

**MTO AGREEMENT NO. 5007-E-0052
FOUNDATION INVESTIGATION
AND DESIGN REPORT
PROPOSED SAND/SALT STRUCTURE
FERONIA PATROL YARD
RR#3, 69955 HIGHWAY 63
TOWNSHIP OF FERONIA**

*Prepared for
MTO Northeastern Region*

September 2008

File 03080770.03

Distribution:

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Geocres No. 31L-124

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September 19, 2008

Ministry of Transportation
Northeastern Region
3rd Floor, 447 McKeown Avenue
Suite 301
North Bay, Ontario
P1B 9S9

Attention: Mr. Andrew Alkins, P. Eng.

Dear Sirs:

Re: Assignment No. 5007E-0052
Foundation Investigation and Design Report
Proposed Sand/Salt Structure, Feronia Patrol Yard
File 03080770.03

We are pleased to submit our Foundation Investigation and Design Report for the proposed construction of a new sand/salt storage structure at the MTO Feronia patrol yard. The report is based on a borehole investigation and laboratory testing program, and addresses the Terms of Reference requirements for the assignment.

We trust that the information provided is sufficient for your requirements.

Yours truly,
JAGGER HIMS LIMITED



J. Stephen Ash, B.Sc., P.Eng.
Project Engineer – Branch Manager





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1.0 INTRODUCTION

Jagger Hims Limited was retained by the Ontario Ministry of Transportation (MTO) Northeastern Region to investigate and report on subsurface conditions to design a foundation for a new sand/salt storage structure at the Feronia Patrol Yard. The work was conducted under MTO Agreement Number 5007-E-0052, and included buried utility clearances, drilling and sampling of boreholes at the proposed structure location, soil sample review and routine laboratory tests, and geotechnical assessments for foundation design and construction considerations. Site details and our findings and recommendations are discussed in subsequent report sections.

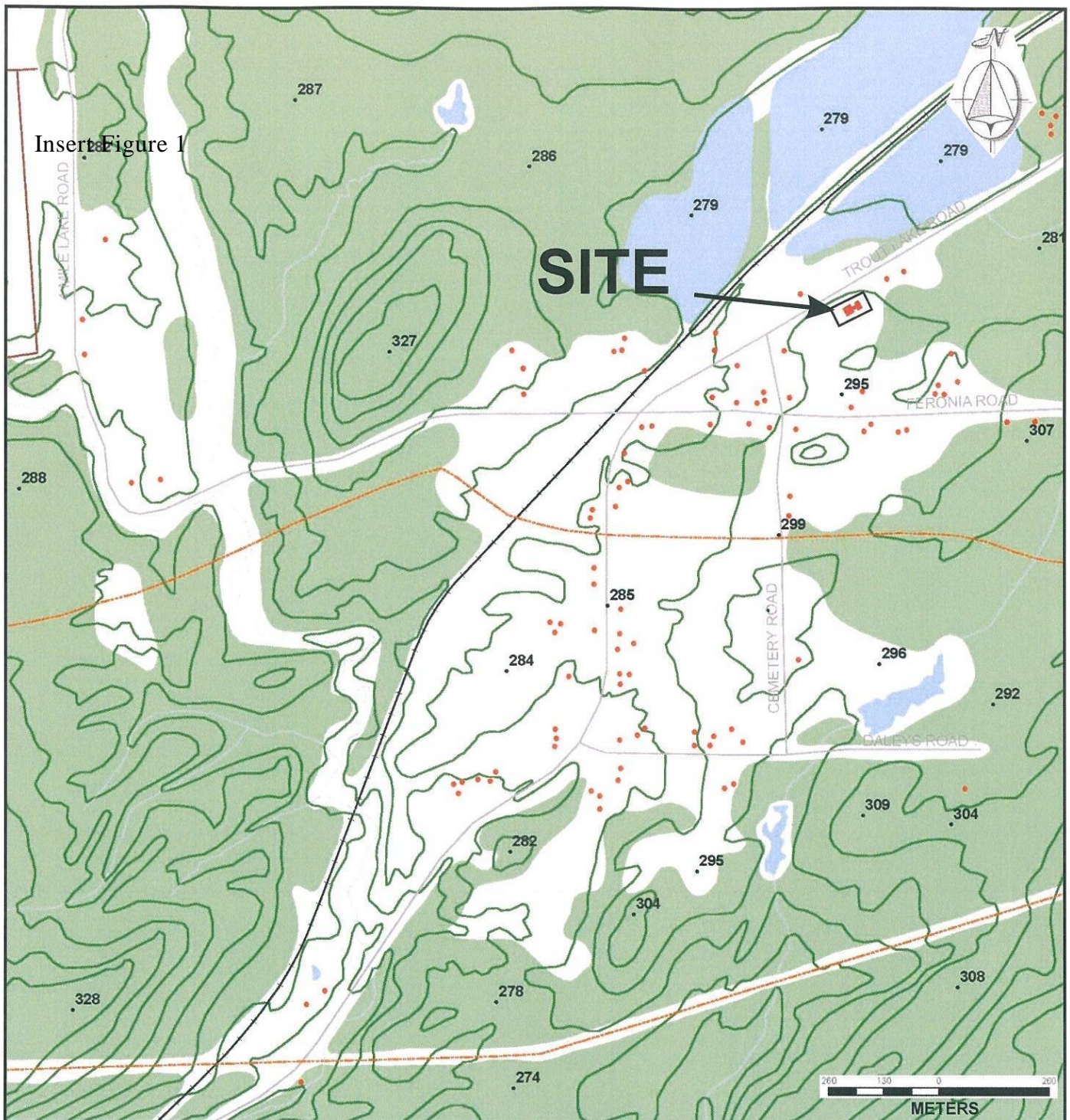
2.0 SITE DESCRIPTION

The Feronia patrol yard (site) is located at RR#3, 69955 Highway 63 in the Township of Feronia. A site location map is included as Figure 1.

The patrol yard has an approximate area of 2.0 ha and is currently occupied by a salt/storage shed, a 28 m diameter sand storage dome, and a 5-bay maintenance garage/office. Floor grade elevations of existing buildings are in the order of 282.6 m (geodetic datum).

Most of the site area around the existing buildings is asphalt paved and other areas are grass or gravel surfaced. The patrol yard also contains stockpiles of sand and gravel for use on MTO projects. A site plan is included as Figure 2.

The site topography is relatively flat, with a lower flooded area located immediately to the southwest. There are no bedrock outcrops on the site; however a nearby outcrop to the southwest indicates granitic formations. Existing vegetation includes perimeter trees with some grass lawn areas surrounding the parking lot.



