Infrastructure Engineering Solutions

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REPORT ON GEOTECHNICAL INVESTIGATION

NEW CHEMICAL SYSTEMS FEED BUILDING
CITY OF FLINT WATER TREATMENT PLANT
FLINT, MICHIGAN

Owner:

City of Flint Water Treatment Plant
4500 Dort Highway
Flint, Michigan 48506

Prepared for:

CDM Smith

645 Griswold Street, Suite 3770
Detroit, Michigan 48226

2019071A
July 3, 2019

Somat Engineering, INCORPORATED

Somat Engineering, INCORPORATED

July 03, 2019
2019071A

Mr. James Broz, P.E.
CDM Smith
645 Griswold Street, Suite 3770
Detroit, Michigan 48226

RE: Report on Geotechnical Investigation
New Chemical Systems Feed Building
Flint Water Treatment Plant
Flint, Michigan

Dear Mr. Broz:

We have completed the report on the geotechnical investigation for the proposed Chemical Systems Feed Building at the Flint Water Treatment Plant in Flint, Michigan. This report presents the results of our observations, geotechnical recommendations, and construction considerations.

The soil samples collected during our field investigation will be retained in our laboratory for 90 days from the date of this final report, at which time these samples will be discarded unless otherwise directed by you.

It was a pleasure working with you on this project. If you have any questions regarding this report, please do not hesitate to contact us.

Sincerely,
Somat Engineering, Inc.

Jane Abadir

Jane M. Abadir, P.E. LEED A.P.
Project Manager

JA/JSS/RA/nf

REPORT SUMMARY

A general summary of the report conclusions and recommendations is provided below:

1. Based on the subsurface findings, shallow spread, continuous, or mat foundations appear to be feasible options for the support of the proposed chemical building structure. These foundation systems should bear at a minimum of 3.5 feet below final site grade (frost depth) (El. 729 feet±) below the finished floor elevation of 732.5 feet±. The foundation soils at this bearing elevation are anticipated to consist of either the existing fill soils or the native granular soils (with an apparent density of loose to very loose) extending to a depth of about 5.5 to 7.5 feet below the foundations and overlying stiff to hard clay soils.

2. To minimize the potential of differential settlement and cracking in the floor slab due to the very loose condition of the subgrade soils, we recommend utilizing a system of geogrids and new aggregate fill below the proposed footings and the floor slabs.

3. For the spread, continuous, or mat foundations bearing on the subgrade soils that have been modified/stabilized as described in this report, we recommend a net allowable soil bearing pressure of 2,500 psf with a factor of safety of 3 on the ultimate bearing capacity. For design of the rigid mat design, we recommend using a modulus of subgrade reaction, k, of 100 kcf. We estimate the total settlement for these foundations, using the recommended bearing pressure, should be less than 1 inch, assuming the bearing soils are not disturbed. The differential settlement is anticipated to be one-half of the estimated total settlement.

4. It will be necessary to lower the groundwater table a <u>minimum</u> of 2 feet below the bottom of the excavations to protect the bottom stability of the excavations and to allow for proper compaction of the subgrade soils. Groundwater control measures by means of specialized dewatering methods such as downhole pumps in slotted casings or wellpoints, will be required. Alternatively, constructing steel sheet pile enclosures toed adequately into the underlying clay soils in conjunction with sump pits and pumping methods could be utilized for groundwater control measures.

5. Based on borings B-03 and B-04, the subgrade soils supporting the proposed pavement are anticipated to be comprised of fill soils consisting of sand and slag aggregate which extended to a depth of about 2 feet (El. 729 feet±) below existing grades. These soils are not considered suitable for supporting the proposed pavement due to the excessive fines content and susceptibility to frost heave. The slag that was observed in the fill soils was friable and deleterious. These fill soils should be removed, within the new pavement limits, down to the complete vertical extent of this material. The recommended backfill will consist of a system of geogrid and fabrics for the support of the paving equipment and the new pavement section.

6. Using the modified geogrid subgrade described in the report, we recommend the following pavement design soil parameters:

    - For rigid pavement design, we recommend a modulus of subgrade reaction (k) of 100 psi/in for Portland cement concrete pavement. The concrete should be air-entrained and have a flexural strength of 650 psi and a compressive strength of 3,500 psi or greater. The length to width ratio of the joints should not exceed 1.25.

    - For flexible pavement design, based on our experience with similar soil conditions, we recommend a CBR of 10 and subgrade resilient modulus of 9,400 psi.

7. We recommend implementing a geotechnical instrumentation program to monitor potential settlement and harmful vibrations due to the construction methods used such as dewatering activities and driving sheet piles. We understand there is an existing 48-inch diameter concrete water main that is located about 15 feet east from the proposed building footprint. This water main and any other above or below grade structures located within a minimum radius of 35 feet from the dewatering wells or the source of vibration should be monitored on continuous basis. For underground concrete sewer structures, we recommend a threshold vibration level consisting of a peak particle velocity (PPV) of 2.0 inches per second along with a frequency of 10 Hz or greater.

The summary presented above is general in nature and should not be considered apart from the entire text of the report with all the qualifications and considerations mentioned therein. Details of our findings and recommendations are discussed in the report.

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1.0 INTRODUCTION

1.1 GENERAL

Upon authorization from CDM Smith (CDM), Somat Engineering, Inc. (Somat) has conducted the geotechnical investigation for the proposed Chemical Systems Feed Building at the City of Flint Water Treatment Plant (WTP), in Flint, Michigan. The geotechnical investigation was performed in accordance with Somat's Proposal No. P180008R, dated May 23, 2019.

The following sections of this report will provide our understanding of the project, a description of our field investigation, the results of the field and laboratory tests, the logs of test borings, our interpretation of subsoil and groundwater conditions, and recommendations related to the geotechnical aspects of the proposed construction.

1.2 PROJECT INFORMATION

Based on the project information provided by the project designer, CDM, the City of Flint WTP is undertaking the development of a new chemical building within its property located at 4500 Dort Highway in Flint Michigan. The proposed building has a plan area of 57 feet by 52 feet and is expected to house seven (7) tanks ranging in capacity between 100 and 6,000 gallons. The building will not have a basement. The proposed site development plan also includes new driveways servicing the proposed building.

1.3 SITE CONDITIONS

The proposed chemical building will be located within the City of Flint WTP towards the northeast corner of the plant. The proposed footprint of the chemical building is covered in grass and the topography of the site is generally flat. The site is bound on the east and northeast sides by the Flint River. The Flint River is about 800 feet east of the site. We understand the 100-year floodplain level is approximately 716.9 feet±.

2.0 SUBSURFACE INVESTIGATION

2.1 FIELD EXPLORATION

The field exploration program consisted of performing a total of four (4) soil borings for the project. Two (2) of the soil borings, B-01 and B-02, were performed within the proposed footprint of the chemical building and were planned to extend to a depth of 30 feet below existing grades. However, B-01 terminated at 22 feet due to encountering an unknown obstruction. Boring B-02 extended to the 30 foot depth below existing grades. Two (2) soil borings, B-03 and B-04, were performed near the alignments of the proposed driveways that will service the new building. Borings B-03 and B-04 extended to a depth of 7.5 feet and 6.5 feet below existing grades, respectively. The number and locations of the borings, as well as the depths of the borings, were selected by CDM and Somat, based on the preliminary site plan. Somat staked the boring locations in the field, taking into account the locations of existing utilities, underground and overhead. Ground surface elevations and State Plane Coordinates were estimated at the boring locations based on our handheld GPS unit and the site topographic maps. A soil boring location diagram, is presented in Appendix A.

2.1.1 Drilling

The drilling operations were performed on June 11, 2019. The borings were drilled using 2¼ inch diameter hollow-stem augers. Upon completion, the boreholes were backfilled to the surface with soil cuttings.

2.1.2 Sampling

Soil samples were recovered using split-spoon sampling procedures in accordance with ASTM Standard D-1586 (“Standard Method for Penetration Tests and Split Barrel Sampling of Soils”). In borings B-01 and B-02, the samples were generally obtained at a regular interval of 2½ feet for the upper 10 feet of the borings, then at a 5 foot interval to the exploration depths of the borings. In borings B-03 and B-04, the samples were obtained continuously from the surface to the exploration depths of the borings. The split-spoon samples were sealed in glass jars in the field to protect the soil and maintain the soil's natural moisture content. All soil samples were transported to Somat's laboratory for further analysis and testing.

The soil samples collected for this investigation will be retained in our laboratory for a period of 90 days from the date of the final report, after which they will be discarded unless we are notified otherwise.

2.1.3 Standard Penetration Test (SPT)

Soil samples collected during the field portion of the subsoil exploration were labeled with the soil boring designation and a unique sample number. Most of the soil samples were obtained by Standard Penetration Tests in accordance with ASTM D1586 procedures, whereby a conventional 2-inch O.D. split-spoon sampler is driven into the soil with a 140-pound hammer repeatedly dropped through a free-fall distance of 30 inches. The sampler is generally driven three successive 6 inch increments, with the blows for each 6 inch increment being recorded. The number of blows required to advance the sampler through 12 inches after an initial penetration of 6 inches is termed the Standard Penetration Test resistance (N-value) and is presented graphically on the individual Logs of Test Borings. As added information, the number of blows for each 6 inch increment is also presented on the boring logs.

