
FROM US GEOLOGICAL SURVEY GEOLOGICAL MAP (I-335)

PRELIMINARY SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING ASSESSMENTS FOR THE PROPOSED MONTE ELVIRA DEVELOPMENT AT SAN ILDEFONZO WARD, COAMO, PUERTO RICO REFERENCE DA/1153302
identified stream runs through the project lands, near the east boundary of the Sports Complex Francisco Coimbre with Monte Elvira project lands. Also some other prominent topographic feature are the promontories at the at the north and northwestern project development land sectors.

The proposed Walkup multi-story Building and the One-story, single-family units structures are distributed throughout the tract of land of development, as shown in the architectural rendering plan provided for the present work.

At the time of this report the grading plans were not available, but from the site distribution and the topographic map available it is estimated that to establish the finished grade elevations the estimated maximum cut section shall be in the order of 10.0 to 15.0 m. For the present evaluations, it is estimated that minor fill sections may be required, to establish the finished floor levels of the dwelling units of development. Further estimated of the cut and fill sections would be provided when the grading plans are available. In any event, the data for the preliminary engineering design assessments of the proposed cut and fill section, to be used for the Site Engineering Design are discussed in this report. Such data and assessment, considering the data secured of the geological profiles and subsurface conditions encountered at the site, should serve as the basis for the proposed earthwork phase of construction, until more detailed geologic information is secured.

III. FIELD SUBSURFACE AND SAMPLING PROGRAM

3.1 Subsurface Investigations

The subsurface soil conditions at the site were investigated via ten (10) standard penetration test borings. The location of the borings is shown in the accompanying Boring Location Plan, Figure No. 2.

Sampling of soils was performed continuously in the upper 7 ft. and thereafter, at approximately five foot intervals. All Standard Penetration (SPT) soil samples were taken with a 2"-O.D. split barrel sampler following the standard penetration test procedures in ASTM D-1586. Penetration resistance from the standard penetration tests are recorded in the "N" column of the boring logs. Rock samples were secured using double-tube core barrel with diamond bits, in accordance to ASTM D-2113. The procedures used for the laboratory tests, as well as the routine and special laboratory procedures used, for the determination of the index soil properties are contained in the Appendix (1) to this report.

3.2 Surface Soil Data and Site Geology

3.2.1 Surface Soil Data

Based on the US Soil Conservation Service Manual of the US Soil Conservation Service for the Ponce Area of Southern Puerto Rico, Sheet # 25, the surface Materials near the site have been described as follows surface soils:
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NOTE:
THIS BORING LOCATION PLAN WAS PROVIDED BY THE CLIENT AND WAS USED AS THE BORING LOCATION PLAN

SCALE:
RESCALE FROM ORIGINAL

Despiau Associates Corp.
SOIL/GEOTECHNICAL ENGINEERING LABORATORIES
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PRELIMINARY SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING ASSESSMENTS FOR THE PROPOSED MONTE ELVIRA DEVELOPMENT AT SAN ILDEFONZO WARD, COAMO, PUERTO RICO
REFERENCE: DA/183302

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1. **Callabo Series** – The series consists of well drained, moderately steep to very steep soils on foot slopes, long and short slopes, hilltops, and ridge tops in the semi-arid uplands. Slope ranges from 12 to 60 percent. These soils formed in moderately fine residuum of weathered volcanic rock. In a representative profile, the surface layer is very dark grayish brown silty clay loam about 5 inches thick. The subsoil is about 14 inches thick. In the upper 8 inches it is dark brown and very dark grayish brown, firm silty clay loam, and in the lower 6 inches it is dark yellowish brown, friable clay loam. The substratum, between depths of 19 and 27 inches, is highly weathered volcanic rock. Semi consolidated rock is at a depth of 27 inches. These soils are moderately permeable. They have low available water capacity. Runoff is medium to very rapid.

2. **Callabo silty clay loam (CoD)** 12 to 20 percent slopes - This is a moderately steep soil on side slopes, foot slopes, and rounded hilltops in the semiarid uplands. It generally is in areas of about 20 to 50 acres. It's similar to the described as representative of the series, but the surface layer is slightly thicker. Includes with this soil in the mapping are Llanos clay in narrow strips along drainage ways, Jacana clay on short foot slopes, and some severely eroded soils on hilltops. Erosion is a hazard because of the slope, and some measure for controlling erosion needed if crops to be grown.

