GEOLOGIC AND PRELIMINARY GEOTECHNICAL INVESTIGATION
LANDMARK PROPERTY
GREENWOOD VILLAGE, COLORADO

Prepared For:

CENTURY COMMUNITIES
8390 East Crescent Parkway
Suite 650
Greenwood Village, Colorado 80111

Attention: Lee Eisenheim

Project No. DN47,809-115

May 29, 2015
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCOPE</td>
<td>1</td>
</tr>
<tr>
<td>SUMMARY OF CONCLUSIONS</td>
<td>1</td>
</tr>
<tr>
<td>SITE CONDITIONS</td>
<td>3</td>
</tr>
<tr>
<td>SITE GEOLOGY AND GEOLOGIC HAZARDS</td>
<td>5</td>
</tr>
<tr>
<td>Old Fill</td>
<td>6</td>
</tr>
<tr>
<td>Shallow Groundwater</td>
<td>6</td>
</tr>
<tr>
<td>Expansive Soil and Bedrock</td>
<td>6</td>
</tr>
<tr>
<td>Seismicity</td>
<td>7</td>
</tr>
<tr>
<td>Other Considerations</td>
<td>7</td>
</tr>
<tr>
<td>PROPOSED DEVELOPMENT</td>
<td>8</td>
</tr>
<tr>
<td>INVESTIGATION</td>
<td>8</td>
</tr>
<tr>
<td>SUBSURFACE CONDITIONS</td>
<td>9</td>
</tr>
<tr>
<td>Fill</td>
<td>9</td>
</tr>
<tr>
<td>Natural Sandy Clay/Clayey Sand</td>
<td>9</td>
</tr>
<tr>
<td>Bedrock</td>
<td>9</td>
</tr>
<tr>
<td>Groundwater</td>
<td>9</td>
</tr>
<tr>
<td>ESTIMATED POTENTIAL HEAVE AND SETTLEMENT</td>
<td>10</td>
</tr>
<tr>
<td>SITE DEVELOPMENT</td>
<td>11</td>
</tr>
<tr>
<td>Demolition and Existing Fill</td>
<td>11</td>
</tr>
<tr>
<td>Excavation</td>
<td>11</td>
</tr>
<tr>
<td>Site Grading</td>
<td>12</td>
</tr>
<tr>
<td>Sub-Excavation</td>
<td>13</td>
</tr>
<tr>
<td>Slopes</td>
<td>15</td>
</tr>
<tr>
<td>Stabilization/Dewatering</td>
<td>16</td>
</tr>
<tr>
<td>Underdrain</td>
<td>16</td>
</tr>
<tr>
<td>Utilities</td>
<td>17</td>
</tr>
<tr>
<td>Pavements</td>
<td>17</td>
</tr>
<tr>
<td>BUILDING CONSTRUCTION CONSIDERATIONS</td>
<td>18</td>
</tr>
<tr>
<td>Foundations</td>
<td>18</td>
</tr>
<tr>
<td>Slab-On-Grade Construction</td>
<td>18</td>
</tr>
<tr>
<td>Below-Grade Areas</td>
<td>19</td>
</tr>
<tr>
<td>Surface Drainage</td>
<td>19</td>
</tr>
<tr>
<td>Concrete</td>
<td>20</td>
</tr>
<tr>
<td>RECOMMENDED FUTURE INVESTIGATIONS</td>
<td>20</td>
</tr>
<tr>
<td>LIMITATIONS</td>
<td>21</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

FIG. 1 – LOCATIONS OF EXPLORATORY BORINGS
FIG. 2 – GROUNDWATER ELEVATION
FIG 3 – CONCEPTUAL SUB-EXCAVATION PROFILE
APPENDIX A – SUMMARY LOGS OF EXPLORATORY BORINGS
APPENDIX B – LABORATORY TEST RESULTS
APPENDIX C – GUIDELINE SITE GRADING SPECIFICATIONS
SCOPE

This report presents the results of our Geologic and Preliminary Geotechnical Investigation for a planned townhome development located at the southwest corner of East Berry Avenue and South Greenwood Plaza Boulevard in Greenwood Village, Colorado (Fig. 1). The purpose of our investigation was to evaluate the subsurface conditions to assist in planning and development of the property. The report includes descriptions of soil strata and groundwater levels found in our exploratory borings, and discussions of site development and construction as influenced by geotechnical considerations. The scope was described in our Proposal (DN 15-0162) dated April 7, 2015.

This report is based on subsurface conditions found in our exploratory borings, results of field and laboratory tests, engineering analysis of field and laboratory data, and our experience with similar projects. The report contains preliminary discussions of foundation and floor support alternatives, and preliminary design and construction criteria for site development, foundations, floor systems, pavements, and surface and subsurface drainage. The preliminary discussions of foundation and floor system alternatives are intended for planning purposes only. Additional, site-specific investigations will be necessary to design structures and improvements. A brief summary of our conclusions and recommendations follows, with more detailed discussion in the report.

SUMMARY OF CONCLUSIONS

1. The site is judged suitable for residential development. The primary geotechnical concerns are shallow groundwater, old fill, and expansive soil and bedrock. We believe these concerns can be mitigated with proper planning, engineering, design and construction. There are no geotechnical constraints that preclude development.
2. Soils encountered in our exploratory borings consisted of about 2 to 19 feet of old fill and native soils underlain by weathered and comparatively unweathered claystone and/or interbedded claystone and sandstone bedrock. Samples of the sandy clay fill were low swelling and claystone bedrock samples were low to moderately expansive. The sandstone bedrock is judged to be non-expansive.