2.1.4 Groundwater Level Observation Procedures

Whenever possible, groundwater level observations were made during the drilling operations and are shown on the individual Logs of Test Borings. During drilling, the depth at which free water was observed, where drill cuttings became saturated or where saturated samples were collected, was indicated as the groundwater level during drilling. In granular, pervious soils, the indicated water levels are considered relatively reliable when solid or hollow-stem augers are used for drilling. However, in cohesive soils, groundwater observations are not necessarily indicative of the static water table due to the low permeability rates of the soils, and due to the sealing off of natural paths of groundwater flow during drilling operations.

It should be noted that seasonal variations and recent precipitation conditions may influence the level of the groundwater table significantly. Groundwater observation wells are generally used if precise groundwater table information is needed; however the installation of groundwater monitoring wells was not included in the scope of the investigation. Therefore, the discussion and recommendations provided within the report are based on our knowledge of the soil and groundwater conditions in this area, which should provide for a reasonable approximation of the groundwater level.

2.2 LABORATORY TESTING

Representative soil samples were subjected to laboratory tests consisting of moisture content determinations, hand penetrometer tests, and unconfined compressive strength tests. These tests were performed on portions of the cohesive samples obtained. All samples were classified in accordance with the Unified Soil Classification System.

In the hand penetrometer test, the unconfined compressive strength of a cohesive soil sample is estimated by measuring the resistance of the sample to the penetration of a small, calibrated spring-loaded cylinder. The maximum capacity of the penetrometer is 4.5 tons per square foot.

Grain size analyses were performed according to ASTM D422 92007) on two (2) selected samples from borings B-01 at a depth of 6 feet and B-03 at a depth of 1.5 feet. Results of the grain size analyses are presented graphically in Appendix C of this report.

Loss-on-Ignition (LOI) tests were performed on samples suspected to contain excessive organic material. In the LOI test, a sample is superheated as a means to burn off all of the organic matter. The organic content is then calculated as a ratio of the weight of organic material to the weight of the overall sample.

The results of the soil classifications and testing are included on the respective logs of test borings in Appendix B. All laboratory tests were performed in accordance with applicable ASTM procedures.

2.3 LIMITATIONS

The scope of our services was strictly geotechnical and did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater or air, on, below or around this site.

Somat has made no observations or recommendations with regard to the presence or absence of mold or other biological contaminants (such as spores, fungi, bacteria, viruses and the byproducts of such organisms), now or in the future, on this site or within or on any structures to be constructed on this site. Any consideration with regard to the presence of mold, or the possibility of mold growth in or on the structure to be constructed on this site are not within our scope of services on this project.

3.0 SUBSURFACE CONDITIONS

3.1 SOIL STRATIFICATION

Soil conditions encountered at the test boring locations have been evaluated and are presented in the form of Logs of Test Borings. The Logs of Test Borings presented in Appendix B include approximate soil stratification with detailed soil descriptions and selected physical properties for each stratum encountered in the test borings. In addition to the observed subsoil stratigraphy, the boring logs present information relating to sample data, Standard Penetration Test results, groundwater level conditions observed in the boring, personnel involved, and other pertinent data. For information, and to aid in understanding the data as presented on the boring logs, General Notes defining nomenclature used in soil descriptions are presented immediately following the Logs of Test Borings in Appendix B. It should be noted that the Logs of Test

Borings included with this report have been prepared on the basis of laboratory classifications and testing as well as field logs of the soils encountered.

A generalized description of the soils encountered, beginning at the existing ground surface and proceeding downward, is provided below:

Surface Materials.

- Topsoil was encountered at the surface of borings B-01 and B-02 in thicknesses of 7 inches and 12 inches, respectively.
- Pavement consisting of 2 inches of asphalt cement concrete over 4 inches of Portland cement concrete was encountered at the surface of boring B-03.
- Road gravel fill layer was encountered at the surface of boring B-04 and was approximately 6 inches in thickness.

Fill. Fill soils consisting of silty sand, fine sand, silty slag sand, and/or a mixture of these soils were encountered below the surface materials in all the borings and extended to depths ranging between 2 and 3.5 feet below existing grades (EL. 729.2 to 728.2 feet±). The fill soils contained trace roots and organic material. LOI tests performed on fill soil samples obtained from a depth between about 2 and 2.5 feet in borings B-01, B-02, and B-03 had organic contents ranging between 4 and 11%. The apparent density of the fill soils ranged from medium dense to very loose.

Sand and Silt. Native soils consisting of sand, silty sand, and silt, or a mixture of these soils, were encountered below the fill soils in all the borings and extended to depths of about 9 to 11 feet (EL. 723 to 721 feet±) below existing grades in borings B-01 and B-02, and to the explored depths of 7.5 feet (EL. 723.5 feet±) and 6.5 feet (EL. 724.7 feet±) below existing grade in borings B-03 and B-04, respectively. The apparent density of these soils ranged between medium dense and very loose.

Clay. Natural hard to stiff gray lean clay was encountered below the native sand and silt in borings B-01 and B-02 and extended to the exploration depth of the borings at 22 feet (EL. 709.7 feet±) below existing grade and 30 feet (EL. 702.1 feet±) below existing grade, respectively. The clay had moisture content ranging between 11% and 32%. A layer of medium dense sand was encountered in the clay soils from a depth of about 18.5 to 23.5 feet below existing grade in boring B-02.

Please refer to the boring logs for the soil conditions at the specific boring locations. It is emphasized that the stratification lines shown on the Logs of Test Borings are approximate indications of change from one soil type to another at the locations of the boreholes. The actual transition from one stratum to the next may be gradual, and may vary within the area represented by the test boring.

3.2 GROUNDWATER LEVEL OBSERVATIONS

Groundwater seepage was reported during drilling and upon completion of drilling in all THE soil borings. Table 1 below summarizes the groundwater information:

Table 1: Summary table of the groundwater information

Boring ID	Groundwater depth reported during drilling (Elevation)	Groundwater depth reported upon completion of drilling (Elevation)
B-01	3.5 feet (EL. 728.2 feet)	3.5 feet (EL. 728.2 feet)
B-02	3.5 feet (EL. 728.5 feet)	3.5 feet (EL. 728.5 feet)
B-03	2.0 feet (EL. 729.0 feet)	2.0 feet (EL. 729.0 feet)
B-04	2.5 feet (EL. 728.7 feet)	2.0 feet (EL. 729.2 feet)

It should be noted that the elevation of the natural groundwater table is likely to vary throughout the year depending on the amount of precipitation, runoff, evaporation and percolation in the area, as well as on the water level in the Flint River in the vicinity affecting the groundwater flow pattern.

3.3 GRAIN SIZE ANALYSIS RESULTS

Grain size analyses were performed on two (2) selected samples from boring B-01 at a depth of 6 feet and B-03 at a depth of 1.5 feet below existing grade. Based on the results, the “fines” content (silt and clay) ranged between 14% and 15%. A graphical presentation of the results is presented in Appendix C.

4.0 ANALYSIS AND RECOMMENDATIONS

Based on the preliminary plans for the proposed chemical building, Sheet V-101 dated May 23, 2019, we understand the building footprint is about 57 feet by 52 feet and the building will be constructed at grade (with no basement). The finished floor is expected to be situated at elevation 732.5 feet±. The proposed building will contain several storage tanks and a few small metering pumps as summarized below:

- Two 3,000 gallon sodium hypochlorite bulk storage tanks,
- One 6,000 gallon sodium hydroxide bulk storage tank,
- One 2,100 gallon orthophosphate bulk storage tank, and
- Three 100 gallon days tanks.

The proposed site development plan also includes new driveways for the chemical trucks access to the proposed building. The following sections of this report address the foundation system options and geotechnical pavement design recommendations.

4.1 FOUNDATION RECOMMENDATIONS

Based on the subsurface data obtained from the borings B-01 and B-02 performed within the proposed building footprint, shallow spread, continuous foundations, or mat foundations appear to be feasible options for supporting the proposed chemical building. These foundation systems should be designed to bear at a minimum depth of 3.5 feet or at elevation 729 feet± (Frost depth for SE Michigan) below the finished grade of 732.5 feet±. At this elevation, both borings B-01 and B-02 indicate this is the elevation where the soils transition from the fill soil stratum to the native sand and silt stratum. We *do not* recommend constructing new foundations on these existing fill soils. The existing fill soils may be undercut and replaced with new engineered fill as described below and the foundations can then be supported at standard frost depth.

The native granular soils below the fill soils are also considered unsuitable for supporting the proposed foundations if left in their current condition due to their current very loose condition and due to the excessive fines content in the silty sand in boring B-01. The loose soils will not adequately support the new foundations resulting in settlement of the footings and the floor slabs. The excessive fines may negatively impact the drainage of the foundations bearing soils. Therefore, supporting the proposed footings and the floor slabs on these soils without bearing soil/subgrade modification is not recommended due to the risk of differential settlement and potential cracking in the proposed floor slabs.

Attempting to compact loose granular soils would typically improve the density of the soils. However, these poor soils conditions extend deep below the foundations and are mostly situated below the long-term groundwater table (saturated) which does not allow for proper compaction or for a stable excavation. Attempting to utilize deep compaction methods such as the vibroflotation methods is not recommended due to the risk of liquefying the soils and further disturbing the subgrade soils.

As an alternative to dealing with the saturated loose sand soils, we also looked at a system of Geopiers (stone columns) or helical piers to support the proposed building. These foundation systems would be feasible, but very expensive given the smaller size and the magnitude of the project. Rather, we recommend utilizing a system of geogrids and aggregate fill below the foundations and the floor slabs. The resulting reinforced soil section will help distribute the load uniformly, bridge over any loose/very loose areas and, minimize the potential for settlement, differential settlement, and cracking of the floor slabs.