3. **Callabo silty clay loam (CoE)** 20 to 40 percent slopes - This is a steep soil generally in areas of more than 100 acres on side slopes and ridged in the semiarid uplands. It's similar to the described as representative of the series. Includes with this soil in mapping, especially on hilltops, are small excessively eroded areas where the surface layer has been washed away and the material from sub soils is exposed. Also include are some areas that have a large amount of rocks and boulders on the surface and some small areas, mainly along drainage ways, where slopes are more than 40 percent. The runoff is rapid and the erosion is a hazard.

4. **Callabo silty clay loam (CoF2)** 40 to 60 percent slopes, eroded - This is a very steep soil is on side slopes and very narrow ridges in the semiarid uplands. It is generally found in areas of more than 100 acres. It is similar to the described as representative of the series, but it has a thinner surface layer and subsoil. Included with this soil in mapping are a few areas that have a large number of boulders and stones on the surface. Also included are small excessively eroded areas where the highly weathered volcanic rock is on the surface and few areas where slopes are less than 40 percent. The runoff is rapid and the erosion is a hazard.

5. **Llanos Series** – The Llanos series consists of well drained, gently sloping to strongly sloping soils on foot slopes, alluvial fans. And stream terraces in the semiarid area. These soils formed in fine textured and moderately fine textured and moderately fine textured sediment that derived from basic volcanic rock. Slope ranges from 2 to 12 percent. In a representative profile, the surface layer is very dark brown clay loam about 5 inches thick. The subsurface layer is black clay about 5 inches thick. The subsoil is about 19 inches thick. In the upper 5 inches it is very dark brown and black firm clay; and in the lower 14 inches it is dark brown, firm clay.
The substratum is dark brown firm clay loam; followed by dark brown, friable sandy clay loam and subsequently, by dark brown, friable sandy loam. The permeability of these soils is moderately slow. The substratum is more permeable than the other layers. These soils have a high available water capacity. The runoff is slow to medium.

6. **Llanos clay (LnC2)** 5 to 12 percent slopes, eroded - This is a strongly sloping soil mainly on foot slopes, and stream terraces in the semiarid uplands. It generally is in areas of about 50 to 100 acres, where gullies are common. It is included a few small areas of soils that are calcareous at a depth below 24 inches. Also included are some small areas of soils that are close to gullies where the underlying coarse material is closer to the surface. Erosion is a hazard and the runoff is medium.

7. **Llanos clay (LnB)** 2 to 5 percent slopes - This is a gently sloping soil on foot slopes, alluvial fans, and terraces in the semiarid area. It generally is in areas of about 50 to 100 acres. It’s similar to the described as representative of the series, except it has a slightly thicker surface layer. Includes in mapping are areas of Jacana clay, small areas of narrow strip along drainage ways where the slope is slightly more than 5 percent, and some small areas of soils that have calcareous material at a depth below 24 inches. The runoff is slow, but in heavy rains erosion is a hazard if the soils are cultivated. The plow layer is difficult to work because the stickiness and plasticity.

### 3.2.2 Site Geology

The units that outcrop at and in the vicinity of the site, as shown in the US Geological Survey Maps I-335 of the Coamo Quadrangle, prepared by Mr. Lynn Glover III. (1961) and Map I-735 of the Rio Descalabrado Quadrangle, Puerto Rico, prepared by Mssrs. Lynn Glover, III and Peter H. Mattson (1973).are as follows:

1. **Coamo Formation, tuff-breccia, tuff Member (Kcot)** – Described in the eastern sector of the Rio Descalabrado Formation, as a massive to thick-bedded coarse pyroxene-andesite tuff breccia and tuff. The most prominent colors are the dark-gray to reddish- and greenish-black. In the Coamo Quadrangle, the volcanic rock are identified as tuff-breccia, tuffaceous conglomerate, and lapilli tuff, mostly dark gray to greenish black, weathering to bright reddish and purplish. The location of an Anticline is shown in the Rio Descalabrado Quadrangle north of State Road PR-14 showing and east to west alignment of the trough line and direction of plunge. This broad westward=plunging anticline appears to be complementary to and coeval with the syncline to the north. Both folds predate the faulting and intrusion and are result of widespread and intense faulting.

