M. Block & Associates Ltd.
Consulting Engineers
CSA CERTIFIED CONCRETE LABORATORY

· Geotechnical Investigations · Environmental Assessments · C.S.A. Certified Material Testing

August 14th, 2023

City of Winnipeg
421 Osborne Street – Finance & Administration
Winnipeg, Manitoba
R3L 2A2
Attention: Mr. Tim Vandekerkhove, Project Manager

Dear Sir:

RE: GEOTECHNICAL INVESTIGATION FOR THE PROPOSED HYDROGEN PRODUCTION AND DISPENSING STATION SITE TO BE LOCATED AT 421 OSBORNE STREET IN WINNIPEG, MANITOBA

1.0 TERMS OF REFERENCE

On August 3rd, 2023, M. Block & Associates Ltd. (MBA) received e-mailed authorization from Mr. Kevin Sim, representing Colliers Project Leader, the proponent's representative and project manager, to proceed with the geotechnical investigation for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba. Therefore, on August 9th, 2023, six test holes in total were bored implementing a track-mounted Acker MP-5 drill rig, using interconnected 5' long x 5" diameter continuous flight solid stem augers, supplied by supplied by Maple Leaf Drilling Ltd. of Winnipeg, Manitoba. Representative "undisturbed" and "disturbed" soil samples were retrieved from the test holes and brought back to MBA's CSA certified materials testing laboratory in Winnipeg for unconfined compression and moisture content testing, respectively, and verification of the field soil classifications. Alternatively, during the field investigation, the fine grained soils' respective 'disturbed' undrained shear strengths were measured implementing a hand-held calibrated Pocket Geotester (PG). Upon the completion of this investigation, the test holes' elevations and the groundwater elevations in them, if any, were measured and referenced to their respective surfaces and also the top of the existing adjacent building's top of concrete main floor at an exterior man-door, as illustrated on pages 17 – 25 of this report. In addition, the test holes were completely backfilled with bentonite and the soil cuttings.

2.0 SOIL LITHOLOGY AND GROUNDWATER CONDITIONS

Test hole #3, placed on a roadway, was overlain with, about 9" of concrete. Test holes #1, #2, #3, #4, #5 and #6 were covered with, approximately, 2', 1', 9", 1', 1' and 4', respectively, of brown, damp, dense, silty gravelly sand fill. Black/grey/brown, firm to stiff, moist, silty clay fill with coal and cinders and also concrete rubble was then traversed in test holes #1, #2, #3, #4, #5 and #6 down to the 7'6", 7', 9'6", 7'6", 7' and 5' depths, respectively. Next, brown, alluvially deposited, stiff, moist, silty clay was observed in, only, test holes #1, #2, #4 and #5 down to the 10', 10', 9' and 9' depths, respectively. Brown, becoming grey in colour below the 26' depth, glaciolacustrine, stiff to firm, moist, silty clay with silt and gypsum inclusions was then noted in test holes #1, #2, #4 and #5 down to the 43', 44', 10' and 10' depths, respectively. Grey, soft, wet, sandy clayey silt with potential cobbles and boulders (glacial till) was next recorded in test holes #1 and #2 down to the 44'9" and 49' depths, respectively. Finally, brown, saturated, dense, poorly-graded silty sand with cobbles and boulders (glacial till) was encountered in test holes #1 and #2 down to the 45' and 50' depths, respectively, where the auger refused on boulders in the primarily coarse-grained glacial till matrix. As such, the deep test holes were terminated at the aforementioned depths. Alternatively, the shallow probe holes were discontinued at the 10' or at auger refusal. Test holes #3, #5a and #6 refused on concrete or rubble at the 9'6", 1'6" and 5' depths, respectively. Upon penetrating the possible fractured limestone bedrock's aquifer, groundwater flowed into the deep test holes at a very high inflow rate. In addition, within ten minutes of obtaining auger refusal, the groundwater elevation in test holes #1 and #2 were measured 32' and 25' below their respective current surface elevations. Furthermore, it is anticipated that this phreatic surface could rise by an additional 10' during wet spring runoffs and/or heavy rainfall runoff events. As such, that contingency will be incorporated into the project's geotechnical designs presented in this report. In addition, groundwater seepage and soil sloughing, emanating from the saturated, dense, poorly-graded primarily coarse-grained glacial till matrix, currently flowed and sloughed into the test holes at severe and significant inflow rates, respectively. The soil lithology in the test holes and their specific locations were appended to this report on pages 17 – 25.

3.0 SUMMARY OF FIELD AND LABORATORY TESTS

TH #	DEPTH	UNCONFINED COMPRESSION	BULK UNIT WEIGHT	MOISTURE CONTENT
2	16'	2167 psf	107.28 pcf	54.73 %
2	26'	2611 psf	110.22 pcf	49.43 %
2	36'	1371 psf	108.82 pcf	51.08 %

The unconfined compressive strengths are also located on test hole #2’s log sheets.
The soils’ measured Pocket Geotester strengths are located on the test holes’ log sheets.
Moisture content vs. Depth graphs are located on the test holes’ log sheets.
A summary of the laboratory data is appended to this report on pages 28 – 29.

4.0 FOUNDATION DESIGN ALTERNATIVES

4.1 SHALLOW CONCRETE STRIP FOOTINGS

Based upon the significant depth of the fill stratum observed in the test holes, it is the writer’s professional opinion that a shallow concrete footing foundation design, potentially constructed on or over the aforementioned potentially deleterious depositions underlying this site, is susceptible to significant and/or differential foundation settlement, and, as such, strongly not recommended as a feasible superstructure support system for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba.

4.2 DEEP CONCRETE FOOTINGS

Predicated upon the well-documented, volumetrically sensitive, glaciolacustrine silty clay deposition in the former Lake Agassiz that has caused significant structural distresses in typical deep below grade footings in similarly constructed structures in the Red River Basin and the upper glaciolacustrine deposition’s stiff unconfined compressive strength, its estimated extremely high liquid limit and plasticity index, and “normal” moisture content on this site above the 15' depth, it is the writer’s professional opinion that a reinforced concrete deep footing foundation system, constructed on the glaciolacustrine soil above the 15' depth on this site, is still susceptible to significant soil swelling, shrinkage and/or rebound, and, as such, strongly not recommended as a feasible foundation support system for this project.

4.3 DRILLED CAST IN PLACE CONCRETE FRICTION PILES

Alternatively, drilled cast in place concrete friction piles could be implemented as the foundation design for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba. Predicated upon the neutral plane of this pile type modeled near the 10' depth and the risk of basal instability occurring in this foundation type below the 36' depth, the allowable effective functional friction length of glaciolacustrine silty clay at this site, **from the present grade of test hole #1**, is **36' – 10' = 26'.** The laboratory data indicates that the factored geotechnical resistance (FGR), using ultimate limit states (ULS) where $\Phi = 0.4$, of the soil/concrete interface from the 10' to 36' depths, only, is 390 psf (360 psf in the SLS analysis for 1" deflection). Based upon these calculations, a 16" diameter friction pile drilled 36' deep, properly constructed, would safely transfer, using ULS, 41 kips of load down to the underlying glaciolacustrine deposition. The concrete, relative to the soil, has an additional net weight of, approximately, 35 pcf in the upper 36' of overburden. Therefore, the additional net weight of the concrete is included in the above analysis. In addition, in order to avoid reducing the piles' net efficiency, they must be spaced at least three pile diameters, on center. Furthermore, in order to resist potential soil swelling and frost jacking uplift stresses, these piles shall have a minimum embedment length of 30' and 35' in heated and unheated areas of the site, respectively, **from the present grade of test hole #**1. Finally, full-length reinforcing steel shall also be installed in all the piles implemented in an unheated service condition.

