APPENDIX H

GEOTECHNICAL ENGINEERING REPORTS AND CORRESPONDENCE

Appendix H-1
Geotechnical Engineering Services Report, Phase I of the Bluff Area Stability Evaluation, PS&S

July 25, 2008

GEOTECHNICAL ENGINEERING SERVICES

BLUFF AREA STABILITY EVALUATION – PHASE I

Prepared for:

INDIAN HILLS COUNTRY CLUB
21 Breeze Hill Road
Northport, New York

JULY 25, 2008

Prepared by:

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July 25, 2008
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Mr. Joseph Caputo
General Manager
Indian Hills Country Club
21 Breeze Hill Road
Northport, New York 11768

RE: Geotechnical Engineering Services
Bluff Area Stability Evaluation – Phase I
Indian Hills Country Club, Northport, New York

Dear Mr. Caputo:

Paulus, Sokolowski and Sartor Engineering, PC (PS&SPC) is pleased to present Phase I of the evaluation of the bluff area stability at the Indian Hills Country Club (IHCC) golf course in Northport, New York. The purpose of the Phase I evaluation was to obtain and review available historical site and subsurface information, monitor surficial movements, and recommend an appropriate future Phase II subsurface investigation and instrumentation program based upon the collected data. The professional services for this project were performed by Paulus, Sokolowski and Sartor, LLC (PS&S) under subcontract to PS&SPC in accordance with our February 15, 2008 proposal which was accepted on March 13, 2008. This report follows our earlier presentation to IHCC on June 6, 2008.

PROJECT AND SITE DESCRIPTION

The Indian Hills Country Club (IHCC) is located on the north shore of Long Island at 21 Breeze Hill Road in Northport, Town of Huntington, Suffolk County, New York; see Figure 1 for a map of the site vicinity. IHCC is bordered to the north by Long Island Sound, to the east by Fresh Pond Road, and to the south and west by residential properties. The northern end of the IHCC consists of bluffs, beach shorelines, and a stone riprap revetment wall up to about 15 feet tall which reportedly was constructed in 2002 to control erosion at the toe of the slope. The northern portion of IHCC is located within the coastal erosion zone which is regulated by the New York State Department of Environmental Conservation (NYSDEC).

A crescent-shaped escarpment exists along the northern edge of the 6th hole; see Figure 2 for an illustration of the project site area and relevant features (e.g. holes, fairways, and greens) discussed herein. The escarpment is about 2300 feet long and has a near vertical face about 30 to 40 feet high near the center. Grades continue to slope downward about 35 to 50 feet from the base of the escarpment to the 13th fairway (about 65 to 90 feet below the 6th hole) at gradients of about 2H:1V (horizontal:vertical). The escarpment and transition slopes from the 6th hole to the 13th fairway are wooded. From the 13th fairway, the site slopes downward again about 15 to 35 feet to the 12th fairway, and then downward again about 25 to 55 feet from the 12th fairway to the rip rap revetment wall, the beach, and the Long Island Sound. The transition slopes from the 13th fairway to the 12th fairway and from the 12th fairway to the rip rap revetment wall are grass covered with gradients ranging from about 2H:1V to 3H:1V.

The landslide, which resulted in the formation of the escarpment along the 6th hole, has reportedly been ongoing for many years and has been documented in professional papers dating back to 1904. The 6th hole is located along the edge of the landslide, and the 12th and 13th holes, with the exception of the 13th green, are located within the landslide area.

IHCC reported that the rate of ground movement was about 1 to 2 inches per year prior to 2004. In 2004, drywells were installed in the 12th and 13th fairways at the direction of the Town of Huntington as surface water control measures. Since 2004, the rate of ground movement according to IHCC has increased to about 5 to 6 feet per year.

PURPOSE AND SCOPE

The purpose of PS&S's geotechnical evaluation is to determine the mode of failure and most probable cause of the differential movement and to provide recommendations to IHCC for remediation of the area, as warranted. However, it is our opinion that our services should be performed in a phased approach as described in our February 15, 2008 proposal. As such, the information, data, discussions and evaluations presented herein are related to the Phase I portion of our evaluation.

