JACOBS®

Memorandum

343 Congress Street
Boston, MA 02210 USA
1.617.242.9222 Fax 1.617.242.9824

Date	March 19, 2015
To	Maine Turnpike Authority (MTA)
From	Jacobs Engineering Group
Subject	Maine Turnpike York Toll Plaza, Interstate 95/Maine Turnpike Geotechnical Memorandum Supplemental Memorandum to Jacobs 11/11/2014 Geotechnical Memorandum

BACKGROUND

This memorandum was prepared by Jacobs in accordance with the contract scope of work between Jacobs and the MTA for Task Order 1 Assignment dated August 28, 2014 and Task Order #1, Amendment #1 – Preliminary Engineering Services for the Southern Toll Plaza dated 01/06/2015. Under the scope of work for Amendment #1, eight supplemental borings (B-3 through B-10) were performed in January 2015 to better define the extent and thickness of the compressible clay soils within 1200 feet south of the existing toll plaza to 1400 feet north of the existing toll plaza, as well as in existing embankment areas east and west of the existing Turnpike that are proposed as potential new roadway areas. The development of the subsurface exploration plan took into account the design alternative of relocating the toll plaza to about 400 feet north of the existing location. The proposed new toll plaza is about 310 feet wide and contains 6 Open Road Tolling (ORT) lanes (3 lanes in each direction) and 9 cash lanes (4 cash lanes northbound and 5 cash lanes southbound).

This memorandum presents the geotechnical conditions encountered along the Turnpike in the vicinity of the proposed new toll plaza at approximately Station 269+00 and between approximately Stations 253+00 and 279+00 based on our subsurface explorations performed in January 2015 and October 2014. The test borings and lab results performed by Haley & Aldrich, Inc. (H&A) in 2009 were also utilized in this report to compare and supplement data collected in the recent Jacobs explorations.

Also presented in this memorandum are settlement and slope stability evaluations based on the field and laboratory test results obtained during the recent 2014 and 2015 explorations as well as our foundation design recommendations for the proposed toll plaza. Our estimates and evaluations are also based on the latest revisions made by Jacobs to the proposed grading plans along the Turnpike between Stations 255+00 and 276+00, with a primary focus on the proposed grading changes within 200 feet north and south of the proposed new toll plaza at Station 269+00. Between Stations 267+00 and 271+00, proposed site grades are estimated to increase by no more than about 2 feet in the vicinity of the ORT northbound lanes, with the southbound ORT site grades matching existing grades or being cut by as much as about 2 feet. In the embankment areas east and west of the existing Turnpike that are proposed as potential new roadway areas, site grades are estimated to increase by as much as approximately 6.5 feet.

Elevations cited herein are referenced to the North American Vertical Datum of 1988 (NAVD 88). Elevations from the 2009 H&A exploration logs were converted to reference the NAVD 88 datum when discussed in this report.

SCOPE OF WORK

The geotechnical work included the following tasks:

- Coordinate and perform a geotechnical subsurface exploration program consisting of eight new borings;
- Select and send representative samples for laboratory testing including Atterberg limits and consolidation tests on undisturbed samples;
- Report and interpret the results of the explorations and laboratory testing program; and
- Summarize geotechnical conditions, conduct engineering evaluations and analyses, and provide foundation design recommendations for the proposed toll plaza.
- Meet with MTA on February 12, 2015 to discuss preliminary findings from our explorations.

SUBSURFACE EXPLORATIONS

Jacobs retained New England Boring Contractors of Hermon, Maine to perform eight additional borings (B-3 through B-10) at the site to obtain additional information on the extent and thickness of the clay layer present in the vicinity of the existing York Toll Plaza. The recent Jacobs exploration logs (from both 2014 and 2015 explorations) along with the H&A exploration logs are provided in Appendix A and the boring locations are shown on Figure 1. Northing/easting coordinates and ground surface elevations of the as-drilled borings were surveyed and provided by Sebago Technics in January 2015.