It is recommended that the geotechnical engineer's personnel inspect the installation of this foundation type in order to verify that it conforms to the contents of this report, the structural drawings and project's specifications.

The foundation contractor shall be fully cognizant that a saturated soil stratum may underlie untested areas of this site in the overburden and, as such, may slough and seep significantly into some or several of the piles’ drilled open excavations during wet seasons and/or years. Therefore, should that situation transpire, steel casing through that entire deposition would then be required. Since soil sloughing during concreting may cause improper foundation performance, special care must be given when removing the steel sleeve not to cause sloughing soil from entering a pile's excavation from in behind it. As such, the foundation contractor should be diligent when removing the steel sleeve not to cause sloughing soil from entering the pile’s excavation from in behind it. In addition, the top 7' of embedment length in every concrete pile should be mechanically vibrated.

The advantages of this piling system are its relatively fast rate of pile installation, frequency of being more economical than other piled foundation designs in this area, efficiency of installation in comparison with driven pre-cast concrete end-bearing piles, the many piling businesses located in the vicinity and minimal magnitude of modeled long-term foundation settlement. The disadvantages of this piling system are the limited functional depth of serviceable clay and, as such, frictional pile capacity on this site, the extra cost, if any, associated with temporary steel sleeving, and pile settlement, if constructed improperly.

4.4 DRILLED SPREAD BORE CONCRETE END-BEARING PILES

Similarly, drilled, cast in place, spread bore concrete end-bearing piles could also be implemented as the foundation design for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba. These piles shall only be mechanically constructed on the stiff glaciolacustrine silty clay 6.0 m below test hole #1’s current elevation, where the FGR, using ULS where $\Phi = 0.4$, and the piling installation supervised by qualified geotechnical personnel, would be 125 kPa (125 kPa in the SLS analysis for 1" deflection). In addition, in order to avoid reducing the piles’ net efficiency, they must be spaced at least two bell and two-and-a-half shaft diameters, on center.

In order to protect these short piles from frost jacking stresses in unheated applications, only, they shall have sono-tube casings installed along their upper 3.0 m of embedment length. Furthermore, the sono-tube shall be wrapped in 6 mil poly and completely greased on its inside. In addition, full-length reinforcing steel shall also be installed in all the piles implemented in an unheated service condition.

The foundation contractor shall be fully cognizant that a saturated soil stratum may underlie untested areas of this site in the overburden and, as such, may slough and seep significantly into some or several of the piles' drilled open excavations during wet seasons and/or years. Therefore, should that situation transpire, steel casing through that entire deposition would then be required. Since soil sloughing during concreting may cause improper foundation performance, special care must be given when removing the steel sleeve not to cause sloughing soil from entering a pile's excavation from in behind it. As such, the foundation contractor should be diligent when removing the steel sleeve not to cause sloughing soil from entering the pile's excavation from in behind it.

The advantages of this piling system are its anticipated relatively short pile embedment length, moderate allowable axial compressive, tensile and frost jacking resistances and minimal magnitude of modeled long-term foundation settlement. The disadvantages of this piling system are its higher cost and longer foundation installation time per pile associated with mechanically constructing the bell and temporary steel sleeving, if any, and the potential for pile settlement, if incorrectly constructed.

4.5 DRIVEN PRE-CAST CONCRETE END BEARING PILES

Finally, driven pre-cast concrete end-bearing piles could also be implemented as the foundation design for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba. All driven pre-cast concrete piles should be pre-drilled exactly 5.0 m below present site grade, prior to being driven to refusal onto a dense stratum, such as, a hard glacial till matrix, a dense granular stratum or bedrock. The estimated length of properly driven pre-cast concrete piles required at this location would be **in the order of 13 m – 16 m from the present ground elevation of test hole #1.** However, the foundation contractor should still verify the estimated length of pre-cast concrete piles required at this site and become fully cognizant with the contents of this report. Following their successful installation, in order to maximize their lateral support and minimize their adhesion and frictional capacity with the underlying volumetrically sensitive glaciolacustrine silty clay, all the piles' oversized pre-bores should then be backfilled with clean sand or another pre-approved equivalent substitute alternative. Furthermore, the geotechnical engineer's personnel should inspect the foundation installation in order to verify the FGR, using ULS where Φ = 0.6, based upon the following pile driving criteria:

PILE DIAMETER	MIN. CONCRETE COMP. STRENGTH	DRIVING ENERGY	REFUSAL CRITERIA	ULS FGR	SLS
305 mm	40 mPa	30 foot * kips	5 blows / 1" (25 mm)	667 kN	578 kN
350 mm	40 mPa	30 foot * kips	10 blows / 1" (25 mm)	934 kN	800 kN
400 mm	40 mPa	30 foot * kips	15 blows / 1" (25 mm)	1200 kN	1023 kN

Note: Max 1" (25.4 mm) penetration per set, for 3 consecutive sets

MBA has performed many pile load tests in The City of Winnipeg during the 1960s. It was through these static pile load tests in The City of Winnipeg that the SLS criteria used by all the labs here were established for the geology underlying The Red River Valley and, as such, The City of Winnipeg. As such, when the new ULS criteria was mandated, MBA just reviewed those pile load tests and modified the pile driving criteria based upon the direct relationship between driving energy, deflection for a set number of blows at that energy and ultimate pile capacity to establish the ULS pile capacities based upon these static load tests inside The City of Winnipeg. Furthermore, based upon these static load tests, all design work in the City of Winnipeg from the 1960s onwards was based upon a direct relationship between driving energy, deflection for a set number of blows at that energy and ultimate pile capacity. In the last few years, these pre-cast pile capacities have been also verified to be true through PDA testing. However, these static pile load test reports cannot be forwarded due to the privacy laws in Canada. However, they are on file at MBA. However, as critically mentioned previously though, all the design and construction work, previously implemented from the 1960s onwards, was using the data from these static load tests that did not require to be constantly re-proven from site to site in The City of Winnipeg from the 1960s to 2010.

In addition to the aforementioned specifications for driven pre-cast concrete piles, MBA offers the following recommendations:

- Pre-drilling through the zone of frost may be required for winter or early spring construction.
- If a drop hammer is to be used to install these piles, the mass of the hammer shall be 3 times greater than the mass of the pile.
- Pile spacing shall not be less than three pile diameters, on center.
- Piles driven within five pile diameters, on center, shall be monitored for heave. Where observed; the piles shall be re-driven to the aforementioned refusal criteria.
- Once pile driving is initiated, all piles shall be driven continuously to their respective refusal depth.

The advantages of this piling system are its very heavy allowable axial compressive capacities and minimal magnitude of modeled long-term foundation settlement. The disadvantages of this piling system are its frequently greater cost per foot of pile and the potentially variable depths to practical refusal across this site.

5.0 CONCRETE DESIGN

Due to the visibly high concentration of sulphate in the glaciolacustrine deposition at this site, Sulphate Resisting Cement shall be used in all the concrete implemented for the aforementioned concrete foundation systems. Its concrete shall have a minimum 28-Day laboratory compressive strength of 32 mPa. Furthermore, the concrete shall contain at least 550 pounds of cement per cubic yard, have a maximum water cement ratio, a plastic concrete air content and slump of 0.45, 4 to 6 percent and 60 mm to 100 mm, respectively.

Alternatively, due to the higher elevation of the proposed structure in relation to the elevations of these test holes and the likely low concentration of sulphate in the alluvial depositions traversed across this site, Normal Portland Cement could be used in all the concrete implemented for the structure’s grade beams and floor slabs.