2. **Colluvium (Qc)** – Described as silt, clay, fine sand and some gravel, mainly slope wash. It grades into and includes small deposits of alluvial gravel and sand on fans.

3. **Terraced alluvium (Qat)** – These are deposits of gravel and sand, commonly with cobbles and boulders. It is generally accompanied with little silt and clay. The terraces are found above present flood level.
4. Quartz keratophyre (Tqk) – Described as dark greenish-gray to pale yellowish-brown dike rock with sparse altered feldspar phenocrysts, in a very fine-grained matrix of albite microlites, quartz and chlorite.

3.3 Stratigraphic Units

3.3.1 Surface Layers

At the alluvial fans, and stream terraces [Borings 3, 4], it was found a surface layer of medium plastic dark brown clay loam exhibiting a moderate shrink/swell potential. This surface layer extends to about 1.5 to 5.0 ft. The standard resistance to penetration (N-values) is at 10 blows/foot. The natural moisture contents vary from 29 to 36 percent. Few to many roots were found in the silty clay with traces of sand layer. A sample from this layer disclosed AASHTO class type A-2-4 (0) with percent free swell values of 10%.

At the foot slopes [Boring 1, 2, 5 through 10], the thin upper layer correspond to a light dark brown, brown, and light olive brown with mottles yellow sandy silt, and silty clay, with traces of sand and traces of angular gravel fragments. Few roots were found in some of the surface samples. The standard resistance to penetration (N-values) varies from 9 to 46 blows/foot. The natural moisture contents vary from 6 to 31 percent. Clay samples from the surface layer [Boring 5 and 10] disclosed AASHTO class type A-7-6 (0) with percent free swell values at 35%.

Beneath the surface layer, at the exploratory locations, the upper layers consist of dense unconsolidated soil materials. The samples from the layers from the upper horizon were described as brown, olive brown and yellow mottled medium to dense completely weathered sandy silt with traces of weathered rock fragments. The coarse soil samples from this layer are correlated with the weathered of the massive thick-bedded coarse pyroxene-andesite tuff breccia and tuff volcanic rock as described in geological plans for fresh rock unit. The standard resistance to penetration (N-values) varies from 27 to 96 blows/foot. The natural moisture contents vary from 7 to 27 percent.

3.3.2 Completely Weathered Layers

Beneath the surface layer, the western foot hill sectors [Boring 1, 2, 9 and 10]; it was found layers of completely to moderately weathered materials generally extending to the depths at which the borings were bottomed. The materials were described as light olive brown, very dark brown, light brownish gray, with mottles yellow completely weathered rock into sandy silt and occasional sandy clayey silt fines. The standard resistance to penetration (N-values) of these intermediate weathered materials varied from 18 to 66 blows/foot, at a dense to very dense State of Relative Density. Also practical refusal to penetration was disclosed, in some of the samples of the completely to moderately weathered material, with values in excess of 60.
blows for a few inches to penetration, as shallow as 9.0 ft. from ground surface. The natural moisture contents vary from 7 to 26 percent.

### 3.3.3 Highly Weathered Layers

At the eastern sectors the borings of higher elevation [Borings 4 through 8], the moderately weathered to highly weathered rock material were encountered at deeper drilled levels. The highly weathered rock showed values exceeding 100 blows for a few inches of penetration. The sample disclosed the rock material from the parent rock, described as light olive brown with mottles yellow coarse-grained massive thick-bedded coarse pyroxene-andesite tuff breccia and tuff volcanic rock. Practical refusal to penetration with values in excess of 100 for 1-inch of penetration is where rock coring is required for advancement of the boring. Usually this is indicative of the occurrence of more fresh materials from the same geologic group. No further drilling was required in the preliminary exploration.

The graphical representation of the soil profiles are found in the boring logs included as Appendix (1) to this report.

### 3.4 Groundwater Levels

The permanent ground water level was not found within the extent of depth drilled in the exploration. The groundwater level is measured after completion of the borings, during the period of the field work. All surface ground and underground water flow should flow from the higher sectors at the north and central areas toward the lowland areas to the gullies and the stream.