LEGEND

SITE LOCATION MAP

GEOTECHNICAL INVESTIGATION
FERONIA PATROL YARD
Feronia, Ontario
For: Ministry of Transportation

DATE: JULY, 2008

SCALE: AS SHOWN

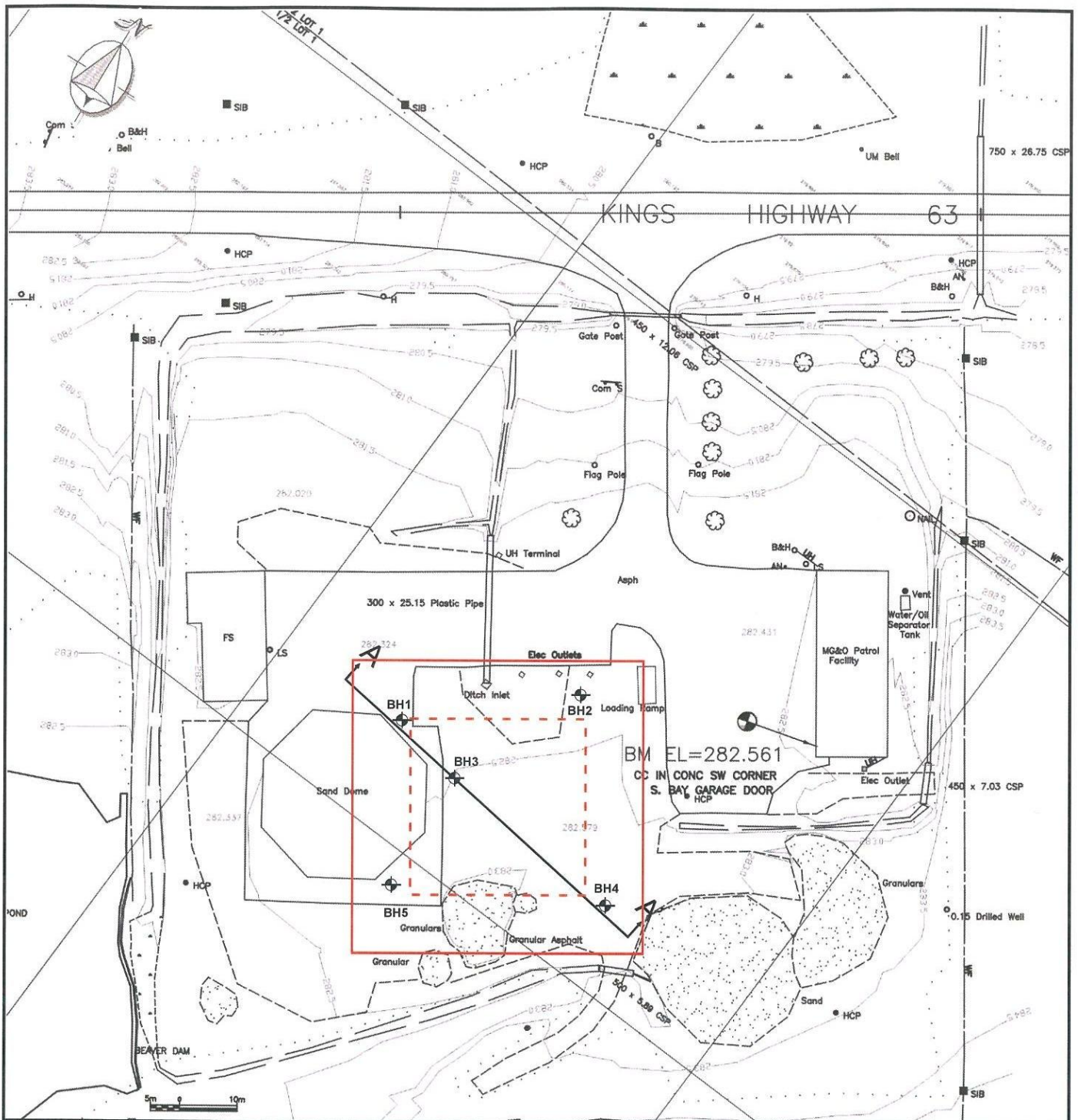
PROJECT: 03080770.03

REF. NO.: 03080770.03SLMFIG1

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FIGURE

1



LEGEND



Borehole Designation and
Approximate Location - 2008



Proposed Structure and
Asphalt Perimeter



Cross Section A-A'

SITE PLAN

GEOTECHNICAL INVESTIGATION
FERONIA PATROL YARD
Feronia, Ontario
For: Ministry of Transportation

DATE: JULY, 2008

SCALE: 1:1,000

PROJECT: 03080770.03

REF. NO.: 0308077003F2

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Environmental Consulting Engineers

FIGURE

2

The proposed sand/salt structure location is at the southeast side of the site, east of an existing dome, as indicated on Figure 2. The proposed structure location is partially occupied by an existing dome that will be demolished. It is understood that the new structure will be approximately 30 m by 30 m in size with an approximate capacity of 4,036 tonnes. We understand that a dome type structure is also being considered. The interior area of the proposed structure, and the exterior perimeter within 10 m surrounding the structure, will be paved with asphalt. A field sketch indicating features in the immediate area around the existing dome is included as Figure 5.