All other concrete exposed to freezing and thawing cycles shall contain an air entraining admixture that corresponds to the applicable class of exposure listed in tables 2-4 of the recent addition of CSA. Concrete poured in cold weather shall be heated and protected in accordance with CSA A23.1-04 clause 21.2.3.

In addition, all concrete poured shall be tested in accordance with CSA A23.1-04 every day and at least once every 50 m^3 per day by a CSA certified concrete testing laboratory.

6.0 SURFACE SLAB ON GRADE CONCRETE FLOOR SLAB DESIGN

A surface slab on grade concrete floor slab design would only be feasible for this project if the, approximately, 7' - 9'6" deep layer of fill (see test hole logs) underlying part or all of a currently unknown area of the proposed building’s footprint is first excavated and then replaced and consolidated as outlined in this paragraph. In addition, any additional deleterious soil encountered at or below the project’s recommended working sub-grade elevation of, approximately, 7'-9'6" below present grade shall also be excavated and then transported off of the site. Next, the in-situ silty clay located at or below the working sub-grade elevation shall then be proof-rolled by a heavy sheepsfoot roller until it has at least 95 % of its standard proctor density (SPD). Areas failing the aforementioned proof-roll test and any other deleterious material encountered at or below the working sub-grade elevation shall be verified and documented by the geotechnical engineer’s personnel. Predicated upon this consultant’s recommendations, the project’s slab on grade sub-contractor shall then excavate and replace the documented failed proof-rolled soil and the other deleterious material encountered at or below the working sub-grade elevation, about, 7'-9'6" below present grade with 100 mm or 50 mm down crushed limestone fill or another pre-approved equivalent bridging material placed in sufficient 150 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

Next, any segments of the proposed building's footprint naturally lower than the proposed sub-grade elevation, if any, shall then be brought up to the sub-grade elevation implementing either a 100 mm or 50 mm down crushed limestone fill, granular C-Base fill or another pre-approved equivalent bridging material, placed in sufficient 150 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

In order to raise the proposed slab on grade up to the underside of the granular base course elevation, the sub-base, consisting of at least one lift of C-Base, 50 mm or 20 mm down crushed limestone fill or another pre-approved equivalent material shall be placed in 150 mm deep layers and compacted until every lift has at least 98 % of its SPD. Finally, the granular base course, composed of a 150 mm deep lift of A-Base, shall be placed and compacted until it has at least 100 % of its SPD. The 150 mm deep reinforced concrete floor slab shall then be poured having a slump in the range of 70 mm to 100 mm. The concrete shall have a maximum water cement ratio of 0.45 and contain a water reducing admixture. An elevation drawing of the building's slab on grade base structure is illustrated on page 26 of this report.

However, if the structural engineer or owner cannot accept the possibility of differential slab displacement of up to 25 mm and 50 mm, in heated and unheated applications, respectively, then a structurally supported concrete floor slab shall be implemented for this project.

7.0 PAVEMENT DESIGNS

All the soil depositions located above the pavements' designated working sub-grade elevation, as designated by the project's forthcoming civil engineering consultant, shall be stripped and then transported off of the site. In addition, all the deleterious soil encountered at or below the project's recommended working sub-grade elevation, if any, shall also be excavated and then transported off of the site. Next, prior to placing the proposed pavement structures' granular sub-base and base courses, the in-situ, primarily fine-grained silty clay fill, with a high plasticity index, located at or below the working sub-grade elevation, shall then be proof-rolled using a sheepsfoot roller until it has at least 95 % of its SPD. Areas failing the aforementioned proof-roll test and any other deleterious material encountered at or below the working sub-grade elevation shall be verified and documented by the geotechnical engineer's personnel. Predicated upon this consultant's recommendations, the project's pavement sub-contractor shall then excavate and replace the documented failed proof-rolled soil and any other deleterious material encountered at or below the working sub-grade elevation with 100 mm or 50 mm down crushed limestone fill or another pre-approved equivalent bridging material placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

Next, any segments of the proposed pavement areas naturally lower than the proposed sub-grade elevation, if any, shall then be brought up to the working sub-grade elevation implementing either a highly plastic silty clay; 100 mm or 50 mm down crushed limestone fill; granular C-Base fill or another pre-approved equivalent bridging material, placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

In order to provide adequate structural support in areas designated for heavy truck traffic and the dumpster area's concrete slab, their sub-bases shall consist of at least two layers of 50 mm down crushed limestone fill, C-Base fill or another pre-approved equivalent material placed in 150 mm deep lifts and compacted until each layer has at least 98 % of its SPD. However, only one lift of granular sub-base is structurally required for the light car traffic's pavement construction. Alternatively, in all traffic areas, the granular base course shall be composed of a 150 mm deep layer of A-Base, compacted until it has at least 100 % of its SPD. Finally, the light car traffic's asphalt pavement shall be laid in two layers with each lift having a minimum thickness of 32 mm. Similarly, areas with heavier truck traffic shall have 2 - 45 mm lifts of asphalt pavement. Each asphalt pavement area shall be consolidated until it has at least 98 % of its respective laboratory Marshall Density. An elevation drawing of the car and heavy truck traffic's pavement structures is illustrated on page 27 of this report.

The asphalt aggregate shall have a crushed count of >60%. The asphalt shall be placed at a temperature of 125°C to 155°C. The ambient temperature may be no less than 6°C when the asphalt is to be laid. The geotechnical engineer's personnel shall test the asphalt of the following aggregate gradation specifications and physical properties.

METRIC SIEVE SIZE (microns)	(% Passing)
16,000	100
10,000	70 – 85
5,000	55 – 70
2,500	40 – 60
1,250	25 – 50
630	15 – 40
315	5 – 20
160	4 – 11
80	3 – 7

Asphalt Cement, % total sample weight	5.0 % - 6.0 %
Voids in Mineral Aggregate	14% minimum
Air Voids	3.0% - 5.0%
Marshall Stability, N at 60° C	7 kN minimum
Flow Index, units of 250 μm	6.0 – 16.0

The pavement's slope and catch basin placement should be designed by the project's municipal engineering consultant. Currently, the writer has not been provided the proposed municipal site plan indicating the proposed cut and fill depths. Ultimately, however, this office should be contacted of any proposed change to the aforementioned range of working sub-grade elevations. Finally, the slope of the pavement, at a minimum, should be sufficiently graded at 2 % for expedient drainage into catch basins or towards the perimeter of the site.

8.0 RECOMMENDATIONS

Predicated upon the soils' aforementioned respective strength parameters, lithology and physical properties, the current and modeled groundwater elevations, if any, the field and laboratory test data, and the proposed hydrogen production and dispensing station site's anticipated moderate applied foundation stresses, drilled cast in place concrete friction piles, drilled cast in place spread bore concrete end-bearing piles or driven pre-cast concrete end-bearing piles could be implemented as the foundation design for the proposed hydrogen production and dispensing station site to be located at 421 Osborne Street in Winnipeg, Manitoba. Based upon the aforementioned advantages and disadvantages of these foundation systems, a drilled cast in place concrete friction piled foundation design would likely be a well performing, more economical and efficient one for the proposed moderately-loaded building placed on a site with the aforementioned geotechnical design parameters and implemented in a heated service condition. However, the choice of foundation type implemented for this project will ultimately depend upon their respective, previously described, advantages and disadvantages, estimated installation costs and the applied foundation loads that will be calculated by the project's structural engineering consultant.

It is recommended in the strongest of terms that the geotechnical engineer's personnel inspect the installation of all the foundation elements in order to verify that they all conform with the contents of this report, the structural drawings and the project's specifications.

