CTI and Associates, Inc.
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May 11, 2012

Ms. Amy Kuras, Landscape Architect
City of Ann Arbor Parks and Recreation Services
301 E. Huron Street
Ann Arbor, Michigan 48104

**RE: Geotechnical Investigation**
**Proposed Tennis Courts – Windemere Park**
**Ann Arbor, Michigan**
**CTI Project No. 3122040016**

Dear Ms. Kuras:

CTI and Associates, Inc. (CTI) has completed a geotechnical evaluation for the proposed tennis courts to be constructed within Windemere Park in Ann Arbor, Michigan. The purpose of our investigation was to determine the general subsurface conditions at the proposed new tennis court location, to provide recommendations regarding support of the tennis court pavement and to provide recommendation for fence post and net post foundation support. Our evaluation was performed in general accordance with the scope of services outlined in the CTI Proposal No. 112PRO2040-060 dated May 1, 2012 and authorized by Ms. Amy Kuras, Landscape Architect, City of Ann Arbor Parks and Recreation Services on May 1, 2012.

## SITE AND PROJECT DESCRIPTION

The proposed development area is located in the eastern portion of Windemere Park. Windemere Park is located on the north side of Windemere Drive, between Charter Place and Markbarry Drive in Ann Arbor, Michigan. The proposed development area is covered by grass and is relatively flat.

The existing tennis courts, located in the western portion of the park, have undergone some pavement distress with visible cracking and depressed areas. A berm was observed on the south and east sides of the existing tennis court. It appeared that runoff from precipitation events flowed from the berm toward the tennis court.

Soil boring logs performed within Windemere Park by ISC on April 12, 2011 were provided to CTI for reference. The test borings reveal poor soil and subsurface drainage conditions in the vicinity of the existing courts.

Based on the provided information, CTI understands that the proposed project will include the construction of two new tennis courts in the eastern portion of Windemere Park. We further understand that a pavement section consisting of 3 inches of asphalt over 6 inches of aggregate base material is desired. We anticipate that the footprint of the proposed courts will be approximately 108 feet wide by 120 feet long. We further anticipate that the courts will be surrounded by an approximately 10 foot high chain link fence.

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## INVESTIGATION PROCEDURES

### Field Investigation

Our field investigation consisted of drilling five test borings within the proposed development area, designated as B-1 through B-5. The borings were extended to a depth of 10 feet below the existing ground surface for a total of 50 lineal feet of drilling. The boring locations were selected by CTI and City of Ann Arbor Parks and Recreation Services personnel. The borings were marked in the field by CTI personnel.

The approximate boring locations are shown on the Boring Location Plan included with this report. The estimated locations of borings SB-3 through SB-5, performed by ISC, are presented on the Boring Location Plan for reference.

The drilling operations were performed by Stearns Drilling personnel under the direction of CTI on May 1, 2012 utilizing a rotary head drilling rig. The soil borings were advanced using continuous flight hollow-stem augers with an inside diameter of 4¼ inches. Soil samples were obtained at intervals of 2½ feet to the explored depths of the borings. The soil samples were obtained by the Standard Penetration Test Method (ASTM D-1586), whereby a 2-inch outside diameter split-barrel sampler is driven into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler is generally driven three successive 6-inch increments, with the number of blows for each increment being recorded. The number of blows required to advance the sampler the last 12 inches is termed the Standard Penetration Resistance, N. The soil samples obtained with the split-barrel sampler were sealed in glass jar containers and transported to our laboratory for further classification and testing. After completion of the drilling operations, the borehole was backfilled with excavated soil (i.e., auger cuttings).

The laboratory testing program determined the general soil classification and physical properties of recovered samples. All laboratory testing was performed in general accordance with applicable ASTM test method standards. The laboratory testing program consisted of visually classifying each collected soil sample in general accordance with the Unified Soil Classification System (USCS), and natural moisture content and loss-on-ignition (organic content) testing of selected samples. The unconfined compressive strength of selected cohesive samples was also estimated based on the resistance to a calibrated spring-loaded hand penetrometer. The results of all laboratory tests are indicated on the boring logs at the depths from which the samples were obtained.

Soil and groundwater conditions observed in the test borings have been evaluated and are presented on the boring logs included in the Appendix. To aid in understanding the data presented on the boring logs, “General Notes for Soil Classification,” describing nomenclature used in soil descriptions, are also included in the Appendix. The soil descriptions reported on the test boring logs are based upon field logs prepared by experienced drillers with modifications made based on the results of laboratory testing and engineering review.

## SUBSURFACE CONDITIONS

### Soil Conditions

Approximately 6 to 8 inches of topsoil/topsoil fill was encountered at the boring locations. At the locations of Borings B-2 through B-5, clay fill containing varying amounts of organics was encountered to depths of 3 to 6 feet below the existing ground surface. Loss-on-Ignition testing indicated that the clay fill materials encountered within B-2, B-4 and B-5 had an organic content ranging from 2.6 percent to 4.5 percent.

Below the fill encountered within B-2 through B-5 and below the topsoil encountered at the location of B-5, apparently native brown and gray clay was encountered to the final explored depth of the borings.

Standard Penetration Test (SPT) resistances (N-values) within the native clay soils typically ranged from 11 to 32 blows per foot. The unconfined compressive strength of the tested clay samples ranged from 6,000 pounds per square foot (psf) to more than 9,000 psf, indicating very stiff to hard consistencies. The moisture contents of representative native clay samples ranged from approximately 12 to 21 percent. The clay samples generally appeared to be in a moist condition when examined in the laboratory.

The stratification depths shown on the soil boring logs represent the soil conditions at the specific boring locations. Variations in the soil conditions may occur between and/or beyond the boring locations.

## Groundwater Conditions

The drillers looked for indications of groundwater seepage both during and after drilling. The test borings were reported as dry both during and after drilling.

