AVILES ENGINEERING CORP.

April 1, 2015

Mr. Dan Simeone, P.E.
KCI Technologies
801 Travis Street, Suite 2000
Houston, Texas 77002

Re: Trench Safety Geotechnical Letter Report
Waterline Replacement in Sharpstown Country Club Estates Area
COH WBS No. S-000035-0173-3
Houston, Texas
AEC Report No. G110-13

Dear Mr. Simeone,

Aviles Engineering Corporation (AEC) is pleased to present the trench safety geotechnical letter report for the above referenced project. The purpose of this letter is to provide geotechnical information and trench safety guidelines for auger pit excavations, which are required for installation of underground utilities using auger methods. Details of the geotechnical investigation, including boring location plan, subsurface investigation, laboratory testing, ground water depths, and boring logs are presented in AEC Report No. G110-13.

Based on information provided to AEC by KCI Technologies, Inc., approximately 27,340 linear feet of existing 6 to 12 inch diameter waterlines will be replaced with new 8 to 12 inch waterlines. The proposed waterlines will be installed primarily by auger method. The maximum invert depths of the waterlines vary from 7 to 19 feet below grade. Auger pits will be excavated by open cut method to start and receive the pipe segments.

The underground utilities should be designed and constructed in accordance with the latest edition of the City of Houston Standard Construction Specifications (COHSCS). The Contractor is responsible for designing, constructing and maintaining safe excavations for installation of underground utilities by open cut methods; the excavations should not cause any distress to existing structures nearby, if any, during construction.

Excavation Stability: Cohesive soils in Houston area contain many secondary features which affect trench wall stability, including sand seams and slickensides. Slickensides are shiny weak failure planes which are commonly present in fat clays; such clays often fail along these weak planes when they are not laterally supported, such as in an open excavation. The Contractor should not assume that slickensides and sand seams/layers/pockets are absent where not indicated on the logs.

Trenches 20 feet and Deeper: The Occupational Safety and Health Administration (OSHA) requires that shoring or bracing for trenches 20 feet and deeper be specifically designed by a licensed professional engineer.

Trenches Less than 20 Feet Deep: Trench excavations that are less than 20 feet deep may be shored, sheeted and braced, or laid back to a stable slope for the safety of workers, the general public, and adjacent structures, except for excavations which are less than 5 feet deep and verified by a competent person to have no cave-in potential. The excavation should be in accordance with OSHA Safety and Health Regulations, 29 CFR, Part 1926. Recommended OSHA Soil Types for excavation design for existing soils can be found on Plates C-1 through C-5 in AEC report G110-13. Fill material should be considered OSHA Class "C" soils. Submerged soils should also be considered OSHA Class "C" soils, unless dewatering is conducted to lower the ground water level below the bottom of the excavation.

Critical Height: Critical Height is defined as the height a slope will stand unsupported for a short time; in cohesive soils, it is used to estimate the maximum depth of open-cuts at given side slopes. Critical Height may be calculated using the soil cohesion. Values for various slopes and cohesion are shown on Plate D-1 in AEC Report G110-13. Cautions listed below should be exercised in use of Critical Height applications:

1. No more than 50 percent of the Critical Height computed should be used for vertical slopes. Unsupported vertical slopes are not recommended where granular soils or soils that will slough when not laterally supported are encountered within the excavation depth.

2. If tension cracks occur, no cohesion should be assumed for the soils within the depth of the crack. The depth of the first waler should not exceed the depth of the potential tension crack. Struts should be installed before lateral displacement occurs.

3. Shoring should be provided for excavations where limited space precludes adequate side slopes, e.g., where granular soils will not stand on stable slopes and/or for deep open cuts.

4. All excavation, trenching and shoring should be designed and constructed by qualified professionals and personnel in accordance with Occupational Safety and Health Administration (OSHA) requirements.

Plate D-2 in AEC Report G110-13presents the maximum (steepest) allowable slopes for OSHA Soil Types for excavations less than 20 feet. If limited space is available for the required side slopes, the space required for the slope can be reduced by using a combination of bracing and open cut as illustrated on Plate D-3 in AEC Report G110-13.

The following method can be used for calculating earth pressure against bracing for open cut trenches. Lateral pressure resulting from construction equipment, traffic loads, or other surcharge should be taken into account by adding the equivalent uniformly distributed surcharge to the design lateral pressure. Hydrostatic pressure, if any, should also be considered. The active earth pressure at depth z can be determined by Equation (1); the design soil parameters are presented on Plates C-1 through C-5 in AEC report G110-13.

$$p_a = (q_s + rh_1 + r'h_2)Ka - 2c\sqrt{K_a} + r_w h_2 \qquad \text{............Equation (1)}$$

where,

p_a	=	active earth pressure, psf.
q_s	=	uniform surcharge pressure, psf.
γ, γ'	=	wet unit weight and buoyant unit weight of soil.
h_1	=	depth from ground surface to ground water table.
h_2	=	$z-h_1$, depth from ground water table to the point under consideration.
z	=	depth below ground surface for the point under consideration.
K_a	=	coefficient of active earth pressure.
c	=	cohesion of clayey soils.
γ_w	=	unit weight of water, 62.4 pcf.

