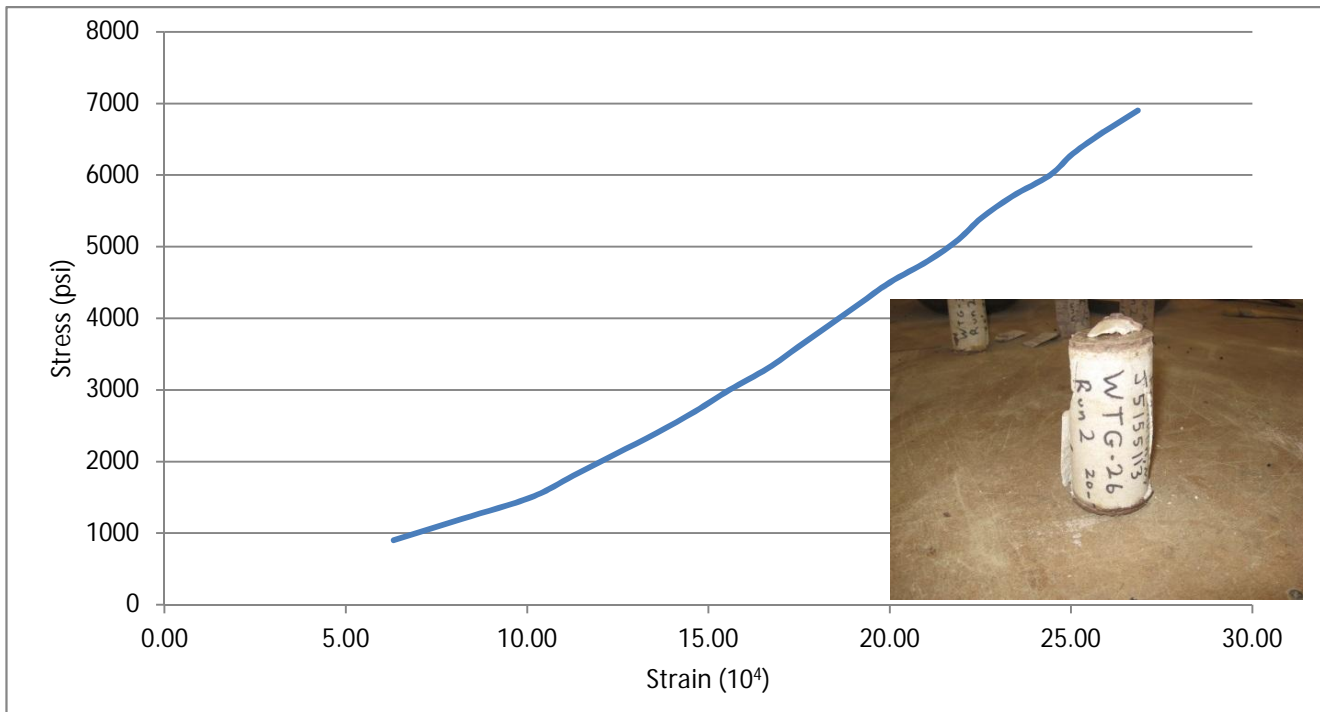
Diameter: 2.06 in  
 Length: 4.59 in  
 End area: 3.33 in<sup>2</sup>



Bulk Density 152.98 pcf

Compressive Strength: 8,368 psi

Modulus of Elasticity ( *E* ) 2,326,817 psi



Checked By: C. Thunberg



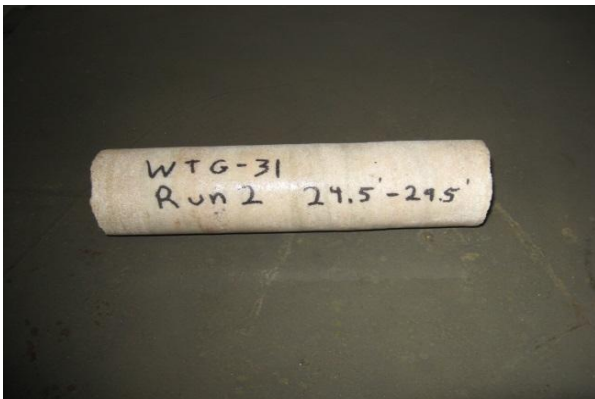
**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind Farm  
 Project No.: J5155113  
 \_\_\_\_\_

