ECS Southwest, LLP
Geotechnical Engineering Report
City of Carrollton Veterans Memorial Plaza

1700 Keller Springs Road
Carrollton, Texas

ECS Project Number 19:7610

February 14, 2019
February 14, 2019

Mr. Jim Waldbauer, P.E.
BW2 Engineers, Inc.
1919 Shiloh Road, Suite 500, LB 27
Garland, Texas 75042

ECS Project No. 19:7610

Reference: Geotechnical Engineering Report
City of Carrollton Veterans Memorial Plaza
1700 Keller Springs Road
Carrollton, Texas

Dear Mr. Waldbauer:

ECS Southwest (ECS) has completed the subsurface exploration, laboratory testing, and geotechnical engineering analyses for the referenced project. Our services were performed in general accordance with our Proposal No. 19:9190-GPr, dated February 4, 2019. This report presents our understanding of the geotechnical aspects of the project along with the results of the field exploration and laboratory testing conducted. The report also contains our findings and recommendations for design and construction.

It has been our pleasure to be of service to you during the design phase of this project. We would appreciate the opportunity to remain involved during the continuation of the design phase, and we would like to provide our services during construction phase operations as well to verify the assumptions of subsurface conditions made for this report. Should you have any questions concerning the information contained in this report, or if we can be of further assistance to you, please contact us.

Respectfully submitted,

ECS Southwest, LLP

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The electronic seal on this document was authorized by Michael P. Batuna No. 92147, on February 14, 2019
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Appendix A – Figures

- Site Location Map
- Hand Auger Boring Location Diagram
- Regional Geology
- Clay Plug Detail

Appendix B – Field Operations

- Reference Notes for Hand Auger Boring Logs
- Hand Auger Boring Logs HA-1 through HA-4

Appendix C – Laboratory Testing

- Laboratory Testing Summary
EXECUTIVE SUMMARY

The following summarizes the main findings of the exploration, particularly those that may have a cost impact on the planned development. Further, our principal foundation recommendations are summarized. Information gleaned from the executive summary should not be utilized in lieu of reading the entire geotechnical report.

- The geotechnical exploration performed for this study consisted of a total of four (4) hand auger borings for the City of Carrollton Veterans Memorial Plaza to depths of approximately 2 to 6.2 feet below the existing site grades.

- The borings encountered Fat Clay (CH) soils to termination depths of about 2 to 6.2 feet below existing site grades. Hand-Auger HA-1 was terminated at a depth of about 2 feet due to existing underground utility. Groundwater seepage was encountered in hand-auger borings HA-2 to HA-4 at depths of about 4 to 4.7 feet during subsurface exploration and at the completion of exploration.

- The planned Veterans Memorial Plaza may be supported on a shallow foundation system consisting of footings, or monolithic slab-on-grade.

- Subgrade treatment of the high plasticity and expansive clay soils are necessary to reduce the potential for vertical movement. Specific details on addressing these high plasticity and expansive clay soils are presented in the body of the report.
1.0 INTRODUCTION

1.1 GENERAL

The purpose of this study was to provide geotechnical information for the design of the foundation for a Veterans Memorial Plaza with associated concrete sidewalks.

The recommendations developed for this report are based on project information provided by the client. This report contains the results of our subsurface exploration and geotechnical laboratory testing program, site characterization, engineering analyses, and recommendations for the design and construction of the planned structure.

1.2 SCOPE OF SERVICES

To obtain the necessary geotechnical information required for evaluation of subsurface soil conditions supporting the structure, four (4) soil hand-auger borings were performed to depths of about 2 to 6.2 feet below the existing site grades. A laboratory-testing program was also implemented to characterize the physical and geotechnical engineering properties of the subsurface soils.

This report discusses our exploratory and testing procedures, presents our findings and evaluations and includes the following:

- A brief review and description of our field and laboratory test procedures and the results of testing conducted.
- A review of surface topographical features and site conditions.
- A review of area and site geologic conditions.
- A review of subsurface soil stratigraphy with pertinent available physical properties.
- A final copy of our soil hand-auger borings.
- Recommendations for site preparation and construction of compacted fills, including an evaluation of on-site soils for use as compacted fills.
- Recommended foundation types.

1.3 AUTHORIZATION

Our services were provided in accordance with our Proposal No. 19:9190-GPr, dated on February 4, 2019 and executed by the client on February 5, 2019.
2.0 PROJECT INFORMATION

2.1 PROJECT LOCATION

The project is located at 1700 Keller Springs Road in Carrollton, Texas. The location is depicted in Figure 2.1.1 as shown below.

![Figure 2.1.1 Site Location](image)

USGS Topographic Map, Carrollton, TX Quadrangle 2016

2.2 CURRENT SITE CONDITIONS

The surface area of proposed Veterans Memorial Plaza is covered with grass. Carrollton Public Library and Senior Center buildings are present on the north portion of project site. Detention ponds can be observed on the northeast and south sides of the site. The site ground surface elevations slopes down from north to south with maximum and minimum elevations of approximately EL 479 feet and EL 475 feet, respectively based on NCTCOG topographic maps.