It will be necessary to lower the groundwater table a <u>minimum</u> of 2 feet below the bottom of the excavations to protect the bottom stability of the excavations and to allow for proper compaction of the subgrade soils. Please refer to the groundwater control discussed in Section 4.1.1 for the dewatering requirements.

The following sections address the recommendations for modifying the foundations soils under the footings and the floor slabs using a system of geogrids.

Footing Areas: Beginning at the bottom of footing elevation, excavate down an additional 12 inches, at a total width of 12 inches beyond each side of the footing. The plan area of soil removal should extend out from the edge of the footing a distance of one foot for every two feet of excavation below the footing level. In other words, the soil to be undercut should be removed at a minimum 1H:2V slope from the edge of the footing to the edge of the undercut excavation to provide suitable bearing for the footing. Compact the bearing soils with a vibratory roller or plate compactor until subsequent passes result in no downward displacement. Place a continuous strip of Tensar TX160 geogrid (or Engineer approved equivalent) over the compacted subgrade. Backfill with 6 inches of clean, drainable, and well compacted engineered fill that meets the gradation of MDOT 21AA stone. Compact with one pass of roller or plate compactor with minimal vibration. Place a second layer of the same geogrid equal in width to the first layer, on the compacted 21AA stone. Place another 6-inch lift of 21AA stone on top of this second geogrid layer and compact with one pass of a roller or plate compactor with minimal vibration. Form and pour the footers over the modified soil subgrade section.

Floor Slab Areas: In areas of the proposed floor slabs, excavate down an additional 12 inches below floor slab bottom elevation. Compact existing subgrade with a vibratory roller or plate compactor until subsequent passes result in no downward displacement. Place a continuous strip of Tensar TX160 geogrid (or Engineer approved equivalent) over the compacted subgrade. Backfill with 6 inches of MDOT 21AA stone. Compact with one pass of roller or plate compactor with minimal vibration. Place a second layer of the same geogrid equal in width to the first layer, on the compacted 21AA stone. Place another 6-inch lift of 21AA stone on top of this second geogrid layer and compact with 1 or 2 passes of a roller or plate compactor with minimal vibration, such that compaction is complete. Place a vapor barrier at the top of the stone lift and then per the published recommendations of Building Science Inc., pour the slabs directly on the vapor barrier, even if it results in some perforations in the vapor barrier.

For the foundations and the floor slab areas, we recommend a 2 foot minimum overlap of the geogrid in conformance with manufacturer’s recommendations to promote continuity of its load distribution performance.

For the spread, continuous, or mat foundations bearing on the stabilized soils as described above, we recommend a net allowable soil bearing pressure of 2,500 psf. This maximum net allowable soil bearing pressures incorporates a minimum factor of safety of 3 on the ultimate bearing capacity.

For design of the mat foundation (assuming a rigid mat design), we recommend using a modulus of subgrade reaction, k, of 100 kcf, which is an estimated value normalized to a 1-foot square plate.

We estimate total settlement for spread, continuous, or mat foundations bearing on the soil-geogrid reinforced section as described above and using the recommended bearing pressure, should be less than 1 inch, assuming the bearing soils are not disturbed. The differential settlement is anticipated to be one-half of the estimated total settlement.

Trench footings (earth-formed footings) will likely not be suitable when extending through existing fill soils, natural sand or granular engineered fill soils due to the potential for caving and sloughing of these materials. Rather, the footing excavations may have to be sloped back and the footings formed in these soil conditions.

For bearing capacity and settlement considerations, isolated spread footing type foundations should be at least 30 inches wide, and continuous strip foundations should be at least 18 inches wide. Foundations along exterior walls, or in any unheated areas, should be situated a minimum of 42 inches below final site grade for protection against frost heave during normal winters. Also, for frost heave considerations, footings subject to frost action should be constructed with vertical sides and should not be allowed to “mushroom out” at the top.

Careful probing and visual observations should be made during construction to make sure foundations are not constructed on any organic soils (topsoil) or existing unsuitable fill soils or on disturbed soils. Any existing underground utility lines to be abandoned within the footprint of the building should be removed or grouted in place. Footings should extend through the level of any abandoned utilities and utility backfill, or the new foundations should be designed to span over these areas.

4.1.1 Groundwater Management Considerations

Based on groundwater information observed in the borings, we estimate the long-term groundwater level at this site to be situated at about elevation 729 to 728 feet±, or approximately 2 to 3.5 feet depth below existing grades. Based on the undercut and subgrade modifications recommendations provided above, we expect the excavations for constructing the foundations of the chemical building will extend to a minimum depth of 4.5 feet (EL. 727.5 feet to 726.5 feet) below existing grades. As such, the long-term groundwater table is anticipated to be situated at a depth of about 2.5 feet above the bottom of the excavations. Prior to excavating, the groundwater level should be lowered a minimum of 2 feet below the *bottom* of the excavation, to allow for proper compaction and to protect the stability of the base of the excavations. Sump pit and conventional pumping methods will NOT be adequate to control the groundwater flow into the excavations. Therefore, specialized dewatering methods will be required to control the groundwater during the excavations for the foundations. These special dewatering procedures could include, but are not limited to, downhole pumps in slotted casings or wellpoints.

Alternatively, if steel sheeting is used to maintain the stability of the excavation sides, toeing the sheeting into the underlying lean clay soils may be an effective method of temporarily sealing off the groundwater from flowing into the excavation. The steel sheeting should be toed a minimum of 2 feet (at about elevation 718 feet±) into the underlying clay soils to provide the necessary seal. The steel sheeting closure would then make it feasible to control the groundwater flow into the excavation by standard sump pit and pumping techniques.

If special dewatering procedures are required, loss of fines should be carefully checked during dewatering operations at this site because of the fine gradation of the silt and clay encountered in the soil borings. The loss of fines through dewatering should be carefully monitored to protect against the settlement of surrounding structures (i.e. building structures and existing utilities), and should be limited to 3 parts per million, based on volume measurements.

The dewatering system will need to be designed by a knowledgeable dewatering contractor. Dewatering should be performed with care and sufficiently localized so as not to cause harmful settlements of nearby foundations, utilities, or pavements.

The Michigan Department of Environmental, Great Lakes and Energy (EGLE), formerly known as Michigan Department of Environmental Quality (MDEQ), regulates the water withdrawal from Michigan's water resources in order to prevent adverse impacts on the surface and groundwater resources of the State of Michigan. The EGLE's withdrawal assessment process is used to regulate new or increased large quantity withdrawals (more than 100,000 gallons of water per day) from any source. The Owner (City of Flint) or the Owner's Prime Consultant (CDM Smith) will need to verify the dewatering requirements and secure potential provisional dewatering permits (if needed) prior to the Contractor's selection.

To facilitate decision making, an internet based screening tool was developed by EGLE to estimate the volume of water that will be depleted and the resulting impact of withdrawing water on the nearby stream ecosystems. This tool's legal name is the Water Withdrawal Assessment Tool (2008 PA189; Michigan Legislature 2008b) and can be accessed using the following link: https://www.egle.state.mi.us/wwat

Use of this no-fee screening tool avoids the cost of having every withdrawal individually evaluated by professional staff as would happen in a conventional permitting program.

The screening tool processes data about factors such as stream flows, pumping frequency, well depth, watershed areas, soil types, and the flow needs of the characteristic fish community. If the screening tool determines the withdrawal is not likely to cause an adverse impact, the Owner/Contractor may register their withdrawal through the screening tool and proceed with the withdrawal without any additional contact with the EGLE. If the proposed withdrawal screening fails, then a site-specific review and a permit will be needed. In order to assist in evaluating a withdrawal, EGLE assigned a series of "zones" A through D; that quantify the associated risk on the water resources.

We performed the on-line screening task and we used the following input parameters assumptions:

- Withdrawal Source: Groundwater,
- Pumping Capacity: 400 gpm,
- Well Casing Depth: 11 feet,
- Aquifer Type: Glacial,
- Hydraulic conductivity, Km: 0.0033 ft/s (for silty sand).

Based on the results of our screening for this site, the withdrawal request has passed the screening process and was assigned zone "A". Prior to the construction, this screening should be re-run by the Owner or the Prime Consultant and a registration should be completed for this requested withdrawal. A registration is valid for 18 months; the withdrawal capacity must be installed within that 18 months or the registration becomes void.

Another consideration would be the discharge of the groundwater. Based on Section B (e) of the MDEQ publication "Instructions for Groundwater Discharge Permit Applications" revised September, 2014; water from a well used temporarily for dewatering at a construction site does not need a permit to be discharged to surface water or an existing sewerage system if the water pumped does not create a site of environmental contamination under Part 201.

Based on the findings of our limited geotechnical investigation, we did not report a smell or color indication of potential soil contamination; however our scope of services was strictly geotechnical and did not include environmental screening, sampling or testing of the soils or groundwater. We are not aware of any Phase I or Phase II Environmental Site Assessment (ESA) report for this site. The Owner may be able to provide information regarding any known contamination based on the past use history of the site. The Owner may request the Prime

Consultant to perform environmental sampling and testing to verify and document the groundwater conditions per Part 201. We advise to have proper documentation to proceed with discharging groundwater to the surface water without treatment, if deemed necessary.

4.1.2 Seismic Site Classification Recommendations

Based on our knowledge of the general geotechnical conditions in the vicinity of the project, we classify this site as Site Class D, as per the Michigan 2006 Building Code Table 1615.1.5.