Date of testing: 6/29/15  
 Lab technician: DPS, A. Suprunenko

Boring No.: WTG-31  
 Sample No.: Run 2  
 Sample depth: 24.5' to 29.5'  
 Sampling date: \_\_\_\_\_

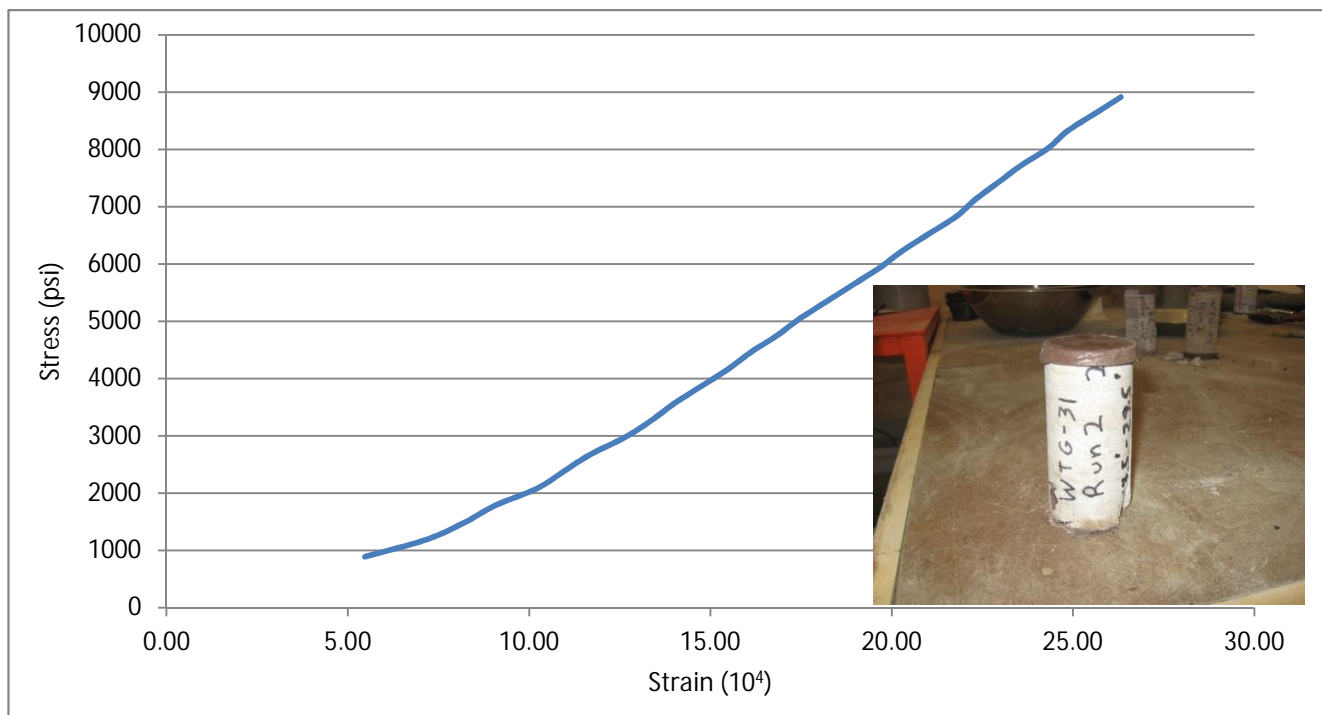
Diameter: 2.07 in  
 Length: 4.66 in  
 End area: 3.37 in<sup>2</sup>



Bulk Density 154.13 pcf

Compressive Strength: 8,998 psi

Modulus of Elasticity ( *E* ) 3,011,069 psi



Checked By: C. Thunberg





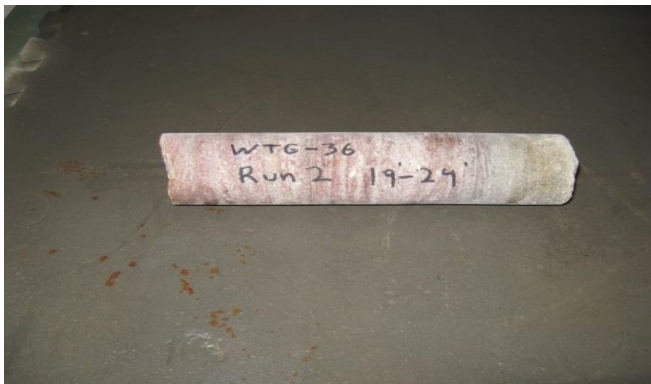
**ASTM D7012 Standard Test Method for**  
**Compressive Strength and Elastic Moduli of Intact Rock Core Specimens**