2.3 PROPOSED CONSTRUCTION

We understand that the project will consist of a Veterans Memorial Plaza with elevated panels constructed with steel posts into the concrete foundations. We assume the columns loads will be less than 25 kips.
3.0 FIELD EXPLORATION

3.1 FIELD EXPLORATION PROGRAM

The field exploration was planned with the objective of characterizing the project site in general geotechnical and geological terms and to evaluate subsequent field and laboratory data to assist in the determination of geotechnical recommendations.

The subsurface conditions were explored by performing a total of four (4) hand-augers borings for the structure to depths of approximately 2 to 6.2 feet below the existing site grades. The subsurface exploration was completed under the general supervision of an ECS representative.

The hand-auger boring locations were located by the City personnel Mr. Darren Gregg, PLA and identified in the field by ECS personnel using the supplied diagram. The hand-auger borings were performed up to depths of about 2 to 6.2 feet below the existing site grades. Existing utility was encountered in one of the hand auger boring (HA-1) at the termination depth of 2 feet. Water was encountered in the other three borings at bottom of the boring termination which prevented the hand auger sampling to go deeper. The approximate hand-auger boring locations are shown on the Hand-Auger Boring Location Diagram in Appendix A. The ground surface elevations noted in this report were obtained from NCTCOG topographic maps (www.dfwmaps.com).

Field logs of the soils encountered in the borings were maintained by the ECS personnel. After recovery, each geotechnical soil sample was collected and visually classified. Representative portions of each soil sample was then wrapped in zip-lock covers and transported to our laboratory for further visual examination and laboratory testing. After completion of the hand auger operations, the boreholes were backfilled with auger cuttings to the existing ground surface.

3.2 REGIONAL GEOLOGY

The regional parent geologic mapping indicates that the site is underlain by Eagle Ford (Kef) geologic formation. The parent rock of the Eagle Ford consists of uniform, dark gray shale. The shale is typically on 200 to 300 feet thick in full section. Since shale weathers easily, this rock typically cannot be seen in creek beds or outcrops. In some areas, it can form an undulating topography. Upper portions of the shale can weather to form a softer clayey shale.

Chemical and mechanical weathering of the shale forms highly plastic clay soils. These clays are considered to exhibit some of the highest shrink/swell volume with moisture fluctuations. Tan and gray shaley clays are common above the rock, becoming dark brown to dark gray at shallower depths.

The location of the site on the geologic map is provided below on Figure 3.2.1.
3.3 SUBSURFACE CHARACTERIZATION

The subsurface conditions encountered were generally consistent with published geological mapping. The following sections provide generalized characterizations of the soil and rock strata encountered during our subsurface exploration. For subsurface information specific information refer to the Boring Logs in Appendix B.

<table>
<thead>
<tr>
<th>Approximate Depth to Bottom of Strata Below Grade (ft)</th>
<th>Material Description</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2* to 6.2*</td>
<td>FAT CLAY, dark brown, light brown, with gravel pieces</td>
<td>–</td>
</tr>
</tbody>
</table>

* Hand-Auger boring refusal depth

Please refer to the attached boring logs and laboratory data summary for this field exploration for a more detailed description of the subsurface conditions encountered in the borings as the stratification descriptions above are generalized for presentation purposes.
3.4 SOIL SURVEY MAPPING

Based on the United States Department of Agriculture soil survey, the site is underlain by the Heiden Clay. The Heiden Clay soils have very low to moderately low permeability, and are well drained. The parent material of these soils is clayey residuum weathered from mudstone.

3.5 GROUNDWATER OBSERVATIONS

Groundwater level observations were made in the borings during hand auger operations. In conventional hand augering operations, groundwater can be observed to naturally flow into and out of the open borings. Groundwater was encountered while performing hand-augers in HA-2 through HA-4 at depths of about 4 to 4.7 feet below the existing site grades.

The highest groundwater observations are normally encountered in the late winter and early spring. Fluctuation in the location of the long-term water table may occur as a result of changes in precipitation, evaporation, surface water runoff and other factors not immediately apparent at the time of his investigation. Therefore, the groundwater conditions at this site are expected to be significantly influenced by surface water runoff and rainfall.
4.0 LABORATORY TESTING

The laboratory testing was performed by ECS on selected samples obtained during our field exploration operations. Classification and index property tests were performed on representative soil samples obtained from the test borings in order to aid in classifying soils according to the Unified Soil Classification System and to quantify and correlate engineering properties. The soil samples were tested for moisture content, Atterberg Limits and gradation.

An experienced geotechnical engineer visually classified each soil sample from the hand-auger borings on the basis of texture and plasticity in accordance with the Unified Soil Classification System (USCS) and ASTM D-2488 (Description and Identification of Soils-Visual/Manual Procedures). After classification, the geotechnical engineer grouped the various soil types into the major zones noted on the hand auger boring logs in Appendix B. The group symbols for each soil type are indicated in parentheses following the soil descriptions on the hand auger boring logs. The stratification lines designating the interfaces between earth materials on the hand auger boring logs are approximate; in situ, the transitions may be gradual.