4.1.3 Coefficient of Friction and Side Wall Friction

For mass concrete (i.e. concrete spread, continuous or mat foundations) that is subjected to lateral loads, and not supported by deep foundations, some of the lateral loads may be resisted by the friction between the concrete and the underlying soil. We recommend the following allowable coefficients of friction, applied to the forces normal to the sliding surface, between the cast-in-place concrete and the underlying soils:

Soil Type	Coefficient of Friction
Sand Fill	0.40
Native Sand	0.45

4.1.4 Lateral Earth Pressure Recommendations

Below grade structures with unbalanced grade levels on opposite sides, such as the temporary cantilever sheet piles that the Contractor may elect to use for shoring and/or groundwater cut-off, should be designed to account for the recommended lateral earth pressures summarized in the following table:

Recommended Lateral Earth Pressures (A,B,C)

Soil		Granular [C]		Clay			Random Fill	MDOT Class II	MDOT 21AA
Consistency		Loose	Dense	Hard	Stiff	Soft	---	95% ASTM 1557	95% ASTM 1557
ACTIVE	Lateral Translation to Mobilize [1]	(0.003)H	(0.001)H	(0.01)H	(0.02)H	(0.05)H	(0.02)H	(0.002)H	(0.001)H
	Active Coefficient (K_a)	0.32	0.28	0.45	0.50	0.60	0.60	0.31	0.22
	Equivalent Fluid Active Earth Pressure [2]	40 psf	35 psf	65 psf	70 psf	75 psf	80 psf	40 psf	30 psf
	Lateral Surcharge (q) Effect [3]	0.32*q	0.28*q	0.45*q	0.50*q	0.60*q	0.60*q	0.31*q	0.22*q
AT-REST	At-Rest Coefficient (K_o)	0.48	0.44	0.63	0.67	0.75	0.75	0.47	0.36
	Equivalent Fluid At-Rest Earth Pressure [2]	60 psf	55 psf	90 psf	90 psf	95 psf	100 psf	55 psf	50 psf
	Lateral Surcharge (q) Effect [3]	0.48*q	0.44*q	0.63*q	0.67*q	0.75*q	0.75*q	0.47*q	0.36*q
PASSIVE	Passive Coefficient (K_p)	3.12	3.54	2.20	2.00	1.67	1.67	3.25	4.60
	Equivalent Fluid Passive Earth Pressure [2,]	375 psf	440 psf	320 psf	270 psf	210 psf	220 psf	405 psf	640 psf
	Lateral Bearing Capacity for Transient Loading [4]	---	---	6 x Clay Cohesion			---	---	---

Notes:

[1] – For active earth pressures, the structure must rotate about the base, with the top of the structure laterally translating between 0.001 and 0.05 of the exposed height to fully mobilize the active earth pressures. Otherwise the structure should be considered to be in an At-Rest condition.

[2] – Equivalent Fluid Earth Pressures should be applied in a triangular distribution laterally against the structure.

[3] – The lateral effect of a surcharge, q, on ground surface at the top of the structure should be applied uniformly against the structure.

[4] – Passive pressures for long term loading conditions. For transient loads, i.e. wind or traffic loading, short term lateral loads will mobilize the cohesion in the clay soils and may be resisted by the "lateral bearing capacity" of the clay soils. However, long term or permanent lateral loads applied to the stiff to soft clays will cause the soils to creep and lose the horizontal resistance. Therefore, the lateral resistance from the clay soils for the life time of the structure will shift from the cohesive "lateral bearing capacity" to the equivalent fluid pressures as the pore water pressure dissipates.

[A] – All earth pressures provided are for the drained condition. If drainage is not provided behind the structure or a soil strata is situated below the long term ground water table, then the equivalent earth pressures should be recalculated using the buoyant unit weight of the soil and include the hydrostatic pressure from the long term groundwater table.

[B] – No factors of safety have been applied to any of the recommended lateral earth pressures. It is anticipated that these factors will be applied with the required load reductions in the design of the structure.

[C] – Granular soils may consist of sand, silt, gravel or a mixture of these soils.

The application of the earth pressures in the design of below grade structures will be influenced by the geometry of the structure, the fixity conditions imposed on the structure, the method and material used for construction and soil and groundwater conditions. As noted, the recommended lateral earth pressures do not include a factor of safety, nor include hydrostatic pressures or account for the long term groundwater level. We anticipate that the necessary factors of safety will be indirectly applied to these recommended pressures through the load reduction factors applied in the structural design. Applying factors of safety to the above recommended pressures before their use in the design calculations would effectively double the safety reductions as these loads are carried through the design, unnecessarily penalizing the design.

4.1.5 Geotechnical Instrumentation

We recommend implementing a geotechnical instrumentation program to monitor any potential settlement and harmful vibrations due to the construction methods used. Settlement should be monitored using settlement points situated on the ground surface or directly over structures to be protected during the dewatering operations. If sheet piles will be driven to seal off the groundwater flow into the excavations, then the induced vibrations should be monitored on ground surface or directly over the structures to be protected. We understand there is an existing 48-inch diameter water main that is located about 15 feet east from the proposed building footprint. This water main and any other above or below grade structures located within a minimum radius of 35 feet from the dewatering wells or the source of vibration should be monitored on continuous basis. For underground concrete sewer structures, we recommend a threshold vibration level consisting of a peak particle velocity (PPV) of 2.0 inches per second (ips) along with a frequency of 10 Hz or greater.

4.2 PAVEMENT DESIGN RECOMMENDATIONS

As we understand, the pavement sections for the access driveways servicing the new building will consist of either Portland cement concrete or asphaltic cement concrete. The new access driveways will be constructed at about the existing grade.

Based on borings B-03 and B-04, performed within the proposed driveways, the subgrade soils supporting the proposed pavement are anticipated to consist of sand and slag sand fill soils which extended to a depth of about 2 feet (El. 729 feet±) below existing grades. These soils are not considered suitable for supporting the proposed pavement due to the excessive fines content, causing susceptibility to frost heave, and the high organic content of the existing soils. The slag that was observed in the fill soils was friable and deleterious. Loss-On –Ignition (LOI) test performed on a fill soil sample obtained from a depth of 2 feet in boring B-03 had an organic content of 11%. These organics may decompose and result in settlement and cracking in the new pavement. Therefore, these fill soils, encountered within the new pavement limits, should be removed to the complete vertical extent of this material.

Below these unsuitable fill soils, native granular soils were encountered and extended to the explored depths of the borings at 6.5 and 7.5 feet below existing grades. These native soils were very loose to medium dense and hence are not considered to be suitable for supporting the new pavement structure, if left in their current condition. Compaction will typically improve the density of the surface layers only but it will not be effective at deeper depths, which may later consolidate and cause the new pavement to settle and crack.

After undercutting the upper 2 feet, we expect the remaining subgrade soils to be saturated based on the groundwater levels encountered during the time of drilling our soil borings. If these soils are saturated during the construction, then we would not recommend to proofroll or compact it as this procedure will tend to further disturb the subgrade soils. If the rough grade is dry, however, we recommend proofrolling per project specifications. The site earthwork should preferably be performed during the typically drier May to September construction season, if possible. We recommend the following backfill section starting from the bottom and proceeding to the surface.

- 200-pound woven geotextile fabric, such as GeoTurfW200 or Engineer approved equivalent,
- Geogrid, such as Tensar TX190L or Engineer approved equivalent. Installing this geogrid at the bottom of the excavation will help protect the granular subgrade soils from rutting by construction traffic during the placement of the new base material.
- 1 x 3 inch stone backfill stabilization layer for support of the paving equipment. This material is self-leveling stone requiring minimal compaction and hence minimizes the disturbance of the saturated granular subgrade soils (minimum thickness 6 inches).
- 200-pound woven geotextile fabric, such as Turf W200 or Engineer approved equivalent,
- Geogrid, such as Tensar TX7 or Engineer approved equivalent,
- New subbase and base material such as MDOT 21AA or equivalent gradation as determined by the pavement designer,
- New asphalt or Portland cement concrete pavement layer.

The geogrid will help distribute the load and bridge over any loose areas and minimize the potential of pavement cracking, faulting, and uneven settlement. The fabric separators should be placed immediately below the geogrids and their purpose is to help minimize the migration of fines into the aggregates and also provide some tensile strength to address the anticipated fluctuation of the groundwater table. There is no need to wrap the geogrids around the aggregates since the aggregates should not translate laterally; however wrapping the fabric around the sides of the aggregate lifts is a common practice that helps mitigating the migration of fines along the edges of the slopes. As such, the fabric would be wrapped up and around the side of the aggregate lift and the fabric edges can be weighed down by the subsequent upper lift of aggregates.

We recommend a minimum overlap (typically 2 feet) of the geogrid and fabric in general conformance with manufacturer's recommendations to promote continuity of its load distribution performance. The subgrade modification should extend a minimum of 3 feet horizontally from the edges of the new pavement or a minimum of 2 feet horizontally from the edges of the unpaved shoulders; whichever is wider.

The thicknesses of the layers of this backfill and pavement section will be determined by the pavement design engineer based on the anticipated traffic loads and the pavement soil design parameters provided below:

- For rigid pavement design, we recommend a modulus of subgrade reaction (k) of 100 psi/in for Portland cement concrete pavement. The concrete should be air-entrained and have a flexural strength of 650 psi and a compressive strength of 3,500 psi or greater. The length to width ratio of the joints should not exceed 1.25.

- For flexible pavement design, using the modified subgrade section as described above, we recommend a CBR of 10 and subgrade resilient modulus of 9,400 psi.

