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July 15, 2010

TRC Environmental Corporation
21 Griffin Road North
Windsor, CT 06095
Attn: Mr. Carl N. Stopper, V.P., P.E.

Re: Geotechnical Engineering Services
Geotechnical Addendum – Driven Pile Evaluation
CRRA South Meadows Generating Station
Jet Fuel Storage Tank No. 6 – Replacement
Hartford, CT
TRC Project No.: 153306

Dear Mr. Stopper,

This letter serves as an addendum to our original geotechnical report for this project dated April 22, 2010. Our original geotechnical report dated April 22, 2009, provided recommendations for support of the proposed tank on a rammed aggregate pier system. It is our understanding that CRRA would like to consider use of a driven pile alternative for support of the proposed tank and containment area. The purpose of this addendum is to present the results of a geotechnical evaluation of a driven pile alternative.

SUMMARY OF SUBSURFACE CONDITIONS

2010 TRC Test Borings

Four (4) test borings (GTB-1 through GTB-4) were drilled by TRC's drilling division for this project. The test boring information reveals that the site is underlain by up to 10 ft of surficial uncontrolled fill material in each boring, underlain by "loose" to "very loose" silty sand/ sandy silt alluvium to a depth of 35 ft below the ground surface (bgs), high plasticity silty clay to a depth of 69 ft bgs, followed by medium dense glacial till materials. Test boring GTB-2 was advanced into the till material and was only advanced a depth of 3 ft into this stratum.

1985 Black and Veatch Test Borings

A number of test borings performed by Black and Veatch (B&V) at the site in the 1985 within 200 to 600 ft north and east of the proposed tank location indicate that the till material is generally "very dense" with near spoon refusal encountered within this stratum at several of the borings. The B&V logs indicate that the till stratum ranges in thickness from 5 to 15 ft, however, is generally less than 10 ft thick. Underlying the till, the B&V borings encountered shale bedrock. It should be noted that the depth to the top of the glacial till, as encountered in the B&V borings, varied from 80 ft to almost 120 ft bgs. In addition, the depth to the top of the shale bedrock, as encountered in the B&V borings varied from 90 to 140 ft, bgs. Due to the large variation in the depth to the top of the till stratum and the top of rock surface observed in the B&V test borings, the top of the bedrock surface cannot accurately be determined at the location of the tank without additional subsurface exploration. However, the borings do provide very consistent information with regard to the density of the glacial till. Based on our review of the B&V logs, it appears that the till material becomes "very dense" within 5 ft of the top of this layer.

GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

We understand that CRRA would like to consider a steel pipe pile or H-Pile. The pile must be capable of resisting design axial compression loads of up to 110 kips and design lateral loads of up to 9 kips and will be spaced 7 ft on-center on a grid-like pattern. Based on our experience with similar subsurface conditions and construction, the very dense till material or bedrock is considered suitable for support of a moderate capacity driven pile, such as what is proposed for this project. A closed-end (CE) steel pipe pile is the preferred pile assuming till as the bearing stratum due to this piles ability to mobilize significant end bearing resistance within dense soil conditions. An H-pile driven to refusal on the top of rock surface is also considered to be a viable alternative.

Pile Axial Compression Analysis and Drivability Evaluation

We performed an axial compression capacity analysis of a 12 in. diameter CE pipe pile and an HP 12x74 H-Pile section using the FHWA software Driven 1.2. According to the results of our evaluation, a 12 in. diameter, CE pipe pile with a 0.5 in. wall thickness, driven 5 to 10 ft into the till soils to estimated depths of 75 to 80 ft bgs should readily provided an allowable compressive capacity of 110 kips at an acceptable factor of safety. The anticipated pile lengths correspond to pipe pile tip elevations ranging from El. -55 to -60.

According to the results of our evaluation, an HP 12x74 pile driven to refusal on the top of rock will provide an allowable capacity of 110 kips at an acceptable factor of safety. However, due to the fact that the recent borings drilled at the location of the proposed tank were terminated above the top of rock, an estimate of pile length and tip elevation is more difficult due the unknown depth to bedrock. We anticipate that the bedrock surface is most likely below elevation El. -60.

A preliminary drivability analysis was performed for the recommended piles considering the subsurface conditions encountered at the site using the GRL WEAP computer program. The DELMAG D22-02 open end diesel (OED) hammer, having 48.5 kip-ft maximum energy was selected for use in our analyses. The following assumptions were also used in the analysis:

- Yield strength of steel for the H-piles equal to 36 ksi.
- GRL WEAP computed values for quake and damping.
- Variable Soil Resistance Distribution based on conditions encountered in the test borings.

According to the results of our drivability evaluation, a DELMAG D22-02 is capable of driving the recommended CE pile and HP pile to an ultimate capacity of 275 kips. Compressive stresses generated within the pile section will approach the maximum allowable stress of 90 percent of the steel yield strength assuming 36 ksi steel is used. Therefore, we recommend that 50 ksi yield strength steel be considered for this project in order to minimize the motential for overstressing the piles during driving. We considered the use of smaller a hammer in our evaluation and found that using a smaller hammer may result in pile refusal conditions (>20 blow/ inch) before reaching the ultimate pile capacity required during driving.