The soil samples will be retained in our laboratory for a period of 60 days, after which, they will be discarded unless other instructions are received as to their disposition.
5.0 DESIGN RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics and subsurface conditions. If there are any changes to the project characteristics or if different subsurface conditions are encountered during construction, ECS should be consulted so that the recommendations of this report can be reviewed. If the finished floor elevation deviates from the provided grade, the recommendations provided below should be evaluated by our office.

5.1 POTENTIAL VERTICAL MOVEMENTS AND SUBGRADE IMPROVEMENTS

The soils encountered at this site are highly expansive. These soils are susceptible to shrink swell tendencies, occurring seasonally, throughout the life of the plaza with the changes in moisture content. Based on test method TEX-124-E in the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, and our experience with similar soils, we estimate potential vertical soil movements (PVM) will be about 4 to 5 inches under dry conditions. The actual movements could be greater if poor drainage, ponded water, and/or other unusual sources of moisture are allowed to saturate the soils beneath the structure after construction.

The soil condition is currently very moist to wet. The in-situ PVM is about 3 to 4 inches. Subgrade treatment recommendations is provided below to reduce the PVM.

Table 5.1.1 Subgrade Improvements for In-Situ Soil Conditions

<table>
<thead>
<tr>
<th>Depth of Non-Expansive Fill (feet)</th>
<th>Depth of Moisture Conditioning (feet)</th>
<th>Total Depth of Improved Zone (feet)</th>
<th>PVM (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

The existing moisture content should be maintained and not allowed to dry. The subgrade improvements should extend at least 5 feet beyond the edge of the building pad, and include any flatwork sensitive to movements such as sidewalks. Select fill should not be used outside of the building pad limits. Exterior grade beam backfill should consist of on-site lime stabilized soils or on site moisture conditioned clay.

5.2 BUILDING DESIGN CONSIDERATIONS

Foundation loads may be designed for support on a shallow foundation system consisting of a monolithic slab or conventional footings. The following sections provide recommendations for foundation design, slabs, seismic design parameters and retaining walls

5.2.1 Monolithic Slabs

The structure can be supported on a monolithic/waffle slab and grade beam foundation system designed in accordance with the following information provided on the recommended treated subgrade to reduce the PVR.
Table 5.2.1.1 Slab Parameters

<table>
<thead>
<tr>
<th>Items</th>
<th>Design Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Bearing Capacity</td>
<td>2,500 psf</td>
</tr>
<tr>
<td>Design PI</td>
<td>60</td>
</tr>
<tr>
<td>Climatic Rating (Cw)</td>
<td>20</td>
</tr>
<tr>
<td>Unconfined Compressive Strength (tsf)</td>
<td>1.5</td>
</tr>
<tr>
<td>Soil-Climate Support Index (1-C)</td>
<td>0.34</td>
</tr>
</tbody>
</table>

A net allowable soil bearing pressure of 2,500 psf can be used to design grade beams founded on the reworked existing soils or compacted non-expansive fill, as described above in the section titled “Earthwork Operations”. Grade beams should have a minimum width of 12 inches to reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" failures. Additionally, the grade beams should extend at least 18 inches and 30 inches below final adjacent grade to utilize this bearing pressure for interior and exterior beams, respectively.

These design parameters assume that positive drainage will be provided away from the structure and with moderate irrigation of surrounding lawn and planter areas with no excessive wetting or drying of soils adjacent to the foundations. Greater potential movements could occur with extreme wetting or drying of the soils due to ponding of water, plumbing leaks or lack of irrigation.

The Wire Reinforcement Institute recommends the mesh reinforcement be placed 2 inches below the slab surface or upper one-third of slab thickness, whichever is closer to the surface. Adequate construction joints, contraction joints and isolation joints should also be provided in the slab to reduce the impacts of cracking and shrinkage. Please refer to ACI 302.1R96 Guide for Concrete Floor and Slab Construction for additional information regarding concrete slab joint design.

5.2.2 Shallow Foundations

Provided subgrades and structural fills are prepared as discussed herein, the proposed structure can be supported by conventional shallow spread footings. A net allowable soil bearing pressure of 2,500 psf may be used for footings bearing on newly placed and compacted fill. Continuous footings should have a minimum dimension of 18 inches and isolated column footings should have a minimum lateral dimension of 24 inches. Footings should extend at least 30 inches (exterior) and 12 inches (interior) below grade in order to utilize this bearing pressure.

These design parameters assume that positive drainage will be provided away from the structure and with moderate irrigation of surrounding lawn and planter areas with no excessive wetting or drying of soils adjacent to the foundations.