The engineer preparing the final pavement designs should consider other factors in addition to the subgrade modulus values. These factors may include, but are not limited to, adequate subgrade preparation, adequate placement of engineered fill and pavement layers, and surface and subsurface drainage. Somat's services related to pavement design and construction on this project were limited to preparing general guidelines for subgrade conditions and estimation of modulus values from the surficial soils encountered at the soil boring locations. The estimates were based on our experience with similar soil conditions.

4.2.1 General Site Preparation, Drainage, and Earthwork Recommendations

Once rough grade has been achieved and prior to placement of engineered fill, the exposed subgrade should be visually checked for the presence of debris, organic matter and other unsuitable materials. If unsuitable or organic subgrade soils (organic content over 4 percent) are encountered at subgrade level during earthwork operations at other locations, these soils should be removed within the proposed slab areas to their full depth, and be replaced with engineered fill.

Within any new pavement construction and pavement removal and replacement areas, the top 12 inches of subgrade should be compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D-1557 (Modified Proctor). It may be necessary in some of these areas to remove disturbed subgrade soils and replace them with a stabilization layer of engineered crushed aggregate fill. The thickness and extent of the required aggregate stabilization layer can be determined in the field by the site geotechnical engineer. We recommend crushed limestone aggregate meeting the gradation requirements of MDOT 21AA material.

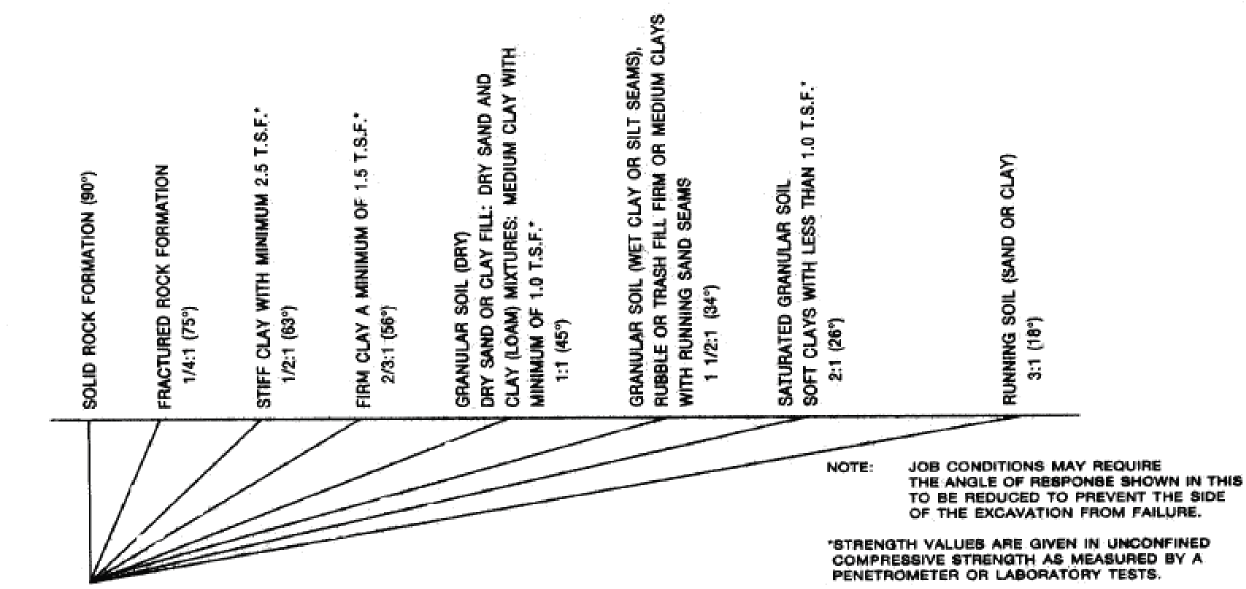
A provision for edge drains wrapped in a fabric sock should be considered to enhance drainage conditions in surface pavement areas and to reduce the effects of frost heave. This will help guard against frost heave and freeze/thaw cracking. We recommend 6 inch diameter or greater perforated or slotted PVC underdrain piping with the pipe center located at the bottom elevation of the 1 x 3 inch stone to make sure that the entire pavement section is adequately drained. The site grading would then direct the drainage to a catch basin or day lighted into a ditch.

5.0 GENERAL EXCAVATION CONSIDERATIONS

Excavation is recognized as one of the most hazardous construction operations. An excavation is any man-made cut, cavity, trench, or depression in an earth surface formed by earth removal. Trenching and excavation hazards are addressed in specific standards for the general industry in OSHA Part 1926 Subpart P "Excavations", specifically 29 CFR 1926.650, .651, and .652. The project must comply with the most stringent trenching and excavation requirements of these standards, MIOSHA Construction Safety Standard Part 9 "Excavation, Trenching, and Shoring", or other OSHA approved requirements.

We anticipate excavations in site fill and sand soils will be prone to caving and sloughing of the excavation sidewalls, especially in areas where the soil conditions are in a loose condition (N value of 9 or less). Appropriate measures will be required to maintain the stability of excavation sidewalls. The required measures will depend on the subsurface materials encountered for the full depth of the excavation, the depth and width of excavation, and groundwater conditions at specific locations. In general, excavation walls should be sloped back to a stable angle in accordance with published MIOSHA guidelines. The side of an excavation more than 5 feet deep shall be sloped as prescribed in the following MIOSHA table (from Part 9), unless the excavation is made entirely in stable rock or supported by a protective system as prescribed in the referenced standards. An excavation less than 5 feet may also require protection if a competent person determines that hazardous earth movement is anticipated.

MAXIMUM ALLOWABLE ANGLE OF REPOSE FOR THE SIDE OF AN EXCAVATION IN EXCESS OF 5' DEPTH



Sloping or benching systems for excavations less than 20 feet deep shall be in accordance with maximum allowable slopes and based on the soil or rock type encountered as prescribed in the standards. If sufficient room is not available for sloping the excavation walls, then shoring, by means such as trench boxes, sliding trench shields or sheeting, will be required to maintain the stability of the sidewalls. The design of support systems, shield systems, and other protective systems shall be in accordance with OSHA 29 CFR 1926.652. Excavations 20 feet deep or greater require that sloping or benching systems, or a protective system, be designed by a registered professional engineer (or approved by a registered professional engineer in accordance with OSHA 29 CFR 1926.652).

Construction traffic, stockpiles of soil and construction materials should be kept away from the edges of the excavations for a distance equal to the depth of the excavation. If such clearances cannot be maintained, the resulting surcharge loads should be considered in the design of the shoring system. However, no loads shall be placed within 2 feet of an excavation edge for any unsupported excavation in which a worker is required to enter (unless a proper shoring system is in place).

Proper testing for atmospheric hazards such as low oxygen, hazardous fumes, and toxic gases should occur prior to worker entry when excavations are greater than 4 feet deep. Daily inspections of an excavation, adjacent area, and any protective system should be made by a competent person prior to the start of work, following a rainstorm or other water intrusion, or during/after any occurrence that could change the conditions of the trench.

In all cases, MIOSHA and other applicable requirements must be followed and adequate protection provided for workers.

Care should be exercised when excavating near existing pavement, utilities, and structures that are to remain, to protect them from damage. Mechanical excavations near existing utilities may also pose a physical hazard to workers if the utility is damaged. The contractor should be aware of existing utility locations before excavating and be prepared to expose them for verification and to support or brace them, as required.

6.0 GENERAL ENGINEERED FILL REQUIREMENTS

Any fill placed below proposed grade slab or pavement areas should be an approved, engineered material, free of frozen soil, organics, or other deleterious material. Engineered fill should be spread in level layers, not exceeding 9 inches in loose thickness, and should be compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D-1557 (Modified Proctor). Fill should not be placed on frozen subgrades.

7.0 GENERAL QUALIFICATIONS

All earthwork and below grade construction activities, including testing and observation of subgrades for foundations and pavement, should be monitored by a qualified engineering inspector, under the direction of a qualified geotechnical engineer, to verify conditions are as presented in this report. Earthwork operations around the proposed project area and in the vicinity of existing structures should also be closely monitored. This report and the attached Logs of Test Borings are instruments of service, which have been prepared in accordance with generally accepted soil and foundation engineering practices. We make no warranties either expressed or implied as to the professional advice included in this report.

The contents of this report have been prepared in order to aid in the evaluation of expected subsoil properties to assist the engineer in the design of *this* project at the site specified herein. The contents of this report should not be relied upon for other projects or purposes. In the event that any changes are made in the geotechnically related aspects of this project, however slight, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and the conclusions of this report are modified in writing by our office.

Since the information obtained from the soil borings is specific to the exact test locations, soil and water conditions could be different from those occurring at other locations of the site. This report does not reflect variations which may occur between the soil borings. The nature and extent of these variations may not become evident until the time of construction. If significant variations become evident, it may be necessary for us to re-evaluate the recommendations provided in this report. This report and the associated Logs of Test Borings should be made available to bidders prior to submitting their proposals and to the successful contractor and subcontractors for their information only, and to supply them with facts relative to the subsurface investigation, laboratory tests, etc.

Somat is not responsible for failure to provide services that other project participants, apart from our client, have assigned to Somat either directly or indirectly. Somat is not responsible for failing to comply with the requirements of design manuals or other documents specified by other project participants that impart responsibilities to the geotechnical engineer without our knowledge and written consent. We are not liable for services related to this project that are not outlined in our scope of services, detailed in our project proposal.

The discussions and recommendations submitted in this report are based on the soil information contained in the Logs of Test Borings and test results appended to this report. We expect that the Logs of Test Borings included in this report along with our discussions and conclusions will assist you in the design of the proposed project. If you have any questions regarding this report, please contact us. Please review the important information regarding geotechnical reports included in Appendix D.