### IV. PRELIMINARY GEOTECHNICAL ENGINEERING ASSESSMENTS

The tract of land is subdivided into two major land sectors (West/East) of the Main Stream (intermittent) Alignment, which runs north to south nearly parallel to State Road PR-138. Parcel of Land No. 1 is approximately of 166,327 Cdas. and Parcel of Land No. 2 is approximately of 27,885 Cdas. The stream is identified in the Soil Conservation Service Manual (Sheet # 25) as terrace alluvial deposits, where the erosional scar is deep. At the north sectors of the stream, remnant of an old detention pond was observed. The pond was apparently abandoned. Presently, the major deep intermittent stream is bordered by trees. Another stream passing through the eastern land sector is also identified to drain towards the south boundary limit and to the fill embankment base of State Road PR-14. The road embankment serves as a barrier to the intermittent stream causing excess water to flow parallel along the north bank of the fill section.

Based on an historical review of aerial photographs (Goggle Maps), it can be gathered that the lands were used for agricultural purposes possibly cattle pasture. Based on the field reconnaissance, near stream alignment of the central/south sector, is currently being used as old car junkyard. Currently, except for the continuous urban developments...
of the peripheral/neighborhood lands, no additional uses have been identified at the study areas.

4.1 General Preliminary Foundation Construction Guidelines

The surface virgin soils at the lowland lands show a deep root zone and mostly are black clay material which sticky and plastic occasionally with a high shrink-swell potential. Below the variable surface deposits it is found typically coarser soils and weathered material, which possess a moderate to low shrink-swell potential. Thus, once the surface soils are removed the remaining soils and completely weathered material are capable to sustain the loads of the proposed Walk-up Buildings and One-story Dwelling Units of development. However, the surface very loose soils and old agriculturally modified fill sections intermixed with old top soil layers were found at some locations.

At the remaining sectors, the material corresponds to moderately steep soil on side slopes, foot slopes, and rounded hilltops in the semi-arid uplands. The solum of the upland sectors of the farm have been described and a thin loamy surface layer followed by weathered rippable material of low to very low shrink-swell potential. These soils formed in residual material weathered from thick-bedded coarse pyroxene-andesite tuff breccia and tuff volcanic rocks. These soils are on side slopes and rounded hilltops of the volcanic hills. The most important consideration is the grading on cut and fill sections beneath the structures, which required a uniformity of thickness to minimize differential settlements. The use of undercutting is one of the possible approaches in the grading design.

The highland sectors of Parcel of Land No. 1 have dedicated as a reserve area. The planned developments areas have been identified at side and foot slopes of the main hill sector. West of the main stream alignment at the prominently of intermediate elevations of Parcel No. 1 are additional development sectors. The topography corresponds to gently sloping slopes and nearly leveled grounds of the alluvial fans, and terraces.

The remaining land sectors pertain to Parcel of Land No. 2, where Single Family Dwelling Units and Walk-up Residences are planned. Also at this sector, Lots for Commercial Development have been identified.

4.2 Fill Embankment Stabilization at Lowland Sectors

As part of the site construction, at the initial stage of construction, it is necessary to pre-treat the existing soils. The following construction stages shall be considered for these sectors of construction:

1. Once the surface unsuitable material (surface vegetative cover) and any remnant of organic soils which may be found close to the banks of the river, gullies and previously filled sectors is removed, the permanent fill layers shall be deposited in stages.
2. A uniform thickness beneath the footprint of the structure shall be provided. In any case, the difference in the total fill thickness beneath any structural unit, as established by the structural designer, shall not exceed 1.0 m.

3. The earth fill material below the existing groundwater level shall be of A-2-4 or better AASHTO type. A-1-a fill type is recommended to be deposited at the flood susceptible zones.

4. Slope embankment section subjected to stream scour shall be also protected with a rip rap facing with suitable erosion protection fabrics over the improved surface virgin soils. The protective cover shall be placed to a minimum elevation of 1.5 m. above the maximum flood level, as storm water shed hydrologic analysis may reveal. Such studies are beyond the scope of the present geotechnical work.

4.3 Preliminary Geotechnical and Foundation Design

Alternate scheduling construction schemes would have to be developed, considering the delay stabilization program at the site, if the fill section exceeds 3.0 m. in thickness. Under the soil improvement scheme presented in the previous section to this report, at the lowland sectors the expected settlements can be tolerated by the proposed One- or Two-story single-family structures of development can be constructed, provided the control of the engineering earth fill construction process is made in accordance to specifications. Detailed Explorations shall be performed for Single Family Dwelling Units and Multi-story Walk-up units of development, once the final grading plans are available.