The net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. The final footing and/or grade beam elevation should be evaluated by competent geotechnical engineering personnel to verify that the bearing soils are capable of supporting the recommended net allowable bearing pressure and suitable for foundation construction.
The settlement of a structure is a function of the compressibility of the bearing materials, bearing pressure, actual structural loads, fills depths, and the bearing elevation of footings with respect to the final ground surface elevation. Estimates of settlement for foundations bearing on engineered or non-engineered fills are strongly dependent on the quality of fill placed. Factors that may affect the quality of fill include maximum loose lift thickness of the fills placed and the amount of compactive effort placed on each lift.

If the recommendations outlined in this report are followed, we expect total and differential settlements for the proposed construction to be on the order of 1 inch. This evaluation is based on our engineering experience and the anticipated loadings for this type of structure, and is intended to aid the structural engineer with their design.

Exposure to the environment may weaken the soils at the foundation bearing level if the foundation excavations remain exposed during periods of inclement weather. Therefore, foundation concrete should be placed the same day that final excavation is achieved and the design bearing pressure verified. If the bearing soils are softened by surface water absorption or exposure to the environment, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete. If the foundation excavation must remain open overnight, or if rainfall is apparent while the bearing soils are exposed, we recommend that a 1 to 3-inch thick "mud mat" of "lean" concrete be placed over the exposed bearing soils before the placement of reinforcing steel.

5.2.3 Building Slab and Perimeter Conditions

We recommend that a modulus of subgrade reaction (ks) of 125 pci be used for the design of slabs on grade for the prepared clay subgrade. If floor treatments that are sensitive to moisture will be used, a vapor barrier of polyethylene sheeting or similar material should be placed beneath the slab to minimize moisture migration through the slab. If a vapor barrier is considered to provide moisture protection, special attention should be given to the surface curing of the slabs to minimize uneven drying of the slabs and associated cracking and/or slab curling. The use of a blotter or cushion layer above the vapor barrier can also be considered for project specific reasons. Please refer to ACI 302.1R96 Guide for Concrete Floor and Slab Construction and ASTM E 1643 Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs for additional guidance on this issue.

Soils placed along the exterior of the building should be on-site clay soils placed and compacted in accordance with this report. The purpose of this clay backfill is to reduce the opportunity for surface or subsurface water infiltration beneath the structure.

Irrigation of lawn and landscaped areas should be moderate, with no excessive wetting or drying of soils around the perimeter of the structure allowed. Positive drainage away from the structure should also be provided. Trees and bushes/shrubs planted near the perimeter of the structure can withdraw large amounts of water from the soils and should be planted at least their anticipated mature height away from the building. Trees and bushes/shrubs planted near the perimeter of the structure can withdraw large amounts of water from the soils and should be planted at least their anticipated mature height away from the building.
5.3 RETAINING WALL/BELLOWS GRADE WALL CONSIDERATIONS (IF REQUIRED)

Retaining walls should be placed on a slope no steeper than 3H:1V and no higher than 5 feet, as defined from the exterior lower footing edge, down to the limit of the slope upon which the retaining wall is built. This requirement is intended to prevent retaining walls from being constructed on excessively steep slopes, threatening both the integrity of the retaining wall, and also the slope to be retained.

The values in the table that follows under “Active Conditions” pertain to retaining walls free to tilt outward as a result of lateral earth pressures. For rigid, non-yielding walls (such as below grade walls) which are not allowed to rotate, the values under “At-Rest Conditions” should be used.

<table>
<thead>
<tr>
<th>Backfill Type (Level Backfill)</th>
<th>Estimated Total Unit Weight (pcf)</th>
<th>Active Condition</th>
<th>At Rest Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Earth Pressure Coefficient, $k_a$</td>
<td>Equivalent Fluid Density (pcf)</td>
</tr>
<tr>
<td>On Site Clay/Imported Clay Fill</td>
<td>125</td>
<td>0.49</td>
<td>61</td>
</tr>
<tr>
<td>Select Fill</td>
<td>125</td>
<td>0.36</td>
<td>0.45</td>
</tr>
<tr>
<td>Granular Fill</td>
<td>120</td>
<td>0.29</td>
<td>35</td>
</tr>
</tbody>
</table>

The values presented above assume the surface of the backfill materials to be level. Sloping the surface of the backfill materials will increase the earth pressures acting on the retaining wall and can be evaluated if required. The above values also do not include the effect of surcharge loads such as construction equipment, vehicular loads, or future buildings near the walls. Nor do the values account for possible hydrostatic pressures resulting from groundwater seepage entering and ponding within the backfill materials. However, these surcharge loads and groundwater pressures should be considered in designing any structures subjected to lateral earth pressures.