The short-term groundwater level observations from the borings are not necessarily indicative of the static, long-term groundwater conditions. The groundwater within cohesive soil deposits (clays) is typically confined within discontinuous sand or silt seams interbedded within the clay soil. Drilling operations in these soils have a tendency to seal off the paths of groundwater flow due to the slurry created during drilling. Seams of water-bearing sand or silt are possible at various depths and locations within the native clay soils. Groundwater seepage through the clays soils at this site will depend highly on the frequency of sand seams present within the soil.

Due to the inherent low permeability of the native clay soils, a long time would be required for the water level in an open borehole to stabilize with the long-term, hydrostatic groundwater level. It would be necessary to install and monitor a series of observation wells (piezometers) over an extended period of time to accurately determine the position of the long-term hydrostatic groundwater level in these soil conditions. The installation of groundwater monitoring wells was beyond the scope of our services for this project.

Normally, if a boring is drilled in cohesive soils, groundwater may not reach a static level immediately after drilling. The groundwater may rise or fall to a static level if the boring is left open for an extended period of time, possibly several days. The depth at which the soil color changes from brown to gray is often an indication of the long-term piezometric level. This color change generally results from the lack of oxidation in the soil below the zone of saturation. Based on the results of the test borings, the long-term piezometric level at this site appears to be at a depth greater than the explored depth of 10 feet. Based on a review of the soil borings performed by ISC, it appears that the long-term groundwater level may be at or below a depth of about 12½ to 15½ feet below the existing grades.

The groundwater conditions discussed herein and indicated on the soil boring logs represent those encountered at the time of the field investigation. The groundwater levels, including perched groundwater accumulations, should be expected to fluctuate seasonally, based on variations in precipitation, evaporation, surface run-off and other factors not evident at the time of our investigation.

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The above soil and groundwater conditions represent a generalized summary of the subsurface conditions and material characteristics. The individual Test Boring Logs and Test Boring Location Plan should be reviewed for specific information and details relating to specific areas of the site.

## ANALYSIS AND RECOMMENDATIONS

### Tennis Court Subgrade Improvement and Pavement Recommendations

Approximately 3 to 6 feet of uncontrolled fill was encountered at four of the five borings performed by CTI. The long-term performance of the tennis court pavement will typically be a function of the quality of the subgrade soil at the time of construction, drainage provisions and the quality, thickness and strength of the overall pavement section. The most critical portion of the subgrade is the 3 feet immediately beneath the pavement section, which provides the primary strength needed for pavement section support. Soils in a saturated condition, uncontrolled fill and/or organic materials present within the upper 2 to 3 feet of the pavement subgrade will be detrimental to pavement performance if the design does not account for this substandard soil condition, especially during the spring freeze-thaw cycles.

At the start of earthwork operations, any topsoil, vegetation and other deleterious materials should be stripped from the proposed tennis court areas. Following cuts in cut areas and prior to fill placement in fill areas, the resulting subgrade soils should be thoroughly proofrolled.

Because of the presence of organic-containing uncontrolled fill across the proposed development area, we recommend strengthening the subgrade soils through the use of a triaxial geogrid in lieu of performing significant undercuts (on the order of 30 inches) across the entire tennis court area. The benefit of improving the subgrade with a geogrid is that the need for undercutting existing subgrade soils is significantly reduced.

The exposed subgrade soils should be cut to a depth of 2 to 3 inches below the design subgrade elevation. The subgrade should be in a relatively level condition following minor grading operations, prior to installation of the aggregate base course layer and geogrid. A non-woven geotextile fabric, such as Tencate Mirafi 140N or equivalent, should be placed over the resulting subgrade to act as a separation layer between the aggregate and subgrade soils. A layer of MDOT 21AA crushed stone should be placed over the non-woven geotextile fabric in a thickness to meet the design subgrade elevation (approximately 2 to 3 inches). A geogrid such as Tensar TX140 should be placed over the layer of MDOT 21AA to provide base reinforcement for the tennis court pavement section. A minimum of 6 inches of aggregate base course material should be placed over the geogrid in one lift and then compacted to a minimum of 98 percent of the material’s maximum dry density.

Following improvement through the use of a geogrid, we anticipate the following pavement section will be adequate for the proposed tennis court pavement:

**Table 1: Tennis Court Pavement Section**

| Layer | Material | Thickness (inches) |
|---|---|---|
| Bituminous Surface | MDOT 13A | 1.5 |
| Bituminous Leveling | MDOT 13A | 1.5 |
| Aggregate Base (Reinforced with Tensar TX140 Geogrid) | MDOT 21AA crushed limestone | 8.0 |

The tennis court pavement system should be properly drained to reduce the potential for weakening the subgrade. Provisions should be made to prevent surface run-off water from accumulating within the aggregate base course of the pavement, such as grading the surrounding ground to drain away from the pavement and into drainage ditches or drains. The pavement and underlying subgrade should be suitably crowned or sloped to promote effective surface drainage, reduce water infiltration into the base course and prevent water ponding. Typical sloping for tennis courts is a minimum of 1 percent slope from side to side. A perimeter drainage system is recommended. The perimeter drainage system should be installed in a trench located outside the perimeter of the tennis court, at or slightly below the design subgrade elevation of the tennis court (at or below the bottom of the aggregate base course). The drainage system should consist of a perforated pipe tied into the storm sewer system. The perforated pipe should be protected with free-draining coarse aggregate material and filter fabric.

It should be recognized that all pavements require regular maintenance and occasional repairs to keep them in a serviceable condition. Of particular value is timely sealing of joints and cracks, which if left un-repaired, can serve to permit water to enter the pavement section and cause rapid deterioration of the pavement during freeze-thaw cycles. The need for such routine maintenance and repair is not necessarily indicative of premature pavement failure. However, if appropriate maintenance and repairs are not performed on a timely basis, the serviceable life of the pavement can be reduced significantly.