3. Groundwater was encountered during drilling in three of the borings between depths of 24 and 34 feet. When the holes were checked several days later, water was measured at depths of 11 to 24 feet in six borings. Groundwater is shallowest in the central portion of the property (Fig. 2). Groundwater levels will likely fluctuate seasonally and may rise in response to precipitation and landscape irrigation.

4. An underdrain system below the sanitary sewer is recommended if an outlet is available to help control groundwater and provide a gravity outlet for basement foundation drains. The underdrain should discharge to a positive gravity outfall or a lift station so that water can be discharged to a storm system.

5. Expansive clay and claystone bedrock and old fill with variable properties are present at depths likely to influence the performance of shallow foundations and slabs-on-grade. Drilled pier or similar deep foundations and structurally-supported floors will be necessary for most of the buildings unless sub-excavation is performed to depths sufficient to reduce potential heave enough to use footings and slab-on-grade floors for basements.

6. Sub-excavation to 12 feet below curb grades should provide about 5 feet of new fill below basements and treat the old fill and shallow bedrock sufficiently to allow use of footing foundations and slab-on-grade floors on most or all sites. Our borings imply the central portion of the site has relatively shallow groundwater. Sub-excavation need not be carried deeper than about 2 feet above groundwater.

7. Pavement subgrade soils are expected to be poor. Based on normal traffic loads for projects of this type, we anticipate access roads and alleys will require full-depth asphalt sections of 7 to 8 inches or concrete sections of 6 to 8 inches. A pavement design should be done after grading is complete.

8. Control of surface and subsurface drainage will be critical to the performance of foundations, slabs-on-grade and pavements. Overall surface drainage should be designed to provide rapid run-off of surface water away from structures, and off of pavements and flatwork.
SITE CONDITIONS

The Landmark Parcel is located at the southwest corner of East Berry Avenue and Greenwood Plaza Boulevard in Greenwood Village, Colorado (Fig. 1 and Photo 1). Commercial and office buildings to the east, south and west while the Landmark Towers apartment buildings are north. A pond is on the east side of Greenwood Plaza Blvd.

Photo 1. (Google Earth® Aerial Site Photo October 2014)
Photo 2. (Google Earth® Aerial Site Photo 1955)

Photo 3. (Google Earth® Aerial Site Photo 1993)
The ground surface slopes gently down to the north and west from the south-east corner. Ground cover predominately consists of grasses and weeds. An air photo taken in 1955 (Photo 2) shows the site was once part of agricultural operations. An embankment dam and pond occupied the northeast corner where the existing sales office stands. This explains the deep old fill found in TH-2. Another low area or pond was located east of the existing traffic circle. Our boring TH-6 found deep fill there. By the 1993 air photo (Photo 3) the site is completely developed with a multi-story office building, a pond and paved parking lots. By 2007 the parking lots were gone and part of the site was used for staging the Landmark Towers project. Demolition of the office building began in 2008. The sales office still stands on the northern portion of the site and some paved parking remains from previous uses for the site.

SITE GEOLOGY AND GEOLOGIC HAZARDS

The geology and existence of geologic hazards on this parcel were evaluated through review of subsurface data, available literature and brief site reconnaissance. According to the Geologic Map of the Highlands Ranch Quadrangle, Arapahoe and Douglas Counties, Colorado by John O. Maberry and Robert M. Lindavall (USGS Map GQ 1413, 1977), the site contains Quaternary loess and artificial fill overlying interbedded claystone and sandstone bedrock from the Denver-Dawson formation of Tertiary age.

Our study identified potential geologic hazards. These hazards can be mitigated with proper planning, engineering, design and construction. No geotechnical constraints were identified which, in our opinion, will preclude the residential development at the site. The hazards we identified include:

- Old Fill
- Shallow groundwater
• Expansive soil and bedrock
• Regional issue of seismicity

These hazards and conceptual mitigation methods are discussed in the following sections.

Old Fill

Old fill associated with past development is present on the site. Samples of the fill did not reveal deleterious materials. The fill was 12 feet or less deep in all but one boring. Engineering characteristics of the fill are variable. We believe the most prudent course is to re-work the fill as part of sub-excavation in foundation areas. If proof-rolling shows the fill is stable, it can be left in place to support site work such as paving.

Shallow Groundwater

Groundwater was measured as shallow as 11 feet in our borings. Provided basements are at least 3 and preferably 5 feet above groundwater, we believe there will not be significant limits to development of the property for residential uses. Our borings imply the central portion of the site has relatively shallow groundwater. Sub-excavation need not be carried deeper than about 2 feet above groundwater. Groundwater fluctuates seasonally and may rise in response to precipitation and landscape irrigation.

Expansive Soil and Bedrock

The fill, sandy clay and claystone bedrock are expansive. Development and landscape irrigation increases the risk of wetting and ground heave that will damage pavements, slabs-on-grade and foundations. Engineered design of grading, pavements, foundations, slabs-on-grade, and surface drainage can reduce, but not elimi-
nate, the effects of expansive soils and bedrock. Deep foundations are sometimes used to isolate structures from expansive soil. Ground improvement (sub-excavation) to reduce the impact of expansive soil and bedrock is discussed in the report. Sub-excavation is typically chosen for light structures and can usually result in a recommendation to use shallow foundations.

Seismicity

Based on available mapping, we found no active faults within or near the site. Significant faulting and structural discontinuities are not expected in the bedrock. The soil and bedrock units are not expected to respond unusually to seismic activity. The 2012 International Building Code (IBC) considers the area to be in Seismic Design Category B for a Site Class C.

Other Considerations

We observed no evidence of unstable slopes. Erosion potential on the site is considered low due to gentle slopes and vegetative cover. Erosion potential can be expected to increase during construction, but should establish pre-construction rates or less if proper grading practices, surface drainage design, and revegetation efforts are implemented. Construction sites within the Denver Metropolitan area are subject to the U.S. Environmental Protection Agency (EPA) regulations regarding the control of storm water discharge and soil erosion.