Project: Jericho Rise Wind Farm  
 Project No.: J5155113  
 \_\_\_\_\_

Date of testing: 6/29/15  
 Lab technician: DPS, A. Suprunenko

Boring No.: WTG-36  
 Sample No.: Run 2  
 Sample depth: 19' to 24'  
 Sampling date: \_\_\_\_\_

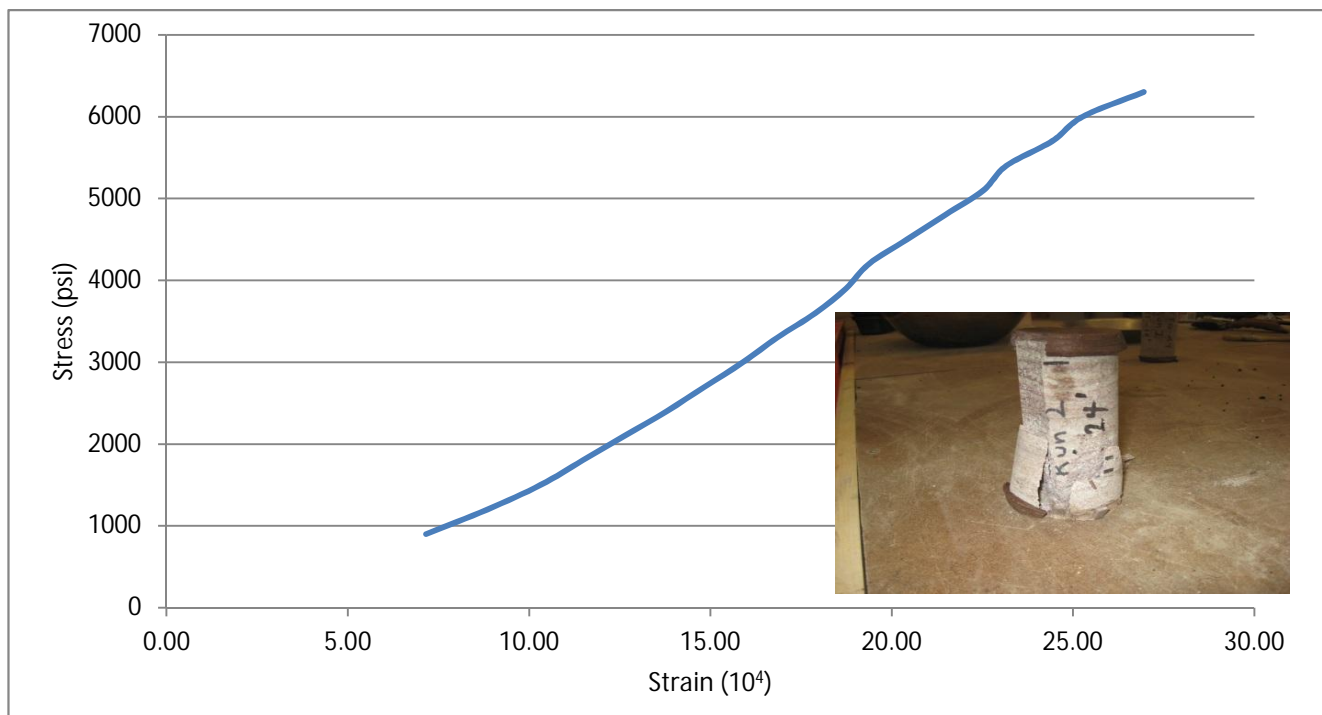
Diameter: 2.06 in  
 Length: 4.70 in  
 End area: 3.33 in<sup>2</sup>