At the selected site, the structures may be founded over the proposed fill section. Obviously, following the removal of any loose or soft organic clay soils or old loose fill section is where the maximum depth of over excavation of unsuitable material is predicted. Also, a uniform fill section is required, for which the expected fill section may increase even more. This is to assure the differential settlements are maintained within tolerable limits for the structural dwelling units.

The design of the foundations of the structures shall consider spread or continuous foundation systems at standard foundation depths for fill sectors. At cut sectors, over the residual soil material or weathered rock, suitable allowable bearing value values shall be considered for the structure types and load conditions.

4.3.1 Special Settlement Considerations at Lowland Sectors

Under the shallow footing type, it shall be considered in the design differential settlement, between the central and extreme sectors of the unit. The estimated and predictions of both differential and total settlements shall be contained in the final geotechnical report, once the final phase of exploration including special laboratory consolidation testing, considering the various load types (new superimposed fill and structure loads). Earth fill embankment slopes shall be treated in the same fashion as for structures.
4.4 Required Soil Improvements at Lowland Sectors

At lowlands sectors (i.e. gully and stream sectors), an over-excavation is required, to remove the surface very loose sandy material and organic sediments, if any, disclosed in the investigation. At these sectors of the project, the over excavation or demucking process shall be required prior to the placement of the structure fill section, where the new fill section is thin or cutting is required for the general grading of the dwelling units.

Thus, at the areas of structures including slopes, pavements and developing areas, it is recommended the partial removal of the surface very loose sandy material and organic sediments, if any. It shall involve the removal of material under the direct supervision of a representative from this office. The expected depth of removal varies at lowland stream sector between 3 to about 7 ft. in depth. At cut sectors, a recompaction of the surface exposed layer or highly eroded surface section. It is suggested that a highland sectors an over cutting to reach the foundation (Df) be done in advance and backfilling be done to establish the finished floor level at the structure and excavation sectors for storm sewers and sanitary sewer pipelines alignments. Thus, such back fill and new fill sections should be considered for final cost estimates.

At the toe of the existing slopes and channel section, where earthwork required raising the lands to higher sloping levels, the demucking phase constitute one of the most important efforts to provide stability of the proposed permanent slopes at the site. The expected thickness of removal shall be established after a detailed exploratory work is done.

4.4.1 Considerations for Fill Construction

The earth fill material shall consist of a granular AASHTO A-2-4 or better type compacted to not less than 95 percent of its laboratory Modified Proctor Compaction Density.

At the location of the structures, the improvement of the surface material is mandatory. These shall be improved to the satisfaction of the inspecting Soils Engineer or approved representative. After removal of all surface top soil roots, the footings of the structure shall be founded over the in-situ soils at the recommended minimum foundation depth. The top soil material containing deep root matter due to previous agricultural land use extends to depth varying from 2.0 to 4.0 ft.

The ground floor slab of the structures shall be casted over a well-engineered fill material, following the standard specifications for fill construction, contained in Appendix II to this report.

Also, it is necessary to remove any surface soil material containing overly saturated plastic clay matter, to depth varying from 1.5 to 4.0 ft. [Borings 3 to 5, 8 & 10]. After the surface top soil material is removed and demucking of organic clay materials, under the direct supervision of a representative from this office, the engineered fill can be placed in 6-
inch lifts. Any surface unsuitable overly saturated plastic clay material, if any, shall be removed prior to the deposition of the new properly engineered structural fill.

4.4.2 Groundwater Considerations

Some dewatering is expected during the foundation excavations and earthwork within the clay material, where ponds of water are normal. Particularly, during periods of intensive rains, some dewatering should be expected in the excavation phase of construction resulting from surface runoff. Any groundwater flows must be intercepted and carried to adequate drainage units outside the dwelling units’ areas.

At the site, moderate precipitation is expected. Nevertheless, dewatering and drainage problems should be carefully planned in advance, to assure proper temporary stability of excavations during construction.

During construction, care should be taken to drain rain water to proper outfalls. All surface run-off water shall be collected and drained away from the structures and from slopes surfaces. Internal structure drains are not recommended.