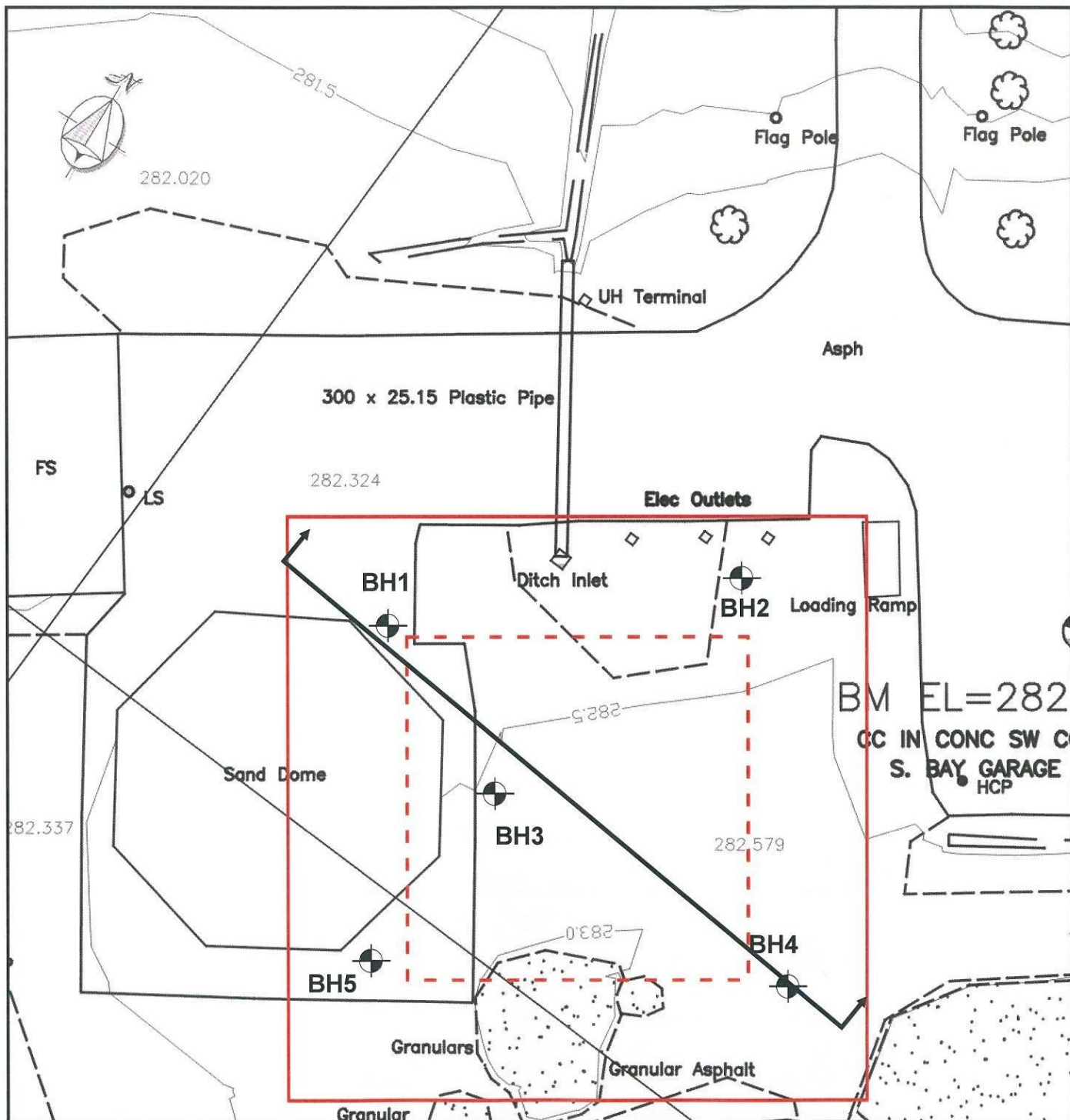
3.0 INVESTIGATION PROCEDURES

3.1 SUBSURFACE INVESTIGATION

Subsurface conditions at the proposed sand/salt structure location were investigated between June 19 and June 21, 2008. Five (5) boreholes, designated as BH1 through BH5, were drilled with a truck-mounted soils investigation rig equipped with 110 mm outside diameter (OD) hollow-stem augers, 51 mm inside diameter (ID) split-spoon samplers, and various other soil testing/sampling apparatus including field vane, dynamic cone penetrometer, and thin wall tube samplers. The rig also had capability for NQ size (48 mm diameter) rock coring. All drilling and sampling was conducted under the supervision of a Jagger Hims Limited soils technologist.

Borehole locations in the proposed building area are plotted on Figure 3. The boreholes were advanced at accessible locations within the proposed building area footprint, as indicated by the site representative.

Prior to undertaking the borehole investigation, existing buried utilities on the site were cleared with a private locator and Ontario One-Call services. MTO site supervisors accompanied field staff on the initial site inspection to stake out borehole locations and clear buried service conflicts.



LEGEND



BH1

Borehole Designation and
Approximate Location - 2008



Proposed Structure and
Asphalt Perimeter



Cross Section A-A'

BUILDING AREA PLAN

GEOTECHNICAL INVESTIGATION

FERONIA PATROL YARD

Feronia, Ontario

For: Ministry of Transportation

DATE: JULY, 2008

SCALE: 1:500

PROJECT: 03080770.03

REF. NO.: 0308077003F3

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FIGURE

3

MTO's minimum requirements for the borehole investigation included the following.

- Five boreholes in the area of the structure, unless justification for additional boreholes was authorized by the MTO Project Manager.
- Boreholes extending to a minimum of 3 m below refusal depth, as defined by material for which Standard Penetration Test (SPT) N values exceed 100 blows per 0.3 m.
- A maximum depth of drilling of 15 m, unless refusal was encountered at shallower depth or justification for deeper drilling was authorized by the MTO Project Manager.
- If bedrock was encountered at foundation element locations, a minimum 3 m core sample was to be obtained from below the bedrock surface. The bedrock/soil interface was determined by geological definition.
- Semi-continuous soil sampling at 0.75 m intervals within critical foundation zones. The maximum sampling interval within the investigated depth was 1.5 m.
- Backfilling of boreholes with bentonite sealant, and repair of holes in asphalt in accordance with abandonment procedures and regulations. Artesian groundwater pressure, if encountered, was to be sealed at the source.

Soil samples were taken mainly using split spoon/standard penetration test procedures (ASTM D1586). Soil samples collected during drilling operations were inspected and logged, and then placed in labeled bags for transport and storage. Jars with tight-sealing Teflon-lined lids were used for laboratory moisture content specimens.

In addition to the general sampling, the following additional sampling procedures were undertaken at this site.

- A 3.0 m bedrock core sample was taken at BH1. The bedrock sample was placed in a wooden core box for shipment and storage.

3.2 LABORATORY TESTING

Soil samples from the borehole investigation were reviewed by the project geotechnical engineer, to confirm field descriptions and assess laboratory testing requirements.

The following routine laboratory testing was conducted on selected soil samples:

- Natural Moisture Content (LS-701): 14
- Particle Size Distribution Analysis (LS-602, LS-702): 8
- Atterberg Limits Tests (LS-703/704): 1

No complex level soil or rock testing was completed for this site.