We did not identify aggregate sources in our borings. Economically valuable aggregate resources would not be expected on the property. In theory most of the Denver Basin may contain oil and gas deposits, whether the resource has economic potential remains to be seen.
PROPOSED DEVELOPMENT

We were provided with a preliminary plan showing 22 townhome buildings comprised of 3 to 6 dwellings each, totaling 95 units. The townhomes will likely have basements and attached garages. Access will most likely be a road running through the property that connects Marin Drive and East Berry Avenue.

INVESTIGATION

Subsurface conditions were investigated by drilling eight exploratory borings at the approximate locations shown on Fig. 1. Prior to drilling, we contacted the Utility Notification Center of Colorado and local sewer and water districts to clear boring locations for conflicts with buried utilities. The borings were advanced to depths of 25 to 35 feet using 4-inch diameter, continuous-flight auger and a truck-mounted drill rig.

Samples of the soil and bedrock were obtained at 5-foot intervals using 2.5-inch diameter (O.D.) modified California barrel samplers driven by a 140-pound hammer falling 30 inches. A representative of CTL | Thompson, Inc. was present during drilling to observe drilling operations, log the soil and bedrock, and obtain samples. We surveyed the elevation of the borings relative to a manhole on Greenwood Plaza Boulevard (assumed elevation = 100 feet). Summary logs of the exploratory borings with results of field penetration resistance tests and a portion of the laboratory data are presented in Appendix A.

The samples were returned to our laboratory where they were examined by our engineers. Laboratory tests included dry density, moisture content, percent silt and clay-sized particles (passing the No. 200 sieve), Atterberg limits, swell-consolidation, soil suction and water-soluble sulfate concentration. Swell-consolidation tests were performed by wetting the samples under approximate overburden pressure (the weight of the overlying soil). Results of laboratory tests are presented in Appendix B and are summarized in Table B-I.
SUBSURFACE CONDITIONS

Soils encountered in our borings consisted of about 2 to 19 fill and natural sand and clay underlain by weathered and comparatively unweathered claystone and/or interbedded claystone/sandstone bedrock. Some pertinent engineering characteristics of the soil and bedrock are discussed in the following paragraphs.

Fill

Fill consisting of sandy clay was encountered in 7 of the borings. The fill was found to be between 4 and 19 feet thick. Four samples of fill swelled between 0.2 and 1.0 percent and one sample did not swell after wetting under approximate overburden pressures. The upper fill has erratic moisture content and density.

Natural Sandy Clay/Clayey Sand

Natural soils consisting of sandy clay and clayey sand were encountered in two of the borings at ground surface or below the fill.

Bedrock

Weathered and comparatively unweathered claystone and interbedded claystone/sandstone bedrock was encountered below the fill and native soils in all of our borings. The comparatively unweathered claystone was medium hard to very hard. Samples of the claystone exhibited low to moderate swell (0.1 to 3.6 percent) when wetted. Ten samples exhibited suction values of 3.82 to 4.37 pF.

Groundwater

Groundwater was encountered during drilling in three of the borings between 24 and 34 feet. When the holes were checked several days later, water was meas-
ured at depths of 11 to 24 feet in six borings. Borings TH-3, 4 and 5 in the central portion of the site had groundwater at depths of 11 to 13 feet. Groundwater levels will likely fluctuate seasonally and may rise in response to precipitation and landscape irrigation.

ESTIMATED POTENTIAL HEAVE AND SETTLEMENT

Expansive soil and bedrock will heave after wetting. We used the results of swell tests to evaluate the potential future heave or settlement of the soil below the site. The analysis involves dividing the soil profile into layers and modeling the swell characteristics of each layer from representative tests. Based on the swell-consolidation test results and our experience, we have estimated the potential heave at each boring location as shown in Table I below. Estimated potential heave ranges from about 1.3 to 4.1 inches. These estimates are expected to be conservative. Actual heave would likely be somewhat less. The estimates were based upon 24 feet of wetting below existing grade. Site grading will affect potential movements. Sub-excavation should reduce potential ground heave to about 1 to 2 inches.

<table>
<thead>
<tr>
<th>Boring</th>
<th>Estimated Heave at Ground Surface (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH-1</td>
<td>2.9</td>
</tr>
<tr>
<td>TH-2</td>
<td>1.3</td>
</tr>
<tr>
<td>TH-3</td>
<td>2.4</td>
</tr>
<tr>
<td>TH-4</td>
<td>2.3</td>
</tr>
<tr>
<td>TH-5</td>
<td>4.1</td>
</tr>
<tr>
<td>TH-6</td>
<td>2.8</td>
</tr>
<tr>
<td>TH-7</td>
<td>2.4</td>
</tr>
<tr>
<td>TH-8</td>
<td>3.2</td>
</tr>
</tbody>
</table>
SITE DEVELOPMENT

The primary geotechnical concerns that we believe will influence development and building performance is the presence of shallow groundwater, old fill and expansive soil and bedrock. This concern can be mitigated with proper planning, engineering, design and construction. We believe there are no geologic or geotechnical constraints at this site that would preclude development. The following sections discuss site development recommendations.

Demolition and Existing Fill

Underground utilities should be removed below new improvements. Excavations resulting from demolition should be backfilled with moisture conditioned, compacted fill. It may be possible to grout abandoned utilities in place. The sales office at the north end of the site will be demolished and removed. Although the extents are not fully known, existing fill and backfill are anticipated throughout the site. Ideally, all existing fill should be removed prior to development. With the recommended sub-excavation below buildings, we believe the existing fill will be adequately treated. For site-work areas, it may be acceptable to leave the fill in place provided it is shown to be stable by examination of test pits and/or proof-rolling with a heavily loaded dump truck. Vegetation, large tree roots and organics should also be removed. Some scattered debris was observed on the ground surface throughout the site. The debris should be removed. An asbestos survey will be required to obtain a demolition permit. We can provide an asbestos survey at your request.