The objective of the Phase I portion of our evaluation was to build a foundation on which to proceed further with future investigations, evaluations, and analyses. The scope of Phase I comprised the following tasks:

- Obtain and review readily available historical site data and subsurface information;
- Perform a current topographic survey of the study area;
- Compare the results of our topographic survey to earlier topographic surveys prepared by other consultants;
- Establish 16 surface monitoring points throughout the landslide;
- Monitor surficial horizontal and vertical movements of each monitoring point on a bi-weekly basis over a period of about 15 weeks;
- Evaluate the collected data to determine the magnitude, direction, and rate of horizontal and vertical movements of the study area over the monitoring time period;
- Compare the results of the monitoring point data with readily available rainfall data to evaluate any apparent correlations; and,
- Prepare a summary report of our evaluation along with recommendations for an appropriate future Phase II subsurface investigation and instrumentation program.

In the future Phase II portion of the evaluation, PS&S would perform the recommended geotechnical subsurface investigation, install and monitor the geotechnical instrumentation (e.g.

inclinometers and piezometers), perform laboratory tests and analyses on samples of the subsurface soils, create detailed interpretative cross sections from the obtained subsurface data, perform stability sensitivity analyses, evaluate the data and results of the stability analyses to provide an engineering opinion regarding the likely mode of failure and most probable cause of the differential movement, and provide recommendations for remediation of the area, as warranted. Actual design of the remediation system(s) would occur during Phase III.

REVIEW OF AVAILABLE INFORMATION

We reviewed readily available regional geologic information, historical documents, historical topographical surveys, and data from previous subsurface investigations provided to us. Pertinent information obtained from the above documents is summarized in the following paragraphs.

Regional Geology

The 1970 Geologic Map of New York, Lower Hudson Sheet, published by the New York State Geological Survey, reprinted 1995, indicates that the site is situated within the Magothy Formation of the Coastal Plain Physiographic Province. The Magothy Formation generally consists of silty clay, sandy clay, sand and gravel.

The 1989 Surficial Geologic Map of New York, Lower Hudson Sheet, published by the New York State Geological Survey, indicates the surficial soils at the site consist generally of glacial till moraine. Moraine soils were typically deposited adjacent to the glacial ice, are more variably sorted than glacial till, and are generally less dense and more permeable than glacial till.

Historical Documents

PS&S obtained and reviewed Professional Paper 82, titled Geology of Long Island, New York, dated 1914 (Paper), published by the United States Geological Survey (USGS). The Paper identifies the existing landslide at IHCC as the "Broken Ground" slide. In 1904, this slide was reportedly the largest on Long Island and was described as follows:

> "The north face of the hill, which has an elevation of 100 feet, has been converted by the slides into a confused jumble of earth masses and prostrate trees. On passing northward over the crest one suddenly comes to a fault scarp varying in height from 5 feet at the ends to 30 or 40 feet at the center. At the base of the scarp is a broad shelf 50 yards across, representing the surface that was dropped by the fault. Beyond this is a succession of slip faults separating narrow tilted blocks, the whole grading off to the more confused earth heaps at the base. In 1904, many of the faults were still open to a depth of 5 to 10 feet. The whole disturbed area has a length of nearly half a mile and a width between an eighth and a quarter of a mile."

The area described as the "broad shelf 50 yards across" is likely the current layout of the 13th fairway which is still about 50 yards across but is now about 65 to 90 feet below the crest of the bluff; whereas, in 1904, it was reportedly only about 30 to 40 feet below the crest. Although there has been significant vertical and horizontal movement within the landslide mass since 1904, the current boundaries (location, length, and width) of the escarpment are still roughly the same as reported in 1904.