Any areas of the yard naturally lower in elevation, if any, shall be brought up to its future grade implementing a highly plastic silty clay fill, 50 mm down limestone fill, granular C-Base fill or another pre-approved equivalent material, placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

The backfill material around the perimeter of the proposed structure shall be brought up to its future grade implementing either a 20 mm down limestone fill; granular C-Base fill; or another pre-approved equivalent material, placed in sufficient 150 mm deep lifts and compacted until each layer has densities in the range of 92 % to 97 % of its SPD.

The proposed surface concrete slab on grade and all the various proposed asphalt pavement surfaces shall be constructed as per the recommendations outlined in section 6.0 and 7.0 of this report, respectively. If the owner or structural engineer cannot accept the possibility of the aforementioned differential surface slab on grade displacement, then a structurally supported main floor slab shall be implemented for this project. Furthermore, the surface concrete slab on grade and pavement contractors shall also take precautions to prevent the fine-grained sub-grade soil from the following conditions; freezing, excessive soil moisture loss or gain, water ponding and heavily loaded axle traffic. In addition, the granular fill placed for this project shall be free of frost, frozen material and placed at an ambient air temperature of at least 6° Celsius. In order to verify compliance with the aforementioned standard proctor and Marshall Density specifications, field compaction tests shall be taken on every lift of granular material and asphalt placed for this project, respectively. All concrete poured shall be tested in accordance with CSA A23.1-04 every day and at least once every 50 m^3 per day by a CSA Certified concrete testing laboratory.

The selected 50 mm down and 20 mm down crushed limestone, A-Base and C-Base gravels implemented for this project shall all meet the following gradation specifications:

METRIC SIEVE SIZE (μm)	20 mm Limestone (% Passing)	50 mm Limestone (% Passing)	A-BASE (% Passing)	C-BASE (% Passing)
50,000		100		
25,000			100	100
20,000	100		80 – 100	
5,000	40 – 70	25 – 80	40 – 70	25 – 80
2,500	25 – 60		25 – 55	
315	8 - 25		13 – 30	
80	6 - 17	5 – 18	5 – 15	5 – 18

In order to minimize frost penetration under the building, 50 mm thick rigid horizontal insulation, or another pre-approved equivalent frost protection, shall be placed around the structure's entire exterior. This insulation shall be placed along the faces of the proposed building out to a distance 1200 mm away from it at a depth of 300 mm below future ground elevation and also along the outside faces of the structure's exterior concrete grade beams.

The building's superstructure and its concrete main floor, unless constructed as stipulated as described in section 6.0 of this report, should be entirely structurally supported by only one of the aforementioned approved foundation systems. In addition, in all the aforementioned feasible piled foundation designs, a void space, of at least 150 mm in thickness, shall be constructed under all pile caps, grade beams and/or walls to allow for the potential expansive capability of the filled and alluvial depositions underlying this site. Any structurally supported concrete main floor shall overlay either a minimum 600 mm deep vented crawlspace or a minimum 150 mm thick biodegradable void form. The surface of any crawlspace shall be covered by a minimum 100 mm deep layer of clean sand fill overlying a 6 mm thick impervious poly vapour barrier. Lastly, the writer understands that a basement and/or crawl space are not intended for the proposed structure.

If any of the aforementioned design elements are modified or deleted, please contact the undersigned to determine if that course of action will be acceptable.

In addition, MBA respectfully requests an opportunity to review all the relevant finalized structural drawings and the project's foundation and materials testing specifications for this project in order to verify their conformance with the contents of this report.

The test holes drilled during the investigation represent only those specific areas tested. The soil conditions on this site may vary from that described in this report. Should that situation occur, please contact this office for further instructions.

All the geotechnical engineering design recommendations presented in this report are predicated upon the assumption that a sufficient degree of inspection will be provided during the project's construction and that a qualified and experienced foundation contractor properly installs an aforementioned pre-approved, engineered and sealed foundation type.

Any uses which a third party makes of this report, or any reliance on decisions to be made based on it, are the sole responsibility of such third parties. MBA accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based upon this report.

Yours Truly,
M. Block & Associates Ltd.

PROVINCE OF MANITOBA
8/14/23
S. J.
BLOCK
REGISTERED PROFESSIONAL ENGINEER

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
M. Block & Associates Ltd.
No. 1527

Jeffrey Block, P. Eng., Senior Geotechnical Engineer

M. Block & Associates Ltd.

2484 Ferrier Street
Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

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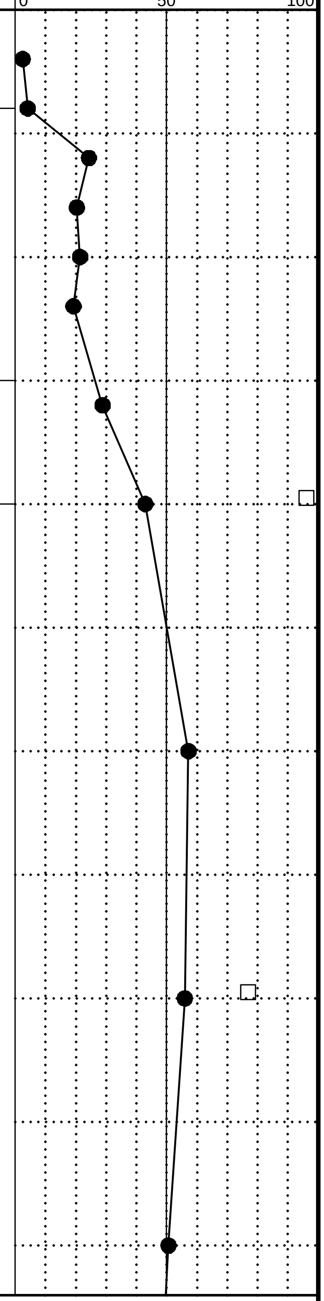
TEST HOLE NO.: 1

Client: City of Winnipeg	Job No.: 2023-2329	Logged By:	J. Block, P. Eng.	Date: 9/8/23
Project: Hydrogen production and dispensing station site		Reviewed By:	J. Block, P. Eng.	Time: 9:00 AM
Location: 421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number:	6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0			SPG		Brown, saturated, dense, silty gravelly SAND FILL
		1			
		2	CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
2.5		3			
		4			
5.0		5			
		6			
7.5		7	CH		Brown, alluvially deposited, stiff, moist, silty CLAY
10.0		8	CH		Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
12.5					
15.0		9			
17.5					
20.0		10			
22.5					
25.0		11			

UNDRAINED SHEAR STRENGTH (psf)
Pocket Pen □
0 650 1300
PLASTIC M.C. LIQUID
0 50 100



Continued Next Page

SAMPLE TYPE SYMBOLS

Split Spoon	Shelby Tube
Vane Shear	Auger Cuttings
Grab Sample	Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

∇ Phreatic Surface #1: 32.0 ft

M. Block & Associates Ltd.
2484 Ferrier Street
Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

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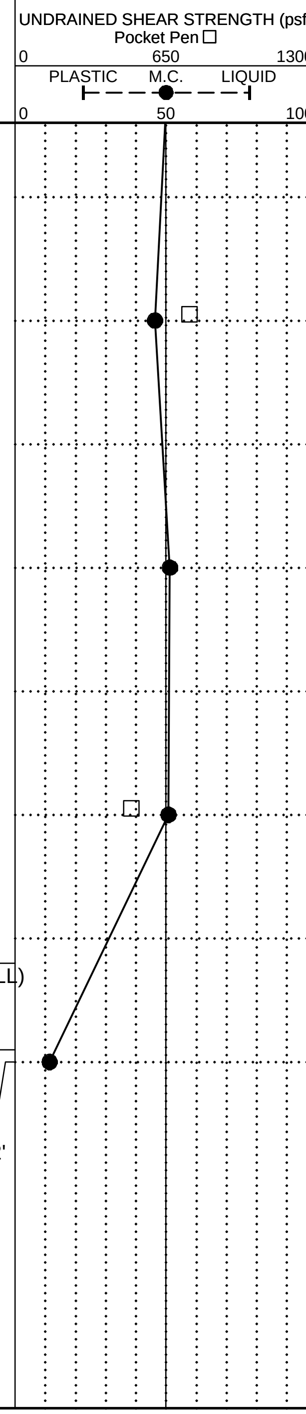
TEST HOLE NO.: 1