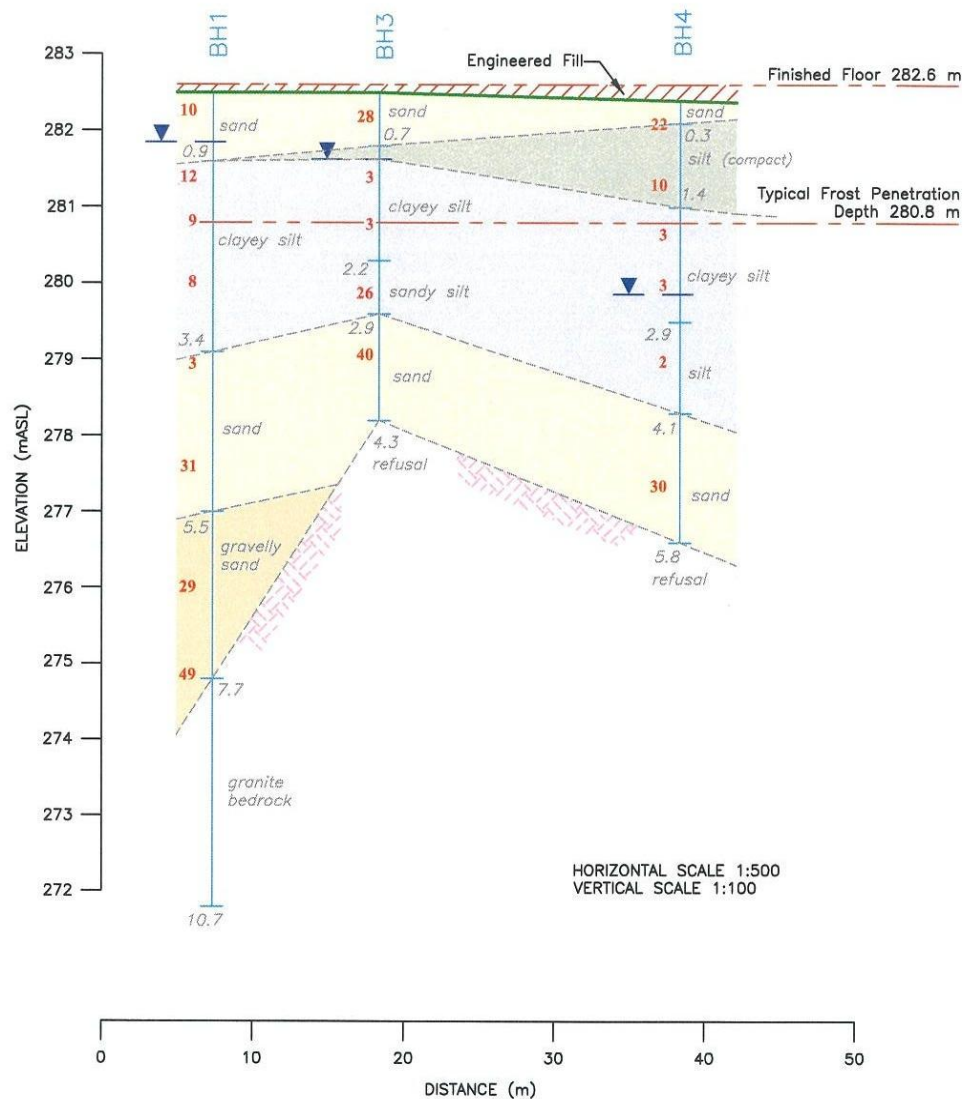
4.0 SUBSURFACE CONDITIONS

4.1 SOIL PROFILE SUMMARY

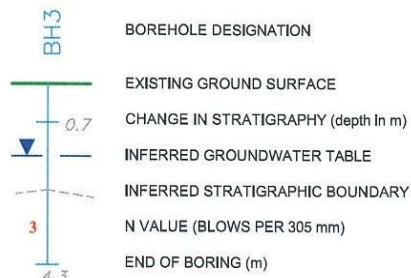
The subsurface profile in the investigated area generally consists of layers of sandy gravel, sand, and silt to clayey silt, overlying confirmed or presumed bedrock surface grade at depths of 4.3 to 7.7 m below the existing ground surface. Wet to saturated soils and groundwater were encountered below 0.6 m to 2 m depth in the boreholes and this is inferred to be the site area groundwater level at the time of drilling. Individual soil units and details are described in the following subsections, and the subsurface profile is shown on Figure 4.

A
West

A'
East



LEGEND



NOTE:
THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

CROSS SECTION A-A'

GEOTECHNICAL INVESTIGATION
FERONIA PATROL YARD
Feronia, Ontario
For Ministry of Transportation

DATE: SEPTEMBER 2008

SCALES: AS SHOWN

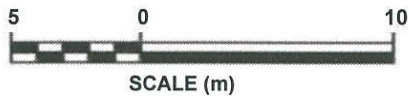
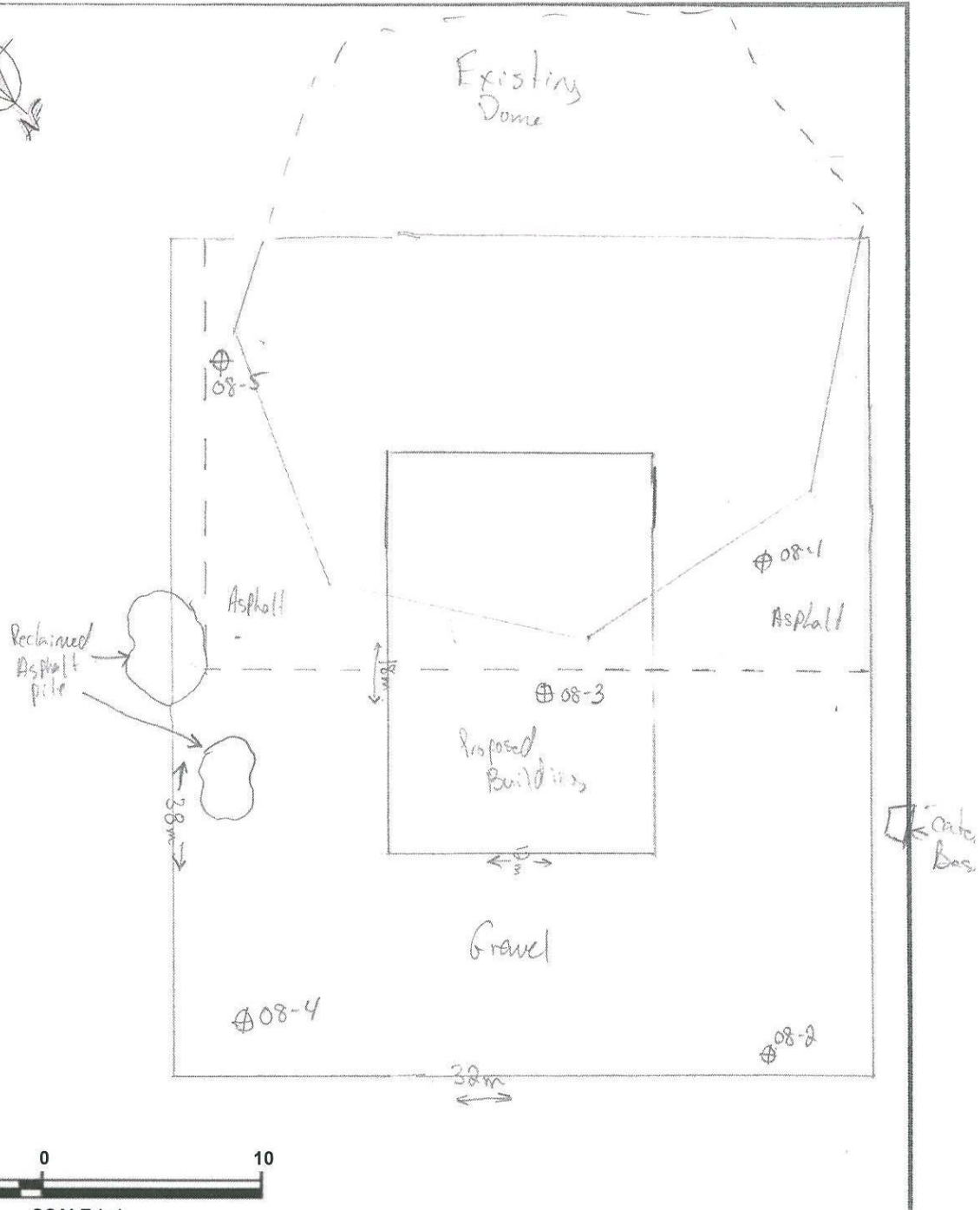
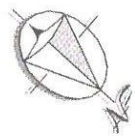
PROJECT: 3-080770.03