As presented in the Paper, the subsurface conditions in the area of the landslide generally consist of sand and gravel overlying clay. The Paper describes the underlying clays as very plastic when wet. The Paper also documents that "there are many places where the plastic clays have been pressed out upon the beach in contorted masses"; and "In every clay slide observed [on Long Island], the clay beds themselves seem to have moved, as indicated by the contorted structure they have assumed." The Paper suggests that softening of the clays may be the reason for the differential movement based on visual observations of the contorted and pressed out clay masses at the toe of the landslides. This observation also suggests that the lowest portion of the failure surface passes through the clay stratum and maybe planar rather than circular. However, the Paper goes on to explain that the actual reasons for the landslides have not been able to be proven because of the absence of good subsurface data and cross sections. Almost 100 years later in 2008, there is still an absence of good subsurface data and cross sections to determine the mode of failure and most probable cause of the differential movement.

Comparison of Topographical Surveys

PS&S obtained and reviewed topographic surveys dated 2000, 2002, and 2003 of portions of the bluff area. The 2000 topography was obtained from the plan titled Topographic Survey of Portion of Indian Hills Country Club, prepared by Albert W. Tay, dated November 21, 2001. The 2002 topography was obtained from the plan titled Topographic Survey of Portion of Indian Hills Country Club, prepared by Albert W. Tay, dated January 15, 2003. The 2003 topography was obtained from the plan titled 12th and 13th Holes Grading & Drainage Plan, prepared by Steven J. Hyman, dated April 15, 2003.

PS&S also performed a topographic survey of the bluff area as part of this evaluation. A comparison of the above-referenced earlier topographic surveys to the current 2008 topographic survey prepared by PS&S indicates that the ground surface generally has moved downward and laterally northward toward the Long Island Sound. The current 2008 topography also indicates that the rip rap revetment wall (beach shoreline erosion protection) reportedly constructed in 2002, is now, in some areas, up to about 17 feet further north than when it was constructed. The top of the wall, in some areas, is now about 4 feet lower than when it was constructed in 2002. Estimated cross sections depicting the earlier and current topography are presented in Figure 3.

Review of Previous Subsurface Investigations

Subsurface investigations have previously been performed at IHCC. Some of these investigations, as described below, were performed in the subject area of the bluffs.

- In September 2007, a subsurface investigation was performed by Roux Associates, Inc. as part of their October 19, 2007 Bluff Area Feasibility Study. The investigation consisted of drilling two borings, identified as SB-B1 and SB-B2, along the 13th hole to depths of about 82 feet and 57 feet, respectively, below the surface, and drilling two borings, identified as SB-C1 and SB-C2, along the 12th hole to depths of 52 feet and 19 feet, respectively, below the surface.

- In August 2001, a subsurface investigation performed by Nelson and Pope, LLP included drilling two borings, identified as B-14 and B-15, along the 6th hole at the top of the bluffs to depth of about 50 feet below the surface.

- In August 1994, a subsurface investigation performed by Soil Mechanics Drilling Corp. included drilling two borings, identified as B-4A and B-5A, along the 13th hole to depths of 100 feet and 50 feet, respectively, below the surface.

The subsurface data obtained from these previous investigations has been reviewed and pertinent information has been included in our evaluation. The approximate locations of the previously performed borings in the area of the bluffs are identified on Figure 2.

Subsurface Conditions

Based on a review of the available boring data obtained by others, the generalized subsurface stratigraphy consists of loose to medium dense sand overlying very stiff clay. The following paragraphs briefly describe the reported soil conditions encountered by other consultants.

6th Hole: Borings B-14 and B-15 were reportedly drilled near the 6th tee and 6th green, respectively, to depths of about 50 feet below the surface. The borings reportedly encountered loose to medium dense brown sand with variable amounts of gravel, which transitioned to medium dense fine sand with some silt at about 43 feet below the surface. The fine sand reportedly extended to the termination depth of the borings. In boring B-14 at a depth of about 33 feet below the surface, an approximately 10-foot thick layer of very stiff brown clayey silt and silty clay was encountered.

12th Hole: Boring SB-C1 was located in the 12th fairway near the 150-yard marker and encountered about 35 feet of loose sand overlying very stiff clay which extended to the termination depth of the boring at about 52 feet below the surface. However, no sand was encountered in boring SB-C2 which was located near the 12th tee on the western edge of the site and encountered silt and clay from the surface to the termination depth of the boring at about 19 feet. At about 5 feet below the surface the consistency of the silty clay transitioned from very soft to very stiff.