4.5 Earthquake Design

The Soil Profile Types (from 2009 International Building Code), which shall be used for the determination of the base shear of the dwelling units shall be as follows:

<table>
<thead>
<tr>
<th>Sector Covered</th>
<th>Range of Depths (ft.)</th>
<th>Soil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borings 1, 2, 10</td>
<td>0' to 5'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>5' to 10'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>deeper than 10'</td>
<td>SC-SB</td>
</tr>
<tr>
<td>Borings 4, 5, 6, 7</td>
<td>0' to 4'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>4' to 10'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>deeper than 10'</td>
<td>SC-SB</td>
</tr>
<tr>
<td>Borings 3, 8, 9</td>
<td>0' to 4'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>4' to 10'</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td>deeper than 10'</td>
<td>SC-SB</td>
</tr>
</tbody>
</table>
4.6 General Earthwork and Site Improvement Recommendations

4.6.1 Existing Slope Stability Conditions at Project Lands

Based on the US Soil Conservation Service Manual the surface soils at the site the surface soils are moderately steep soil on side slopes, foot slopes, and rounded hilltops, where their susceptibility to erosion is of concern. At sectors where the runoff is rapid, the thin surface clayey soils and the erosion is a hazard. However, the substratum, and underlying material consist saprolitic material weathered from volcanic rocks. Based on the US Geological Survey of the zone, the Colluvium and Terraced alluvial soils correspond to the units which may be considered susceptible to erosion.

If slopes are steep enough, movements can occur on any land form. However, on land forms susceptible to landslides, other factors being equal, the steepest slopes are the most vulnerable locations. The most common cause of a large number of slides that occur on steep slopes is in residual or colluvial soils sliding on a weathered bedrock surface. The loose, unconsolidated soils cannot maintain as steep a slope as that which can be imparted to the underlying rock surface, and are, consequently, in a delicate balance.

Based on the site reconnaissance and subsurface soil data at the project under the prevailing topographic conditions, no evidence of slope stability problems was disclosed. Considering the subsurface data secured in the exploration and geotechnical evaluations, except at the more steeper sloping terrain and at some small areas of soils that are close to gullies is where the erosion is a hazard during heavy rains. However, the occurrences of slope stability problems are not foreseeable in the completely and moderately weathered materials of the tuff-breccia, tuffaceous conglomerate, and lapilli which are the parent volcanic rock units at the site.

In any event, the specification for construction earthwork contained in the following Sections (Sections 4.6.2 to 4.6.5) provide the necessary construction requirements for cut and fill sector for the different project types being considered at this stage of planning. In addition, (Section 4.7 - Storm Water Run-off Control) also provide adequate assessments for the planning phase. Such guidelines shall be incorporated in the design for each construction phase to incorporate further assurance that no unstable slope stability conditions are created. To cope with undisclosed soil and steep sloping condition, due to topographic conditions existing or as required by grading, several retaining structure solutions are available, which can be used where design requirements so require. At this stage such conditions are not foreseeable.

4.6.2 Special Considerations for Earthfill Embankment Construction

As previously indicated, the surface loose material found at some sectors of the project present problems associated with loose sands and medium soft clay materials, which must be treated prior to the performance of major earthwork operations. Prior to filling, at structure development sectors the removal of surface unsuitable soils is of paramount importance. It is for such reason, it is recommended to remove the surface very loose sands and surface organic section, to cast foundations at shallow levels over a well-
engineered fill section. The earthwork required under such circumstances involves the cutting of existing material beneath the existing clay material found at the explored locations. After the surface undesirable material is removed, under the direct supervision of a representative from this office, the engineered fill can be placed in 6-inch lifts.

Of particular importance is the pre-construction phase, prior to the deposition of any fill at the site. The following fill construction guidelines shall be incorporated in the plans and specification for fill construction.

1. All fill slopes shall be constructed at a maximum slope ratio of 2H: 1V (Horizontal: Vertical). At cut sectors or where the very loose sands and near the stream the slope ratio shall be 2.25H: 1V. The surface exposed material to stream forces shall be provided with stone armor adequately protected against stream currents as an hydrologic study may reveal. This criterion shall supersede any other standard specification related to slope construction.