Excavation

We believe the soils penetrated by our exploratory borings can generally be excavated with typical heavy-duty equipment. Our borings did not reveal that unusually hard bedrock is below the site.
We recommend the owner and the contractor become familiar with applicable local, state and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. Based on our investigation and OSHA standards, we anticipate the clay fill and weathered bedrock will classify as Type B soil and the claystone bedrock will classify as Type A based on OSHA Standards governing excavations published in 29 CFR, Part 1926. Type A soil requires a maximum slope inclination of ¾:1 (horizontal to vertical), and Type B requires 1:1 for temporary excavations in dry conditions. Saturated soils may require flatter slopes or bracing. Excavation slopes specified by OSHA are dependent upon soil types and groundwater conditions encountered. The contractor’s “competent person” should identify the soils encountered in the excavations and refer to OSHA standards to determine appropriate slopes. Stockpiles of soils and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. A professional engineer should design excavations deeper than 20 feet.

Site Grading

A site grading plan is not available at this time. We believe grading can be accomplished using conventional heavy-duty construction equipment.

The ground surface in areas to be filled should be stripped of vegetation and existing fill, scarified, and moisture conditioned to between optimum and 4 percent above optimum moisture content for clay and claystone, and within 2 percent of optimum for sand and sandstone, and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698). We anticipate 3 to 6 inches of topsoil for the majority of the site.

The properties of fill will affect the performance of foundations, slabs-on-grade, utilities, pavements, flatwork and other improvements. If imported soil is needed to achieve site grades, the material should be tested and approved by our firm prior to
importing to the site. The on-site soils are suitable for use as site grading fill provided they are substantially free of debris, organics and other deleterious materials. Fill should be placed in thin loose lifts, moisture conditioned and compacted prior to placement of the next lift using the criteria presented in the previous paragraph. The placement and compaction of site grading fill should be observed and density tested by our representative during construction. Guideline grading specifications are presented in Appendix C.

Our experience indicates fill and backfill can settle, even if properly compacted to criteria provide above. Factors that influence the amount of settlement are depth of fill, material type, degree of compaction, amount of wetting and time. The degree of compression of fill under its own weight will likely range from low for granular soils (½ percent or less), to moderate for clay/sand mixtures (1 to 2 percent), to high for highly plastic clay and claystone (2 percent or more).

Sub-Excavation

We calculated potential ground heave of about 1 to 4 inches for an assumed depth of wetting of 24 feet. Old fill with erratic properties is also present on the site. Drilled pier foundations and structurally supported floor systems are commonly used on sites where non-uniform or expansive soils predominate. Alternatively, some builder-developers choose to perform sub-excavation to reduce potential heave and provide a relatively uniform fill layer that is likely suitable for footings and slab-on-grade basement floors.

Sub-excavation has been employed in the Denver area with satisfactory performance for the large majority of the sites where this ground modification method has been completed. We have seen isolated instances where differential settlement of sub-excavation fill has led to damage to buildings supported on footings. In most cases, the settlement was caused by wetting associated with poor surface drainage
or seepage, and/or poorly compacted fill placed at the horizontal limits of excavation. Wetting of the fill may cause softening and settlement.

If sub-excavation is chosen, we recommend excavation to at least 12 feet below high curb grade at each building. Our borings imply the central portion of the site has relatively shallow groundwater. Sub-excavation need not be carried deeper than about 2 feet above groundwater. The bottom of the sub-excavated area should extend laterally at least 5 feet outside the largest possible foundation footprints to ensure foundations are constructed over moisture-conditioned fill. Conceptual sub-excavation profiles are shown on Fig. 3. The excavation slopes should meet OSHA, state, and local safety standards.

The excavation contractor should be chosen carefully to assure they have experience with fill placement at over-optimum moisture and have the necessary compaction equipment. In order for the sub-excavation procedure to be performed properly, close control of fill placement to specifications is required. Special precautions should be taken for compaction of fill at corners, access ramps and edges of the sub-excavation due to equipment access constraints. The contractor should have the appropriate equipment to reach and compact these areas. Our representative should observe and test compaction of the fill. The fill should be tested during and after the fill placement to evaluate swell and whether footing or pad-type foundations can be used.

If the fill dries excessively prior to construction, it may be necessary to rework the upper drier materials prior to constructing foundations. We judge the fill should retain adequate moisture for about two years. We can check moisture conditions in each excavation as construction progresses, if requested.
Based on our experience, several problems have been encountered from the use of sub-excavation. The most common problem arises from placement of the structure outside of the sub-excavated area. The following suggestions should aid in planning and performing sub-excavation:

1. We recommend design of the treatment area and depth to satisfy the recommendations presented above. For all lots, the anticipated foundation elevation (bottom of deepest footing) will be limited by the bottom elevation of treatment and the recommended minimum depth of treatment below foundations.

2. We recommend a surveyor document the actual limits of the treatment, and create "as-built" plans. These plans should be provided to the civil/surveyor who prepares plot plans so that they can verify that each residence is over the treated area. In the case of deep sub-excavation, the "treated area" stops at the toe of the deep sub-excavation slope. It would be prudent to show the horizontal limits and bottom elevation of treatment on the plot plans.