Bulk Density 154.03 pcf

Compressive Strength: 6,730 psi

Modulus of Elasticity ( E ) 2,478,566 psi



Checked By: C. Thunberg

**APPENDIX C**  
**SUPPORTING DOCUMENTS**

DRAFT

# UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>					Soil Classification	
					Group Symbol	Group Name <sup>B</sup>
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 <sup>C</sup>	Cu ≥ 4 and 1 ≤ Cc ≤ 3 <sup>E</sup>	GW	Well-graded gravel <sup>F</sup>	
			Cu < 4 and/or 1 > Cc > 3 <sup>E</sup>	GP	Poorly graded gravel <sup>F</sup>	
		Gravels with Fines: More than 12% fines <sup>C</sup>	Fines classify as ML or MH	GM	Silty gravel <sup>F,G,H</sup>	
			Fines classify as CL or CH	GC	Clayey gravel <sup>F,G,H</sup>	
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines <sup>D</sup>	Cu ≥ 6 and 1 ≤ Cc ≤ 3 <sup>E</sup>	SW	Well-graded sand <sup>I</sup>	
			Cu < 6 and/or 1 > Cc > 3 <sup>E</sup>	SP	Poorly graded sand <sup>I</sup>	
		Sands with Fines: More than 12% fines <sup>D</sup>	Fines classify as ML or MH	SM	Silty sand <sup>G,H,I</sup>	
			Fines classify as CL or CH	SC	Clayey sand <sup>G,H,I</sup>	
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots on or above “A” line <sup>J</sup>	CL	Lean clay <sup>K,L,M</sup>	
			PI < 4 or plots below “A” line <sup>J</sup>	ML	Silt <sup>K,L,M</sup>	
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay <sup>K,L,M,N</sup>
			Liquid limit - not dried			Organic silt <sup>K,L,M,O</sup>
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above “A” line	CH	Fat clay <sup>K,L,M</sup>	
			PI plots below “A” line	MH	Elastic Silt <sup>K,L,M</sup>	
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay <sup>K,L,M,P</sup>
			Liquid limit - not dried			Organic silt <sup>K,L,M,Q</sup>
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat	

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

<sup>D</sup> Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$$^E Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.

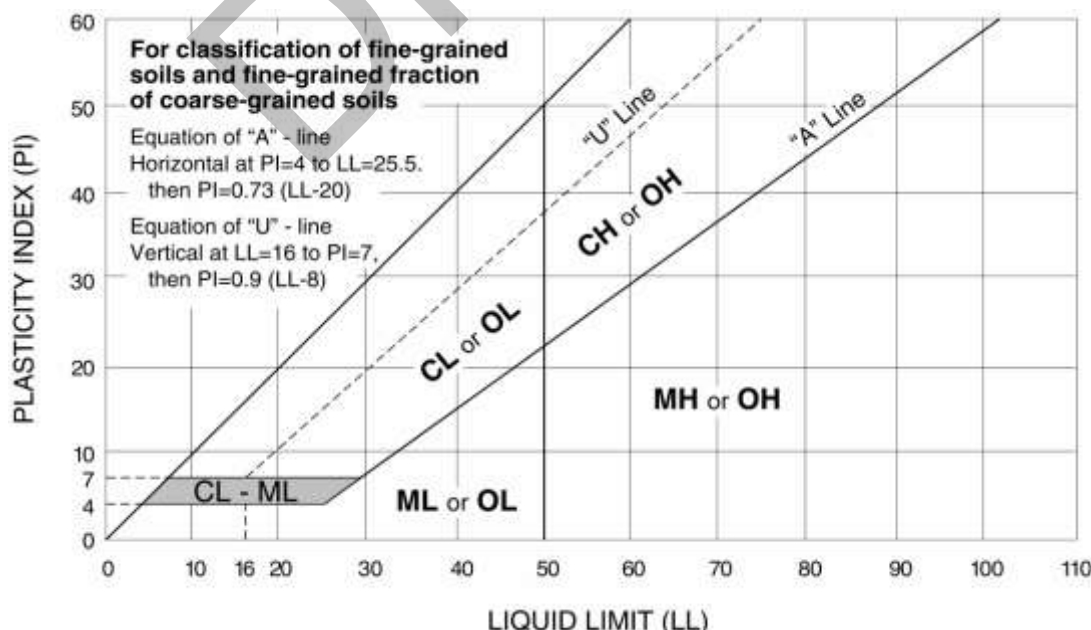
<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup> PI plots on or above "A" line.

<sup>Q</sup> PI plots below "A" line.



# DESCRIPTION OF ROCK PROPERTIES

## WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

## HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

### Joint, Bedding, and Foliation Spacing in Rock <sup>a</sup>

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

### Rock Quality Designator (RQD) <sup>a</sup>

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces  
4 in. and longer/length of run.

### Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

## FOUNDATION CALCULATION METHODOLOGY

### FOUNDATION DESIGN INFORMATION

This summary of calculations describes the methods used to evaluate the allowable bearing pressure and estimated settlement of the gravity turbine foundations for the Jericho Rise Wind Project. In summary, our methodology was as follows:

- The effective foundation areas under the eccentric loading conditions of the extreme load for normal load cases and extreme load for abnormal load cases were evaluated for the assumed foundation size.
- The average contact pressure under the effective area was calculated.
- Minimum soil shear strengths to accommodate the calculated average contact pressure (including factors of safety) were determined by back-calculation from traditional bearing capacity equations.
- The soil shear strengths at the gravity turbine locations were evaluated against the back-calculated minimum soils shear strengths and an appropriate bearing pressure was assigned.
- Elastic and long-term settlements were estimated using the average contact pressure and effective bearing area of the mean operating loading condition, along with elastic and consolidation properties obtained from the exploration and traditional analysis methods. Analyses were performed for generalized profiles. Some adjustments of the assigned bearing pressure were made based upon the settlement analysis.

EDP Renewables provided the design information tabulated below. The bases of the octagonal-shaped footings were assumed to bear about 8 to 10 feet below grade and have a width of about 60 feet for an allowable design bearing pressure of 6,000 psf. The following table incorporates our assumptions for foundation size.

Item	Description	
<b>Characteristic Extreme Loads on Tower Base (Per Gamesa Document: GD092758-en Revision 2, February 3, 2012, G97 Design Loads and Definition of Interfaces)</b>	<b>90m tower</b>	
	■ Tower and turbine dead weight	<b>692.6 kips</b>
	■ Approx. weight of overlaying soil	<b>830.1 kips</b>
	■ Approximate weight of concrete	<b><u>1222.8 kips</u></b>
	■ Maximum vertical load at base	<b>2745.5 kips</b>
	■ Maximum horizontal base shear	<b>201.8 kips</b>
	■ Maximum base moment	<b>56,616 ft-kips</b>

## EFFECTIVE BEARING AREAS AND AVERAGE CONTACT PRESSURE

The eccentric loading of the foundation size was evaluated for the Extreme Loads on Tower Base to calculate effective foundation area. These calculations were performed using the procedures outlined in “Guidelines for Design of Wind Turbines”, RISO, 2<sup>nd</sup> Edition, 2002.

Effective area  $A_{eff} = 2 \left[ R^2 \arccos\left(\frac{e}{R}\right) - 2\sqrt{R^2 - e^2} \right]$

Major axes of elliptical effective area  $b_e = 2(R - e)$

$$l_e = 2R \sqrt{1 - \left(1 - \frac{b}{2R}\right)^2}$$

Bearing pressure  $q = \frac{V}{A_{eff}}$

Eccentricity  $e = \frac{M}{V}$

Length of equivalent rectangle  $l_{eff} = \sqrt{A_{eff} \frac{l_e}{b_e}}$

Width of equivalent rectangle  $b_{eff} = \frac{l_{eff}}{l_e} b_e$

The average contact pressure at the base of the foundation was then calculated by dividing the total vertical load by the effective foundation area for the foundation size and loading conditions. These results are summarized below.

Maximum Allowable Design Bearing Pressure (psf)	Loading Case	Effective Area – Equivalent Rectangle		Average Contact Pressure on Effective Foundation Area (psf)
		Width $b_{eff}$ (feet)	Length $l_{eff}$ (feet)	
6,000	Extreme Load on Tower Base	15.6	36.2	4,900

## MINIMUM REQUIRED SHEAR STRENGTH

We performed bearing capacity analyses using the equation developed by Terzaghi, Meyerhoff, and Vesic in accordance with the AASHTO LRFD Bridge Design Specification, Fifth Edition, 2010, Section 10.6.3.1 Bearing Resistance of Soil (for Spread Footings). This equation was used along with the previously calculated effective bearing areas and average contact pressures to back-calculate the required shear strength, including a factor of safety of 3 for the extreme load condition.