2. The fill shall be of an inorganic and non-swelling nature, having an A-2-4 or better AASHTO Classification. All borrow materials shall be taken to a soils laboratory for testing and approval prior to their use at the project. Refer to Appendix 3 for classification test results of samples from the surface layers of the site.

3. At fill sectors where the sloping grounds exceed 8H: 1V, benching is required prior to placement of the earth fill embankments. Benching requires horizontal cuts in the existing slope, to physically notched out and connects the original side slope to the new embankment. Appendix 2-A detail the specifications and standard criterion for excavation and earthwork benching.

All fill material for pavement sectors shall also comply with AASHTO A-2-4 or better classification and shall be compacted in layers not to exceed 6 inches to not less than 95% of the Modified Proctor Density. The enclosed fill specifications (Appendix 2) detail our recommended Fill Specifications.

4.6.3 Special Considerations for Cuts for Grading

1. At cut sectors, the slopes the upper unconsolidated section (some 5 to 10 ft. thickness) shall be provided with a slope ratio of 2H: 1V (Horizontal: Vertical).

2. The moderately weathered material shall be provided with a maximum slope ratio of 1.5H: 1V (Horizontal: Vertical).

3. Cuts into fresh rock can be provided with a 1H: 1V slope ratio. These materials were not drilled in the present preliminary boring program. Thus, verification of the exposed material by observation of a representative from this office shall be required, in order to assure slope stability of permanent slopes. The erosion potential and weathering of the exposed material prior to cutting shall be ascertained through actual field observations.
4.6.4 Earthwork Demucking Operations

At some locations, the surface loose and undesirable material shall be adequately removed during an initial demucking phase of construction which shall follow the general stripping of the vegetative cover.

At the gully and stream channels is where the surface loose and undesirable organic material has been found beneath the surface top soil layer. These shall be adequately removed during an initial demucking phase of construction.

Based on the present profile data, the demucking, which includes but not limited to the stripping of topsoil, an over excavation of wet over saturated clay soils, shall be considered as a first phase for the earth construction contract for the demucking at lowland sectors. The actual depth and horizontal extend of excavation shall be determined directly at the field by the inspecting Soils Engineer.

4.6.5 Excavations and Rippability Characteristics

For most parts of the project, shallow excavations not exceeding 4 to 5 ft. can be performed using back hoe equipped with a short tip radius and narrow bucket. Frequent occurrence of consolidated materials, and boulders and rock fragments within the fill section and upper alluvial profiles above the base of foundation elevations will increase both the time and cost of the operations. Some locations were found to exhibit high resistance to penetration values above the 3 ft. level, beneath existing grade at the presently investigated locations.

It is estimated that for trench excavations, which are limited in dimensions, the use of back hoes shall be used for the excavations. These shall be equipped with special demolition tools to drill through the more consolidated portions in the profiles to attain the desired invert elevations of the pipes. The difficulty of excavations begins to be of consideration for materials exhibiting higher than 40 blows/foot of penetration.

In this project, it is evident that such types of materials are found and they will be more evident after the general grading operations are done. Since maximum cuts to approximately up to 30 ft. are presently contemplated, the residual, weathered rock and highly weathered rock material from the weathered from thick-bedded coarse pyroxene-andesite tuff breccia and tuff volcanic rock shall be encountered. At most of the explored locations the material corresponds to completely weathered materials from the parent rock.

Experience dictate with similar materials, such as consolidated clays, and residuum of the weathered volcanic rock found much deeper. Sometimes it is required the use of systematic drilling and even the use of pave-breakers, to lower excavation through these very hard residual materials.

A careful review of the geological plans with the herein enclosed profile information would assist the planners in the selection of the adequate cutting equipment of the project. It should be noted that sound rock material was not drilled in the present test boring program. Gravely soils and weathered rock nuclei and outcrops of the partially weathered...
rock material may be found. The surface elevation of the hard rock layers is predicted at some locations at the depth at which the borings were bottomed.

Additional seismic refraction survey shall be performed to establish and predict the required earth-moving equipment to excavate through the different geological formations and rock types, at each sector of the project. It is known that excavation in rock depends on the bedding planes (joint spacing and thickness of beds).