REF. NO.: 3-08077003F4-CR Feronia

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FIGURE

4



LEGEND

PEDOLOGICAL FIELD SKETCH

GEOTECHNICAL INVESTIGATION
FERONIA PATROL YARD
Feronia, Ontario
For: Ministry of Transportation

DATE: JULY, 2008

SCALE: AS SHOWN

PROJECT: 03080770.03

REF. NO.: 0308077003PEDOFIG5

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FIGURE

5

4.1.1 Asphalt

Boreholes BH1, BH4 and BH5 penetrated existing asphalt and recycled asphalt concrete with respective thicknesses of 75 mm, 100 mm and 75 mm (average 83 mm). Borehole BH3 encountered asphalt debris within the first 0.5 m of sampling.

4.1.2 Sandy Gravel and Gravelly Sand

Brown sand to sandy gravel and gravelly sand, containing a trace to some silt, was encountered below the asphalt, to a maximum depth of 0.9 m below existing grade. Occasional cobble size material was encountered at BH1. This top granular layer is inferred to be compact to dense based on penetration resistance (N) values of 9 to 28 blows per 305 mm. Laboratory particle size analyses (results appended) of samples from the upper layer indicate that the material contains 15 % to 40 % gravel, 26 % to 79 % sand, 6 % to 11 % silt, and 0 to 3 % clay. Natural moisture contents range from 6 % to 8 %, based on laboratory tests.

4.1.3 Silt to Clayey Silt

Grey silt to clayey silt, with occasional silty clay, silt and sand seams, was encountered at boreholes BH1 and BH3 through BH5. The clayey silt ranged in thickness from 1.5 m to 2.5 m. Based on sample observations and on N values ranging from 12 to 3 blows per 305 mm, the silt layer at BH4 is inferred to be loose to compact and the clayey soils are inferred to be stiff to firm.

Laboratory particle size analyses of samples from the clayey silt layer indicate that the material contains 1 % to 6 % sand, 68 % to 75 % silt, and 23 % to 31 % clay. Natural moisture contents range from 28 % to 34 %. Liquid and plastic limits of 32% and 21% were measured in one sample.

4.1.4 Bedrock

The boreholes met refusal at depths of 4.27 m to 7.70 m below existing ground level, and the inferred bedrock surface is irregular. The bedrock was cored for a depth of 3.0 m at BH1. Based on the core sample inspection, the bedrock is mottled white, pink and grey, massive granitic rock. The core recovery was 100 percent, and the Rock Quality Designation for the sample was good (87 %).

4.1.5 Groundwater

Open hole water level depths of 0.61 m to 0.78 m were measured at BH1, BH2 and BH3. This is inferred to be representative of the site area groundwater level on June 19, 2008. Deeper open hole water levels were measured at BH4 and BH5 after drilling but we suggest that the groundwater level at these locations had not been stabilized.

5.0 MISCELLANEOUS INFORMATION

5.1 BURIED UTILITY LOCATOR

Buried utility clearances were performed by Cable Master of Newmarket, Ontario (ph: 905-715-7305).

5.2 DRILLING COMPANY IDENTIFICATION

The drilling company used on the assignment was Abraflex of Lively, Ontario (ph: 705-222-2272).

5.3 LABORATORY IDENTIFICATION

Medium complexity laboratory tests were conducted by Golder Associates of Mississauga, Ontario (ph: 905-567-4444), under a subcontract with Jagger Hims Limited.

5.4 SITE INVESTIGATORS

Mr. David Lembke of Jagger Hims Limited supervised the field drilling program. Mr. Stephen Ash, P. Eng., Mr. Stuart Baird, P. Eng., and Mr. Ben McWade, EIT, of Jagger Hims Limited, completed the geotechnical assessments and prepared the reports. Mr. Ash was the project manager and lead contact for the assignment.

6.0 STRUCTURE FOUNDATION DESIGN

6.1 GENERAL DISCUSSION

We understand that the sand/salt pile in the proposed rectangular or square structure will not extend to the structure walls. This feature, in combination with the angle of repose slope of the sand/salt pile, creates a condition where the sand/salt pile loads should not affect the somewhat compressible shallow clayey silt layer below the structure walls to any significant degree.

Some settlement of the asphalt surfaced area below the actual stockpile is expected. We have assumed that provision can be made to resurface the asphalt covered area if settlements are sufficient to affect the function of the surface.

The alternative domed structure creates a condition where the sand/salt pile is confined at least partially by a 2.4 m high perimeter retaining wall and the weight of the sand/salt will increase stresses in the clayey silt below the retaining wall to a significant degree. For this type of structure, some degree of preloading is recommended to ensure that settlements do not cause detrimental distress to the structure.

6.2 TYPE AND DEPTH OF FOUNDATION

Based on the subsurface profile determined by the borehole investigation, the site location is suitable for a shallow foundation design, and the subject sand/salt structure can be supported on a reinforced concrete strip footing and grade beam.