Retaining walls, and all below grade walls, should also account for surcharge loads within a 45° slope from the base of the backside of the wall. In addition, the design pressure outlined above should be modified if a sloping backfill is required. The passive resistance should be neglected in the stability calculations if there is a possibility that the soil in front of the wall footing will be excavated at any time in the future. The retaining wall should have a minimum factor of safety of 1.5 or greater against sliding and overturning. The recommendations contained above assume the retaining wall is properly drained. Drainage of the backfill may be accomplished through the use of 3 inch diameter weep holes at 10 foot spacing, through the wall, immediately above the proposed grade in front of the wall. Alternatively, a longitudinal drain line may be placed behind the retaining wall, sloped to discharge by gravity or to a storm sewer.

Passive lateral pressures at the face of the footing, for resistance purposes, can be 250 psf per foot of soil height. The passive resistance should be ignored if the material in front of the wall will be excavated at any time in the future. A zero psf cohesion factor is recommended for the design, and a friction angle of 30° is also recommended. The frictional resistance against sliding ($N \tan \phi$)
is 0.3N on natural or compacted soil. This can be increased to 0.5N using a passive pressure of 60 ksf within the limestone.

A net allowable soil bearing pressure of 2,500 psf can be used to design foundations bearing on the reworked existing soils or compacted fill, as described above in the section titled “Earthwork Operations”. Footings should have a minimum width of 12 inches to reduce the possibility of foundation bearing failure and excessive settlement due to local shear or "punching" failures. Additionally, the footings should extend at least 18 inches below final adjacent grade to utilize this bearing pressure. Fills should be sloped to drain surface water away from the structure.

Compaction of the materials placed for the wall should be conducted in accordance with this report and depends on the type of material used. If retaining walls are required as part of this development, we recommend that ECS be consulted during the design phase in order to evaluate that our recommendations are appropriately applied as well as to determine if a global stability analysis is required.
6.0 SITE CONSTRUCTION RECOMMENDATIONS

6.1 SUBGRADE PREPARATION

In a dry and undisturbed state, the upper 1-foot of the majority of the soil at the site will provide good subgrade support for fill placement and construction operations. However, when wet, this soil will degrade quickly with disturbance from contractor operations. Therefore, good site drainage should be maintained during earthwork operations, which would help maintain the integrity of the soil.

The surface of the site should be kept properly graded in order to enhance drainage of the surface water away from the proposed plaza areas during the construction phase. We recommend that an attempt be made to enhance the natural drainage without interrupting its pattern.

The soils at the site are moisture and disturbance sensitive, and contain fines which are considered moderately erodible. Therefore, the contractor should carefully plan his operation to minimize exposure of the subgrade to weather and construction equipment traffic, and provide and maintain good site drainage during earthwork operations to help maintain the integrity of the surficial soils. All erosion and sedimentation shall be controlled in accordance with sound engineering practice and current jurisdictional requirements.

In preparing the site for construction, all loose, poorly compacted existing soils, vegetation, organic soil, existing pavements, foundations or utilities, existing fill material (as defined in this report), or other unsuitable materials should be removed from all proposed Veterans Memorial and any areas receiving new fill.

6.1.1 Stripping and Grubbing

The subgrade preparation should consist of stripping all vegetation, root mat, topsoil, existing pavements, foundations or utilities and any other soft or unsuitable materials from the 10-foot expanded building and to 5 feet beyond the toe of structural fills.

6.1.2 Proofrolling

After stripping and removing all unsuitable surface materials, cutting to the proposed grade, and prior to the placement of any structural fill, the exposed subgrade should be examined by the Geotechnical Engineer or authorized representative. The exposed subgrade should be thoroughly proofrolled with previously approved construction equipment having a minimum axle load of 10 tons (e.g. fully loaded tandem-axle dump truck). The areas subject to proofrolling should be traversed by the equipment in two perpendicular (orthogonal) directions with overlapping passes of the vehicle under the observation of the Geotechnical Engineer or authorized representative. This procedure is intended to assist in identifying any localized yielding materials. If the area is deemed too small for a piece of equipment to traverse the excavated area it should be thoroughly probed by the Geotechnical Engineer or authorized representative.
In the event that unstable or “pumping” subgrade is identified by the proofrolling, those areas should be marked for repair prior to the placement of any subsequent structural fill or other construction materials. Methods of repair of unstable subgrade, such as undercutting or moisture conditioning or chemical stabilization, should be discussed with the Geotechnical Engineer to determine the appropriate procedure with regard to the existing conditions causing the instability.

6.2 EARTHWORK OPERATIONS

Prior to placement of any new fill, all subgrades should be scarified to a minimum depth of 6 inches; moisture conditioned and compacted to at least 95% of Maximum Dry Density as obtained by the Standard Proctor Method (ASTM D-698) moisture conditioned above the optimum value. All fills should be bench into the existing soils.

Imported soil used for general fill should not have a Plasticity Index (PI) of greater than the material encountered onsite. All general fill material, outside of the building subgrade improvements, should be moisture conditioned at or above optimum moisture content and compacted to at least 95% of the Maximum Dry Density as obtained by the Standard Proctor Method (ASTM D-698).

Soil moisture levels should be preserved (by various methods that can include covering with plastic, watering, etc.) until new fill, or slabs are placed. All fill soils should be placed in 8 inch loose lifts for mass grading operations and 4 inches for trench type excavations where walk behind or “jumping jack” compaction equipment is used.