The 2015 borings were drilled with either a truck-mounted or an ATV-mounted drill rig and were advanced using rotary-wash techniques. Standard penetration tests (SPTs) were performed by using a 140-pound safety hammer falling 30 inches to drive a split-spoon sampler 24 inches (or until practical refusal was attained) to establish the relative density and consistency of the subsurface soils. The SPTs were typically performed and soil samples recovered at 5-foot intervals. The obtained samples were sealed in glass jars to retain their natural moisture content. Field pocket penetrometer tests were conducted on the clay samples collected. Multiple field vane shear tests were performed in the clay layer at elevations determined in the field by Jacobs engineers. The pocket penetrometer and field vane test results are presented in the boring logs in Appendix A. Six undisturbed clay samples were collected from different depths by pushing Shelby tubes during drilling. No rock core samples were collected in the recent 2015 explorations. Borings in the paved areas (B-4, B-5 and B-6) were backfilled with cement grout and patched with asphalt on the top. Borings in the grass-covered areas (B-3, B-7, B-8, B-9 and B-10) were backfilled with bentonite chips, soil cuttings and sand to the original grade.

The recent borings were observed and logged in the field by a Jacobs engineer. Soil was classified following the modified Burmister soil classification system; approximate stratum breaks were interpolated from drilling and sampling observations. Boring logs were prepared by Jacobs based on the field observations and laboratory testing.

LABORATORY TESTING

Laboratory tests were performed on five undisturbed clay samples from borings B-9 and B-10 to provide specific data to aid in evaluating the strength, sensitivity and consolidation properties of the clay. The soil laboratory testing program consisted of Atterberg limits, lab torvane and one-dimensional consolidation tests (ASTM D2435-04). The key test results are summarized in Table 1 below, along with results from previous testing from samples taken from borings B-1 and B-2 and are presented in Figures 4 through 7. The laboratory test report for borings B-9 and B-10 is attached in Appendix B.

Table 1: Laboratory Soil Test Results Summary

Boring No.	Sample No.	Depth (feet)	Natural Water Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Liquidity Index (LI)	Consolidation (D2435-04)			
								CR[2)]	RR[2)]	P_c'[1)] (tsf)	e_o
B-1	UD-1	22-24	33.5	35	19	16	0.91	0.14	0.012	1.3	0.896
B-1	UD-2	65-67	36.9	31	21	10	1.59	0.17	0.015	2.0	1.106
B-2	UD-1	14.5-16.5	24.9	29	18	11	0.63	0.12	0.010	4.0	0.667
B-2	UD-2	42-44	38.3	30	19	11	1.75	0.17	0.018	1.4	1.270
B-9	UD-1	12-14	38.0	24	19	5	3.80	0.17	0.012	0.80	1.075
B-9	UD-2	24-26	33.0	26	17	9	1.78	0.14	0.009	0.85	0.980
B-9	UD-3	62-64	41.7	37	20	17	1.28	0.20	0.013	2.0	1.113
B-10	UD-1	6-8	27.2	34	19	15	0.55	0.13	0.013	3.9	0.778
B-10	UD-2	41-43	36.3	27	17	10	1.93	0.23	0.013	2.0	1.118

Notes: 1) P_c' = Maximum Past Pressure
2) CR and RR values are based on the Engineer's estimates from the lab data.

Also note the lab report designates that the clay sample from 6 to 8 feet deep (B-10, UD-1) as "desiccated" (or overconsolidated) and the clay samples from the other four depths from borings B-9 and B-10 as "Sensitive". Clayey soils are considered sensitive when the Liquidity Index (LI) is close to or greater than 1. If the LI is greater than 1, the soil will be essentially a very viscous liquid when sheared. As long as they are not disturbed in any way, they can be relatively strong, but if for some reason they are sheared and the structure of the soil breaks down, then they can flow like a liquid.

Note the Atterberg limits results presented in Figure 4 include results of samples from Jacobs borings B-1, B-2, B-9 and B-10, as well as results on one sample from Haley & Aldrich boring HA09-1. The Atterberg limits results are consistent and indicate an LI of generally greater than 1 at and below elevation 25 feet.

Undrained shear strength data presented in Figure 5 include field and lab tests results on samples from borings B-1, B-2, B-9 and B-10. The data were categorized by the testing methods (field vane and lab Torvane). Figure 5 indicates that the field vane test results generally showed a higher clay undrained shear strength as compared to the lab torvane. Pocket penetrometer testing was performed in the field but in general did not provide a reliable strength for the soft clay layer below approximately elevation 25 feet. The field vane results were corrected for plasticity.

