APPENDIX A

GEOTECHNICAL REPORT

Dated October 21, 2008

The attached Geotechnical Engineering Investigation and dewatering ground water sampling was accomplished for the utilization of the Design Engineer during the design phases of this project. The criteria and recommendations stated herein are not to be construed as direction from the Design Engineer to the Contractor and are hereby provided only as general information, furnished as a courtesy to the Contractor.
Report of Subsurface Exploration and Geotechnical Engineering Evaluation
Tealwood Cove/Lakewood Forest/Tuckaway Terrace
Water and Wastewater System Improvements
Orange County, Florida
Dear Mr. Sanders:

Nodarse & Associates, Inc. (N&A) is pleased to present this report of our subsurface exploration and geotechnical engineering evaluation for the referenced project. This evaluation was performed in general accordance with our revised proposal for geotechnical services dated March 7, 2008. The purpose of the exploration was to obtain geotechnical engineering data to assist in the design/construction of water and wastewater improvements at the above-referenced site. The report describes our exploration procedures, exhibits the data obtained and presents our geotechnical evaluation.

PROJECT AND SITE DESCRIPTION

The project site is located in Section 29, Township 21 South, and Range 29 East in northern Orange County, Florida. The project concerns water and wastewater infrastructure improvements within the existing Tealwood Cove, Lakewood Forest, and Tuckaway Terrace residential subdivisions.

According to information provided by you, proposed improvements are to include the following:

- Installation of approximately 17,250 linear feet of new PVC water mains within rights-of-way alongside existing streets throughout the subdivisions, to be installed at a depth of 3 to 5 feet.
- Excavation and replacement of seven (7) manholes located along Contoura Drive, to be installed at a depth of 6 to 10 feet.
- Installation of approximately 2,100 linear feet of new gravity sewer mains along Contoura Drive, to be installed at a depth of about 7 feet.
- Replacement of an existing pump station. The new pump station is to be installed at a depth of about 20 feet.
- Expansion of an existing wet-bottom stormwater pond.

Review of the USGS Quadrangle Map (Figure 1 in the Appendix) indicates Lake Hill, located northeast of the subdivision, as having a recorded water elevation of +61 feet NGVD. Ground surface elevations within the subdivision generally slope downwards to the east and north towards Lake Hill, and range from +110 feet NGVD to the lake level. In addition, the quadrangle map indicates the presence of a very small low-lying area in the southeastern portion of the project area, prior to the development of that section.

Review of the United States Department of Agriculture (USDA)/Soil Conservation Service (SCS) Map of Orange County, Florida for the vicinity of the project site (Figure 2 in the Appendix) indicates that the near surface soil types present on the site are:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Description</th>
<th>Depth to Seasonal High Groundwater Table Under Natural Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Candler-Urban land complex, 0 to 5 percent slopes</td>
<td>Greater than 80 inches</td>
</tr>
<tr>
<td>45</td>
<td>Smyrna-Urban land</td>
<td>Less than 10 inches (in undrained areas)</td>
</tr>
<tr>
<td>47</td>
<td>Tavares-Millhopper fine sands, 0 to 5 percent slopes</td>
<td>40 to 72 inches</td>
</tr>
<tr>
<td>48</td>
<td>Tavares-Urban land complex, 0 to 5 percent slopes</td>
<td>40 to 80 inches (in undrained areas)</td>
</tr>
</tbody>
</table>

In addition, areas of Samsula-Hontoon-Basinger association soils, associated with seasonal high groundwater levels at or above existing grade and with surface organic soils, were mapped around the perimeter of Lake Hill. However, this soil type is not mapped in areas where construction is anticipated.
SOIL AND GROUNDWATER CONDITIONS

Subsurface Soil Conditions: The general subsurface soil conditions within the site were explored and evaluated from the following:

- Nine (9) Standard Penetration Test (SPT) borings (TB-1 through TB-7, TB-9, TB-10) to depths of 20 to 30 feet performed in proposed manhole locations and along the proposed gravity sewer main alignment along Contoura Drive.
- One (1) SPT boring (TB-8) to a depth of 30 feet, performed near the proposed pump station location and near the proposed pond expansion area. One (1) relatively undisturbed soil sample was also obtained from this boring at a depth of about 5 feet for laboratory permeability testing.
- Twenty-five (25) hand auger borings (HA-1 through HA-25) to depths of up to 10 feet, performed along the proposed water main alignment throughout the subdivision.
- Visual classification of recovered soil samples with soil classification.

Borings were located in the field by referencing existing site features and measuring from selected features. The locations should be considered approximate. The approximate locations of the soil borings are presented on Figure 3 in the Appendix.