Client:	City of Winnipeg	Job No.: 2023-2329	Logged By:	J. Block, P. Eng.	Date: 9/8/23
Project:	Hydrogen production and dispensing station site		Reviewed By:	J. Block, P. Eng.	Time: 9:00 AM
Location:	421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number:	6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
			CH		Grey, glaciolacustrine, stiff to firm, moist, silty CLAY with silt inclusions
27.5					
30.0		12			
32.5 (▽)					
35.0		13			
37.5					
40.0		14			
42.5					
			CL		Grey, soft, wet, sandy clayey SILT with potential cobbles and boulders (GLACIAL TILL)
45.0		15	SM		Brown, saturated, dense, poorly-graded, silty SAND with cobbles and boulders (GLACIAL TILL) - Severe soil sloughing and groundwater seepage
					45'- Auger refusal on a suspected boulder in the glacial till matrix; - Upon completion, the groundwater & sloughed soil was measured at the 32' and 42' depths, respectively
47.5					
50.0					



SAMPLE TYPE SYMBOLS

- Split Spoon
- Shelby Tube
- Vane Shear
- Auger Cuttings
- Grab Sample
- Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

▽ Phreatic Surface #1: 32.0 ft

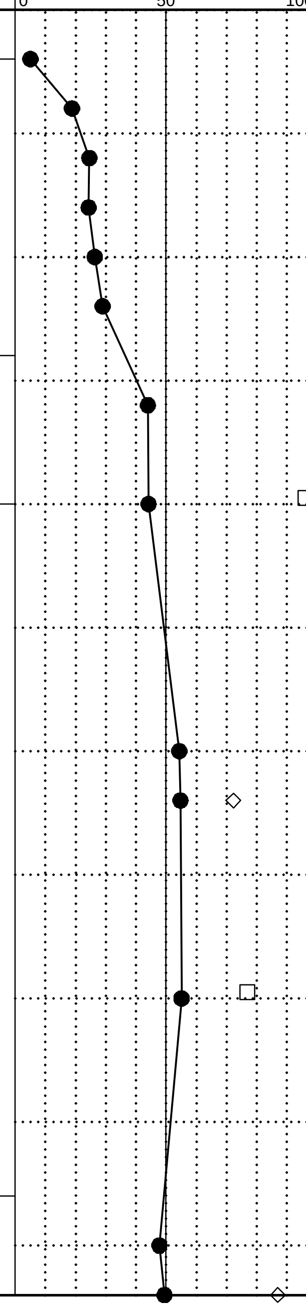
M. Block & Associates Ltd.
2484 Ferrier Street
Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

TEST HOLE NO.: 2

Client:	City of Winnipeg	Job No.: 2023-2329	Logged By:	J. Block, P. Eng.	Date: 9/8/23
Project:	Hydrogen production and dispensing station site		Reviewed By:	J. Block, P. Eng.	Time: 12:30 PM
Location:	421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number:	6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0			SPG		Brown, saturated, dense, silty gravelly SAND FILL
	Split Spoon	37	CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
	Split Spoon	38			
2.5	Split Spoon	39			
	Split Spoon	40			
5.0	Split Spoon	41			
	Split Spoon	42			6' - Dry coal and cinders fill
			CH		Brown, alluvially deposited, stiff, moist, silty CLAY
7.5	Split Spoon	43			
10.0	Split Spoon	44	CH		Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
12.5					
15.0	Split Spoon	45			
	Shelby Tube	46			
17.5					
20.0	Split Spoon	47			
22.5					
			CH		Grey, glaciolacustrine, stiff to firm, moist, silty CLAY with silt inclusions
▽ 25.0	Split Spoon / Shelby Tube	48			

UNDRAINED SHEAR STRENGTH (psf) Pocket Pen □ 0 650 1300
UNCONFINED COMPRESSIVE STRENGTH (psf) ◇ 0 1500 3000
PLASTIC M.C. LIQUID 0 50 100



Continued Next Page

SAMPLE TYPE SYMBOLS

Split Spoon | Shelby Tube
Vane Shear | Auger Cuttings
Grab Sample | Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

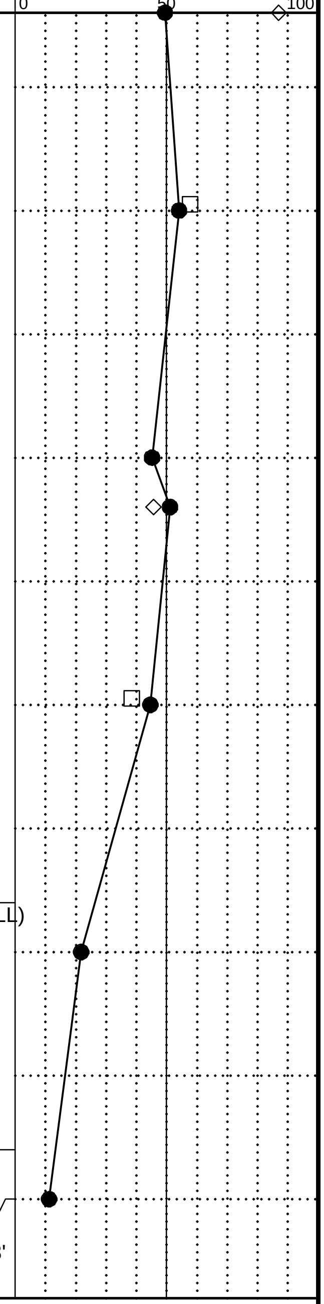
▽ Phreatic Surface #1: 25.0 ft

M. Block & Associates Ltd.		**TEST HOLE NO.: 2**
2484 Ferrier Street Winnipeg, Manitoba, R2V 4P6 Telephone: 204-334-5356 Fax: 204-339-7976	.	Sheet 2 of 2

Client: City of Winnipeg	Job No.: 2023-2329	Logged By:	J. Block, P. Eng.	Date: 9/8/23
Project: Hydrogen production and dispensing station site		Reviewed By:	J. Block, P. Eng.	Time: 12:30 PM
Location: 421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number:	6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
	Shelby Tube	49	CH		Grey, glaciolacustrine, stiff to firm, moist, silty CLAY with silt inclusions *(continued)*
27.5					
30.0		50			
32.5					
35.0		51			
	Shelby Tube	52			
37.5					
40.0		53			
42.5					
			CL		Grey, soft, wet, sandy clayey SILT with potential cobbles and boulders (GLACIAL TILL)
45.0		54			
47.5					
			SM		Brown, saturated, dense, poorly-graded, silty SAND with cobbles and boulders (GLACIAL TILL)
50.0		55			- Severe soil sloughing and groundwater seepage 50'- Auger refusal on a suspected boulder in the glacial till matrix; - Upon completion, the groundwater & sloughed soil was measured at the 25' and 48' depths, respectively

UNDRAINED SHEAR STRENGTH (psf) Pocket Pen □
0 650 1300
UNCONFINED COMPRESSIVE STRENGTH (psf) ◇
0 1500 3000
PLASTIC M.C. LIQUID
0 50 100