## Foundation Support

The proposed fence posts and net posts can be supported on conventional shallow pier footings bearing on the native hard clay soils encountered below the near-surface clay fill at this site. Foundations placed on the native hard clay soils at the design bearing depths can be designed for a maximum net allowable soil bearing pressure of 4,000 psf.

It is anticipated that the fence post and net post foundations will be excavated with an auger and have a minimum diameter of 6 inches. CTI should be notified if a smaller diameter is used so that these recommendations can be adjusted. The footings should be founded a minimum of 42 inches below exterior finished grade for protection against frost penetration during normal winters. We recommend that where the foundations extend through near-surface fill, a minimum embedment depth of 1 foot into the native clay be achieved.

Where foundation elements extend through the geogrid reinforcement, the geogrid should be cut to allow foundation excavation. Alternatively, the foundation elements could be constructed prior to the installation of the geogrid.

The foundation excavation should be observed and concrete placed as quickly as possible to avoid exposure of the foundation bearing soil to wetting and drying. Surface runoff water should be drained away from the excavations and not be allowed to pond. The foundation concrete should be placed during the same day the excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture.

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## GENERAL COMMENTS

The evaluations and recommendations discussed in this report are based on the provided design drawings and the soil conditions encountered in the test borings performed at the approximate locations indicated on the attached Boring Location Plan and on the date indicated on the boring logs.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance, please contact our office.

Sincerely,

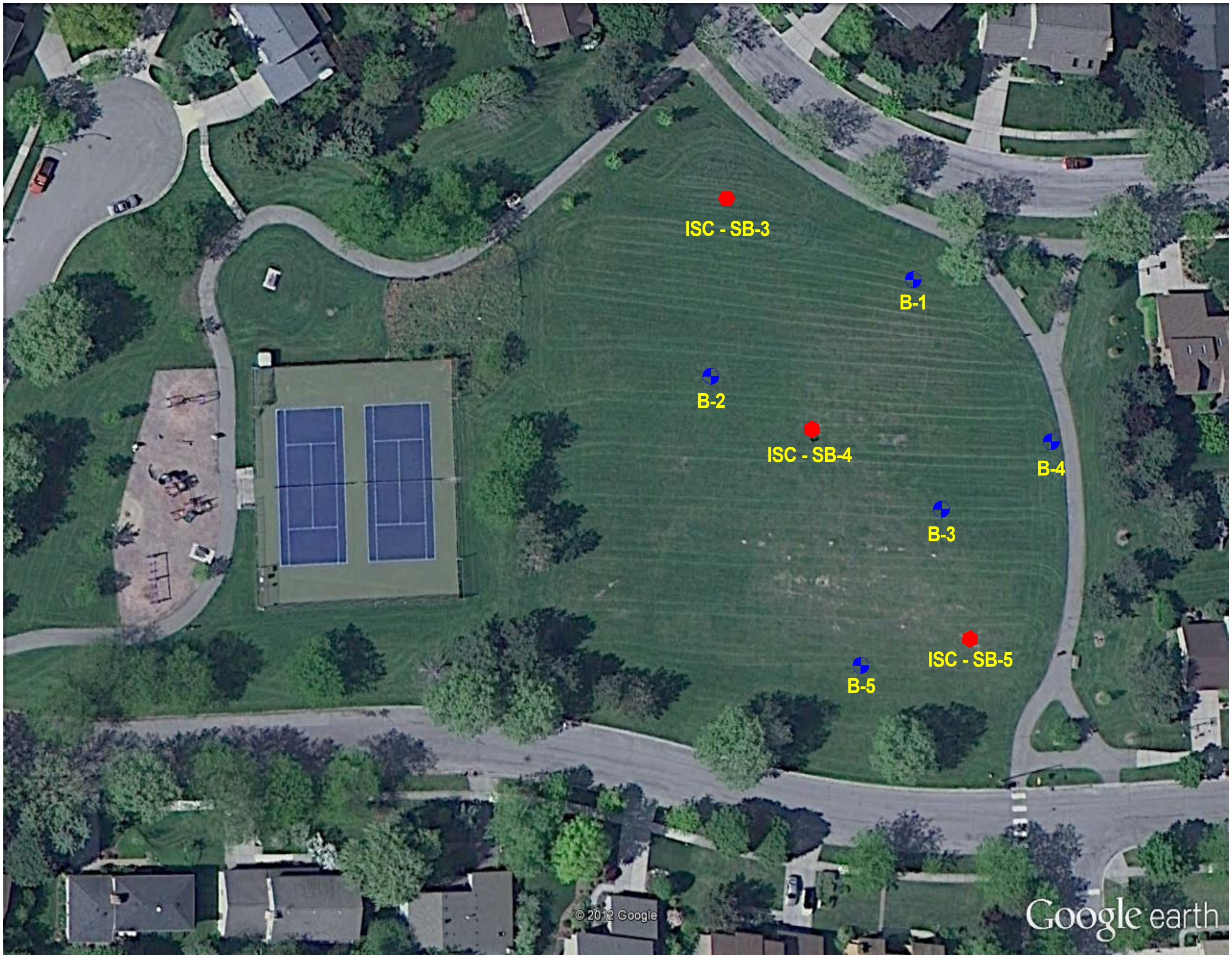
**CTI and ASSOCIATES, INC.**

Theresa M. Marsik, P.E., LEED AP
Senior Project Engineer

Kevin Foye, Ph.D., P.E.
Project Engineer

Attachments - Boring Location Plan
- Boring Logs:
  - CTI Boring Logs B-1 through B-5
  - ISC Boring Logs SB-3 through SB-5 (for reference only)
- Summary of Laboratory Test Results
- General Notes for Soil Classification

N




NOTE: IMAGE REPRODUCED FROM GOOGLE EARTH.