With the exception of Borings TB-9 and TB-10, the SPT borings were initially augered to a depth of up to 2 feet to clear the existing pavement section (borings TB-1 through TB-7) or to a depth of 6 feet due to the presence of nearby buried utilities. Standard Penetration Tests (SPT) were then performed continuously in the SPT borings to a depth of 10 feet and at 5 foot depth intervals thereafter. Each sample was removed from the sampler in the field and was examined and visually classified by an engineering technician. Representative portions of each sample were packaged and sealed for transportation to our laboratory for further examination and visual classification. Water levels were measured in the boreholes at the time of our field exploration to evaluate the depth to groundwater.

The hand auger borings consisted of manually turning a 3-inch diameter, 6-inch long sampler into the soil until it was full. The sampler was then retrieved and the soils in the sampler were visually examined and classified. The procedure was repeated until the desired termination depth was achieved.
The following soil strata were encountered in the borings:

<table>
<thead>
<tr>
<th>Stratum No.</th>
<th>Material Description</th>
<th>Unified Soil Classification Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gray to brown fine sand to fine sand with silt</td>
<td>SP, SP-SM</td>
</tr>
<tr>
<td>2</td>
<td>Dark brown and dark reddish-brown fine sand with silt to silty fine sand</td>
<td>SP-SM, SM</td>
</tr>
<tr>
<td>3</td>
<td>Reddish-brown to orange-brown fine sand with silt to silty fine sand, with cementation (hardpan)</td>
<td>SP-SM, SM</td>
</tr>
<tr>
<td>4</td>
<td>Brown silty fine sand</td>
<td>SM</td>
</tr>
<tr>
<td>5</td>
<td>Gray clay</td>
<td>CH</td>
</tr>
<tr>
<td>6</td>
<td>Light brown clayey sand</td>
<td>SC</td>
</tr>
</tbody>
</table>

In general, the hand auger borings encountered Stratum 1 soils from existing grade to the boring termination depths of 10 feet. Stratum 3 soils (hardpan) were encountered in two of the hand auger borings (HA-13 and HA-14) at depths of about 3 to 8 feet. The SPT borings generally encountered soils from Strata 1, 2, and 4 from existing grade to the boring termination depths of 20 to 30 feet. Borings TB-1 and TB-2 encountered very dense layers of Stratum 3 soils at depths of about 3 to 10 feet. For details at the individual boring locations, refer to the boring profiles on Figures 4 and 5 in the Appendix.

**Groundwater Table:** Groundwater levels were measured in the open boreholes at the time of drilling (September 2008).

Groundwater was measured at depths of 2 feet below existing grade to not encountered below a depth of 10 feet in the hand auger borings. In the SPT borings performed along Contura Drive, groundwater generally was encountered from 6 to 12 feet below existing grade. Groundwater was not encountered to a depth of 10 feet in Boring TB-6. A perched groundwater condition...
resulting from near-surface very dense soils was encountered at a depth of about 4.5 feet in Boring TB-2.

Groundwater levels regularly fluctuate throughout the year, and therefore, may be different at other times. Groundwater levels at the site will also vary due to fluctuations in the amount of local rainfall or due to irrigation. In addition, groundwater may temporarily perch on top of layers of very dense/hardpan soils (Stratum 3) or clayey sands (Stratum 6).

Encountered and estimated seasonal high groundwater levels are shown adjacent to the individual boring profiles on Figures 4 and 5 in the Appendix.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the project characteristics previously described, the data obtained in our field exploration and our experience with similar subsurface conditions and construction types. If the proposed pipe alignment or installation depth are significantly different from those previously described, or if subsurface conditions different from those disclosed by the borings are encountered during construction, we should be notified immediately so that we might review and modify, if necessary, the following recommendations in regards to such changes. The general guidelines included in this report are not intended to supersede any more stringent requirements mandated by Orange County specifications.

General Site Preparation: Based on the information provided, the proposed water mains will be installed at depths of 3 to 5 feet below existing grade, and the gravity sewer mains will be installed at depths of about 7 feet. The following general procedures are recommended for site preparation:

- All excavations required for pipe installation should be performed in accordance with appropriate Occupational Safety and Health Administration (OSHA) standards. These standards typically include side slopes for temporary excavations not steeper than 1.5 Horizontal to 1 Vertical (1.5H:1V) to provide for adequate worker safety.

- If these side slopes cannot be maintained or are not desired due to other considerations, a properly designed braced excavation, trench shield, sheet piling, or chemically grouted wall would be required for stable excavations. All shields, shoring and bracing systems, or sheet piling should be designed and reviewed by an experienced Professional Engineer registered in the State of Florida. Adjacent traffic loads, and induced vibrations among other factors should be included in the design of these stabilization systems.
Difficult excavation may be encountered in areas of the proposed pipe locations. Very dense soils/hardpan (Stratum 3) were encountered in several borings at depths ranging from 3 to 8 feet. Specialized equipment may be required at these locations to penetrate the dense soil conditions encountered.

