

August 26, 2013

**Subject: Preliminary Findings and Recommendations
Beaufort National Cemetery Expansion
Beaufort, South Carolina
AMEC Project No. 6250-13-0042.02**

Pre-placed Concrete Lawn Crypts

Borings B-1 through B-6 were drilled in the areas proposed for placement of the pre-placed concrete lawn crypts. Borings B-7 through B-9 were drilled in the corridor of the proposed cemetery drive which is within the area of both the currently proposed and future pre-placed crypts.

Subsurface Conditions - In general, the borings encountered very loose and loose fine sand (SP) within the top 20 to 25 feet below the existing ground surface. Firm sand (SP) was encountered between 0 to 3 feet in borings B-1 and B-7.

Boring B-2 was drilled to a depth of 100 feet. This boring encountered loose to very loose fine sand (SP) from the ground surface to 32 feet deep (0 to 32 feet), firm fine to medium sand to 37 feet (32 to 37 feet), loose fine to medium sand (SP/SW) and clayey sand (SP/SC) to 47 feet (37 to 47 feet), firm fine to coarse clayey sand with shells (SC/SW) to 52 feet (47 to 52 feet), very dense clayey fine to coarse sand with shells to 57 feet (52 to 57), and firm to dense fine to coarse sand with gravel (SW) to 100 feet (57 to 100).

Groundwater – Groundwater was encountered in each of the soil test borings at the approximate depths listed below. Stabilized groundwater levels were recorded between 2 and 24 hours after drilling.

Boring No.	Groundwater Depth, ft Time of Boring	Groundwater Depth, ft Stabilized
B-1	15	15
B-2	14	15.5
B-3	14	14.5
B-4	13.5	14.5
B-5	15	16.5
B-6	14	12
B-7	14.5	16
B-8	18	17.5
B-9	14	15

Groundwater is not expected to be present within the 7-feet deep excavation for the crypts.

Infiltration Rates – Infiltration testing was performed at four locations within the areas proposed for placement of the concrete lawn crypts. Testing was performed with a Geulph permeameter, a constant head permeameter, at a depth of 7 feet below the existing ground surface elevation.

The following in-situ (preliminary) Ksat values were calculated based on field measurements using the Glover equation:

Site 1: 46.59 inches/hour

Site 2: 21.46 inches/hour

Site 3: 32.95 inches/hour

Site 4: 46.59 inches/hour

Excavation Conditions – The material encountered within the proposed 7-foot excavation depth should be easily excavated with conventional earth moving equipment. Difficult excavation conditions should not be encountered. Groundwater is not expected to be present within the 7-foot deep excavation for the crypts.

Underground obstructions

Ground penetrating radar (GPR) was used at the boring location to determine if existing utilities or obstructions were present prior to drilling our soil test borings. In the area of boring B-6, apparent obstructions were indicated to be present at various depths and locations. Because GPR was only used in a limited area surrounding the proposed boring locations, the presence of existing underground obstructions in other areas of the site is not known. Contractors that will be performing the excavation for the pre-placed concrete lawn crypts should be made aware that underground obstructions may be present (specifically in the area of boring B-6).

Corrosion Potential of Site Soils – Laboratory analysis to determine the corrosion potential of the onsite soils will be performed on select soil samples collected during drilling. Laboratory test results are not available at this time.

Roadway Construction

Borings B-7 through B-9 were drilled within the proposed loop roadway alignment.

Subsurface Conditions – Borings B-7, B-8, and B-9 encountered very loose to firm, fine and fine to medium sand (SP) within the top 20 to 25 feet below the existing ground surface. We understand that up to 2 feet of cut is expected to be required for construction of the proposed roadways. Therefore, the roadway subgrade will consist of very loose to loose sand (SP).

Groundwater – Groundwater information is presented in the previous table. Stabilized groundwater levels were recorded at depths of 16, 17.5, and 15 feet, respectively, in the borings located within the proposed roadway alignment.

Recommendations – We understand that the traffic loading on the proposed asphalt-paved roadway is expected to be minimal. Typical minimum pavement sections for this area should be suitable for use for this roadway.

Columbarium and Well-house Building Expansion

Boring B-10 was drilled in the area of the proposed well-house expansion and columbarium construction. Borings B-11 and B-12 were drilled in the area proposed for construction of the columbarium.

Subsurface Conditions – Topsoil was encountered at each of the boring locations, with thicknesses of 2, 1, and 1.5 feet, respectively. Below the topsoil layer, the borings encountered very loose to firm, fine and fine to medium sand. Average N-values ranged from 3 to 12 blows per foot.

Multiple underground utilities are present in this area. These utilities will need to be relocated prior to construction of the well-house building expansion and the columbarium. Existing utility trench backfill can be expected to be present at shallow depths in the area of the underground utilities. Utility trench backfill is typically not well compacted and can be expected to need to be reworked or replaced during construction of the foundations for the proposed structures.

Groundwater - Groundwater was encountered in each of the soil test borings at the approximate depths listed below. Stabilized groundwater levels were recorded between 2 and 24 hours after drilling.

Boring No.	Groundwater Depth, ft Time of Boring	Groundwater Depth, ft Stabilized
B-10	14	14
B-11	13	13
B-12	14	12.5

Groundwater is not expected to be present within excavations for the shallow foundations for the proposed structures.

Foundation Recommendations – Based on the subsurface conditions encountered at the proposed well-house building expansion and columbarium locations, the proposed structures can be supported on shallow foundations designed for a maximum allowable bearing pressure of 1,000 psf. The foundations should be embedded a minimum of 24 inches to allow for protective embedment.

Frost Depth – According to NAVFAC Soil Mechanics Design Manual, the extreme frost penetration depth for Beaufort, South Carolina is 5 inches.

Design Recommendations

Liquefaction Potential - Liquefaction is a phenomenon that can occur during an earthquake when loose sands are present below the groundwater table. During liquefaction, shear waves cause strain reversal that lead to the generation of excess pore water pressures in loose sands below the groundwater table, and the sands lose shear strength and behave as fluid. Following the earthquake event, the liquefied soils reconsolidate.

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Based on preliminary analysis of the subsurface conditions encountered at the site (specifically boring B-2), potentially liquefiable soils are present. These results will be confirmed when the results of the laboratory classification testing has been completed.

Seismic Site Class - Based on the average N-value within the top 100 feet of the subsurface profile at this site, calculated in accordance with Chapter 16 of the International Building Code, the site classifies as a Site Class E. However, because potentially liquefiable soils are present at the site, a Site Class F should be used for design of the proposed structures (unless otherwise exempt from this requirement in the Building Code).


Lateral Earth Pressures - Based on previously developed correlations for clean sands (on-site soil) and washed stone drainage aggregate, the soil properties and earth pressure coefficients for a horizontal backfill condition are recommended in the following table:


Recommended Soil Properties and Earth Pressure Coefficients						
Material Description	Effective Stress Properties			Earth Pressure Coefficients(a)		
	Total Unit Weight (pcf)	Cohesion (psf)	Internal Angle of Friction (degrees)	Ko	Ka	Kp
Clean Sand	120	0	30	0.50	0.33	3.0
Clean washed stone (#57)	100	0	40	0.36	0.22	4.6
Note: Ko = At-Rest earth pressure coefficient Ka = Active earth pressure coefficient Kp = Passive earth pressure coefficient (divide by SF=2, use with active opposite case) (a) for horizontal backfill						

Closing

The findings and recommendations provided in this report are based on preliminary review of the encountered subsurface conditions and maybe subject to change based on further review and the results of the laboratory testing.

Sincerely,
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