Slopes

We recommend permanent cut and fill slopes be designed with a maximum grade of 3:1 (horizontal:vertical). Use of 4:1 or flatter slope is better to control erosion. If site constraints (property boundaries and streets) do not permit construction with recommended slopes, we should be contacted to evaluate the subsurface soils and steeper slopes. Slopes greater than 20 feet high should be evaluated by our office on a case-by-case basis. Surface drainage should not be allowed to sheet flow across slopes or pond near the crest of slopes. All cut and fill slopes should be designed and re-vegetated as soon as possible after grading to reduce potential for erosion problems. Excavation contractors should evaluate ground conditions and control slopes in accordance with OSHA criteria.
Stabilization/Dewatering

Stabilization of soft soils may be needed in excavation bottoms. If groundwater is encountered during utility or basement construction, temporary dewatering may be required. Dewatering can likely be accomplished by sloping excavations to temporary sumps and removing the water by pumping. The sumps should bottom several feet below the bottom of the excavations so that water is drawn down through the soils rather than up through the bottom of the excavation.

Underdrain

Groundwater levels will fluctuate with seasons and will likely rise after development. The use of an underdrain system below sanitary sewer mains and services is a common method to control groundwater which develops after development and, in some cases, to lower groundwater levels. We believe installation of underdrains also helps to control unusually deep wetting, which can lead to higher frequency of heave and settlement related foundation problems. We recommend plans for this site include underdrains incorporated into sanitary sewer design if allowed by the sewer district.

The underdrain should include ¾ to 1½-inch clean, free draining gravel surrounding a perforated PVC pipe. The line should consist of a perforated or slotted rigid PVC pipe placed at a grade of at least 0.5 percent. A positive cutoff (concrete) should be constructed around the sewer pipe and underdrain pipe immediately downstream of the point where the underdrain pipe leaves the sewer trench. Solid pipe should be used down gradient of this cutoff wall. The gravity outfall should be constructed with a permanent concrete headwall and trash rack. The underdrain should be installed with clean-outs and be maintained by the homeowner’s association or another entity. To reduce the risk of cross-connecting sewer and underdrain services, we recommend using a different size pipe for the sewer and underdrain services.
Where feasible, the underdrain services should be installed deep enough so that the lowest point or the sump pit of the basement foundation drain can be connected to the underdrain service as a gravity outlet.

Utilities

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. Trench backfill should be placed in thin (6 inches or less) compacted lifts and moisture conditioned to between optimum and 4 percent above optimum moisture content for clay and within 2 percent of optimum for sand and compacted to at least 95 percent of maximum dry density (ASTM D 698). The placement and compaction of utility trench backfill should be observed and tested by a representative of our firm during construction.

Our experience indicates use of a self-propelled compactor results in more reliable performance compared to backfill “compacted” by a sheepsfoot wheel attachment on a backhoe or trackhoe. The upper portion of the trenches should be widened to allow the use of a self-propelled compactor. Special attention should be paid to backfill placed adjacent to manholes as we have seen instances where settlement in excess of 2 percent has occurred. Any improvements placed over backfill should be designed to accommodate movement.

Pavements

We anticipate pavement subgrade will consist of sandy clay after grading. This material is relatively poor pavement subgrade. We anticipate access drives and alleys will require full-depth asphalt sections of 7 to 8 inches and concrete sections of 6 to 8 inches. A pavement design should be done after grading is complete.
BUILDING CONSTRUCTION CONSIDERATIONS

The following discussions are preliminary and are not intended for design or construction. After grading is completed, design-level investigations should be performed on a lot-specific basis.

Foundations

We assume sub-excavation will be performed. Sub-excavation as described previously should allow shallow footing foundations and slab-on-grade basement floors on most or all treated sites.

Slab-On-Grade Construction

Slab-on-grade basement floors may be considered on low and some moderate swell lots where potential heave is acceptable. Structurally-supported basement floors should be used on all lots with high or very high risk of poor basement slab performance. Sub-excavation should reduce potential heave and should allow wider use of slab-on-grade floors.

The performance of garage floors, driveways, sidewalks and other surface flatwork will likely be poor at this site, unless sub-excavation is performed. The following precautions will be required to reduce the potential for damage due to movement of slabs-on-grade:

1. Isolation of the slabs from foundation walls, columns and other slab penetrations;

2. Voiding of interior partition walls to allow for slab movement without transferring movement to the structure;

3. Flexible water and gas connections to allow for slab movement. A flexible plenum above furnaces will be required; and
4. Proper surface grading and foundation drain installation to reduce water availability to sub-slab and foundation soils

Below-Grade Areas

Surface water can penetrate relatively permeable loose backfill soils located adjacent to residences and collect at the bottom of relatively impermeable basement excavations causing wet or moist conditions. Basement foundation walls should be designed for lateral earth pressures. Foundation drains should be constructed around the lowest excavation levels and ideally should be connected to an underdrain system (if allowed) to provide a gravity outlet. The drains can be connected to a sump pit where water can be removed by pumping if an underdrain is not provided.

Surface Drainage

The performance of improvements will be influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each building. The ground surface around each building should be sloped to provide positive drainage away from the foundation. We recommend a slope of at least 10 percent for the first 10 feet surrounding each building, where practical. If the distance between buildings is less than 20 feet, the slope in this area should be 10 percent to the swale between them. Where possible, drainage swales should slope at least 2 percent. More slope is desirable. Variation from these criteria is acceptable in some areas. For example, for lots graded to direct drainage from the rear yard to the front, it is difficult to achieve the recommended slope at the high point behind the building. We believe it is acceptable to use a slope of about 6 inches in the first 10 feet at this location. Roof downspouts and other water collection systems should discharge beyond the limits of all backfill around structures.

Proper control of surface runoff is also important to control the erosion of surface soils. Sheet flow should not be directed over unprotected slopes. Water should
not be allowed to pond at the crest of slopes. Permanent slopes should be prepared in such a way to reduce erosion.