Pipe Subgrade Soils: Soils encountered in the borings appear suitable to support the proposed reclaimed water line. Regarding the pipe subgrade soils, we offer the following recommendations:

- The bedding soil beneath the pipe should be properly shaped to completely support the pipe section and areas should be excavated to accommodate any bells or other raised portions of the pipe to help avoid point loading conditions.

- If silty sands, clayey sands, or very dense (hardpan) materials are encountered within 2 feet below the pipe bottom, it is recommended that these soils be removed to a depth of 2 feet below the pipe bottom and replaced with well draining granular sands with a fines content of 12% or less passing the No. 200 U.S. Standard sieve by weight. Very dense soils encountered in pipe bedding locations should be undercut and backfilled with clean granular fill material to avoid uneven loading (point loads) of pipes and fittings.

- Compaction of the subgrade soils at the base of the pipe to at least 95 percent of the soil’s modified Proctor maximum dry density (ASTM D-1557) is recommended. At least one (1) in-place density test per 300 lineal feet of pipe should be performed at this depth to verify that the soils have been properly compacted.

- A minimum separation of 2 feet between the bottom of the compacted subgrade level and the groundwater level is recommended during construction and backfilling operations. A properly designed dewatering system may be required to maintain this minimum separation.

- After the subgrade soils have been prepared as recommended above, the pipe may be installed.

Pipe Backfill Soils: Regarding the pipe subgrade soils we offer the following recommendations:

- Compaction of backfilled soils around the pipe should be accomplished in lift thicknesses no thicker than 8 inches.

- All fill should be inorganic, non-plastic, granular soils (clean sands). The excavated clean granular soils should be suitable for use as pipe backfill. Strata 1 and 2 soils are acceptable for this use. Stratum 3 soils may also be used as backfill, but these soils should be pulverized prior to placement due to their cementation.
From 1 foot above the pipe to the finished grade elevation, compaction should be accomplished with a small plate or hand-guided drum type vibratory compactor. Extreme caution should be exercised when operating vibratory equipment near existing structures. Smaller hand compactors should be utilized in all restricted areas, such as beneath pipe haunches and to 1 foot above the pipe to help provide uniform compaction around the pipe.

At least one (1) density test per 300 lineal feet of pipe length per lift should be performed to verify that the soil has been compacted to at least 95 percent of its modified Proctor maximum dry density (ASTM D-1557). Care should be taken to also test the haunch area and to 1 foot above the pipe on this same frequency of one (1) test per 300 lineal feet of pipe installed.

If compaction difficulties arise during construction, the Geotechnical Engineer should be consulted to provide further recommendations.

**Very Dense (Hardpan) Soils:** As previously mentioned, very dense soils/hardpan (Stratum 3) was encountered in several borings at depths of about 3 to 8 feet. Regarding difficult excavation, we offer the following recommendations:

- A note should be added to the plan that indicates difficult excavation of very dense soils should be anticipated.
- The Contractor should be made aware that very dense soil layers were encountered in the borings during our field exploration and may be encountered in other locations along the proposed alignment.
- The Contractor shall anticipate the need for special equipment and/or procedures to facilitate excavations, dewatering, and penetration along the alignment.
- Very dense soils encountered in pipe bedding locations will have to be undercut and backfilled to avoid uneven loading (point loads) of pipes and fittings.

**Temporary Dewatering:** Groundwater was observed between 2 to 12 feet below existing grade. Seasonal high groundwater levels are anticipated to range from 1 to 5 feet below existing grades throughout the site. Based on this information and the proposed embedment depths of the pipe, dewatering will be required to facilitate construction, backfilling, and compaction in the dry. Regarding dewatering, we offer the following recommendations:

- Dewatering operations at this site for pipe installation should be accomplished with a properly designed dewatering system operating outside the excavation limits.
The dewatering system should be adequate to lower groundwater levels to at least 2 feet below the lowest compaction surface and keep it there during backfilling to facilitate excavations in the dry and proper compaction of bedding and backfill soils.

Special dewatering recommendations should be anticipated in these areas where very dense soil/hardpan layers are encountered. The Contractor should review the boring profiles prior to implementing the dewatering system to be aware of the encountered locations of very dense/hardpan soils. Very dense/hardpan soils may also be encountered in other locations along the alignment. These soils may cause difficulty for the installation of well points, and specialized equipment may be necessary to penetrate these soils. Additionally, these soils may act as a relatively impermeable confining layer, requiring well point screening both above and below these layers.

The construction should be sequenced so that the dewatering system is not turned off until the pipe has enough weight placed over it to counteract an uplift force equivalent to the height of standing water above the base of the pipe. The resisting weight of soil over the pipe should be calculated using a buoyant unit weight of the soil of 50 pounds per cubic foot.