APPENDIX A

SOIL BORING LOCATION DIAGRAM

PLOT DATE: 6/17/2019 6:13:02 PM SAVE DATE: 6/17/2019 6:08:09 PM HELEN RUSSELL C:\Users\hrussell\Downloads\with boring location_Flint TP 2017.dwg Layout = V-101

B.M. WP#3 ELEV. = 737.62 NAVD 1988
CHISELED + TOP/SOUTH BOLT OF S'LY MOST LEG OF WATER TOWER

B.M. WP#4 ELEV. = 735.62 NAVD 1988
MAG. SPIKE IN WEST FACE OF POWER POLE 48'± N OF PWR SUB STATION FENCE

LEGEND

EXISTING

- WATER MAIN
- SANITARY SEWER
- STORM SEWER
- GAS MAIN
- UNDERGROUND ELECTRIC
- UNDERGROUND CABLE
- UNDERGROUND TELEPHONE/CONDUIT
- UNDERGROUND FIBER OPTIC
- ASPHALT PAVEMENT
- CONCRETE PAVEMENT
- GRAVEL SURFACE
- LIGHT POLE
- GUY ANCHOR
- GUY POLE
- POWER POLE
- TELEPHONE MANHOLE
- U/G TELEPHONE BOX
- U/G CABLE TV BOX
- U/G ELECTRIC BOX
- GAS METER
- ELECTRIC METER
- ELECTRIC MANHOLE
- ELECTRIC OUTLET
- MAILBOX
- SIGN
- POST
- CONCRETE FILLED POST
- GUARD POST
- WATER SERVICE - SHUT OFF
- GATE VALVE IN WELL
- SPRINKLER VALVE
- SPRINKLER HEAD
- FIRE HYDRANT
- FIRE HYDRANT VALVE
- STORM MANHOLE
- CATCH BASIN
- SANITARY MANHOLE
- CLEAN OUT
- FOUND IRON/RE-ROD/PIPE
- FOUND MONUMENT
- ELEVATION TAKEN HERE
- ELECTRIC MARKER
- GAS MARKER
- MONITORING WELL
- DECIDUOUS TREE W/DRIPLINE
- CONIFEROUS TREE W/DRIPLINE
- BUSH

Legend:

Soil Boring Location

Soil Boring Coordinates			
Boring ID	Northing	Easting	Ground Surface Elevation
B-01	13309627.1178	568366.1967	731.7
B-02	13309589.0178	568359.2150	732.1
B-03	13309551.9393	568312.3116	731.0
B-04	13309600.0434	568396.1602	731.2

811 3 FULL WORKING DAYS BEFORE YOU DIG CALL
Know what's below. Call before you dig. MISS DIG System, Inc. 1-800-482-7171 www.missdig.net

Johnson&Anderson
A DLZ Company

WARNING

UTILITY LOCATIONS ARE NOT CONFIRMED. THOSE SHOWN WERE OBTAINED FROM UTILITY OWNERS OR PLANS. THREE FULL WORKING DAYS PRIOR TO BEGINNING WORK THE CONTRACTOR SHALL NOTIFY UTILITY OWNERS TO HAVE WORK AREA STAKED AND HE SHALL PROTECT OR HAVE RELOCATED, AS NOTED IN THE SPECIFICATIONS, ALL UTILITIES THAT MIGHT INTERFERE WITH CONSTRUCTION

CDM Smith Michigan Inc.
645 Griswold, Suite 3770
Detroit, MI 48226

Topographic Mapping of a portion of the Flint Water Treatment Plant

N

SCALE 1" = 40'
0 20 40 80

MARK	ISSUED FOR	DATE

DRAWN BY: J&A
DESIGN BY: JMS
CHECKED BY: JMS

J&A JOB NUMBER: 1845689300

SHEET NO.

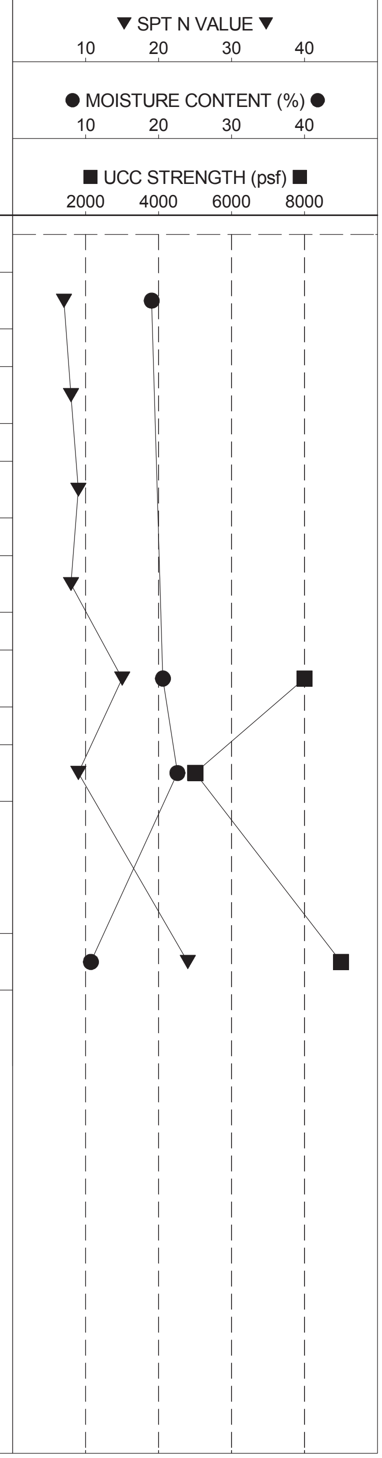
V-101

APPENDIX B

LOGS OF TEST BORINGS AND GENERAL NOTES

PROJECT NO. 2019071A **DATE STARTED:** 6/11/2019 **DATE COMPLETED:** 6/11/2019 **LOG OF TEST BORING B-01**

ELEVATION ft	LOG OF SOIL PROFILE	DEPTH (ft)	SAMPLE NO.	NO. OF BLOWS FOR 6-inch DRIVE	N VALUE	SAMPLE TIP DEPTH (ft)	UNCONFINED COMP STRENGTH (psf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT	PLASTICITY INDEX	% PASSING #200
	Ground Surface Elevation 731.7 ft	0										
730.7	7 inches of TOPSOIL	1.0										
728.2	FILL - Loose silty fine sand, trace topsoil, trace roots, trace gravel, dark brown, moist (SM) (Organic Content at 2.5 ft. = 3.8%)	3.5	SS1	4-2-5	7	2.5		19.0				
			SS2	4-4-4	8	5.0						
723.2	Loose SILTY FINE SAND with gravel, brown, wet (SM)	8.5	SS3	2-4-5	9	7.5						15
720.7	Loose SILT, trace sand, brown to gray (ML/CL-ML)	11.0	SS4	3-4-4	8	10.0						
	Hard to very stiff LEAN CLAY, trace sand, trace gravel, occasional silt partings above 12.5 ft., gray (CL)		SS5	3-6-9	15	12.5	8000*	20.6				
713.2		18.5	SS6	3-4-5	9	15.0	5000*	22.6				
709.7	Hard LEAN CLAY, few sand, trace gravel, gray (CL)	22.0	SS7	8-12-12	24	20.0	9000+*	10.7				
	End of Boring at 22 ft. (Boring terminated on obstruction)											



GROUNDWATER READINGS
First Encountered: 3.5 feet
Upon Completion: 3.5 feet

BORING LOCATION INFORMATION
Easting: 568366.2
Northing: 13309627.1

Coordinates/GSE determined by:
GPS and topographic map

KEY
Torvane
* Penetrometer
<> Disturbed Sample

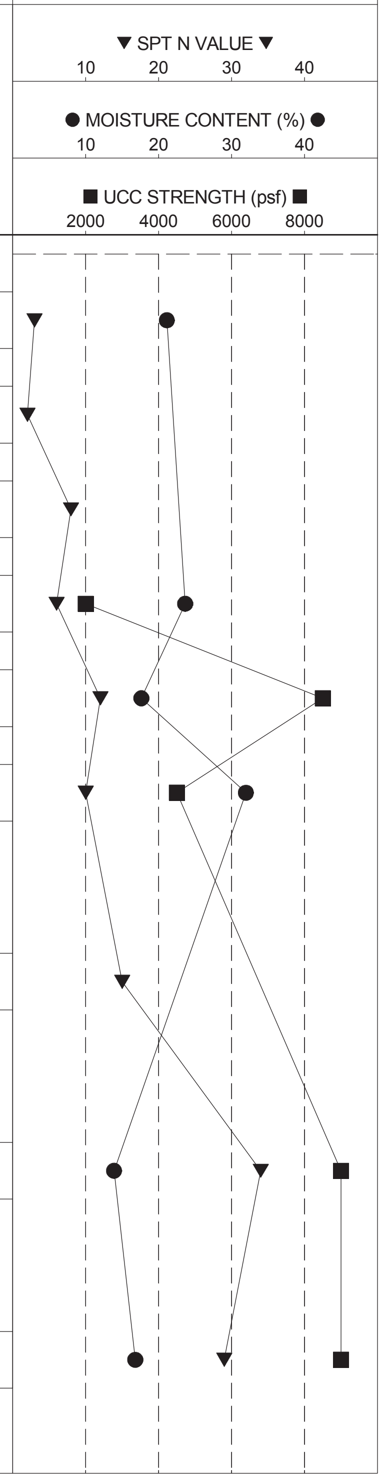
Drilling Company: Brax Drilling
Drill Rig: CME 75
Engineer on Rig: R. Calkins
Drilling Method: HSA
Method Notes:
Hammer Type: Automatic
Backfilled With: Cuttings
Checked By: ALOG
QA/QC By: JA
Remarks:

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant
Flint, Michigan

PROJECT NO. 2019071A **DATE STARTED:** 6/11/2019 **DATE COMPLETED:** 6/11/2019 **LOG OF TEST BORING B-02**

ELEVATION ft	LOG OF SOIL PROFILE	DEPTH (ft)	SAMPLE NO.	NO. OF BLOWS FOR 6-inch DRIVE	N VALUE	SAMPLE TIP DEPTH (ft)	UNCONFINED COMP STRENGTH (psf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT	PLASTICITY INDEX	% PASSING #200
	Ground Surface Elevation 732.1 ft	0										
731.5	12 inches of TOPSOIL	0.6										
728.6	FILL - Very loose silty fine sand, trace topsoil, trace clay, trace roots above 2.5 ft., brown and dark brown, moist (SM) (Organic Content at 2 feet = 3.8%)	3.5	SS1	2-1-2	3	2.5		21.1				
			SS2	3-1-1	2	5.0						
723.1	Very loose to loose poorly graded FINE SAND, trace silt, trace gravel, brown, wet (SP)	9.0	SS3	1-2-6	8	7.5						
721.1	Stiff LEAN CLAY, trace sand, trace gravel, frequent silt layers, gray (CL)	11.0	SS4	2-3-3	6	10.0	2000*	23.6				
718.6	Hard LEAN CLAY, trace sand, trace gravel, occasional silt partings, gray (CL)	13.5	SS5	3-5-7	12	12.5	8500*	17.6				
713.6	Very stiff LEAN CLAY, trace sand, trace gravel, gray (CL)	18.5	SS6	3-4-6	10	15.0	4500*	32.0				
708.6	Medium dense poorly graded FINE TO MEDIUM SAND, trace silt, trace gravel, gray, wet (SP)	23.5	SS7	4-5-10	15	20.0						
702.1	Hard LEAN CLAY, trace sand, trace gravel, frequent silt seams, gray (CL)	30.0	SS8	9-14-20	34	25.0	9000*	13.9				
			SS9	8-12-17	29	30.0	9000*	16.8				
	End of Boring at 30 ft.											



GROUNDWATER READINGS
First Encountered: 3.5 feet
Upon Completion: 3.5 feet

BORING LOCATION INFORMATION
Easting: 568359.2
Northing: 13309589.0

Coordinates/GSE determined by:
GPS and topographic map

KEY
\# Torvane
* Penetrometer
<> Disturbed Sample

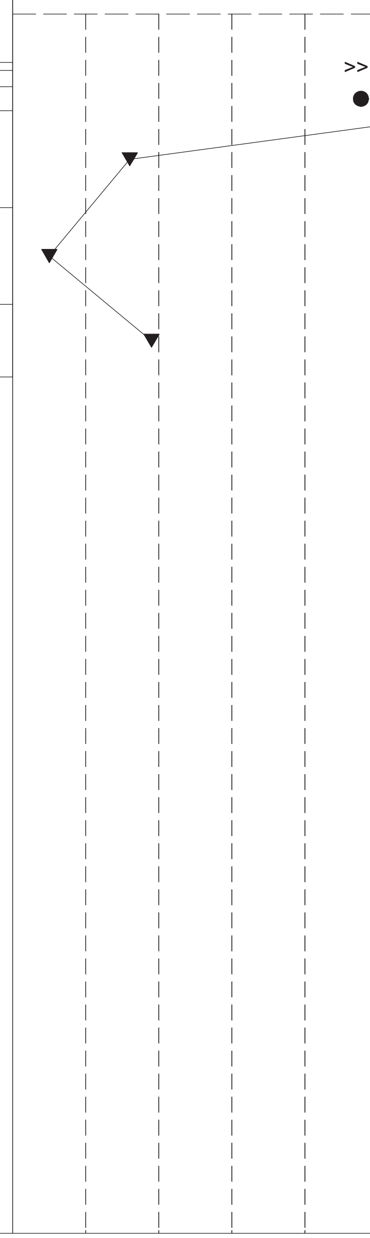
Drilling Company: Brax Drilling
Drill Rig: CME 75
Engineer on Rig: R. Calkins
Drilling Method: HSA
Method Notes:
Hammer Type: Automatic
Backfilled With: Cuttings
Checked By: ALOG
QA/QC By: JA
Remarks:

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant
Flint, Michigan

PROJECT NO. 2019071A **DATE STARTED:** 6/11/2019 **DATE COMPLETED:** 6/11/2019 **LOG OF TEST BORING B-03**

ELEVATION ft	LOG OF SOIL PROFILE		DEPTH (ft)	SAMPLE NO.	NO. OF BLOWS FOR 6-inch DRIVE	N VALUE	SAMPLE TIP DEPTH (ft)	UNCONFINED COMP STRENGTH (psf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT	PLASTICITY INDEX	% PASSING #200
	Ground Surface Elevation 731.0 ft		0										
730.8	2 inches of ASPHALTIC CEMENT CONCRETE	0.2											
730.5	4 inches of PORTLAND CEMENT CONCRETE	0.5		SS1	50/2"	50 +	1.2						
729.0	FILL - Silty fine to coarse slag sand with gravel, black, moist to wet (SP) (Organic Content at 2 feet = 11.1%)	2.0		GB2			2.0		47.7				14
				SS3	11-7-9-4	16	4.0						
726.0	Medium dense to loose poorly graded fine sand, trace silt, trace gravel, brown, wet (SP)	5.0	5	SS4	2-2-3-3	5	6.0						
725.0	Loose SANDY SILT, few silt, occasional gray fine sand layers, black, wet (ML)	6.0		SS5	6-8-11	19	7.5						
723.5	Medium dense poorly graded FINE SAND, trace silt, trace gravel, gray, wet (SP)	7.5											
	End of Boring at 7.5 ft.		10										
			15										
			20										
			25										



GROUNDWATER READINGS

First Encountered: 2 feet
Upon Completion: 2 feet

BORING LOCATION INFORMATION

Easting: 568312.3
Northing: 13309551.9

Coordinates/GSE determined by:
GPS and topographic map

KEY

\# Torvane
* Penetrometer
<> Disturbed Sample

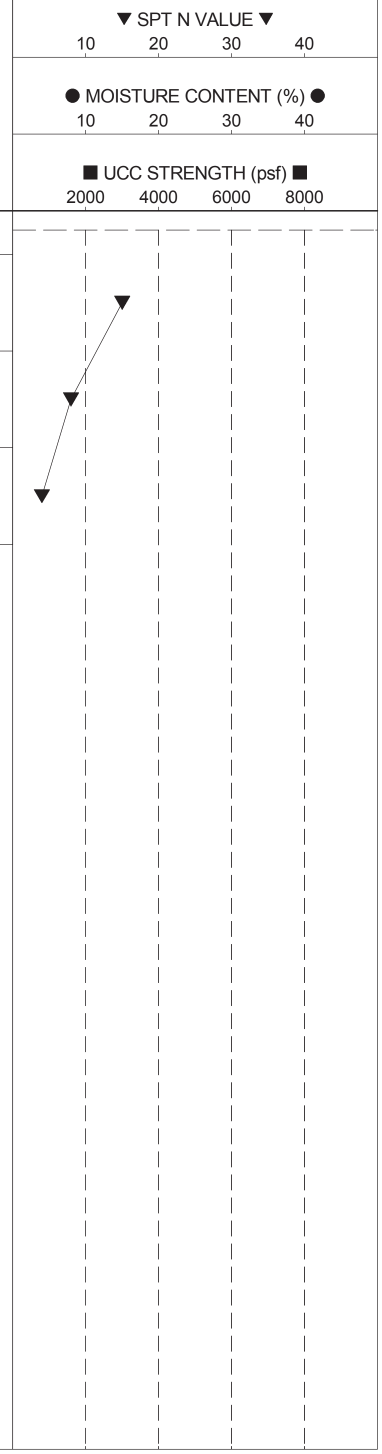
Drilling Company: Brax Drilling
Drill Rig: CME 75
Engineer on Rig: R. Calkins
Drilling Method: HSA
Method Notes:
Hammer Type: Automatic
Backfilled With: Cuttings
Checked By: ALOG
QA/QC By: JA
Remarks:

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant
Flint, Michigan

PROJECT NO. 2019071A **DATE STARTED:** 6/11/2019 **DATE COMPLETED:** 6/11/2019 **LOG OF TEST BORING B-04**

ELEVATION ft	LOG OF SOIL PROFILE	DEPTH (ft)	SAMPLE NO.	NO. OF BLOWS FOR 6-inch DRIVE	N VALUE	SAMPLE TIP DEPTH (ft)	UNCONFINED COMP STRENGTH (psf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT	PLASTICITY INDEX	% PASSING #200
	Ground Surface Elevation 731.2 ft	0										
730.7	6 inches of gravel FILL (Road Material)	0.5										
729.2	FILL - Medium dense poorly graded fine sand with silt, trace gravel, brown and dark brown, moist (SP-SM)	2.0	SS1	5-9-6-6	15	2.5						
726.7	Medium dense to loose poorly graded fine to coarse sand, trace silt, few gravel, dark brown, wet (SP)	4.5	SS2	3-4-4-6	8	4.5						
724.7	Very loose silty fine sand, trace clay, trace gravel, dark brown, wet (SM) NOTE: Field Engineer reported stone in cut shoe	6.5	SS3	4-3-1-5	4	6.5						
	End of Boring at 6.5 ft.											