Pressure distribution for the design of struts in open cuts for clay and sand are illustrated on Plates D-4 through D-6 in AEC Report G110-13. If there is water behind the bracing, hydrostatic pressure should be included in the design.

Bottom Stability: In open-cuts, the possibility must be considered of the bottom failing by heaving, due to the removal of the weight of excavated soil. In fat and lean clays, heave normally does not occur unless the ratio of Critical Height to Depth of Cut approaches one. In silty clays and granular soils, heave can occur if an artificially large head of water is created due to installation of impervious sheeting in bracing the cut; this can be mitigated if ground water is lowered below the excavation by dewatering the area. Guidelines for evaluating bottom stability in clay soils are presented on Plate D-7 in AEC Report G110-13.

If the excavation extends below the ground water level and the soils at or near the bottom of the excavation are mainly sands, silts or low plasticity clays having low undrained shear strength, the bottom can fail by blow-out (boiling) at the bottom when a sufficient hydraulic head exists. The potential for boiling or in-flow of granular soils increases where the ground water is pressurized. If the braced excavation terminates in granular soils or low-plasticity clays below ground water, we recommend the ground water table be lowered to at least 5 feet below the excavation to avoid bottom boiling in accordance with the latest edition of the COHSCS.

If the braced excavation terminates in a cohesive soil, but is underlain by granular soils and is subject to hydraulic pressure, the factor of safety against bottom failure can be conservatively calculated (neglecting soil cohesion) from the Equation (2) presented below:

$$F = \gamma_s h_s / \gamma_w h_w \qquad \text{...........Equation (2)}$$

where,
- F = safety factor against blow-out (minimum value of 1.25 is recommended)
- γ_s = unit weight of cohesive soil above sand layer, pcf
- h_s = height of cohesive soil above sand layer, feet
- γ_w = unit weight of water, pcf
- h_w = hydrostatic head, feet

The most effective means of improving the bottom stability is to lower the ground water table to at least 5 feet (or more as determined by analysis) below the bottom of the braced excavation.

Calcareous nodules, slickensides, and silt/sand seams within cohesive soil strata encountered may become sources of localized instability when they are exposed during excavation, especially when they become saturated. Such soils have a tendency to slough or cave in when not laterally confined, such as in open cut excavations. The Contractor should be aware of the potential for cave-in of the soils. Low plasticity soils (silts and clayey silts) will lose strength and may behave like granular soils when saturated.

Excavation Dewatering: Ground water levels will fluctuate depending on seasonal rainfall and other climatic events. Dewatering may or may not be required depending on location, excavation depth, ground water level, and time of year construction is in progress. We recommend that the Contractor include the cost of dewatering as a line item in his/her bid package and that he/she verify ground water depths, seepage rates and areas where ground water is pressurized and dewatering is required. The Contractor is responsible for designing, installing and maintaining a dewatering system for ground water control and taking precautions to avoid distress to existing structures nearby, as a result of dewatering. Ground water control should be in accordance with the latest edition of the COHSCS. The following is intended to provide guidance to the Contractor for dewatering.

Seepage in sandy lean clays/fat clay will probably be low. Seepage influx will be primarily from sand seams and pockets. Gravity drainage with sumps can be effective in removing seepage water in these clayey soil zones.

Greater seepage and slope stability problems may be experienced in silt/silty sand/sand strata, especially when they are at or below ground water depth. Where excavations extend into water-bearing silt or sand, well points or eductors may be used to lower the ground water level. Well points are not generally effective below a depth of about 15 feet below the top of the well point. Multi-staged well points or deep wells with turbine or submersible pumps will be required when the dewatering depth is greater than 15 feet. Generally, the ground water depth should be lowered at least 5 feet below the excavation bottom to be able to work on a firm surface. Extended and/or extensive dewatering can result in settlement of existing structures in the vicinity; the Contractor is to take necessary precautions to minimize the effects on these structures.

<u>Construction Monitoring:</u> The Contractor is responsible for monitoring nearby existing structures and taking necessary action to minimize impact to adjacent structures. Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems or other hazardous conditions. An inspection should be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence.

To avoid surcharging the excavation walls, stockpiling of the excavated materials immediately adjacent to the excavation face should be prohibited. We recommend the stockpiled materials be placed at least 6 feet away from the edge of the excavation face, and no higher than 4 feet. Construction equipment working near the trench may also induce excessive surcharge loads; we recommend appropriate shoring or shield system be provided considering such impact in addition to lateral earth/water pressure.

The information contained in this letter report summarizes conditions found on the dates the borings were drilled. The boring logs attached in AEC Report G110-13 are true representations of the soils encountered at the specific boring locations on the dates of drilling. Reasonable variations from the subsurface information presented in this report should be anticipated. If conditions encountered during construction are significantly different from those presented in this report; AEC should be notified immediately.

AEC appreciates the opportunity to be of service on this project and looks forward to our continuing association during the construction phase of this project and on future projects.

AVILES ENGINEERING CORPORATION
(TBPE Firm Registration No. F-42)

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Reports Submitted: 3 KCI Technologies, Inc.
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