**LEGEND:**

- APPROXIMATE CTI BORING LOCATION
- ESTIMATED ISC BORING LOCATION

| | |
|---|---|
| SCALE: | As Shown |
| PROJECT NUMBER: | 3122040016 |
| FILE NAME: | BORINGPLAN.CAD |
| DATE: | 5-9-12 |

# BORING LOCATION PLAN

PROPOSED TENNIS COURTS - WINDEMERE PARK
ANN ARBOR, MICHIGAN

PLATE:
I

CTI and Associates, Inc.

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# BORING NUMBER B-1



**CLIENT** City of Ann Arbor - Parks and Recreation Services

**PROJECT NAME** Proposed Tennis Courts - Windemere Park

**PROJECT NUMBER** 3122040016

**PROJECT LOCATION** Ann Arbor, Michigan

**DATE STARTED** 5/3/12 **COMPLETED** 5/3/12

**GROUND ELEVATION** N/A

**DRILLING CONTRACTOR** Stearns Drilling

**GROUND WATER LEVELS:**

**DRILLING METHOD** 4-1/4-inch HSA

**DURING DRILLING** None

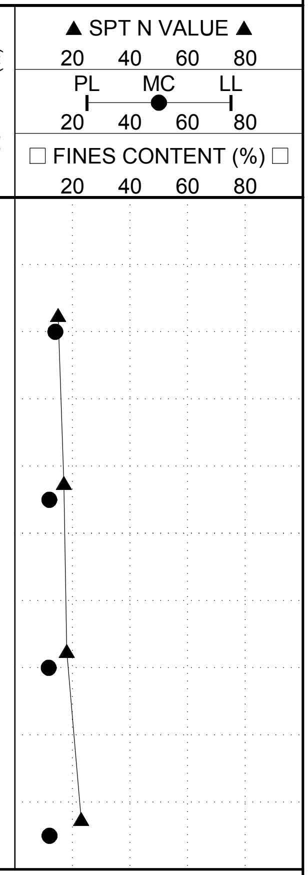
**LOGGED BY** J. Huntoon **CHECKED BY** T. Marsik

**AFTER DRILLING** None

**NOTES** Boring backfilled with auger cuttings

**COLLAPSE DEPTH** ---

| DEPTH (ft) | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) UNC. STRENGTH (psf) | NATURAL MOISTURE CONTENT (%) |
|---|---|---|---|---|---|---|
| 0 | 6 inches of brown sandy TOPSOIL | | | | | |
| | Brown and gray variegated moist hard CLAY with silt, traces of gravel and sand and occasional silt partings - (CL) | SS 1 | 100 | 4-7-8 (15) | 4.5+ | 14 |
| 5 | | SS 2 | 100 | 6-8-9 (17) | 4.5+ | 12 |
| | | SS 3 | 100 | 6-9-9 (18) | 4.5+ | 12 |
| 10 | | SS 4 | 100 | 7-11-12 (23) | 4.5+ | 12 |




Bottom of borehole at 10.0 feet.

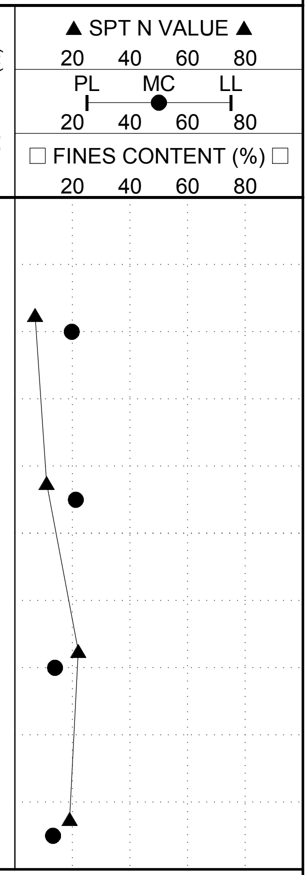
# BORING NUMBER B-2



CTI and Associates Inc

**CLIENT** City of Ann Arbor - Parks and Recreation Services
**PROJECT NAME** Proposed Tennis Courts - Windemere Park
**PROJECT NUMBER** 3122040016
**PROJECT LOCATION** Ann Arbor, Michigan
**DATE STARTED** 5/3/12 **COMPLETED** 5/3/12
**GROUND ELEVATION** N/A
**DRILLING CONTRACTOR** Stearns Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** 4-1/4-inch HSA
**DURING DRILLING** None
**LOGGED BY** J. Huntoon **CHECKED BY** T. Marsik
**AFTER DRILLING** None
**NOTES** Boring backfilled with auger cuttings
**COLLAPSE DEPTH** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) UNC. STRENGTH (psf) | NATURAL MOISTURE CONTENT (%) |
|---|---|---|---|---|---|---|---|
| 0 | | 6 inches of brown sandy TOPSOIL FILL | | | | | |
| | | Brown and dark gray variegated moist CLAY with silt, traces of sand and organics, frequent sand seams and occasional hair roots - (FILL)<br>Organic Content = 2.7% | SS 1 | 100 | 3-4-3 (7) | | 20 |
| | | Brown and gray variegated moist very stiff to hard CLAY with silt, traces of gravel and sand and occasional silt partings - (CL) | SS 2 | 100 | 4-5-6 (11) | 3.0 | 21 |
| 5 | | | SS 3 | 100 | 7-10-12 (22) | 4.5+ | 14 |
| 10 | | | SS 4 | 100 | 5-8-11 (19) | 4.5+ | 13 |




Bottom of borehole at 10.0 feet.