Attention should be paid to compact the soils behind curb and gutter adjacent to streets and in utility trenches during the development. If surface drainage between preliminary development and construction phases is neglected, performance of the roadways, flatwork and foundations may be poor.

Concrete

Concrete in contact with soil can be subject to sulfate attack. We measured a water-soluble sulfate concentration of less than 0.01 percent in one sample from this site. For this level of sulfate concentration, ACI 332-08 Code Requirements for Residential Concrete indicates there are no special requirements for sulfate resistance.

Superficial damage may occur to the exposed surfaces of highly permeable concrete. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious materials ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high water tables. Concrete should have a total air content of 6 percent +/- 1.5 percent. We recommend all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams) be damp-proofed.

RECOMMENDED FUTURE INVESTIGATIONS

We recommend the following investigations and services:

1. Review of grading plans and possibly additional drilling and testing to better define depths of sub-excavation, if ground improvement is desired.
2. Construction testing and observation during site development, grading, and pavement construction.

3. Subgrade investigation and pavement design after grading;

4. Design-level Soils and Foundation Investigation(s) after grading; and

5. Foundation installation observations.

LIMITATIONS

Our borings were widely spaced to provide a general picture of subsurface conditions for preliminary planning of development and construction. We believe this investigation was conducted in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made.

If we can be of further service in discussing either the contents of this report or the analysis of the influence of subsurface conditions on the design of the proposed development, please call.

Alexander C. Franceski, E.I.T.
Staff Engineer

David A. Glater, P.E., C.P.G.
Principal Geotechnical Engineer

ACF:DAG/nn
(3 copies)

Via email:  leee@centurycommunities.com
            InspRep-CO@centurycommunities.com
LEGEND:

- **TH-1**: APPROXIMATE LOCATION OF EXPLORATORY BORING
- **TBM**: TEMPORARY BENCHMARK
- **MANHOLE COVER ON SOUTH SIDE OF GREENWOOD PLAZA BOULEVARD (ASSUMED ELEV. = 100.0')**
- **(82)**: INDICATES GROUNDWATER ELEVATION AT BORING LOCATION (FEET)
- **78**: INDICATES ESTIMATED ELEVATION OF GROUNDWATER (FEET)

**NOTE:**

THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS AND SEASONAL FLUCTUATIONS.
APPENDIX A
SUMMARY LOGS OF EXPLORATORY BORINGS
SUMMARY LOGS OF EXPLORATORY BORINGS

NOTES:

1. THE BORINGS WERE DRILLED APRIL 23, 2015 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A TRUCK-MOUNTED DRILL RIG.

2. VC - INDICATES MOISTURE CONTENT (%).
DD - INDICATES DRY DENSITY (PCF).
SW - INDICATES SWELL WHEN WETTED UNDER APPLIED PRESSURE (%).
UC - INDICATES UNCONFINED COMPRRESSIVE STRENGTH (psi).
SS - INDICATES WATER-SOLUBLE SULFATE CONTENT (%).
pF - INDICATES SOIL SUCTION VALUE (psi).

3. BORING LOCATIONS AND ELEVATIONS WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM REFERENCING THE TEMPORARY BENCHMARK SHOWN ON FIG. 1.
APPENDIX B
LABORATORY TEST RESULTS
Sample of WEATHERED CLAYSTONE
From TH-1 AT 4 FEET

Dry Unit Weight = 101 PCF
Moisture Content = 24.7 %

Sample of WEATHERED CLAYSTONE
From TH-1 AT 9 FEET

Dry Unit Weight = 99 PCF
Moisture Content = 24.7 %

Swell Consolidation Test Results

FIG. B-1
Sample of WEATHERED CLAYSTONE
From TH-1 AT 14 FEET

Sample of FILL, CLAY, SANDY
From TH-2 AT 9 FEET

Swell Consolidation Test Results

FIG. B-2
**Swell Consolidation Test Results**

FIG. B-3

**Sample of Fill, Clay, Sandy**
From TH-2 AT 14 FEET

- **Dry Unit Weight:** 102 PCF
- **Moisture Content:** 21.1%

**Sample of Claystone**
From TH-2 AT 19 FEET

- **Dry Unit Weight:** 96 PCF
- **Moisture Content:** 26.5%
Sample of FILL, CLAY, SANDY
From TH-3 AT 4 FEET
DRY UNIT WEIGHT = 99 PCF
MOISTURE CONTENT = 21.5%

Sample of CLAYSTONE
From TH-3 AT 9 FEET
DRY UNIT WEIGHT = 107 PCF
MOISTURE CONTENT = 20.1%

Swell Consolidation Test Results
FIG. B-4
Sample of CLAYSTONE
From TH-3 AT 14 FEET
DRY UNIT WEIGHT = 108 PCF
MOISTURE CONTENT = 20.9 %

Sample of CLAYSTONE
From TH-3 AT 19 FEET
DRY UNIT WEIGHT = 108 PCF
MOISTURE CONTENT = 18.0 %

Swell Consolidation Test Results

FIG. B-5
Sample of CLAYSTONE

Dry Unit Weight = 111 PCF

From TH-3 AT 24 FEET

Moisture Content = 19.8%

Expansion Under Constant Pressure Due to Wetting

TEST RESULTS

FIG. B-6

Swell Consolidation

Century Communities
Landmark Property
Project No. DN47,809-115
S:\Projects\47800\DN47809.000\115\2. Reports\R1\DN47809-120-R1-X1(Swell).xlsx
Sample of INTERBEDDED CLAYSTONE/SANDSTONE