The general bearing capacity equation is:

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5BN_{\gamma m} C_{w\gamma}$$

with  $N_{cm} = N_c s_c i_c$

$$N_{qm} = N_q s_q d_q i_q$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$$

$c$  = cohesion

$N_c$  = cohesion term

$N_q$  = surcharge term

$N_\gamma$  = unit weight term

$\gamma$  = total unit weight of soil

$D_f$  = footing embedment depth

$B$  = footing width

$C_{wq}, C_{w\gamma}$  = groundwater correction factors

$s_c, s_\gamma, s_q$  = footing shape correction factors

$d_q$  = depth correction factor

$i_c, i_\gamma, i_q$  = load inclination factors

The effective foundation size and average contact pressures (with factors of safety included) were applied to these equations to determine the minimum required shear strengths for the cohesive and granular soil cases for each foundation size and loading condition. The results are summarized below.

Net Allowable Design Bearing Pressure (psf)	Loading Case	Minimum Friction Angle (degrees)
6,000	Extreme Load on Tower Base	24

## EVALUATION OF SHEAR STRENGTH AND DESIGN BEARING PRESSURE

The soil shear strength at was evaluated against the back-calculated minimum soils shear strengths and an appropriate bearing pressure was assigned. The soil shear strengths were evaluated as follows:

For cohesionless soils, the friction angle was evaluated using the following methods:

- Correlations between the SPT N-values and the friction angle  $\phi$ . The SPT N-values reported on the boring logs are blow counts recorded in the field. In accordance with



FHWA's Geotechnical Engineering Circular No. 6: Shallow Foundations (2002), the energy corrected  $N_{60}$  is calculated using the following equation:

$$N_{60} = \frac{ER}{60\%} N_{field}$$

where:  $N_{60}$  = SPT N-value corrected to a hammer efficiency of 60%  
 $ER$  = energy ratio of SPT drive hammer  
 $N_{field}$  = blow count recorded in field

Since the energy ratio of the auto hammer is about 80 percent:

$$N_{60} = \frac{80\%}{60\%} N_{field} = 1.33 N_{field}$$

In general, adequate bearing conditions were encountered at or near the assumed 10-foot bearing depth for the turbine foundation.

## FOUNDATION SETTLEMENT

The settlement analysis was based on our estimated foundation widths and estimates of the effective foundation areas and average contact pressures developed under the provided loads, coupled with the boring and laboratory data.

We analyzed the settlement for the following loading condition and effective area in accordance with the "Guidelines for Design of Wind Turbines", Riso, 2nd Edition, 2002.

Maximum Allowable Design Bearing Pressure (psf)	Loading Case	Effective Area – Equivalent Rectangle		Average Contact Pressure on Effective Foundation Area (psf)
		Width $b_{eff}$ (feet)	Length $l_{eff}$ (feet)	
6,000	Extreme Load on Tower Base	15.6	36.2	4,900

### Immediate Settlement

To calculate the immediate settlement, we used the method per Bowles' 5<sup>th</sup> Edition: Foundation Analysis and Design, 1996.

$$\text{Settlement} = q_o B \frac{1-\mu^2}{E} I_S I_F$$

$$\text{with } I_S = I_1 + \frac{1-2\mu}{1-\mu} I_2$$

$$I_1 = \frac{1}{\pi} \left[ M \ln \frac{(1+\sqrt{M^2+1})\sqrt{M^2+N^2}}{M(1+\sqrt{M^2+N^2+1})} + \ln \frac{(M+\sqrt{M^2+1})\sqrt{1+N^2}}{M+\sqrt{M^2+N^2+1}} \right]$$

$$I_2 = \frac{N}{2\pi} \tan^{-1} \left[ \frac{M}{N\sqrt{M^2+N^2+1}} \right]$$

$$M = \frac{L}{B}$$

$$N = \frac{H}{B}$$

$q_o$  = contact pressure

$B$  = width of foundation

$L$  = length of foundation

$H$  = thickness of soil layer(s) below loaded area susceptible to settlement

$I_f$  = depth factor of 0.85

$E$  = elastic modulus of soil layer(s) below the loaded area

$\mu$  = Poisson's ratio

The widths and lengths of the effective foundation areas were used in the above equation. Based on our calculations using the large strain elastic modulus  $E = 14,900$  ksf and the Poisson's ratio  $\mu = 0.3$  from section 4.3.5 Wind Turbine Foundation Soil Stiffness, we anticipate the immediate settlement to be on the order of 1/4 inch for the foundation design.