SAMPLE TYPE SYMBOLS

Split Spoon
Shelby Tube
Vane Shear
Auger Cuttings
Grab Sample
Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

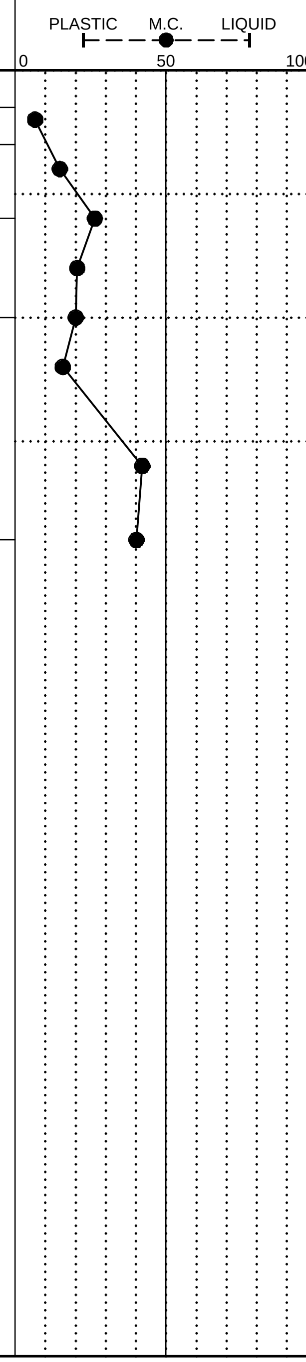
WATER LEVELS

Phreatic Surface #1: 25.0 ft

M. Block & Associates Ltd.	TEST HOLE NO.: 3
2484 Ferrier Street Winnipeg, Manitoba, R2V 4P6 Telephone: 204-334-5356 Fax: 204-339-7976	Sheet 1 of 1

Client: City of Winnipeg	Job No.: 2023-2329	Logged By: J. Block, P. Eng.	Date: 9/8/23
Project: Hydrogen production and dispensing station site		Reviewed By: J. Block, P. Eng.	Time: 2:00 PM
Location: 421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number: 6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0					CONCRETE
	Split Spoon	56	SPG		Brown, saturated, dense, silty gravelly SAND FILL
	Split Spoon	57	CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
2.5	Split Spoon	58	FILL		Black, dry, coal and cinders FILL
	Split Spoon	59			
5.0	Split Spoon	60	CH		Black/grey/brown, firm, moist, silty CLAY FILL
	Split Spoon	61			
7.5	Split Spoon	62			
	Split Spoon	63			
10.0					9'6"- Auger refusal on a suspected concrete or rubble in the fill matrix;
12.5					
15.0					
17.5					
20.0					
22.5					
25.0					



SAMPLE TYPE SYMBOLS

- Split Spoon
- Vane Shear
- Grab Sample
- Shelby Tube
- Auger Cuttings
- Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

No Ground Water Encountered

M. Block & Associates Ltd.

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Winnipeg, Manitoba, R2V 4P6
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Fax: 204-339-7976

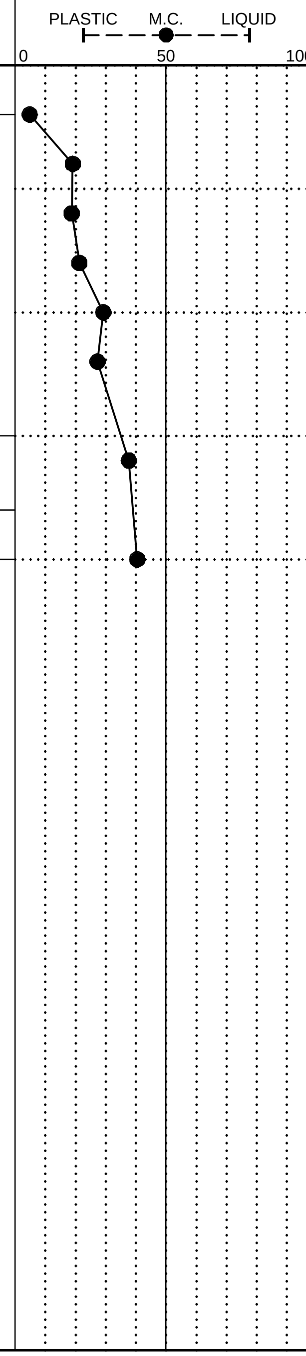
.

TEST HOLE NO.: 4

Sheet 1 of 1

Client:	City of Winnipeg	Job No.: 2023-2329	Logged By:	J. Block, P. Eng.	Date: 9/8/23
Project:	Hydrogen production and dispensing station site		Reviewed By:	J. Block, P. Eng.	Time: 11:15 AM
Location:	421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number:	6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0			SPG		Brown, saturated, dense, silty gravelly SAND FILL
		16	CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
		17			
2.5		18			
		19			
5.0		20			
		21			
7.5		22	CH		Brown, alluvially deposited, stiff, moist, silty CLAY
			CH		Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
10.0		23			10' - End of test hole;
12.5					
15.0					
17.5					
20.0					
22.5					
25.0					



SAMPLE TYPE SYMBOLS

Split Spoon
Shelby Tube
Vane Shear
Auger Cuttings
Grab Sample
Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

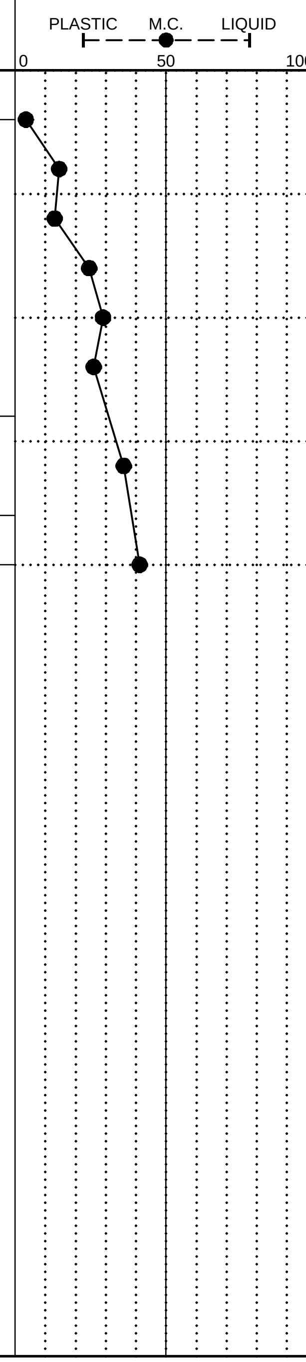
WATER LEVELS

No Ground Water Encountered

M. Block & Associates Ltd.		
2484 Ferrier Street Winnipeg, Manitoba, R2V 4P6 Telephone: 204-334-5356 Fax: 204-339-7976	.	**TEST HOLE NO.: 5** Sheet 1 of 1

Client: City of Winnipeg	Job No.: 2023-2329	Logged By: J. Block, P. Eng.	Date: 9/8/23
Project: Hydrogen production and dispensing station site		Reviewed By: J. Block, P. Eng.	Time: 11:35 AM
Location: 421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number: 6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0			SPG		Brown, saturated, dense, silty gravelly SAND FILL
		24			
			CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
		25			
2.5		26			
		27			
5.0		28			
		29			
			CH		Brown, alluvially deposited, stiff, moist, silty CLAY
7.5		30			
			CH		Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
10.0		31			10' - End of test hole;
12.5					
15.0					
17.5					
20.0					
22.5					
25.0					



SAMPLE TYPE SYMBOLS

- Split Spoon
- Shelby Tube
- Vane Shear
- Auger Cuttings
- Grab Sample
- Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