The maximum past pressure data shown in Figure 6 indicate that the clay layer in borings B-9 and B-10 below approximately elevation 25 feet is normally consolidated. The clay layer above approximately elevation 25 feet is overconsolidated. The outlier point at elevation of -3.6 feet is at the bottom of the clay layer (near the glacial till) at boring B-10. The maximum past pressure data from B-9 and B-10 were plotted again along with previous data from B-1 and B-2 and the H&A data in 2009 in Figure 7 for comparison and adjustments were made to the estimated maximum past pressure values to correct for potential sample disturbance. For our analyses, we assumed the top five feet of clay was overconsolidated.

SUBSURFACE CONDITIONS

The subsurface conditions at the existing toll plaza area were presented in Jacobs' Geotechnical Memorandum dated 11/11/2014. The primary goal of the eight supplemental borings (B-3 through B-10) performed in the recent 2015 explorations was to better define the extent and thickness of the compressible

clay soils over a larger area extending 1200 feet south of the existing toll plaza to 1400 feet north of the existing toll plaza, as well as in the existing embankment areas east and west of the existing Turnpike that are proposed as potential new roadway areas.

The existing subsurface conditions in this enlarged area are summarized in Table 2 and are discussed below. Borings B-1 and B-2 performed by Jacobs in the 2014 explorations and the two H&A borings (HA09-1 and HA09-2) are also presented in Table 2 for comparison and are incorporated into the discussion below. For additional information refer to the exploration logs in Appendix A and the subsurface profile presented in Figure 3.

Table 2: Summary of Subsurface Conditions at Borings

Boring Number	Approx. Ground Surface Elev. (ft)	Approx. Asphalt Thickness (ft)	Approx. Fill Thickness (ft)	Top of Clay Elev. (ft)	Approx. Clay Layer Thickness (ft)	Approx. Bottom of Clay Elev. (ft)	Bottom of Boring Elev. (ft)	Approx. Ground Water Elev. (ft)
B-1	47.5	2.0	12	33.5	56	-22.5	-28.5	34.8
B-2	46.7	2.0	12	32.7	63	-30.3	-32.8	34.2
B-3	46.9	0	5	41.9	11	28.9	14.9	42.2
B-4	46.1	0.8	6.2	39.1	51.5	-12.4	-15.1	41.4
B-5	46.6	1.3	9.2	36.1	46.2	-10.1	-15.4	40.4
B-6	44.7	1.0	8.5	35.2	64.5	-29.3	-32.3	39.7
B-7	43.7	0	8.5	35.2	36.5	-1.3	-4.5	40.5
B-8	48.2	0	4.8	43.4	26.7	16.7	14.2	44.9
B-9	38.8	0	4	34.8	69	-34.2	-38.7	39.8
B-10	38.2	0	4.3	33.9	40.2	-6.3	-13.7	40.6
HA09-1	47.2 ±	1.7	10.8	34.7	71	-36.3	-37.9	43.2
HA09-2	45.3 ±	0.8	10.7	33.8	58.5	-24.7	-26.1	41.9

Asphalt

About 10 to 16 inches of asphalt pavement was encountered at the toll plaza location during the recent 2015 field explorations. The asphalt pavement is generally thicker (up to 24 inches) at the existing toll plaza where borings B-1 and B-2 were performed and gradually becomes thinner at locations further away from the plaza.

Soil

Fill: The encountered fill layer was approximately 4 to 12 feet thick and typically consists of very loose to very dense sand and gravel with trace amounts of silt. SPT N-values in the fill layer range from 2 to over 100 blows per foot (bpf). Frozen ground near the surface and obstructions such as cobbles encountered during sampling contributed to the high variability in the blow counts. The fill layer is generally thicker (up to 12 ft or more) at the existing toll plaza location and gradually becomes thinner at locations further away from the plaza.

Marine Clay Deposits: The marine clay deposits encountered below the fill consisted predominantly of inorganic marine clay of about 11 to 71 feet thick. The top 5 to 10 feet of the clay was medium stiff to hard with SPT N-values ranging from 4 to 33 bpf. The remaining portion of this layer was generally very soft to soft, with SPT N-values ranging from Weight of Rods (WOR) to 3 bpf. Occasional to frequent silty fine sand lenses and seams were also observed in this layer. The marine clay deposit layer was observed to be thickest

(up to 71 ft) near the existing toll plaza location and gradually thins at locations further away from the plaza to approximately 11 feet at boring B-3 (southern extent) and approximately 27 feet at boring B-9 (northern extent).