### Long-Term Settlement

In our long-term settlement analyses, we calculated the settlement parameters of cohesionless soils by the Hough Method in accordance with FHWA's Geotechnical Engineering Circular No. 6 – Shallow Foundations, 2002. The Hough method uses the SPT values corrected for the hammer efficiency and normalized for the effect of the overburden pressure. The SPT values  $N'$  used in the Hough Method is equal to the  $N_{60}$  values.

Per the Hough method, we determined the bearing capacity index,  $C'$ , for the cohesionless soil layers based on  $N'$  using Figure 5-19: Bearing Capacity Index versus Corrected SPT from FHWA's Geotechnical Engineering Circular No. 6 – Shallow Foundations, 2002. The vertical strain for the virgin compression  $C_{c\varepsilon}$  was calculated using the following formula:

$$C_{c\varepsilon} = \frac{1}{C'}$$

The vertical strain for the recompression  $C_{r\varepsilon}$  was estimated to be one order of magnitude less than that of the virgin compression. An assumed preconsolidation pressure of 5,000 psf was

used to model past glaciation. We divided the soil into several layers and calculated the stress increase  $\Delta\sigma$  at the mid-depth of each soil layer using the Boussinesq stress distribution in accordance with Braja M. Das' Principles of Foundation Engineering, Fifth Edition, 2004.

$$\Delta\sigma = q_o I$$

$$\text{with } I = \frac{1}{4\pi} \left( \frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1} \cdot \frac{m^2+n^2+2}{m^2+n^2+1} + \tan^{-1} \frac{2mn+\sqrt{m^2+n^2+1}}{m^2+n^2+1-m^2n^2} \right)$$

$$\text{when } m^2 + n^2 + 1 < m^2n^2$$

$$\text{then } I = \frac{1}{4\pi} \left( \frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1} \cdot \frac{m^2+n^2+2}{m^2+n^2+1} + \tan^{-1} \left( \pi - \frac{2mn+\sqrt{m^2+n^2+1}}{m^2+n^2+1-m^2n^2} \right) \right)$$

$$\text{where } m = \frac{B}{z}$$

$$\text{and } n = \frac{L}{z}$$

The stress increase  $\Delta\sigma$  was calculated for each layer at both the center of the effective area and the edge of the foundation.

We performed the long-term settlement analyses in accordance with the equations from FHWA's Geotechnical Engineering Circular No. 6 – Shallow Foundations, 2002. The total settlement  $S_c$  was determined as the sum of the incremental layer settlements.

$$S_c = \sum_1^n H_o C_{c\varepsilon} \log_{10}(\sigma'_{vf}/\sigma'_{vo}) \text{ for normally consolidated soils}$$

$$S_c = \sum_1^n H_o \left( C_{r\varepsilon} \log_{10} \left( \frac{\sigma'_p}{\sigma'_{vo}} \right) + C_{c\varepsilon} \log_{10} \left( \frac{\sigma'_{vf}}{\sigma'_p} \right) \right) \text{ for over-consolidated soils}$$

With  $n$  = number of layers

$H_o$  = thickness of layer

$C_{r\varepsilon}$  = vertical strain for recompression

$C_{c\varepsilon}$  = vertical strain for virgin compression

$\sigma'_p$  = preconsolidation pressure

$\sigma'_{vo}$  initial effective vertical stress at mid-point of layer

$\sigma'_{vf}$  final effective vertical stress at mid-point of layer

$$\text{where } C_{c\varepsilon} = \frac{C_c}{1+e_o}$$

$$\text{and } \sigma'_{vf} = \sigma'_{vo} + \Delta\sigma$$

with  $C_c$  = compression index

$e_o$  = initial void ratio

$\Delta\sigma$  = stress increase

Based on our calculations using the aforementioned assumptions for generalized and specified soil profile, gravity foundations would experience total settlements of less than about ¾ to 1 inch under the provided extreme loads.

**APPENDIX D**  
**ROCK CORE PHOTOS**

DRAFT



**Photo 1:** Exhibit D-1: Rock Cores WTG A4 & WTG 36



**Photo 2:** Exhibit D-2: Rock Core from WTG 36 (bottom)



**Photo 3:** Exhibit D-3: Rock Core from WTG 13



**Photo 4:** Exhibit D-4: Rock Core from WTG 23





**Photo 5:** Exhibit D-5: Rock Core from WTG 26



**Photo 6:** Exhibit D-6: Rock Core from WTG 31/Met 31C