It is obvious that the surface completely weathered and alluvial soils found in the thin shallow levels are relatively easy to remove. The residual is relatively deep and due shallow cuts are predicted. However, residual and weathered rock or fragments of boulders, cobbles may be found. The field data contained in subsurface explorations through these materials tend to give a false impression that they can be easily removed with standard heavy equipment, as they are broken with the split spoon sampler device during sampling. The necessity of alternate tandem ripping with demolition tools attached to the back hoe shall be considered as a required item in the earth-moving contract for the trench excavations. Actual fresh rock drilling was not required during the drilling operation, within the extent of depth drilled in the present exploration.

4.7 Storm Water Run-off Control

Whenever large topographic changes are made, groundwater flows are usually found, which can be detected during the grading process. Such conditions shall be observed and the flow diverted to proper outfall, through adequate drainage units.

To prevent underground degradation of the fills, it is necessary to provide adequate drains, consisting of crushed stone or clean gravel enclosed in filter fabrics to prevent clogging. The drains minimum cross section dimension shall be established based on the water shed analysis of the gully or stream being considered.

Drainage units of sufficient capacity shall be also provided. All surface water shall drain freely away from the embankment slope mass. The existing gullies shall be provided with coarse gravelly materials to prevent erosion. Thus, French drains shall be provided along existing gullies and embankments, to allow adequate drainage of subsurface flows once the gullies are filled. The "French Drains" shall be properly enclosed in non-woven filter fabrics.

4.8 Recommended Final Geotechnical Exploration

In this project, an additional comprehensive subsurface exploration requires a sufficient amount of borings with pertinent tests, to evaluate the horizontal extent of the critical profiles and to quantify the stress/strain behavior upon placement of the new earth backfill and permanent structure loads to be considered in the final design.

It is necessary to provide the foundation types required for each sector of development. Thus, it is required for the final geotechnical exploration phase to include a
sufficient number of borings and specimens (SPT and special undisturbed thin-wall samples) to permit an adequate prediction of the settlement, time of stabilization and the design of the required improvement necessary for the prevailing soils conditions, at each identified building sector.

The final grading plans and final building layout for each development area shall be available to this office to establish the additional complementary exploration needed. Also, the building types and descriptions (i.e. number of stories, and loading conditions) shall be also known in advance of the final site exploratory effort.

Standard Geotechnical exploration guidelines require the identification of soil parameters to be used in the prediction of the soils behavior of under the design loads. For settlement calculations it is necessary to establish physical index properties for each soil layer found. Soil properties such as natural moisture content (w), unit weight of soils (γ), specific gravity of soils (G) and the results of oedometer tests, among others, are a few of the special laboratory tests required for the final geotechnical recommendations.

4.9 Additional Recommendations

We urge that our firm be retained to review those portions of the plans and specifications that pertain to earthwork and foundations to determine whether they are consistent with our recommendations.

The recommended geotechnical design concepts must be complemented with a structural design, which include and is not limited to the preparation of plans and specifications. For such purposes we urge the structural designer to contact this office to clarify and review the designed process and to assist in the preparation of the specifications for the required work, to meet the geotechnical requirements herein being presented.

In addition, we are available to observe construction, particularly during earthwork and the pile installation process, and other field observations as may be necessary.

VI. LIMITATIONS OF THIS REPORT

The above recommendations are based in the information and interpretation of laboratory data of an arbitrary number of test borings. Actual conditions, especially at intermediate locations, may differ from the information obtained in this exploration. The owner or contractor are urged to contact this office if different conditions than those herein described are encountered.

The recommendations contained in this report may have to be varied to accommodate recommendations to cope with undisclosed conditions. Furthermore, the monitoring and inspection of earthwork related construction procedures, as well as the supervision of the implementation of the herein given recommendations shall be made by the writer or his approved representative.
Otherwise, the inspecting engineer shall study this report, perform additional tests as he deems necessary, to submit his own recommendations or assume full responsibility of the herein given recommendations in their entirety.

Respectfully Submitted,

DESPIAU ASSOCIATES

Benigno R. Despiau, P. E.
Consulting Engineer

November 8, 2011
DA/11S3302

Appendix (1) - Boring Logs
Appendix (2) - Earthwork Specifications
Appendix (2-A) - Specifications for Excavation and Earthwork Benching
Appendix (3) - Special Laboratory Tests
APPENDIX (1)

Boring Logs