Till: A till and weathered rock layer of approximately 1 to 15 feet thick was encountered below the marine clay deposits. The top of the glacial till was encountered at depths ranging from 16 to 83.3 feet, corresponding to elevations ranging from +30.9 to -36.1 feet. This layer typically consists of very dense, grey, fine to coarse sand or gravel with some silty clay. SPT N-values in the till layer range from 12 to over 100 blows bpf.

Bedrock

Probable bedrock was encountered in borings B-1, B-2, B-7, B-8, B-9 and B-10 at a depth ranging between 32.3 and 77.2 feet below the ground surface, corresponding to approximate elevations ranging from 15.9 to -38.4 feet. No rock core samples were taken in any of the explorations.

Groundwater

Groundwater levels were measured in the test borings during and after completion of drilling. The data indicated the groundwater depth ranged from approximately 3.2 to 6.2 feet below the ground surface, corresponding to elevations ranging from 44.9 to 39.7 feet. Note in borings B-1 and B-2 ground water levels between 12.5 and 12.7 feet were observed, corresponding to elevations ranging from 34.8 to 34.2 feet, which are lower than the groundwater level readings from other borings. The adjacent undeveloped areas to the east and west of the site are at approximately elevation +40 to +42 feet. It should be noted that in borings B-9 and B-10, artesian conditions were encountered after the boreholes were advanced into the till layer. The observed ground water levels at borings B-9 and B-10 upon completion of the boreholes were about 1 to 2.4 feet above the existing ground surface, corresponding to ground water elevations ranging from approximately 39.8 to 40.6 feet.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. Local and periodic variations of ground water elevations may also be influenced by local subsurface drainage, leaking water or sewer pipes, and precipitation.

GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS

Preliminary geotechnical analyses and evaluations for the existing toll plaza area were presented in Jacobs 11/11/2014 Geotechnical Memorandum. Additional geotechnical analyses and evaluations were conducted for the design alternative presented herein in which the toll plaza will be relocated 400 feet north of the existing location. Our estimates are based on the latest revisions made by Jacobs to the proposed grading plans along the Turnpike between Stations 255+00 and 276+00, with a primary focus on the proposed grading changes within 200 feet north and south of the proposed new toll plaza at Station 269+00. Between Stations 267+00 and 271+00, proposed site grades are estimated to increase by no more than about 2 feet in the vicinity of the ORT northbound lanes, with the southbound ORT site grades essentially matching existing grades or being cut by as much as about 2 feet. In the embankment areas east and west of the existing Turnpike that are proposed as potential new roadway areas, site grades are estimated to increase by as much as approximately 6.5 feet.

Settlement Evaluation and Mitigation

Based on our evaluation of the recent 2014 and 2015 lab consolidation test data in the vicinity of the proposed York toll plaza, it appears that the top five feet of clay is overconsolidated and the rest of the clay is normally consolidated. It also appears that the primary consolidation from the site filling that was performed between 1947 and 1968 is complete. Therefore, if no additional load is applied from the proposed new toll plaza construction, the site is anticipated to settle only due to the secondary compression of the clay. Settlement due to secondary compression at the proposed plaza location from 2014 to 2050 (i.e. 36 years, or approximately three normal repaving cycles) is estimated to be less than about 1 inch. The site consolidation settlements due to filling through different time periods since 1947 were estimated by considering the settlement contributions from each filling operation. Consolidation settlement from historic filling was estimated using computer software and assuming the clay is normally consolidated and under two-way drainage. Detailed settlement calculations as well as the assumptions included in our analyses are presented in Appendices C.1 and C.2.

The most recent Jacobs grading profile indicate that the proposed grades in the vicinity of the northbound ORT lanes are estimated to increase by up to two feet compared to existing roadway grades. This increase in grade is estimated to result in approximately 4.5 inches of settlement, which we understand is not acceptable, especially at the ORT lanes. In our opinion, the future settlement of the clay in the existing roadway area can most economically be limited by unloading the site by means such as replacing some of the existing fill with lightweight aggregate materials. Based on the 2 foot raise in grade, and assuming a 3.5 foot thick pavement box section is maintained, we estimate that approximately 1.7 feet of existing fill would need to be removed and replaced with 3.7 feet of lightweight aggregate with a unit weight of 55 pcf (refer to the attached calculations in Appendix C.3). This would maintain the effective stress profile at the site at its current level and minimize potential future primary settlement. An excavation of about 5.2 feet (1.7 + 3.5 = 5.2 feet) would be required for this construction and would provide a buffer of about 4.8 feet of existing fill material above the top of the existing clay layer. For constructability, to limit potential disturbance of the underlying sensitive clay by construction equipment, a buffer of about 4.5 to 5 feet should be maintained.