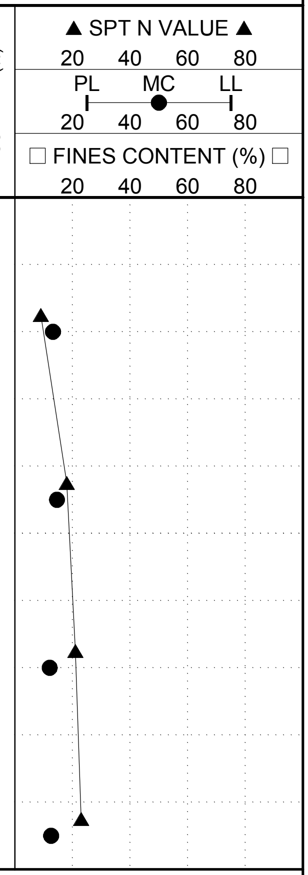
# BORING NUMBER B-3



CTI and Associates Inc

**CLIENT** City of Ann Arbor - Parks and Recreation Services
**PROJECT NAME** Proposed Tennis Courts - Windemere Park
**PROJECT NUMBER** 3122040016
**PROJECT LOCATION** Ann Arbor, Michigan
**DATE STARTED** 5/3/12 **COMPLETED** 5/3/12
**GROUND ELEVATION** N/A
**DRILLING CONTRACTOR** Stearns Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** 4-1/4-inch HSA
**DURING DRILLING** None
**LOGGED BY** J. Huntoon **CHECKED BY** T. Marsik
**AFTER DRILLING** None
**NOTES** Boring backfilled with auger cuttings
**COLLAPSE DEPTH** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) UNC. STRENGTH (psf) | NATURAL MOISTURE CONTENT (%) |
|---|---|---|---|---|---|---|---|
| 0 | | 6 inches of brown sandy TOPSOIL FILL | | | | | |
| | | Brown and dark gray variegated moist CLAY with silt, traces of sand and organics and frequent silt seams - (FILL) | SS 1 | 100 | 4-4-5 (9) | | 13 |
| | | Brown and gray variegated moist hard CLAY with silt, traces of gravel and sand and occasional silt partings - (CL) | SS 2 | 100 | 5-7-11 (18) | 4.5+ | 15 |
| 5 | | | SS 3 | 100 | 6-9-12 (21) | 4.5+ | 12 |
| 10 | | | SS 4 | 100 | 6-11-12 (23) | 4.5+ | 13 |




Bottom of borehole at 10.0 feet.

# BORING NUMBER B-4



CTI and Associates Inc

**CLIENT** City of Ann Arbor - Parks and Recreation Services

**PROJECT NAME** Proposed Tennis Courts - Windemere Park

**PROJECT NUMBER** 3122040016

**PROJECT LOCATION** Ann Arbor, Michigan

**DATE STARTED** 5/3/12 **COMPLETED** 5/3/12

**GROUND ELEVATION** N/A

**DRILLING CONTRACTOR** Stearns Drilling

**GROUND WATER LEVELS:**

**DRILLING METHOD** 4-1/4-inch HSA

**DURING DRILLING** None

**LOGGED BY** J. Huntoon **CHECKED BY** T. Marsik

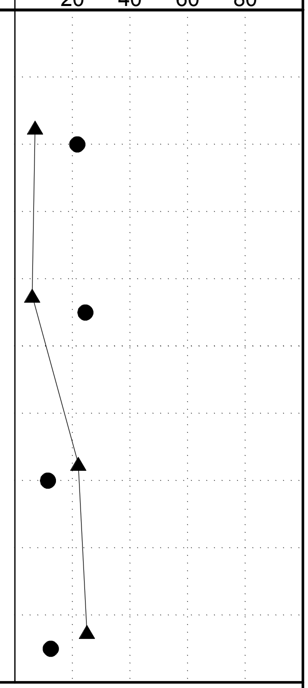
**AFTER DRILLING** None

**NOTES** Boring backfilled with auger cuttings

**COLLAPSE DEPTH** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) UNC. STRENGTH (psf) | NATURAL MOISTURE CONTENT (%) |
|---|---|---|---|---|---|---|---|
| 0 | | 8 inches of brown sandy TOPSOIL FILL | | | | | |
| | | Brown and dark gray variegated moist CLAY with silt, traces of sand and organics and occasional sand partings - (FILL)<br>Organic Content = 4.5% | SS 1 | 100 | 2-3-4 (7) | | 22 |
| 5 | | Brown, dark brown and gray variegated moist CLAY with silt and traces of sand and organics - (FILL)<br>Organic Content = 2.8% | SS 2 | 100 | 2-2-4 (6) | | 24 |
| | | Brown and gray variegated moist hard CLAY with silt, traces of gravel and sand and occasional silt partings - (CL) | SS 3 | 100 | 7-10-12 (22) | 4.5+ | 11 |
| 10 | | | SS 4 | 100 | 8-11-14 (25) | 4.5+ | 12 |

▲ SPT N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ FINES CONTENT (%) ☐ 20 40 60 80



Bottom of borehole at 10.0 feet.

# BORING NUMBER B-5



CTI and Associates Inc

**CLIENT** City of Ann Arbor - Parks and Recreation Services
**PROJECT NAME** Proposed Tennis Courts - Windemere Park
**PROJECT NUMBER** 3122040016
**PROJECT LOCATION** Ann Arbor, Michigan
**DATE STARTED** 5/3/12 **COMPLETED** 5/3/12
**GROUND ELEVATION** N/A
**DRILLING CONTRACTOR** Stearns Drilling
**GROUND WATER LEVELS:**
**DRILLING METHOD** 4-1/4-inch HSA
**DURING DRILLING** None
**LOGGED BY** J. Huntoon **CHECKED BY** T. Marsik
**AFTER DRILLING** None
**NOTES** Boring backfilled with auger cuttings
**COLLAPSE DEPTH** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) UNC. STRENGTH (psf) | NATURAL MOISTURE CONTENT (%) | ▲ SPT N VALUE ▲ 20 40 60 80; PL MC LL 20 40 60 80; ☐ FINES CONTENT (%) ☐ 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|
| 0 | | 6 inches of brown sandy TOPSOIL FILL | | | | | | |
| | | Brown and dark gray variegated moist CLAY with silt, traces of sand and organics and occasional sand partings - (FILL) | | | | | | |
| | | Organic Content = 2.6% | SS 1 | 100 | 7-6-5 (11) | | 15 | |
| | | Brown and gray variegated moist hard CLAY with silt, traces of gravel and sand and occasional silt partings - (CL) | SS 2 | 100 | 8-15-17 (32) | 4.5+ | 13 | |
| 5 | | | | | | | | |
| | | | SS 3 | 100 | 9-10-13 (23) | 4.5+ | 12 | |
| 10 | | | SS 4 | 100 | 6-7-10 (17) | 4.5+ | 13 | |

Bottom of borehole at 10.0 feet.