Upon completion of the filling operations, care should be taken to maintain the soil moisture content prior to construction of floor slabs. If the soil becomes desiccated, the affected material should be removed and replaced, or these materials should be scarified, moisture conditioned and recompacted.

Utility cuts should not be left open for extended periods of time and should be properly backfilled. Backfilling should be accomplished with properly compacted on-site soils, rather than granular materials. If granular materials are used, a utility trench cut-off at the building lines is recommended to help prevent water from migrating through the utility trench backfill to beneath the proposed structure.

Field density and moisture tests should be performed on each lift as necessary to verify that adequate compaction is achieved. As a guide, one test per 2,500 square feet per lift is recommended in the building (two tests minimum per lift). Utility trench backfill should be tested at a rate of one test per lift per each 150 linear feet of trench (two tests minimum per lift). Certain jurisdictional requirements may require testing in addition to that noted previously. Therefore, these specifications should be reviewed and the more stringent specifications should be followed.
6.3 MATERIAL SPECIFICATIONS

The Subgrade Preparation Options provided in the “Analysis and Recommendations” portion of this report outline the required subgrade improvements in order to achieve a PVR of 1 inch or less. This section is intended to outline the material requirements of those recommendations.

6.3.1 Clay Fill

Within the planned building pad, and flatwork sensitive to movements, moisture conditioning should be performed as outlined in this report. Reworking of the existing clays, and all new clayey fill, is performed to increase the moisture of the clays to a level that reduces their ability to absorb additional water that could result in post-construction heave in these soils.

The moisture conditioning should consist of undercutting, scarifying and/or reworking, as required to achieve the required subgrade improvement. During this process, the clay should receive adequate amounts of water to ensure a uniform moisture content of at least +5% or higher above the optimum moisture content. During the addition of water, the soils should be adequately mixed, and re-mixed, to ensure a uniform distribution of the moisture throughout the soil mass. Once appropriately mixed, the material should be compacted to at least 93% of the Maximum Dry Density as obtained using the Standard Proctor Method (ASTM D-698).

Outside of the moisture conditioned zone and where clay is used to establish site grades, we recommend that this material may be placed and compacted to at least 95% of the Maximum Dry Density as obtained using the Standard Proctor Method (ASTM D-698). These soils should be free of deleterious materials, and be reworked to ensure a uniform distribution of water in order to achieve a uniform moisture content above the optimum moisture content.

Care should be taken to verify and preserve the specified moisture levels in the reworked clays prior to placement of non-expansive fill.

6.3.2 Select Fill

For the purposes of this report, Select Fill may consist of onsite or imported material that is free of debris and organic matter and have a Plasticity Index (PI) of 5 to 15, and contain 40 to 70 percent passing the No. 200 sieve.

Crushed limestone may also be used for this purpose. The crushed limestone used for this process should have a minimum Dry Density of 115 pcf. The PI of this material should be evaluated by ECS at the time of construction and will largely be based on the granularity of the material, rather than the PI. The crushed limestone should have a maximum dimension of 1 inch (if used within the final 4 feet of fill) or 4 inches if used deeper than 4 feet below the slab subgrade.

This material should be placed and compacted at workable moisture contents above the optimum moisture content and compacted to at least 95% of the Maximum Dry Density as obtain using the Standard Proctor Method (ASTM D-698).
7.0 CLOSING

ECS has prepared this report of findings, evaluations, and recommendations to guide geotechnical-related design and construction aspects of the project.

The description of the proposed project is based on information provided to ECS by the client. If any of this information is inaccurate, either due to our interpretation of the documents provided or site or design changes that may occur later, ECS should be contacted immediately in order that we can review the report in light of the changes and provide additional or alternate recommendations as may be required to reflect the proposed construction.

We recommend that ECS be allowed to review the project’s plans and specifications pertaining to our work so that we may ascertain consistency of those plans/specifications with the intent of the geotechnical report.

Field observations, monitoring, and quality assurance testing during earthwork and foundation installation are an extension of and integral to the geotechnical design recommendation. We recommend that the owner retain these quality assurance services and that ECS be allowed to continue our involvement throughout these critical phases of construction to provide general consultation as issues arise. ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

The analysis and recommendations submitted in this report are based upon the data obtained from the soil borings and tests performed at the locations as indicated on the Boring Location Diagram and other information referenced in this report. This report does not reflect any variations, which may occur between the borings. In the performance of the subsurface exploration, specific information is obtained at specific locations at specific times. However, it is a well-known fact that variations in subsurface conditions exist on most sites between boring locations and also such situations as groundwater levels vary from time to time. The nature and extent of variations may not become evident until the course of construction. If variations then appear evident, after performing on-site observations during the construction period and noting characteristics and variations, a reevaluation of the recommendations for this report will be necessary.
APPENDIX A – Figures