Table 1

MTO Assignment 5007-E-0052
Shallow Foundation Design (CHBDC CAN/CSA-S6-00 Method)
Our File: 3080770.03

Calculated Geotechnical Resistance at ULS:

$q_u = c'N_{scik} + \gamma' D N_{sqik} + 0.5 \gamma' B N_{\phi i \gamma}$

Case No. : 1 (Cohesive clayey silt soils)

Foundation Design Variables			Soil Strength Properties				Bearing Coefficients			Foundation Shape Factors				Load Inclination Factors					
Footing Width, B (m)	Footing Length, L (m)	Footing Depth, D (m)	Overburden γ' (kN/m3)	ϕ' (degrees)	c_u (kPa)*	Soil Below Footing c' (kPa)*	γ' (kN/m3)*	Nc	Nq	N γ	ea	el	Effective Width, B' (m)	Effective Length, L' (m)	$s_c = s_q$	s_y	δ^*	$i_c = i_q$	i_γ
0.45	30	0.60	19.00	0.00	40.70	42.00	10.00	5.14	1.00	0.00	0.00	0.00	0.45	30.00	1.00	0.99	0.00	1.00	1.00

*Note: For $\phi=0$, Input $c_u=c'$

$q_u =$	228 kPa
$H_{fs} =$	454 kN
$H_{fs} =$	439.56 kN (short term ,clays only)
$H_{fi} =$	454 kN

The apparent shallow groundwater level is of concern for constructing footings at normal frost penetration depths. To avoid dewatering issue, the perimeter footing could be placed at a depth of about 0.6 m below existing site grades using high density Styrofoam insulation for frost protection, as detailed in Section 10.0. An alternative would be to excavate a trench at least 1.5 times the footing width using a toothless backhoe, and backfill to a higher footing grade using clear stone surrounded completely with non-woven geotextile (Terrafix 220 or equal). The clear stone should be compacted with a maximum of two passes with a vibratory plate compactor. Excessive compaction could disturb the underlying clayey silt soils. This alternative would decrease the settlement potential of the clayey silt.

6.3 BEARING RESISTANCE

In accordance with the MTO Terms of Reference, foundation design for the storage structure is based on the procedure stated in Section 6 of the Canadian Highway Bridge Design Code (CHBDC), published by the Canadian Standards Association (CSA/CAN-S6-00). It is understood shallow depth foundations are preferred, if possible, to minimize the amount of excavation disturbance. The shallow footing widths might be determined by structure wind resistance considerations rather than geotechnical considerations. The bearing capacity of shallow footings will be determined primarily by the clayey silt soils, which are treated as cohesive materials. An average total stress shear strength of 42 kPa is recommended for design.

6.3.1 Geotechnical Resistance at ULS

The unfactored geotechnical resistance at Ultimate Limit State (ULS) for a concentrically loaded footing founded in uniform soil is calculated from the following formula:

$$q_u = c'N_{cs}i_c + q'N_{qs}i_q + 0.5\gamma'BN_{\gamma s}i_{\gamma}$$

where,

q_u is the ultimate geotechnical pressure resistance (kPa),

c' is the effective cohesion of the soil (kPa),

q' is the effective overburden pressure at the foundation level (kPa),

γ' is the effective unit weight of the soil (kN/m³),

B is the footing width (m),

N_c , N_q , N_γ are dimensionless bearing coefficients based on the effective angle of internal friction (degrees),

s_c , s_q , s_γ are foundation shape factors, and

i_c , i_q , i_γ are load inclination factors.

A total stress ($\phi' = 0$) bearing capacity analysis is presented in Table 1, using a 0.45 m wide strip footing situated at 0.6 m below grade. A footing length (L) of 30 m was used, which represents the length of one side of the structure. Vertical footing loads are assumed. The total stress shear strength of the inferred clayey silt subsoil is 42 kPa.

The calculated unfactored bearing resistance at ULS is 228 kPa and, based on Table 6.6.2.1 of the CHBDC, the factored bearing resistance is 114 kPa.

6.3.2 Settlement and SLS Design Considerations

The footing settlements will be related almost entirely to the compressibility of the underlying clayey silt soils, and as previously discussed, the sand/salt fill pile is unlikely to have a significant influence on loadings of soil below the footings if the rectangular structure design is used. The following settlement assessment is for this rectangular construction.

The 32 percent liquid measured for the clayey silt-silty clay sample of BH1 is considered to be representative of the more clayey soils at the site. Using the conventional $C_c = 0.008$ (LL-10) for the compression coefficient, C_c , the value is 0.176.

Historically it is reasonable to assume the groundwater levels were at least 1.2 m below current ground levels. The existing historic stress, p_o , at the middle of the thickest clayey soil layer would be $1.2 \times 19 + 1.0 \times 10 = 32.8$ kPa.

Assuming a footing width of 0.7 m, a 0.6 m deep footing base stress of 72 kPa and a 60 degree slope stress reduction envelope with depth, the effective footing load created stress, Δp , at the midpoint of the clayey soil layer would be 21 kPa. The initial void ratio e_o , of the clay should be in the order of the specific gravity G (2.7) times the moisture content of 32%, which is 0.86.

Using the above inferred soil data in the settlement equation, $s = (C_c / 1+e_o)(H) \log (1+\Delta p/p_o)$ with H = the layer thickness of 2000 mm, the predicted settlement would be $(0.176 / 1.86) (2000) \log (1+21 / 32.8) = 40.6$ mm. The 2000 mm layer thickness allows for less immersible silt seams in the clayey silt layer.

The settlement inducing stress from the footings is primarily the long term dead load and it is unlikely that the dead load stress exceeds 60 percent of the 72 kPa total stress. If the 0.6 value is assumed, the predicted maximum settlement reduces to $s = 0.176 / 1.86 (2000) \log (1+12.6 / 32.8) = 26.7$ mm.

The inferred parameters are believed to be conservative and settlements probably will be less than predicted. Consequently, 72 kPa SLS footing design stress is considered appropriate for the rectangular building footings.

6.3.3 Dome Type Structure Preloading

A preload to compress only the clay soils below the perimeter footings could consist of a fill pile at least 3 m high and 3 m wide, centered on the building perimeter. Because of layering in the clayey soils, including some silt seams and occasional sandy seams, it is probable that a preload of less than three months is sufficient. However, field measurements of settlement are recommended to confirm the adequacy of settlement.

After the preloading is complete, the structure footings could be designed with a factored ULS stress of up to 300 kPa and SLS design stress of up to 120 kPa.