ISC **INSPECTION SERVICES COMPANY**

# LOG OF TEST BORING

| | |
|---|---|
| PROJECT: Windemere Park | |
| LOCATION: Ann Arbor, Michigan | |
| PROJECT NO. : 1291 | BORING NO. : SB-3 |
| DATE : 4/12/11 | PAGE : 1 of 1 |

| Elev. (ft) | SOIL DESCRIPTION | Depth (ft) | Sample Type | Blows/ 6-Inches | SPT* (N) | Moisture Content (%) | Dry Density (pcf) | Shear Strength ** (psf) |
|---|---|---|---|---|---|---|---|---|
| | Ground Surface 0.0' | | | | | | | |
| FILL | Dark brown sandy CLAY TOPSOIL(grass) 0.2' | | | | | | | |
| FILL | Stiff mottled medium & dark brown sandy CLAY trace gravel 2.6' | 1 | | | | | | |
| | | | | 3 | | | | |
| | | 2 | | 4 | | | | 3900 |
| | | | S-1 | 3 | 7 | | | |
| | Stiff black very sandy CLAY some organics 3.3' | 3 | | | | | | |
| | Stiff mottled brown & gray silty CLAY trace gravel 5.0' ▼ | 4 | | 3 | | | | |
| | | | | 4 | | | | 3800 |
| | | 5 | S-2 | 5 | 9 | | | |
| | 6.0' | 6 | | | | | | |
| | Hard mottled brown & gray silty CLAY trace gravel 6.8' ▽ | | | 6 | | | | 8200 |
| | Loose WET (6.8' -7.1') mottled brown & gray silty clayey medium SAND 7.1' | 7 | | 4 | | | | |
| | | | S-3 | 6 | 10 | | | 8000 |
| | Hard mottled brown & gray silty CLAY trace gravel 14.1' | 8 | | | | | | |
| | | 9 | | 7 | | | | |
| | | | | 12 | | | | >9000 |
| | | 10 | S-4 | 15 | 27 | | | |
| | | 11 | | | | | | |
| | | 12 | | | | | | |
| | | 13 | | | | | | |
| | Hard gray silty CLAY trace gravel 16.5' | 14 | | 13 | | | | |
| | | | | 15 | | | | >9000 |
| | | 15 | S-5 | 18 | 33 | | | |
| | | 16 | | | | | | |
| | Hard gray silty sandy CLAY trace gravel 22.6' | 17 | | | | | | |
| | | 18 | | | | | | |
| | | 19 | | 8 | | | | |
| | | | | 10 | | | | 9000 |
| | | 20 | S-6 | 11 | 21 | | | |
| | | 21 | | | | | | |
| | | 22 | | | | | | |
| | Very stiff gray silty CLAY trace gravel 24.7' ▽ | 23 | | | | | | |
| | | 24 | | 6 | | | | |
| | | | | 7 | | | | 4700 |
| | Medium compact WET gray silt 25.0' | 25 | S-7 | 14 | 21 | | | |
| | END OF BORING - 25.0' | | | | | | | |

| LEGEND | SAMPLE TYPE | DRILLING INFORMATION | |
|---|---|---|---|
| Topsoil | S-Split spoon sample | METHOD: | 4" solid-stem augers |
| Sand | LS- Liner sample | | |
| Clay | AS-Auger sample | CO. / REP: | |
| Silt | BS-Bulk sample | | G. Groenwood, P.E. |
| Gravel | ST-Shelby tube | BACKFILL: | Soil |
| Concrete | C-Core | | |

**REMARKS**

*Standard Penetration Test (N) : Driving 2" OD Sampler 18" with 140# Hammer Falling 30", Count made at 6" Intervals.

** Shear Strength Determined by Pocket Penetrometer

**FILL to 2.6'**

**GROUNDWATER**

| | |
|---|---|
| During: 7.1' and 24.7' ▽ | 0.5 Hrs After Completion: 5.0' ▼ |

**ISC** *INSPECTION SERVICES COMPANY*

# LOG OF TEST BORING

| | |
|---|---|
| PROJECT: Windemere Park | |
| LOCATION: Ann Arbor, Michigan | |
| PROJECT NO. : 1291 | BORING NO. : SB-4 |
| DATE : 4/12/11 | PAGE : 1 of 1 |

| Elev. (ft) | SOIL DESCRIPTION | Depth (ft) |
|---|---|---|
| | Ground Surface | 0.0' |
| | Brown very sandy CLAY TOPSOIL (grass) | 0.3' |
| | ▼ | 0.4' |
| | Very stiff brown sandy CLAY | 1.9' |
| | Very stiff brown silty CLAY | 2.9' |
| | Hard mottled brown & gray silty CLAY trace gravel ▽ | 7.2' |
| | Medium compact WET (7.2'-8.0') brown silty fine-medium SAND | 8.0' |
| | Very stiff brown silty sandy CLAY | 9.0' |
| | Very stiff mottled brown & gray silty CLAY trace gravel | 9.6' |
| | Hard mottled brown & gray silty CLAY trace gravel | 12.8' |
| | Very stiff gray silty CLAY ▽ | 15.2 |
| | Medium compact WET (15.2'-18.0') gray silty clayey fine-medium SAND | 18.0' |
| | Medium compact WET (18.0'-20.5') gray SILT | 20.5' |
| | Very stiff gray silty CLAY some seams of WET gray silty sand | 24.0' |
| | | 25.0' |
| | END OF BORING - 25.0' | |