Site Location Map
Hand Auger Boring Location Diagram
Regional Geology
Clay Plug Detail
Site Location Map
City of Carrollton Veterans Memorial Plaza
1700 Keller Springs Road
Carrollton, Texas

USGS Topographic Map, Carrollton, TX Quadrangle 2016
Hand Auger Boring Location Diagram

City of Carrollton Veterans Memorial Plaza
1700 Keller Springs Road
Carrollton, Texas

Approximate Hand Auger Boring Locations
Kef – Eagle Ford Formation
Geologic Atlas of Texas, Dallas Sheet, 1987
REFER TO MEP AND/OR CIVIL DRAWINGS FOR TYPICAL BEDDING MATERIALS AT EXTERIOR FACE OF BUILDING. REPLACE BEDDING MATERIALS WITH SITE CLAY SOIL. EXTEND CLAY 2 FEET FROM BUILDING. PLACE IN 8" MAX. LOOSE LIFTS, COMPACT TO 92% OF STANDARD PROCTOR (ASTM D-698), ABOVE OPTIMUM MOISTURE CONTENT.
APPENDIX B – Field Operations

Reference Notes for Boring Logs
Hand-Auger Boring Logs HA-1 through HA-4


**REFERENCE NOTES FOR BORING LOGS**

### MATERIAL

- ASPHALT
- CONCRETE
- GRAVEL
- TOPSOIL
- SHALE
- LIMESTONE
- AGGREGATE BASE COURSE

### FILL

- GW WELL-GRATED GRAVEL
- GP POORLY GRADED GRAVEL
- GM SILTY GRAVEL
- GC CLAYEY GRAVEL
- SW WELL-GRATED SAND
- SP POORLY GRADED SAND
- SM SILTY SAND
- SC CLAYEY SAND
- ML SILT
- MH ELASTIC SILT
- CL LEAN CLAY
- CH FAT CLAY
- OL ORGANIC SILT or CLAY
- OH ORGANIC SILT or CLAY
- PT PEAT

### CLASSIFICATIONS AND SYMBOLS PER ASTM D 2488-09

#### PARTICLE SIZE IDENTIFICATION

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>PARTICLE SIZES</th>
</tr>
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<tbody>
<tr>
<td>Boulders</td>
<td>12 inches (300 mm) or larger</td>
</tr>
<tr>
<td>Cobbles</td>
<td>3 inches to 12 inches (75 mm to 300 mm)</td>
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<tr>
<td>Gravel:</td>
<td>¾ inch to 3 inches (19 mm to 75 mm)</td>
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<tr>
<td>Sand:</td>
<td>0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)</td>
</tr>
<tr>
<td>Silt &amp; Clay:</td>
<td>&lt;0.074 mm (smaller than a No. 200 sieve)</td>
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#### COHESIVE SILTS & CLAYS

<table>
<thead>
<tr>
<th>COMPRESSIVE STRENGTH, (Q_c)</th>
<th>SPT(^5) (BPF)</th>
<th>CONSISTENCY(^7)</th>
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<tbody>
<tr>
<td>&lt;0.25</td>
<td>&lt;3</td>
<td>Very Soft</td>
</tr>
<tr>
<td>0.25 - &lt;0.50</td>
<td>3 - 4</td>
<td>Soft</td>
</tr>
<tr>
<td>0.50 - &lt;1.00</td>
<td>5 - 8</td>
<td>Medium Stiff</td>
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<tr>
<td>1.00 - &lt;2.00</td>
<td>9 - 15</td>
<td>Stiff</td>
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<td>2.00 - &lt;4.00</td>
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<td>4.00 - 8.00</td>
<td>31 - 50</td>
<td>Hard</td>
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<tr>
<td>&gt;8.00</td>
<td>&gt;50</td>
<td>Very Hard</td>
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#### GRAVELS, SANDS & NON-COHESIVE SILTS

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<td>Medium Dense</td>
</tr>
<tr>
<td>31 - 50</td>
<td>Dense</td>
</tr>
<tr>
<td>&gt;50</td>
<td>Very Dense</td>
</tr>
</tbody>
</table>

### WATER LEVELS

- WL Water Level (WS)(WD)
- SHW Seasonal High WT
- ACR After Casing Removal
- WL Water Level at Drilling Completion

---

2. To be consistent with general practice, “POORLY GRADED” has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.
3. Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-FILL)].
4. Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).
5. Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). “N-value” is another term for “blow count” and is expressed in blows per foot (bpf).
6. The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.
7. Minor deviation from ASTM D 2488-09 Note 16.
8. Percentages are estimated to the nearest 5% per ASTM D 2488-09.