Dry Unit Weight = 110 PCF

From TH-3 AT 29 FEET

Moisture Content = 18.8%

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF

Swell Consolidation Test Results

FIG. B-7
Sample of INTERBEDDED CLAYSTONE/SANDSTONE
DRY UNIT WEIGHT = 102 PCF
From TH-3 AT 34 FEET
MOISTURE CONTENT = 16.8 %

APPLIED PRESSURE - KSF

Swell Consolidation Test Results

FIG. B-8
Sample of FILL, CLAY, SANDY
From TH-4 AT 4 FEET

Dry Unit Weight = 101 PCF
Moisture Content = 20.9%

APPLIED PRESSURE - KSF

Expansion under constant pressure due to wetting

Swell Consolidation Test Results

FIG. B-9
Sample of CLAYSTONE

Dry Unit Weight = 96 PCF

From TH-4 AT 14 FEET

Moisture Content = 24.4%

Swell Consolidation Test Results

FIG. B-10
Sample of **CLAYSTONE**

Dry Unit Weight = 114 PCF

From TH-4 at 19 Feet

Moisture Content = 16.2%

---

Sample of **WEATHERED CLAYSTONE**

Dry Unit Weight = 104 PCF

From TH-5 at 14 Feet

Moisture Content = 22.2%

---

**Swell Consolidation Test Results**

**FIG. B-11**
Sample of CLAYSTONE
From TH-5 AT 24 FEET
DRY UNIT WEIGHT = 107 PCF
MOISTURE CONTENT = 20.8 %

Sample of FILL, CLAY, SANDY
From TH-6 AT 4 FEET
DRY UNIT WEIGHT = 106 PCF
MOISTURE CONTENT = 18.6 %

Swell Consolidation Test Results
FIG. B-12
Sample of CLAYSTONE
From TH-6 AT 14 FEET
DRY UNIT WEIGHT = 106 PCF
MOISTURE CONTENT = 19.8 %

Sample of CLAYSTONE
From TH-6 AT 19 FEET
DRY UNIT WEIGHT = 101 PCF
MOISTURE CONTENT = 22.7 %

Swell Consolidation Test Results
FIG. B-13
Sample of WEATHERED CLAYSTONE
From TH-7 AT 9 FEET

DRIY UNIT WEIGHT = 98 PCF
MOISTURE CONTENT = 25.0 %

Sample of CLAYSTONE
From TH-7 AT 24 FEET

DRIY UNIT WEIGHT = 103 PCF
MOISTURE CONTENT = 21.0 %

Swell Consolidation Test Results
FIG. B-14
Sample of FILL, CLAY, SANDY
From TH-8 AT 4 FEET
DRY UNIT WEIGHT = 102 PCF
MOISTURE CONTENT = 16.3 %

Sample of WEATHERED CLAYSTONE
From TH-8 AT 9 FEET
DRY UNIT WEIGHT = 108 PCF
MOISTURE CONTENT = 18.1 %

Swell Consolidation Test Results

FIG. B-15
Swell Consolidation Test Results

**FIG. B-16**

Sample of CLAYSTONE
From TH-8 AT 14 FEET

**Dry Unit Weight:** 115 PCF
**Moisture Content:** 16.9%

Sample of CLAYSTONE
From TH-8 AT 19 FEET

**Dry Unit Weight:** 106 PCF
**Moisture Content:** 21.7%
Sample of CLAYSTONE

DRY UNIT WEIGHT = 103 PCF
MOISTURE CONTENT = 19.1 %

APPLIED PRESSURE - KSF

EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

CENTURY COMMUNITIES
LANDMARK PROPERTY
PROJECT NO. DN47,809-115
S:\PROJECTS\47800\DN47809.000\115\2. Reports\R1\DN47809-120-R1-X1(SWELL).xlsm
### TABLE B-1