No Ground Water Encountered

M. Block & Associates Ltd.
2484 Ferrier Street
Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

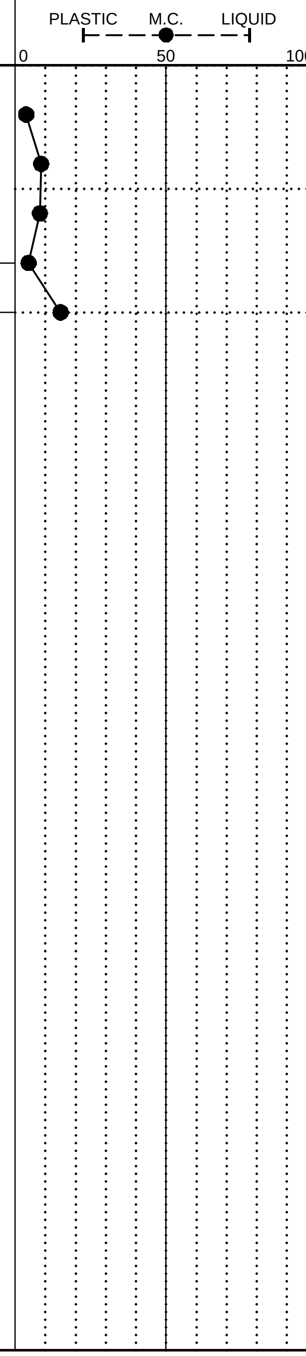
.

TEST HOLE NO.: 6

Sheet 1 of 1

Client: City of Winnipeg	Job No.: 2023-2329	Logged By: J. Block, P. Eng.	Date: 9/8/23
Project: Hydrogen production and dispensing station site		Reviewed By: J. Block, P. Eng.	Time: 12:01 PM
Location: 421 Osborne Street in Winnipeg, Manitoba	Elevation:	Drawing Number: 6092	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0.0			SPG		Brown, saturated, dense, silty gravelly SAND FILL
		32			
		33			
2.5					
		34			
		35	CH		Black/grey/brown, firm to stiff, moist, silty CLAY FILL
5.0		36			5'- Auger refusal on a suspected concrete or rubble in the fill matrix;
7.5					
10.0					
12.5					
15.0					
17.5					
20.0					
22.5					
25.0					



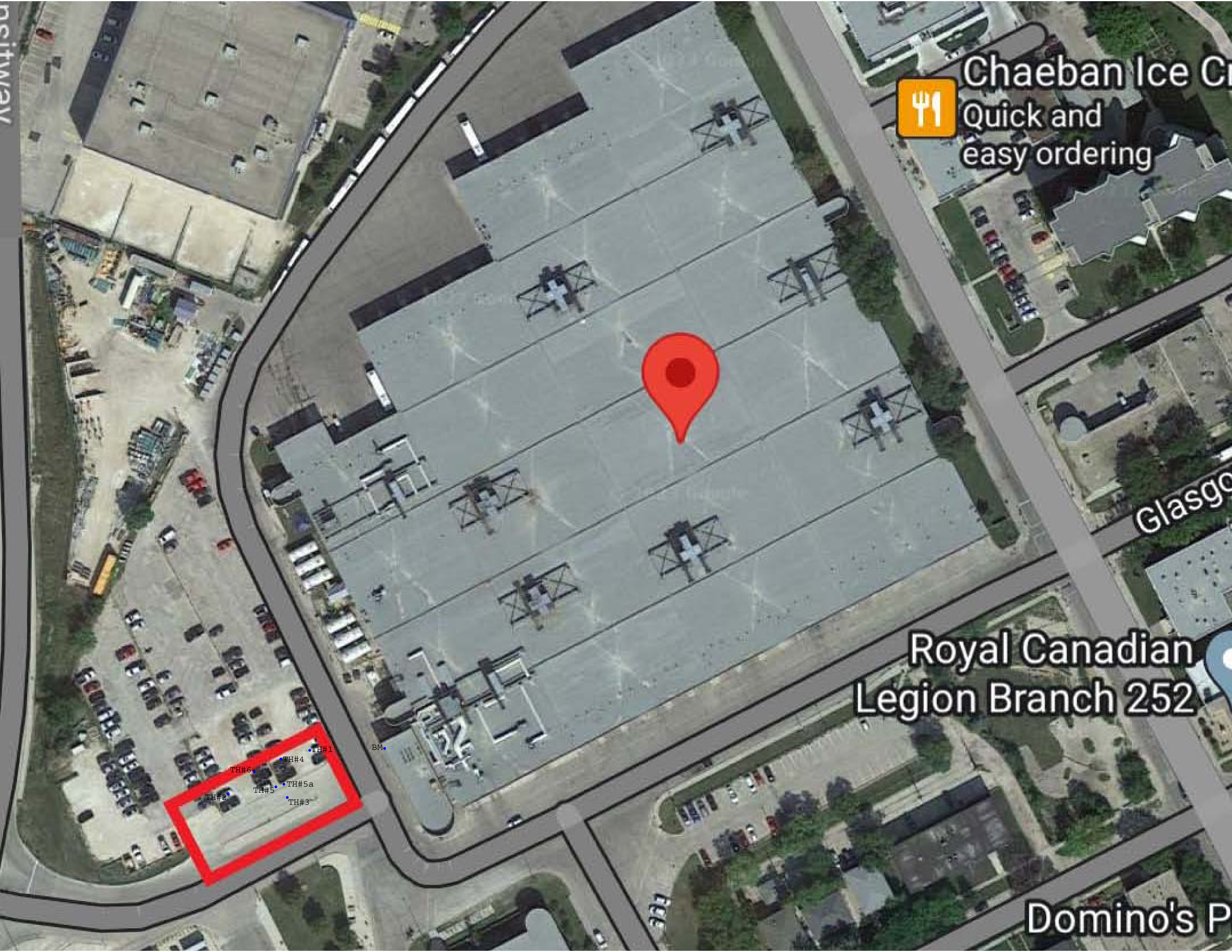
SAMPLE TYPE SYMBOLS

Split Spoon
Shelby Tube
Vane Shear
Auger Cuttings
Grab Sample
Rock Core

Drill Rig:	Track-mounted Acker drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

No Ground Water Encountered



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BM
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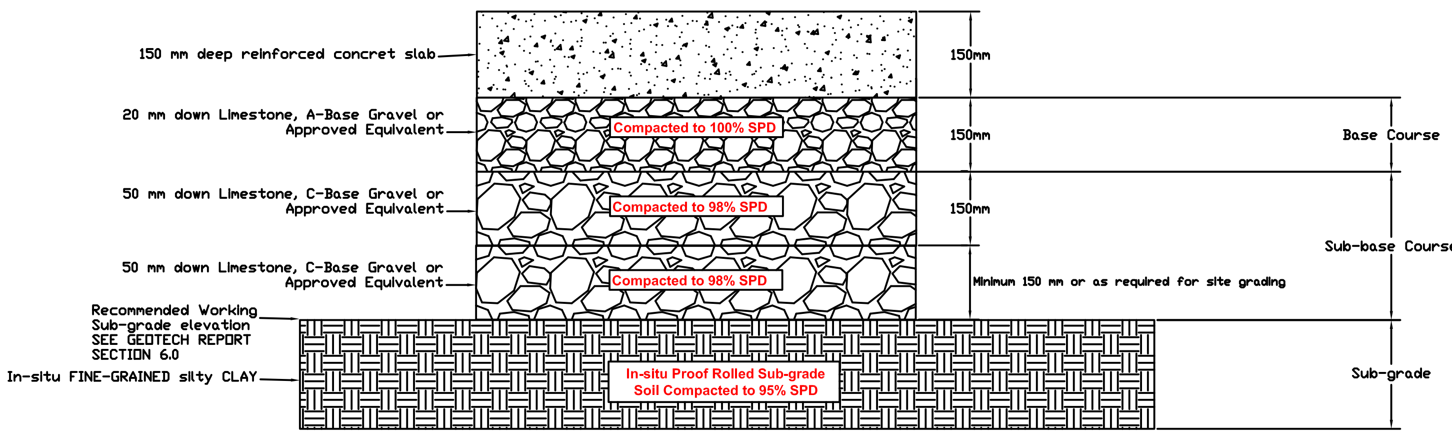
TH#6
TH#5a
TH#5
TH#2
TH#3