Reference Notes for Boring Logs (FINAL 10-13-2016)

© 2016 ECS Corporate Services, LLC. All Rights Reserved
**PROJECT NAME:**
City of Carrollton Veterans Memorial Plaza

**CLIENT:**
BW2 Engineers, Inc.

**HA-1**

**HAND AUGER #**

**SURFACE ELEVATION**

19:7610

**ELEVATION**

478

---

**LOCATION:**
1700 Keller Springs Road, Carrollton, TX

**ARCH./ENG.:**
BW2 Engineers, Inc.

**CLIENT:**
BW2 Engineers, Inc.

**Job #:**
19:7610

---

**DESCRIPTION OF MATERIAL**

- **0 ft:** (CH) FAT CLAY, brown, moist
- **1 ft:** HAND AUGER REFUSAL DUE TO UTILITY @ 2'

---

**DEPTH (FT.)** | **ELEV. (FT.)** | **LOCATION:** | **ARCH./ENG.:** | **EXCAV. EFFORT** | **DCP** | **QP (TSF)** | **SAMPLE NO.** | **MOIST CONT. (%)**
--- | --- | --- | --- | --- | --- | --- | --- | ---
0 | 478 | **1700 Keller Springs Road, Carrollton, TX** | **BW2 Engineers, Inc.** | **E** | | | S-1 | 34.5

---

**REMARKS:**

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

GROUND WATER: While Drilling: E - EASY M - MEDIUM D - DIFFICULT VD - VERY DIFFICULT

EXCAVATION EFFORT: E - EASY M - MEDIUM D - DIFFICULT VD - VERY DIFFICULT

ECS REP.: RGG

DATE: 02/05/19

UNITS: Feet

Cave-in Depth: Dry

Groundwater While Drilling: Groundwater: Dry
PROJECT NAME: City of Carrollton Veterans Memorial Plaza

CLIENT: BW2 Engineers, Inc.

HA-19:7610

SURFACE ELEVATION: 476

LOCATION: 1700 Keller Springs Road, Carrollton, TX

ARCH./ENG: BW2 Engineers, Inc.

DESCRIPTION OF MATERIAL:

- (CH) FAT CLAY, brown, moist
- (CH) SANDY FAT CLAY, light brown, moist

END OF HAND AUGER @ 6’

REMARKS:

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

GROUND WATER: While Drilling After Drilling

EXCAVATION EFFORT: E - EASY M - MEDIUM D - DIFFICULT VD - VERY DIFFICULT

REFERENCES: Cave-in Depth: Groundwater While Drilling: Groundwater:

ECS REP.: RGG DATE: 02/05/19 UNITS: Feet

DCP: 42.1 QP (TSF): 36.2

S-1 S-2 SAMPLE NO. MOIST. CONT. (%) 4 4
PROJECT NAME: City of Carrollton Veterans Memorial Plaza

CLIENT: BW2 Engineers, Inc.

HAND AUGER #: HA-3

SURFACE ELEVATION: 475

LOCATION: 1700 Keller Springs Road, Carrollton, TX

ARCH./ENG: BW2 Engineers, Inc.

DESCRIPTION OF MATERIAL

(CH) FAT CLAY, brown, moist

(S-1) 40.6

(CH) SANDY FAT CLAY, light brown, moist

E

END OF HAND AUGER @ 6.2'

REMARKS:

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

GROUND WATER: While Drilling After Drilling EXCAVATION EFFORT: E - EASY M - MEDIUM D - DIFFICULT VD - VERY DIFFICULT

ECS REP.: RGG

DATE: 02/05/19

UNITS: Feet

Cave-in Depth: 4.7

Groundwater While Drilling: 4.7

Groundwater: 4.7
**DESCRIPTION OF MATERIAL**

- **Level 0**: (CH) FAT CLAY, brown, moist
- **Level 1**: (CH) SANDY FAT CLAY, light brown, moist, with gravel pieces

**EXCAVATION EFFORT**

- **S-1**: E
- **S-2**

**GROUND WATER**

- While Drilling: 4
- After Drilling: 4

**EXCAVATION EFFORT**

- E - EASY
- M - MEDIUM
- D - DIFFICULT
- VD - VERY DIFFICULT

**Cave-in Depth**: 4

**Groundwater While Drilling**: 4

**Remarks**: The stratification lines represent the approximate boundary lines between soil types. In-situ the transition may be gradual.
APPENDIX C – Laboratory Testing

Laboratory Testing Summary
# Laboratory Testing Summary

**Date:** 2/14/2019  
**Project Number:** 7610  
**Project Name:** City of Carrollton Veterans Memorial Plaza  
**Project Engineer:** RGG  
**Principal Engineer:** MPB  
**Summary By:** RGG

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<tr>
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<th>Sample Number</th>
<th>Depth (feet)</th>
<th>MC(^1) (%)</th>
<th>Soil Type(^2)</th>
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<th>PL</th>
<th>PI</th>
<th>Atterberg Limits(^3)</th>
<th>Percent Passing No. 200 Sieve(^5)</th>
<th>Dry Unit Weight (pcf)</th>
<th>One-Dimensional Swell(^6)</th>
<th>Unconfined Compressive Strength (tsf)</th>
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<td>HA-1</td>
<td>S-1</td>
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**Notes:**  

**Definitions:**  