6.4 SAND/SALT STOCKPILE SETTLEMENTS

The stresses induced in the clayey silt layer by the sand/salt stockpile will be significant and some compression of the clayey soils will occur. Without preloading, the actual amount of settlement could exceed 75 mm. It is recommended that the surface coarse paving be deferred for at least one year to allow the compression to occur.

6.5 LATERAL RESISTANCE

The factored horizontal resistance (H_{rs} and H_{ri}) for the 0.45 m wide footing at the ULS design loading is 454 kN, as shown on Table 1. Resistance increases for wider footings.

7.0 EARTH PRESSURE DESIGN

No shoring or earth retaining systems are anticipated for this project, so lateral earth pressure design requirements are minimal.

The following active (K_a) and passive (K_p) earth pressure coefficients are recommended, using a resistance factor of 0.5 applied to an assumed 35° internal friction angle for granular fill soils.

- $K_a = 0.53$
- $K_p = 1.9$

8.0 SEISMIC DESIGN

Based on Table 4.1.8.4.A of the Ontario Building Code, and the inferred dense soil and hard bedrock conditions to a depth of 30 m below ground, we recommend that Site Class C be used for seismic design (if required). Acceleration and velocity based site coefficients can be obtained from Tables 4.1.8.4.B and 4.1.8.4.C.

9.0 UNWATERING AND SUBDRAINAGE

With the exception of removing accumulated precipitation and runoff from the foundation excavation, no groundwater unwatering is required for dome construction.

The foundation grade is above the groundwater table, so no subdrains are recommended.

10.0 FROST PENETRATION

Based on the MTC report RR225 “Aspects of Prolonged Exposure of Pavements to Sub-Zero Temperatures”, the depth of frost penetration for Feronia is typically 1.8 m. Laboratory particle size distribution test results indicate that the existing subgrade soils within the frost penetration depth have low to medium frost susceptibility.

To provide sufficient protection against frost heave, we recommend that footings be insulated with high density Styrofoam board with the following minimum specifications:

- compressive strength of 215 kPa
- thermal resistance of 0.87 m²°C/W
- water absorption less than 0.7 % by volume

The Styrofoam insulation board should be at least 75 mm thick, placed at a depth of 0.45 m below final grade, and should extend horizontally at least 1.5 m from both faces of the footing or grade beam. The insulation board should also be placed on both vertical sides of the footing or grade beam, extending from the ground surface to a depth of at least 0.6 m below final grades. The horizontal insulation board should abut the vertical board to form a tightly sealed joint.

An alternative would be to place the footing on a layer of very high density Styrofoam that extends at least 1.4 m to either side of the footing.

11.0 BEDROCK EXCAVATION

No bedrock excavation is required for shallow foundation construction at this site.

12.0 CONSTRUCTION CONCERNS

12.1 SITE PREPARATION

Trenching will be required for the foundation excavation and should be conducted in accordance with OPSS 206 and the Occupational Health and Safety Act (OHSA). Type 3 cohesionless materials are expected, and the sides of trenches must be sloped at 1:1, or must be temporarily supported in accordance with OHSA.

Site preparation may involve leveling and grading of the proposed structure area to the design elevations. Foundation excavations might be done first, with fill material added later. A finished floor/exterior grade elevation of 282.6 m is recommended, which is consistent with existing onsite structures and adjacent areas. Site preparation will involve stripping of loose surficial material and placement of granular engineered fill to the design elevations. Fill should consist of Granular B (Type I or II) per OPSS 1010, and fill should be placed and compacted in accordance with OPSS 206, 501 and 514, as applicable.

The subsoil below the structure is competent to support the stockpile and foundation loadings. We recommend that the subgrade soil below the interior floor of the structure be compacted with a minimum of eight (8) passes of a heavy (at least 25-tonne) vibratory roller prior to building construction, to consolidate any looser surficial material remaining. Compaction should generally be in accordance with OPSS 206, 501 and 514, as stated in this report.

12.2 FOUNDATION BACKFILL

Foundation backfill must be free-draining, non-frost susceptible granular material such as OPSS 1010 Granular B (Type I or II), or approved equivalent. Backfill must be placed and compacted in accordance with OPSS 501.

12.3 PAVEMENT DESIGN

The interior floor of the structure and the exterior perimeter within approximately 10 m of the structure will be paved with asphalt. The pavement structure consists of 90 mm of Superpave asphalt and 150 mm of OPSS 1010 Granular A base. Design details are provided in our pavement design memorandum dated July 22, 2008.

12.4 SPECIAL REQUIREMENTS

No special requirements are noted for this site.

13.0 CLOSURE

This concludes the foundation investigation and design report for the proposed structure.
Please direct any questions to the undersigned.

JAGGER HIMS LIMITED



J. Stephen Ash, P. Eng.
Branch Manager



Stuart E. Baird, P. Eng.
Project Engineer

APPENDIX

**BOREHOLE LOGS
GRAIN SIZE ANALYSES
ATTERBERG LIMIT RESULTS**

BOREHOLE LOG EXPLANATION FORM

This explanatory section provides the background to assist in the use of the borehole logs. Each of the headings used on the borehole log, is briefly explained.

DEPTH

This column gives the depth of interpreted geologic contacts in metres below ground surface.

STRATIGRAPHIC DESCRIPTION

This column gives a description of the soil based on a tactile examination of the samples and/or laboratory test results. Each stratum is described according to the following classification and terminology.

<u>Soil Classification *</u>		<u>Terminology</u>	<u>Proportion</u>
Clay	<0.002 mm		
Silt	0.002 to 0.06 mm	"trace" (eg. trace sand)	<10%
Sand	0.06 to 2 mm	"some" (eg. some sand)	10% - 20%
Gravel	2 to 60 mm	adjective (eg. sandy)	20% - 35%
Cobbles	60 to 200 mm	"and" (eg. and sand)	35% - 50%
Boulders	>200 mm	noun (eg. sand)	>50%

* Extension of MIT Classification system unless otherwise noted.

The use of the geologic term "till" implies that both disseminated coarser grained (sand, gravel, cobbles or boulders) particles and finer grained (silt and clay) particles may occur within the described matrix.

The compactness of cohesionless soils and the consistency of cohesive soils are defined by the following:

<u>COHESIONLESS SOIL</u>		<u>COHESIVE SOIL</u>	
Compactness	Standard Penetration Resistance "N", Blows / 0.3 m	Consistency	Standard Penetration Resistance "N", Blows / 0.3 m
Very Loose	0 to 4	Very Soft	0 to 2
Loose	4 to 10	Soft	2 to 4
Compact	10 to 30	Firm	4 to 8
Dense	30 to 50	Stiff	8 to 15
Very Dense	Over 50	Very Stiff	15 to 30
		Hard	Over 30

The moisture conditions of cohesionless and cohesive soils are defined as follows.