**Stormwater Pond:** As previously mentioned, the existing wet-bottom stormwater pond at the site is planned to be expanded to the south. One (1) SPT boring to a depth of 30 feet was performed near this pond expansion area. One (1) relatively undisturbed soil sample was obtained from this boring at a depth of about 5 feet for laboratory permeability testing.

Generally, soil conditions encountered in the proposed pond expansion location consisted of Stratum 1 soils (fine sand to fine sand with silt) at the existing ground surface a depth of about 13 feet, underlain by Stratum 4 soils (silty fine sand) and Stratum 5 soils (clay) to the boring termination depth of 30 feet. Groundwater was encountered in this boring at a depth of about 6 feet below existing grade.

Laboratory permeability testing indicates vertical permeability rates of 27 feet per day for Stratum 1 soils. For purposes of pond design, we recommend the following parameters:

- Horizontal permeability rate: 30 feet per day
- Vertical permeability rate: 15 feet per day
- Bottom of aquifer: 13.5 feet
- Fillable porosity: 25 percent

We recommend limiting the pond’s design permeability rates to the values presented above in order to account for the potential siltation and hydrocompaction of the pond bottom over time.
Pump Station: A pump station is proposed for the sewer system on the site. Boring TB-8 was performed near the approximate location of the pump station as indicated by provided site plans. Groundwater was encountered in the boring at a depth of 6 feet below existing grade. At this time, the anticipated depth of the pump station is approximately 20 feet below existing grade.

- Dewatering will be required for construction of the pump station. Dewatering the pump station area will require the use of a properly designed well point system. Other dewatering systems utilizing sumps within shored or braced excavations may also be feasible. However, design of shoring/sump systems should be carefully evaluated with regard to blow outs of the excavation bottom due to unbalanced hydrostatic conditions. The Contractor should be allowed to review the soil stratification to determine the most feasible dewatering system for the pump station areas.

- All excavation should be performed in accordance with appropriate Occupational Safety and Health Administration (OSHA) standards. These standards typically include side slopes for temporary excavation no steeper than 1.5 horizontal to 1 vertical (1.5H: 1V) to provide adequate worker safety.

- If these side slopes cannot be maintained or are not desired due to other considerations, a properly designed and braced excavation or sheet piling would be required. All shoring and bracing systems or sheet piling should be designed and reviewed by an experienced professional engineer registered in the State of Florida.

- We recommend compaction of the subgrade soils at the base of the wet well to at least 95 percent of the soil’s modified Proctor maximum dry density (ASTM D-1557). We recommend at least two (2) in-place density tests be performed at the proposed foundation depth to verify that the soils have been properly compacted.

- After the subgrade soils have been prepared as recommended above, the pump station may be supported on a monolithic slab foundation or spread footing. The foundation can utilize a maximum net soil bearing pressure of 2,000 pounds per square foot.

- Compaction of backfilled soils around the wet well should be accomplished in lift thicknesses no greater than 8 inches. The fill material should consist of relatively clean granular sands with no more than 12 percent passing the No. 200 U.S. standard sieve by weight.

- Compaction can likely be accomplished in these areas with a small plate or hand guided drum type vibratory compactor and loose lift thicknesses should be limited to 8 inches. At least one (1) density test should be performed on each lift to verify that the soil has been compacted to at least 95 percent of its modified Proctor maximum dry density (ASTM D-1557).
If compaction difficulties arise during construction, the geotechnical engineer should be consulted to provide further recommendations.

The construction should also be sequenced so that a dewatering system, if necessary, is not turned off until the wet well pump station has enough weight to counteract an uplift force equivalent to the amount of water displaced. It may also be prudent to place additional concrete in the structure foundation to provide ballast against such an uplift force. This uplift force should account for the head difference from the bottom elevation of the foundation to the seasonal high groundwater level or the groundwater level at the time of construction, whichever is most shallow, plus any possible flooding conditions that may occur at the project site.

For calculations of resistance to the uplift force, 50 pounds per cubic foot may be used for the buoyant unit weight of the soil. The buoyant weight of the concrete and overlying soils should be used in calculating the necessary amount of ballast required.

**CLOSURE**

The recommendations provided above are based on widely spaced borings. This report does not reflect variations in soil conditions between or away from the boring locations. The nature and extent of the variations between the borings may not become evident until during construction. If such variations are encountered during construction, N&A should be informed and given an opportunity to re-evaluate the recommendations above after performing on-site observations during the construction period and noting the characteristics of the variations.
N&A appreciates the opportunity to be of service to you on this project. If you should have questions concerning the contents of this report, or if we may be of further assistance, please do not hesitate to contact us.

Sincerely,

NODARSE & ASSOCIATES, INC.

Tom Kunzen, E.I.          Richard G. Acree, P.E.
Project Engineer          Geotechnical Department Manager, VP
                          FL Registration No. 53962

Attachment: Appendix
APPENDIX