Pile Lateral Load Analysis
We performed a lateral load analysis using LPILE v5.0, which accounts for the nonlinear behavior of soil and rock under lateral loading (P-y analysis). Because the top of the piles are to be structurally tied in a 2 ft thick reinforced concrete mat, the top of the pile was assumed to be fixed. According to the results of our analysis, a maximum lateral load of 9 kips applied to the top of the pile will result in less than ¼ in. of lateral deflection for both 12 in. diameter CE piles and HP 12x74 piles.

Recommendations for Driven Pile Testing
We recommend that Pile Dynamic Analysis (PDA) be performed on indicator piles (as discussed below) driven for support of the proposed tank and containment area. PDA is a dynamic pile test method used to verify pile axial capacity that takes place during driving through the use of strain gauges and accelerometers mounted to the pile walls. The test method applies wave energy theory and provides pile capacity data in real time during driving as well as a basis for establishing end-of-drive blow count criteria. The PDA test method is also used for maintaining stresses within acceptable limits and minimizing the potential for pile damage. We recommend that PDA be used to verify an ultimate field driving capacity of 2.5 times the allowable compression capacity to an ultimate capacity of 275 kips.

In addition to dynamic pile testing, a wave equation analysis should be completed by the Contractor to verify the suitability of the proposed driving equipment, as well as pile drivability based on subsurface conditions. Results of the dynamic monitoring should be submitted for approval within 72 hours of installation. Both the wave equation analysis and dynamic monitoring must be performed by and results sealed by a Professional Engineer licensed in the State of Connecticut. It is noted that selection of the appropriate hammer type, energy and cushion material by the contractor will be critical to a successful and efficient pile driving operation.

Because test borings advanced in the immediate vicinity of the proposed tank do not extend to/ below the estimated pile tip elevations, we recommend that two indicator piles be driven prior to sizing and ordering all the piles to be driven for this project. The indicator piles can be sized based on the assumption that the pile will be driven to the minimum expected pile tip elevation (maximum depth). For CE pipe piles, we recommend that 90 ft pile lengths be used for the indicator pile program. We expect that this pile length will be sufficient as we anticipate that CE pipe piles will achieve the required ultimate capacity between depths of 75 to 80 ft bgs. However, regarding HP piles driven to refusal, a greater degree of uncertainty exists with the actual depth to the top of rock. Due to this, in the event an HP 12x74 pile is used on this project, the contractor may want to consider advancing a test boring to the top of rock at the proposed tank location in order to more accurately establish pile lengths. An indicator pile program with PDA testing would still be required in order to monitor pile stresses and establish a blow count refusal criteria. Regardless of the pile section selected for use on this project, if PDA testing indicates that the ultimate pile capacity has not been achieved at the estimated pile tip elevations, additional pile length should be added using a welded splice and the pile driven to the required capacity. Based on observed trends in the top of rock surface in other areas of the site, we recommend that the two indicator piles be driven on opposite sides of the proposed tank (northeast and southwest corners) in order to help identify variations in the top of CE pipe and HP pile bearing strata. The indicator piles can also be used as production piles.

Construction Considerations

Construction-induced vibrations such as those generated as a result of pile driving in very dense substrata may adversely affect nearby structures (i.e. buried utilities, equipment and brick/ masonry structures). The magnitude of construction-induced vibrations is difficult to predict with great accuracy due to the fact that site heterogeneity and spatial variation of soil properties have a significant effect on the characteristics of propagated waves. The dynamic effect of these construction vibrations on nearby structures depends on the subsurface conditions at the site as well as the susceptibility of the structures themselves. A pre-construction survey is recommended for documentation of the condition of existing structures. Vibration monitoring should be implemented prior to the start of pile driving and continuing during pile driving to ensure the safety and serviceability of nearby structures. It should be noted, that any existing above ground or buried structure within the vicinity of the proposed tank which is considered to be vulnerable to vibrations will need to be identified prior to pile driving and vibration monitoring.

In the event that pipe piles are selected for support of the tank, the pipe piles should be concreted after installation. Typically, a short length reinforcing steel cages are installed into the concrete after curing so that the pile can be structurally connected to the pile. It should be noted that we assume that piles will be structurally connected to reinforced concrete mat. In the event that piles are not structurally connected to the mat, the depth of the bottom of the mat will be controlled by the frost depth, as discussed in the geotechnical report.

Recommendations for Additional Services

We recommend that TRC provide engineering consultation and field inspection services during construction operations to determine if soils, other materials, and ground water conditions encountered during construction are similar to those encountered in the borings, and that they have comparable engineering properties and influences on the design of the structures. TRC should review specifications for earthwork and foundation construction when they are prepared. TRC is also capable of providing both PDA and vibration monitoring services, as well as inspection of pile driving activities. We would be pleased to provide these additional services, which fall outside the scope of our current agreement.

We trust that this report contains the information required and we thank you for the opportunity to assist you on this project. If you have any questions regarding the contents of this report, please call our office.

Sincerely,

TRC Engineers, Inc.

Thomas M. Caruso
Geotechnical Engineer

Frederick A. Brinker
Manager, Geotechnical Engineering Service