| Depth (ft) | Sample Type | Blows/ 6-Inches | SPT* (N) | Moisture Content (%) | Dry Density (pcf) | Shear Strength ** (psf) |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| | | 3 | | | | 4300 |
| 2 | | 3 | | | | 5800 |
| | S-1 | 4 | 7 | | | |
| 3 | | | | | | |
| 4 | | 8 | | | | |
| | | 11 | | | | >9000 |
| 5 | S-2 | 15 | 26 | | | |
| 6 | | | | | | |
| | | 7 | | | | |
| 7 | | 10 | | | | |
| | S-3 | 10 | 20 | | | |
| 8 | | | | | | |
| 9 | | 5 | | | | 5500 |
| | | 8 | | | | 6000 |
| 10 | S-4 | 11 | 19 | | | 8500 |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | 7 | | | | |
| | | 8 | | | | 6500 |
| 15 | S-5 | 9 | 17 | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | 11 | | | | |
| | | 11 | | | | |
| 20 | S-6 | 13 | 24 | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | 5 | | | | |
| | | 7 | | | | 5200 |
| 25 | S-7 | 9 | 16 | | | |

| LEGEND | SAMPLE TYPE | DRILLING INFORMATION |
|---|---|---|
| Topsoil | S-Split spoon sample | METHOD: 4" solid-stem augers |
| Sand | LS- Liner sample | |
| Clay | AS-Auger sample | CO. / REP: |
| Silt | BS-Bulk sample | G. Groenwood, P.E. |
| Gravel | ST-Shelby tube | BACKFILL: Soil |
| Concrete | C-Core | |

**REMARKS**

*Standard Penetration Test (N) : Driving 2" OD Sampler 18" with 140# Hammer Falling 30", Count made at 6" Intervals.

** Shear Strength Determined by Pocket Penetrometer

**GROUNDWATER**

| | |
|---|---|
| During: 7.2' and 15.2' ▽ | 2.5 Hrs After Completion: 0.4' ▼ |

**ISC** *INSPECTION SERVICES COMPANY*

# LOG OF TEST BORING

| | |
|---|---|
| PROJECT: Windemere Park | |
| LOCATION: Ann Arbor, Michigan | |
| PROJECT NO.: 1291 | BORING NO.: SB-5 |
| DATE: 4/12/11 | PAGE: 1 of 1 |

| Elev. (ft) | SOIL DESCRIPTION | Depth to base | Depth (ft) | Sample Type | Blows/ 6-Inches | SPT* (N) | Moisture Content (%) | Dry Density (pcf) | Shear Strength ** (psf) |
|---|---|---|---|---|---|---|---|---|---|
| | Ground Surface | 0.0' | | | | | | | |
| | Dark brown sandy CLAY TOPSOIL (grass) | 0.3' | | | | | | | |
| | Stiff bown silty sandy CLAY | 1.2' | 1 | | | | | | 3800 |
| | ▼ | 1.5' | | | 4 | | | | |
| | Very stiff brown silty CLAY | 2.1' | 2 | | 4 | | | | 5300 |
| | | | | S-1 | 8 | 12 | | | >9000 |
| | Hard mottled brown & gray silty CLAY trace gravel | | 3 | | | | | | |
| | | | 4 | | 6 | | | | |
| | | | | | 9 | | | | >9000 |
| | | | 5 | S-2 | 12 | 21 | | | |
| | ▽ | 6.1' | 6 | | | | | | |
| | Loose WET (6.1'-6.7')mottled brown & gray silty SAND | 6.8' | | | 4 | | | | |
| | Very stiff mottled brown & gray silty CLAY trace gravel | 7.3' | 7 | | 3 | | | | 5600 |
| | | | | S-3 | 5 | 8 | | | >9000 |
| | Hard mottled brown and gray silty CLAY trace gravel | | 8 | | | | | | |
| | | | 9 | | 7 | | | | |
| | | | | | 11 | | | | >9000 |
| | | | 10 | S-4 | 15 | 26 | | | |
| | | | 11 | | | | | | |
| | | | 12 | | | | | | |
| | | | 13 | | | | | | |
| | | | 14 | | 10 | | | | |
| | | | | | 13 | | | | >9000 |
| | | | 15 | S-5 | 16 | 29 | | | |
| | | 15.8' | 16 | | | | | | |
| | Stiff gray silty CLAY | | 17 | | | | | | |
| | | | 18 | | | | | | |
| | ▽ | 18.4' | | | | | | | |
| | Med.compact WET (18.4'-19.7')brown silty fine SAND | 19.7' | 19 | | 4 | | | | 3600 |
| | | | | | 8 | | | | |
| | Medium compact WET (19.7'-20.3')brown fine SAND | 20.3' | 20 | S-6 | 10 | 18 | | | |
| | Stiff gray silty CLAY | | 21 | | | | | | |
| | | | 22 | | | | | | |
| | | | 23 | | | | | | |
| | | | 24 | | 4 | | | | |
| | | | | | 5 | | | | 2900 |
| | | 25.0' | 25 | S-7 | 8 | 13 | | | |
| | END OF BORING - 25.0' | | | | | | | | |

| LEGEND | SAMPLE TYPE | DRILLING INFORMATION | |
|---|---|---|---|
| Topsoil | S-Split spoon sample | METHOD: | 4" solid-stem augers |
| Sand | LS- Liner sample | | |
| Clay | AS-Auger sample | CO. / REP: | G. Groenwood, P.E. |
| Silt | BS-Bulk sample | | |
| Gravel | ST-Shelby tube | BACKFILL: | Soil |
| Concrete | C-Core | | |

**REMARKS**

*Standard Penetration Test (N) : Driving 2" OD Sampler 18" with 140# Hammer Falling 30", Count made at 6" Intervals.