13th Hole: Borings SB-B1, SB-B2, and B-4A were located in the 13th fairway between the 100-yard marker and the 200-yard marker, and boring B-5A was located west of the 13th green. Beneath the fairway, the borings encountered about 42 to 65 feet of loose to medium dense sand overlying very stiff silt and clay to the termination depth of the borings.

Groundwater: Static groundwater levels were not reported to be encountered in any of the borings; however, the soils near the sand/clay interface beneath the 13th fairway were reported to be wet.

SURFACE MONITORING DATA

On March 24, 2008, PS&S established 16 surface monitoring points throughout the subject area to periodically monitor horizontal and vertical movements of the ground surface over a period of about 15 weeks. These monitoring points were surveyed eight times at intervals ranging from 13 to 20 days from March 24, 2008 through July 8, 2008. A summary of the results of the surface monitoring is presented below and graphical data are presented in the Appendix.

During the monitoring period, surface monitoring points located within the landslide impacted area typically moved to the north about 3.2 to 7.2 inches and settled up to about 4.4 inches with total movements ranging from about 4.5 to 7.4 inches. This magnitude of movement observed over the monitoring period of 106 days represents a calculated average rate of total movement ranging between about 0.04 and 0.07 inches per day; for comparison purposes, 1/16 inches per day equals 0.0625 inches per day.

PS&S also compared the monitoring data with readily available published rainfall data for the same time period, and there appears to be a direct correlation with the amount of rainfall and the amount of surficial movement; in summary, surficial movement increases when rainfall increases. The monitoring period was performed over a relatively short time frame near the end of the wet season and partially into the drier hot summer months. In addition, precipitation was below average during the monitoring period (April, May and June), so surficial movements observed during this time period may have been less than average and movements greater than what PS&S documented should be anticipated. To confirm the apparent correlation between surface movement and precipitation, the surface monitoring should be continued.

DISCUSSION AND EVALUATION

Based on our review of the historical data and surface monitoring, the landslide continues to move generally in a northerly direction and the ground continues to settle. Historical documents indicate this movement has been ongoing since well before 1904. However, the boundaries (location, length and width) of the landslide appear to be roughly the same since 1904. As the land continues to slide down and to the north, the near vertical escarpment along the 6th hole will continue to increase in height. Consequently, the exposed slope will gradually erode and slough down to a more stable slope which will likely encroach into the 6th tee and green. This process will continue to repeat itself until the landslide mass achieves stability at which point the driving forces and resisting forces are equalized.

At this point, neither the cause of the landslide nor the mode of failure can be predicted without further subsurface investigations and specific stability analyses. At some point in time, prior to 1904, the resisting forces exceeded the driving forces and the bluffs were stable. Then the slope became unstable and a section of the bluffs began to slide. Slopes become unstable by either an increase in the driving forces, a decrease in the resisting forces, or a combination of both. Driving forces are typically increased when weight is added to the upper portion of the slope by water infiltration, fill placement, or surcharge loads (i.e. loads from traffic or structures). Resisting forces are typically decreased when the weight of soil is reduced at the lower portion or toe of the slope by either natural processes (i.e. erosion or scour along the water's edge) or mechanical excavation. It is also possible to decrease the resisting forces by lowering the shear strength of the supporting soils. An increase in the soil moisture content soil may result in a softening of the soil and a decrease of the shear strength of that soil. As such, groundwater plays an important factor in the stability of a slope because it can reduce the resisting force and increase the driving force.

As previously discussed, there appears to be a correlation of the ground movement with rainfall data. The golf course superintended reportedly has observed minor land movement after periods of little precipitation, and major land movement after periods of significant precipitation. This generally agrees with our surface point monitoring data when comparing it to the rainfall data. In addition, since construction of the drywells in 2004, the rate of movement reportedly has significantly increased.