SURFACE CONCRETE SLAB-ON-GRADE FLOOR DESIGN (AS PER SECTION 6.0 OF GEOTECHNICAL REPORT, ONLY)



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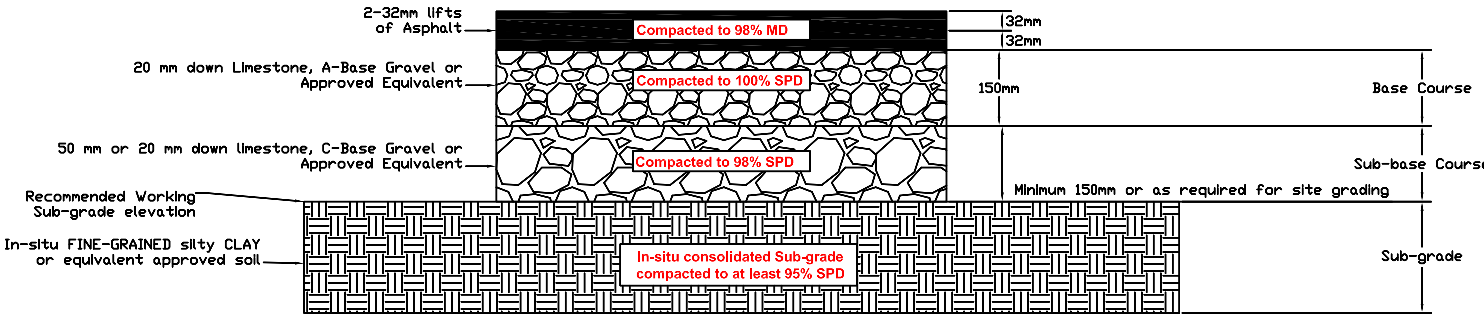
2484 Ferrier Street
Winnipeg, Manitoba
R2V 4P6
Phone: (204)-334-5356
Fax: (204)-339-7976

Drawing: Surface Slab-on-grade Design
Drawn By: J. Block, P. Eng.
Reviewed By: J. Block, P. Eng.

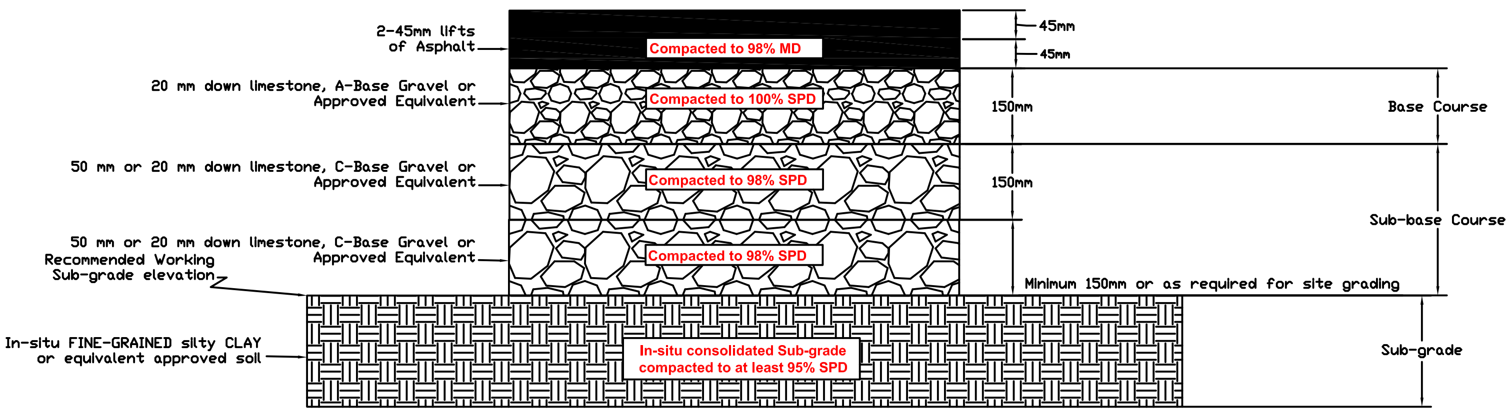
Project: 421 Osborne St., Winnipeg, Manitoba
Project Number: 2023-2329
Drawing Number: 6092

PAVEMENT DETAILS

Car Traffic Areas



Truck Traffic Areas



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2484 Ferrier Street
Winnipeg, Manitoba
R2V 4P6
Phone: (204)-334-5356
Fax: (204)-339-7976

Drawing: PAVEMENTS' STRUCTURES
Drawn By: TG/JB
Reviewed By: J. Block, P. Eng.

Project: 421 Osborne St., Winnipeg, Manitoba
Project Number: 2023-2329
Drawing Number: 6092

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
1	1.0							2.4			
1	2.0							4.1			
1	3.0							24.3			
1	4.0							20.3			
1	5.0							21.4			
1	6.0							19.2			
1	8.0							28.8			
1	10.0							43.0			
1	15.0							57.2			
1	20.0							56.0			
1	25.0							50.6			
1	30.0							46.3			
1	35.0							51.3			
1	40.0							50.8			
1	45.0							11.4			
2	1.0							5.0			
2	2.0							18.8			
2	3.0							24.6			
2	4.0							24.3			
2	5.0							26.3			
2	6.0							29.0			
2	8.0							43.9			
2	10.0							44.1			
2	15.0							54.4			
2	16.0							54.7			
2	20.0							55.1			
2	25.0							47.7			
2	26.0							49.4			
2	30.0							54.1			
2	35.0							45.1			
2	36.0							51.1			
2	40.0							44.6			
2	45.0							21.8			
2	50.0							11.1			
3	1.0							6.6			
3	2.0							14.8			
3	3.0							26.4			
3	4.0							20.5			
3	5.0							20.1			
3	6.0							15.7			
3	8.0							42.1			
3	9.5							40.1			
4	1.0							4.8			

M. Block & Associates Ltd.
2484 Ferrier Street
Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

Summary of Laboratory Results

Client: City of Winnipeg
Project: Hydrogen production and dispensing station site
Location: 421 Osborne Street in Winnipeg, Manitoba
Number: 2023-2329

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
4	2.0							19.1			
4	3.0							18.7			
4	4.0							21.2			
4	5.0							29.2			
4	6.0							27.3			
4	8.0							37.7			
4	10.0							40.5			
5	1.0							3.5			
5	2.0							14.6			
5	3.0							13.1			
5	4.0							24.5			
5	5.0							29.1			
5	6.0							26.0			
5	8.0							35.9			
5	10.0							41.2			
6	1.0							3.6			
6	2.0							8.6			
6	3.0							8.2			
6	4.0							4.4			
6	5.0							15.0			

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Winnipeg, Manitoba, R2V 4P6
Telephone: 204-334-5356
Fax: 204-339-7976

Summary of Laboratory Results

Client: City of Winnipeg
Project: Hydrogen production and dispensing station site
Location: 421 Osborne Street in Winnipeg, Manitoba
Number: 2023-2329