** Shear Strength Determined by Pocket Penetrometer

**GROUNDWATER**

| During | 4.5 Hrs After Completion |
|---|---|
| During: 6.1' and 18.4' ▽ | 4.5 Hrs After Completion: 1.5' ▼ |

# SUMMARY OF LABORATORY RESULTS



CTI and Associates Inc

**CLIENT** City of Ann Arbor - Parks and Recreation Services

**PROJECT NAME** Proposed Tennis Courts - Windemere Park

**PROJECT NUMBER** 3122040016

**PROJECT LOCATION** Ann Arbor, Michigan

| Borehole | Depth | Liquid Limit | Plastic Limit | Plasticity Index | Maximum Size (mm) | %<#200 Sieve | Class-ification | Water Content (%) | Dry Density (pcf) | Unc. Strength (tsf) | Loss-on-Ignition (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 2.5 | | | | | | CL | 14 | | 4.5+ | |
| B-1 | 5.0 | | | | | | CL | 12 | | 4.5+ | |
| B-1 | 7.5 | | | | | | CL | 12 | | 4.5+ | |
| B-1 | 10.0 | | | | | | CL | 12 | | 4.5+ | |
| B-2 | 2.5 | | | | | | FILL | 20 | | | 2.7 |
| B-2 | 5.0 | | | | | | CL | 21 | | 3.0 | |
| B-2 | 7.5 | | | | | | CL | 14 | | 4.5+ | |
| B-2 | 10.0 | | | | | | CL | 13 | | 4.5+ | |
| B-3 | 2.5 | | | | | | FILL | 13 | | | |
| B-3 | 5.0 | | | | | | CL | 15 | | 4.5+ | |
| B-3 | 7.5 | | | | | | CL | 12 | | 4.5+ | |
| B-3 | 10.0 | | | | | | CL | 13 | | 4.5+ | |
| B-4 | 2.5 | | | | | | FILL | 22 | | | 4.5 |
| B-4 | 5.0 | | | | | | FILL | 24 | | | 2.8 |
| B-4 | 7.5 | | | | | | CL | 11 | | 4.5+ | |
| B-4 | 10.0 | | | | | | CL | 12 | | 4.5+ | |
| B-5 | 2.5 | | | | | | FILL | 15 | | | 2.6 |
| B-5 | 5.0 | | | | | | CL | 13 | | 4.5+ | |
| B-5 | 7.5 | | | | | | CL | 12 | | 4.5+ | |
| B-5 | 10.0 | | | | | | CL | 13 | | 4.5+ | |

CTI and Associates, Inc.

# GENERAL NOTES FOR SOIL CLASSIFICATION

51331 W. Pontiac Trail Wixom, MI 48393 248.486.5100 Main 248.486.5050 Fax

**STANDARD PENETRATION TEST: Driving a 2" outside diameter, 1-3/8" inside diameter sampler a distance of 18 inches into undisturbed soil with a 140 pound hammer free falling a distance of 30 inches. The sampler is driven three successive 6-inch increments. The number of blows required for the last 12 inches of penetration is termed the Standard Penetration Resistance (N).**

**GROUNDWATER: Observations are made at the times indicated on logs. Porosity of soil strata, weather conditions and site topography may cause changes in the water levels.**

**SOIL CLASSIFICATION PROCEDURE: Classification on the logs is generally made by visual inspection. For fine-grained soils (silt, clay and combinations thereof), the classification is primarily based upon plasticity. For coarse-grained soils (sand and gravel), the classification is based upon particle size distribution. Minor soil constituents are reported as "trace" (0-5%), "some" (5-12%) and "with" (15-29%). Where the minor constituents are in excess of 29%, an adjective is used preceding the major constituent name (i.e. for sands containing 35% silt, the soil is classified as silty sand).**

## PARTICLE SIZE DISTRIBUTION

| | | |
|---|---|---|
| Boulders | - | Greater than 12 inches average diameter |
| Cobbles | - | 3 inches to 12 inches |
| Gravel – | | |
| Coarse | - | ¾ inches to 3 inches |
| Fine | - | No. 4 (4.75mm) to ¾ inches |
| Sand – | | |
| Coarse | - | No. 10 (2.00mm) to No. 4 (4.75mm) |
| Medium | - | No. 40 (0.425mm) to No. 10 (2.00mm) |
| Fine | - | No. 200 (0.075mm) to No. 40 (0.425mm) |
| Silt and Clay | - | Less than 0.075mm, Classification based upon plasticity. Generally silt particles size ranges from 0.005mm to 0.075mm and clay particle size is less than 0.005mm. |

## CONSISTENCY OF FINE GRAINED SOILS IN TERMS OF UNCONFINED COMPRESSIVE STRENGTH AND N-VALUES

| Consistency | Unconfined Compressive Strength (Tons per square foot) | Approximate range of N |
|---|---|---|
| Very Soft | Less than 0.25 | 0 - 2 |
| Soft | 0.25 to 0.5 | 3 - 4 |
| Medium Stiff | 0.5 to 1.0 | 5 - 8 |
| Stiff | 1.0 to 2.0 | 9 - 15 |
| Very Stiff | 2.0 to 4.0 | 16 - 30 |
| Hard | over 4.0 | over 31 |

## RELATIVE DENSITY OF COARSE GRAINED SOILS ACCORDING TO N-VALUES

| Density Classification | Relative Density, % | Approximate Range of N |
|---|---|---|
| Very Loose | 0 – 15 | 0 – 4 |
| Loose | 16 – 35 | 5 – 10 |
| Medium Dense | 36 - 65 | 11 - 30 |
| Dense | 66 - 85 | 31 – 50 |
| Very Dense | 86 – 100 | over 50 |

**Relative density of cohesionless soils is based upon an evaluation of the Standard Penetration Resistance (N), modified as required for overburden pressure.**