**SUMMARY OF LABORATORY TEST RESULTS**

<table>
<thead>
<tr>
<th>BORING</th>
<th>DEPTH (ft)</th>
<th>MOISTURE CONTENT (%)</th>
<th>DRY DENSITY (pcf)</th>
<th>SWELL TEST DATA</th>
<th>SWELL SUCTION</th>
<th>UNCONFINED COMPRESSIVE STRENGTH</th>
<th>SOIL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SWELL (%)</td>
<td>APPLIED PRESSURE (psf)</td>
<td>SWELL PRESSURE (psf)</td>
<td>COMPR ESSIVE STRENGTH (psf)</td>
</tr>
<tr>
<td>TH-1</td>
<td>4</td>
<td>24.7</td>
<td>101</td>
<td>0.6</td>
<td>500</td>
<td>0.5</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>24.7</td>
<td>99</td>
<td>2.0</td>
<td>1,100</td>
<td>2.0</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td>TH-1</td>
<td>14</td>
<td>25.1</td>
<td>92</td>
<td>1.9</td>
<td>1,800</td>
<td>1.8</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td>TH-2</td>
<td>9</td>
<td>19.5</td>
<td>101</td>
<td>0.6</td>
<td>1,100</td>
<td>0.6</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>21.1</td>
<td>102</td>
<td>0.0</td>
<td>1,800</td>
<td>0.0</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>26.5</td>
<td>96</td>
<td>1.5</td>
<td>2,400</td>
<td>1.5</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td>TH-3</td>
<td>4</td>
<td>21.5</td>
<td>99</td>
<td>0.7</td>
<td>500</td>
<td>1,300</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>20.1</td>
<td>107</td>
<td>2.1</td>
<td>1,100</td>
<td>6,600</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>20.9</td>
<td>108</td>
<td>1.4</td>
<td>1,800</td>
<td>7,500</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>18.0</td>
<td>108</td>
<td>1.7</td>
<td>2,400</td>
<td>7,200</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>18.5</td>
<td>111</td>
<td>1.1</td>
<td>3,000</td>
<td>9,000</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td>TH-3</td>
<td>29</td>
<td>18.8</td>
<td>110</td>
<td>0.3</td>
<td>3,600</td>
<td>5,000</td>
<td>CLAYSTONE/SANDSTONE</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>16.8</td>
<td>102</td>
<td>0.1</td>
<td>4,200</td>
<td>5,200</td>
<td>CLAYSTONE/SANDSTONE</td>
</tr>
<tr>
<td>TH-4</td>
<td>4</td>
<td>20.9</td>
<td>101</td>
<td>1.0</td>
<td>500</td>
<td>4,500</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>24.4</td>
<td>96</td>
<td>1.3</td>
<td>1,800</td>
<td>2,400</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>16.2</td>
<td>114</td>
<td>2.0</td>
<td>2,400</td>
<td>4,900</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td>TH-5</td>
<td>9</td>
<td>21.4</td>
<td>106</td>
<td>3.6</td>
<td>1,800</td>
<td>6,900</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>22.2</td>
<td>104</td>
<td>2.3</td>
<td>3,000</td>
<td>2,400</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>20.8</td>
<td>107</td>
<td>2.3</td>
<td>3,000</td>
<td>6,900</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td>TH-6</td>
<td>4</td>
<td>18.6</td>
<td>106</td>
<td>0.9</td>
<td>500</td>
<td>9,000</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>19.8</td>
<td>106</td>
<td>2.6</td>
<td>1,800</td>
<td>3,600</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>22.7</td>
<td>101</td>
<td>1.3</td>
<td>2,400</td>
<td>7,200</td>
<td>FILL, CLAY, SANDY</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>25.0</td>
<td>102</td>
<td>0.2</td>
<td>1,100</td>
<td>9,000</td>
<td>WEATHERED CLAYSTONE</td>
</tr>
<tr>
<td>TH-7</td>
<td>18</td>
<td>21.1</td>
<td>105</td>
<td>1.7</td>
<td>3,000</td>
<td>10,500</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>21.0</td>
<td>103</td>
<td>3.0</td>
<td>3,000</td>
<td>2,400</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>16.3</td>
<td>102</td>
<td>0.2</td>
<td>500</td>
<td>1,200</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>18.1</td>
<td>108</td>
<td>2.0</td>
<td>1,100</td>
<td>4,900</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>16.9</td>
<td>115</td>
<td>2.2</td>
<td>1,800</td>
<td>12,000</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>21.7</td>
<td>106</td>
<td>2.3</td>
<td>2,400</td>
<td>13,000</td>
<td>CLAYSTONE</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>19.1</td>
<td>103</td>
<td>1.0</td>
<td>3,000</td>
<td>6,000</td>
<td>CLAYSTONE</td>
</tr>
</tbody>
</table>
APPENDIX C
GUIDELINE SITE GRADING SPECIFICATIONS
GUIDELINE SITE GRADING SPECIFICATIONS

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of excess cut materials that may be placed outside of the subdivision and/or filing boundaries.

2. GENERAL

The Soils Representative shall be the Owner's representative. The Soils Representative shall approve fill materials, method of placement, moisture contents and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation, trees, brush and rubbish before excavation or fill placement begins. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

Topsoil and vegetable matter shall be substantially removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified to a depth of 8 inches, moisture treated to above optimum moisture content, and compacted until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction by the equipment to be used.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods to a depth of 8 to 12 inches, brought to the proper moisture content (between optimum and 4 percent above optimum for clay and within 2 percent of optimum for sand) and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698. The foundation materials shall be worked, stabilized, or removed and replaced if necessary in accordance with the soils representative’s recommendations in preparation for fill.

6. FILL MATERIALS

Fill soils shall be substantially free from vegetable matter or other deleterious substances, and shall not contain rocks having a diameter greater than six (6) inches and claystone pieces larger than three (3) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.
On-site materials classifying as CL, CH, SC, SM, SW, SP, GP, GC and GM are acceptable. Concrete, asphalt, organic matter and other deleterious materials or debris shall not be used as fill.

7. MOISTURE CONTENT

For fill material classifying as CH, CL or SC, the fill shall be moisture treated to between optimum and 4 percent above optimum moisture content. Soils classifying as SM, SW, SP, GP, GC and GM shall be moisture treated to within 2 percent of optimum moisture content as determined from Proctor compaction tests. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Representative, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disc the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Representative, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACPTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill shall be compacted to at least 95 percent of the maximum density as determined in accordance with ASTM D 698. At the option of the Soils Representative, soils classifying as SW, GP, GC, or GM may be compacted to 95 percent of maximum density as determined in accordance with ASTM D 1557 or 70 percent relative density for cohesionless sand soils. Fill materials shall be placed such that the thickness of loose materials does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction as specified above shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other approved equipment. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient passes to ensure that the required density is obtained.
9. **COMPACTION OF SLOPES**

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is not an appreciable amount of loose soils on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to 5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

10. **PLACEMENT OF FILL ON NATURAL SLOPES**

Where natural slopes are steeper than 20 percent in grade and the placement of fill is required, cut benches shall be provided at the rate of one bench for each 5 feet in height (minimum of two benches). Benches shall be at least 10 feet in width. Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

11. **DENSITY TESTS**

Field density tests shall be made by the Soils Representative at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

12. **SEASONAL LIMITS**

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Representative indicates that the moisture content and density of previously placed materials are as specified.

13. **NOTICE REGARDING START OF GRADING**

The Contractor shall submit notification to the Soils Representative and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

14. **REPORTING OF FIELD DENSITY TESTS**

Density tests made by the Soils Representative, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, and percentage compaction shall be reported for each test taken.
15. DECLARATION REGARDING COMPLETED FILL

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, and was placed in general accordance with the specifications.