GROUNDWATER READINGS
First Encountered: 2.5 feet
Upon Completion: 2 feet

BORING LOCATION INFORMATION
Easting: 568396.2
Northing: 13309600.0

Coordinates/GSE determined by:
GPS and topographic map

KEY
Torvane
* Penetrometer
<> Disturbed Sample

Drilling Company: Brax Drilling
Drill Rig: CME 75
Engineer on Rig: R. Calkins
Drilling Method: HSA
Method Notes:
Hammer Type: Automatic
Backfilled With: Cuttings
Checked By: ALOG
QA/QC By: JA
Remarks:

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant
Flint, Michigan

APPENDIX C

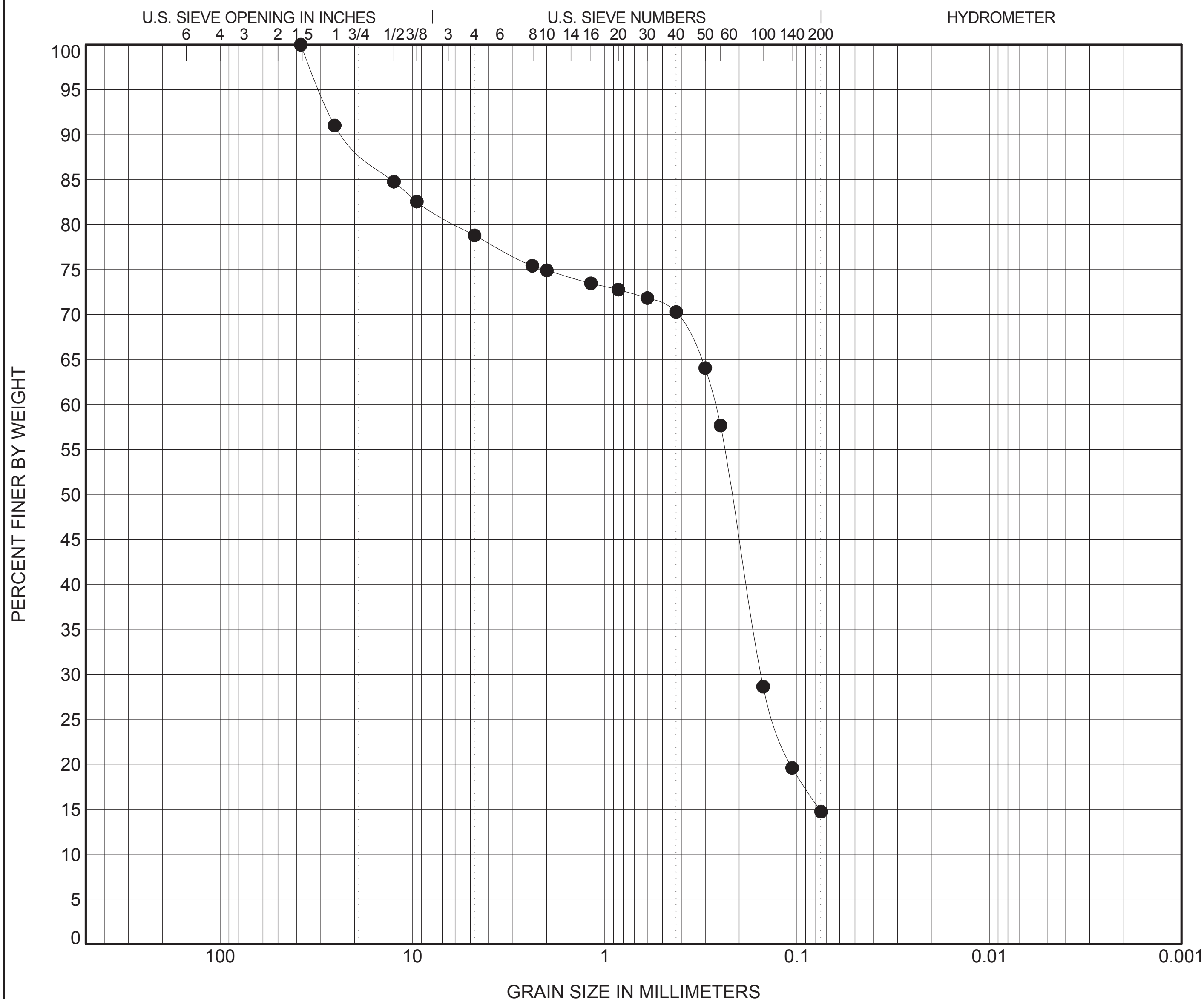
GRAIN SIZE ANALYSIS RESULTS

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant

GRAIN SIZE DISTRIBUTION

PROJECT NO. 2019071A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Depth ft.	Remarks	LL	PL	PI	Cc	Cu
● **B-01**	**6.0**						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-01**	**6.0**	**38.1**	**0.267**	**0.154**		**21.2**	**64.1**	**14.7**	

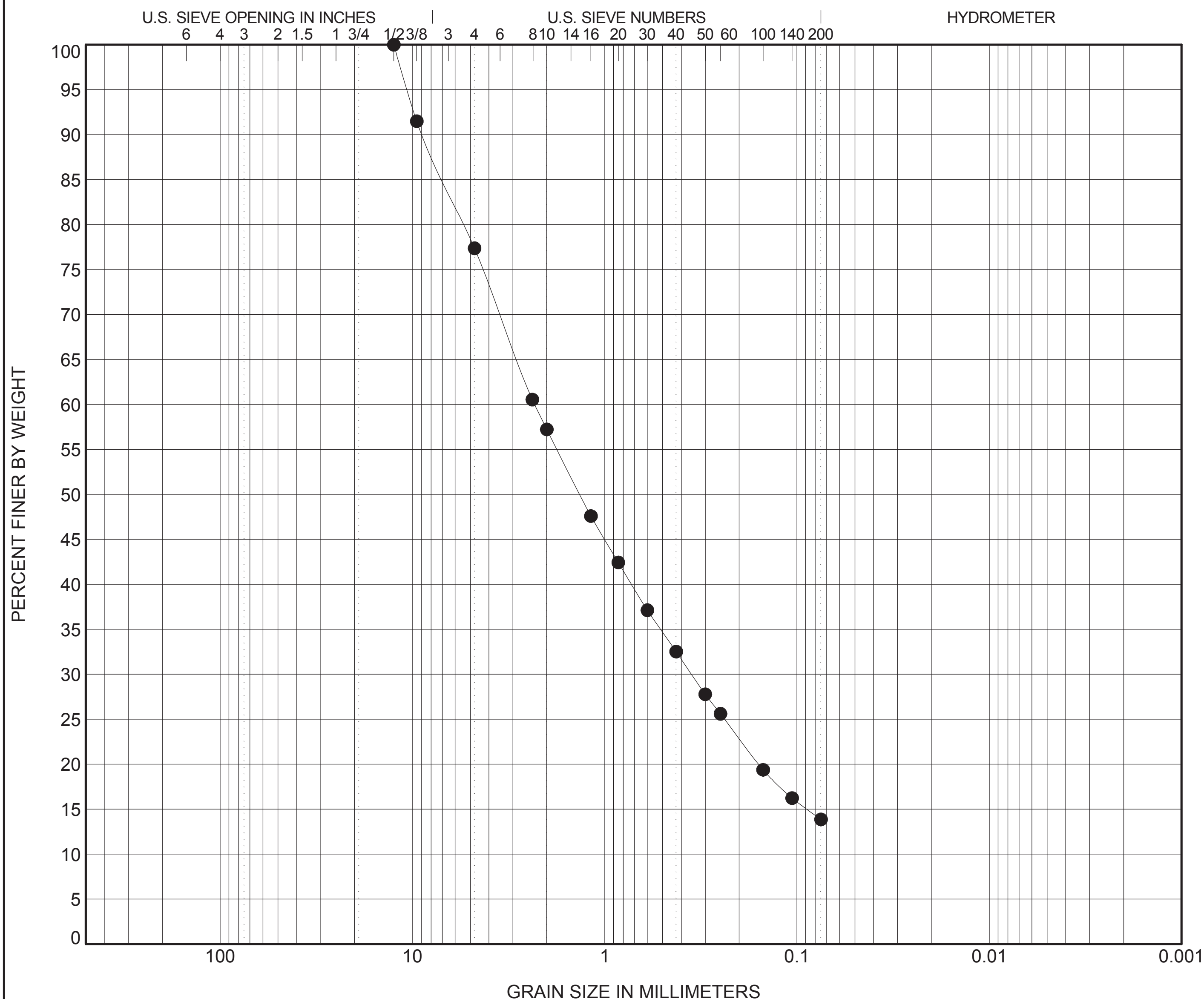
GRAIN SIZE FLINT WTP NEW CHEMICAL BLDG.GPJ SOMAT.GDT 6/23/19

GRAIN SIZE DISTRIBUTION

Somat Engineering

New Chemical Systems Feed Building
Flint Water Treatment Plant

PROJECT NO. 2019071A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Depth ft.	Remarks	LL	PL	PI	Cc	Cu
● **B-03**	**1.5**						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-03**	**1.5**	**12.5**	**2.313**	**0.353**		**22.6**	**63.5**	**13.9**	

GRAIN SIZE FLINT WTP NEW CHEMICAL BLDG.GPJ SOMAT.GDT 6/23/19

APPENDIX D

"IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT"

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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