It is our understanding that the future ORT slabs should not be allowed to settle and will be supported on piles. Approach slabs to the south and north of the proposed ORT slabs, in combination with the use of the lightweight aggregate fill, as described above, are recommended to minimize potential differential settlement. We anticipate that the limits of lightweight aggregate fill would extend from approximately Station 267+00 to 271+00, about 200 feet north and south of the new toll plaza location.

Approach slabs are also recommended to the south and north of the proposed access tunnel in the cash lane areas of the existing roadway to minimize potential differential settlement. We also recommend the use of lightweight aggregate fill in the existing roadway areas proposed for the cash lanes extending from approximately Station 267+00 to 271+00.

New Roadway Areas

At the east and west sides of the Turnpike roadway in the area of the proposed new toll plaza, a raise in grade of up to about 6.5 feet is expected to create the new roadway areas. This increase in grade is estimated to result in approximately 20 inches of settlement. Therefore, to compensate for this settlement and the subsequent need to place more fill up to the proposed ground surface elevations, which would induce more settlement, it will be necessary to place more than 6.5 feet of fill in these areas. It will also be necessary to compensate for secondary compression of the clay by using the surcharge. Therefore, we estimate that it will

be necessary to place up to about 12 feet of fill; the settlement from this is estimated to be approximately 32 inches.

In order to reduce the duration of this settlement to within one construction season such that approximately 99% of the consolidation settlement has occurred prior to final roadway construction, we evaluated the use of wick drains spaced at 4 to 5 feet on center in a triangular pattern installed through the clay to expedite the consolidation. We estimate that about 4 to 6.5 months would be required to achieve 99% consolidation of the clay using wick drains spaced at 4 or 5 feet on center, respectively. If the coefficient of consolidation for horizontal drainage is 1.5 times greater than the vertical coefficient of consolidation, then the consolidation time would be reduced to about 4.5 months for the 5 foot wick drain spacing option. Refer to the calculations in Appendix C.4.

Slope Stability Evaluation

A stability analysis was conducted for the proposed surcharge embankment where up to 12 feet of fill may be placed using the computer software SLOPE/W by GeoStudio. Our analyses results indicate that the slope has an estimated factor of safety against global instability of at least 1.9 (refer to the plots in Appendix C.5).

Dewatering and Temporary Excavation Support

Due to the anticipated excavation depth and existing groundwater at approximately elevation 40 feet, the anticipated bottom of excavation to remove and replace the existing fill with lightweight fill will be slightly below the existing groundwater elevation. Therefore, a dewatering system will be needed to maintain a stable excavation during excavation. Depending on staged construction requirements, temporary excavation support may also be required; however, selection of appropriate temporary excavation support methods should consider the sensitive nature of the existing clay which can become disturbed with excessive vibrations.

LIMITATIONS

This geotechnical data memorandum has been prepared for the exclusive use of Maine Turnpike Authority and their representatives for specific application to the planning and geotechnical design of the Interstate 95 toll plaza in York, Maine.

This report was prepared in accordance with generally accepted soil and foundation engineering practices. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions regarding this report.

Very truly yours,

Jacobs Engineering Group

Da Ha, PhD, PE
Geotechnical Engineer

Paul J. Murphy, PE
Geotechnical Department Manager

ATTACHMENTS

Figure 1 – Site Location Plan
Figure 2 – Subsurface Exploration Plan
Figure 3 – Subsurface Exploration Profile
Figure 4 – Atterberg Limits Results
Figure 5 – Undrained Shear Strength Data
Figure 6 – Maximum Past Pressure (B-9 and B-10)
Figure 7 – Maximum Past Pressure (All Data)
Appendix A – Exploration Logs
Appendix B – Laboratory Data (2015 Explorations)
Appendix C – Geotechnical Calculations
Appendix D – Technical References

O:\INFRASTRUCTURE\GEOTECHNICAL\Maine Turnpike Authority - York Plaza\Geotechnical\Supplemental Geotech Memo 2015\York Plaza - Supplemental Geotech Memo - 031915.docx