At this time, we know that groundwater has a direct effect on the ground movement. However, the mode of failure (wedge, circular, or translational), the extent of the failure surface (shallow or deep), and the properties of the foundation soils have not been adequately defined by the previous geotechnical investigations. Specifically, it is likely that many of the borings did not extend sufficiently deep to confidently intersect the failure surface, nor did the earlier studies include geotechnical strength testing. The location (depth and shape) of the failure surface, the depth to groundwater, and the shear strength of the soil are parameters needed to perform a proper slope stability analysis. While some of these input parameters can be estimated or assumed, confidence in the results of the stability analyses is, thereby, correspondingly reduced.

The results and conclusions of our Phase I evaluation confirm that the current instability is a major landform process that has been taking place for a century or more. There may be multiple factors contributing to instability of the bluff and until all the factors are adequately and confidently defined, remediation measures mitigating only some of the factors will likely not prevent future ground movements. While the revised surface water drainage system implemented in 2004 seems to have accelerated recent movements, the underlying cause of the instability is independent of current site activities. A proper understanding of the underlying cause and failure mode are crucial to evaluating appropriate further remediation measures. The previous investigations, while extremely useful, are insufficient and additional borings and stability studies are needed.

At this time, the appropriate future remediation measures cannot be determined with confidence. Additional studies are necessary to further evaluate the subsurface conditions and confirm the mode of failure and failure surfaces so that effective mitigation measures can be recommended, designed and implemented, and the effectiveness of such measures can be confidently predetermined. However, the range of possible remediation measures may include the following:

- Construct major stabilization measures in an effort to achieve a factor of safety greater than unity and halt the movements;
- Implement less extensive remedial measures in an effort to slow the ongoing movements so that a program of periodic maintenance and repairs can be developed; or
- Abandon and relocate the impacted areas.

After we have developed a clear understanding of the most probable cause and mode of failure, PS&S can then evaluate the appropriate remediation response alternatives and coordinate with appropriate specialty contractors so that order of magnitude cost estimates can be formulated. IHCC's selection of the appropriate future action would be a function of both cost and risk acceptance.

RECOMMENDED PHASE II EVALUATION

As discussed above and during our June 6, 2008 meeting, evaluation of the appropriate remedial measures depends on a proper understanding of the failure surface and the associated failure mechanism. As such, prior to design of a remediation system, a more comprehensive geotechnical engineering investigation and monitoring program should be performed as Phase II of the evaluation. The purpose of Phase II would be to determine the mode of failure and probable cause of the differential movement, and to provide recommendations for remediation, if warranted.

The Phase II evaluation would consist of performing a geotechnical subsurface investigation with deep borings, installing and monitoring geotechnical instrumentation including inclinometers and vibrating wire piezometers, performing laboratory testing and analysis of the subsurface soils, and evaluating the data to determine the mode of failure and most probable cause of the differential movement. The objective of Phase II would also be to evaluate general recommendations for remediation of the area. Remedial concepts should be evaluated in Phase II, and detailed design of the proposed remediation system(s) would be performed in Phase III.

At this time, based on the information known to date, the minimum Phase II investigation should consist of the installation of at least two borings, two inclinometers, and two vibrating wire piezometers along the 12th and 13th fairways near the 150-yard markers. The borings and instruments should be advanced deep into the underlying clay to depths of at least 100 feet in the 12th fairway and 150 feet in the 13th fairway. Continuous sampling should be performed in the underlying clay in an attempt to evaluate the subsurface failure boundaries and to obtain samples for laboratory testing. Inclinometer casing should be installed into each borehole for the purposes of evaluating subsurface movement and confirming failure boundaries. Vibrating wire piezometers (VWP) with multiple transducers should be attached to each inclinometer casing to determine ground water elevations and evaluate fluctuations in ground water levels.

CLOSURE

PS&SPC appreciates the opportunity to provide continuing services to Indian Hills Country Club. If you have any questions regarding this report or require further information, please contact us.

Very truly yours,

PAULUS, SOKOLOWSKI AND SARTOR ENGINEERING, PC

Walter W. Burke, P.E.
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FIGURES

Site Location Map
Location Plan
Estimated Sections