<u>COHESIONLESS SOILS</u>		<u>COHESIVE SOILS</u>	
Dry		DTPL	- Drier Than Plastic Limit
Moist		APL	- About Plastic Limit
Wet		WTPL	- Wetter Than Plastic Limit
Saturated		MWTPL	- Much Wetter Than Plastic Limit

STRATIGRAPHY

Symbols may be used to pictorially identify the interpreted stratigraphy of the soil and rock strata.

MONITOR DETAILS

This column shows the position and designation of standpipe and/or piezometer ground water monitors installed in the borehole. Also the water level may be shown for the date indicated.

	Standpipe and Designation		Cement Seal
	Piezometer and Designation		Granular Pack
	Gas Monitor and Designation		Granular Backfill
	Borehole Seal (Peltonite, Bentonite or Hole Plug)		Native Soil Backfill/Cave

Where monitors are placed in separate boreholes, these are shown individually in the "Monitor Details" column. Otherwise, monitors are in the same borehole. For further data regarding seals, screens, etc., the reader is referred to the summary of monitor details table.

SAMPLE

These columns describe the sample type and number, the "N" value, the water content, the percentage recovery, and Rock Quality Designation (RQD), of each sample obtained from the borehole where applicable. The information is recorded at the approximate depth at which the sample was obtained. The legend for sample type is explained below.

SS = Split Spoon	GS = Grab Sample
ST = Thin Walled Shelby Tube	CS = Channel Sample
AS = Auger Flight Sample	WS = Wash Sample
CC = Continuous Core	RC = Rock Core

$$\% \text{ Recovery} = \frac{\text{Length of Core Recovered Per Run}}{\text{Total Length of Run}} \times 100$$

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of core recovered, counting only those pieces of sound core that are 100 mm or more in length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

<u>RQD Classification</u>	<u>RQD (%)</u>
Very poor quality	< 25
Poor quality	25 - 50
Fair quality	50 - 75
Good quality	75 - 90
Excellent quality	90 - 100

TEST DATA

The central section of the log provides graphs which are used to plot selected field and laboratory test results at the depth at which they were carried out. The plotting scales are shown at the head of the column.

Dynamic Penetration Resistance - The number of blows required to advance a 51 mm diameter, 60° steel cone fitted to the end of 45 mm OD drill rods, 0.3 m into the subsoil. The cone is driven with a 63.5 kg hammer over a fall of 750 mm.

Standard Penetration Resistance - Standard Penetration Test (SPT) "N" Value - The number of blows required to advance a 51 mm diameter standard split-spoon sampler 300 mm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 750 mm. In cases where the split spoon does not penetrate 300 mm, the number of blows over the distance of actual penetration in millimetres is shown as $\frac{x \text{ Blows}}{\text{mm}}$

Water Content - The ratio of the mass of water to the mass of oven-dry solids in the soil expressed as a percentage.

W_P - Plastic Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

W_L - Liquid Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

REMARKS

The last column describes pertinent drilling details, field observations and/or provides an indication of other field or laboratory tests that were performed.

BOREHOLE NO. 1

PAGE 1 of 1

PROJECT NAME: FERONIA PATROL YARD

PROJECT NO.: 3080770.03

CLIENT: MINISTRY OF TRANSPORTATION

DATE COMPLETED: Jun. 19, 2008

BOREHOLE TYPE: 110 mm I.D HSA / 51 mm O.D SPLIT SPOON

SUPERVISOR: DCL

GROUND ELEVATION: 282.45 m (Relative datum)

REVIEWER: JSA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE					CONE PENETRATION "N" VALUE 10 20 30 SHEAR STRENGTH	WATER CONTENT % 10 20 30 W _p W _L	REMARKS
				TYPE	N VALUE	% WATER	% RECOVERY	ROD (%)			
0.0	ASPHALT (75mm)										ELEVATIONS ARE RELATIVE TO THE FINISHED FLOOR ELEVATION OF THE EXISTING GARAGE (282.56 m) N 46.3682 W 79.3060 WATER IN OPEN HOLE AT 0.61 m DEPTH ON COMPLETION BOREHOLE CAVED AT 2.44 m DEPTH ON COMPLETION GSA SS1&2 40% GRAVEL 26% SAND 11% SILT 3% CLAY LSFH GSA SS3&4 6% SAND 70% SILT 24% CLAY HSFH
0.1	SANDY GRAVEL: BROWN SANDY GRAVEL, SOME SILT, TRACE COBBLES, MOIST, COMPACT			SS1	10	6	38				
0.9	CLAYEY SILT: GREY CLAYEY SILT, TRACE SAND, WOOD FIBRES AT 1m DEPTH, RED CLAY NODULES BELOW 2 m DEPTH, MOIST TO SATURATED BELOW 2.7 m, VERY STIFF TO STIFF			SS2	12	28	38				
2.0				SS3	9	33	50				
3.0				SS4	8	30	58				
3.4	SAND: GREY FINE SAND, SOME GRAVEL, TRACE SILT, TRACE COBBLES, WET, DENSE			SS5	3		83				
4.0											
5.0				SS6	31		71				
5.5	SAND: BROWN GRAVELLY SAND, TRACE SILT, SATURATED, COMPACT TO DENSE			SS7	29		50				
7.0											
7.7	BEDROCK: GREY, BLACK SPECKLED MICRODIORITE, FINE TO MEDIUM GRAINED (0.5 mm TO 2 mm), FOLIATION OF MAFIC MINERALS (HORNBLENDE) AT 30 DEGREES TO VERTICAL AXIS, UNIFORM APPEARANCE, STRONG, HARD			SS8	49		50			49	
8.0				RC10				87			
9.0											
10.0				RC11							
10.7	BOREHOLE TERMINATED AT 10.7 m IN GRANITE BEDROCK										
11.0											
12.0											
13.0											

BOREHOLE NO. 2

PAGE 1 of 1

PROJECT NAME: FERONIA PATROL YARD

PROJECT NO.: 3080770.03

CLIENT: MINISTRY OF TRANSPORTATION

DATE COMPLETED: Jun. 20, 2008

BOREHOLE TYPE: 110 mm I.D HSA / 51 mm O.D SPLIT SPOON

SUPERVISOR: DCL

GROUND ELEVATION: 282.45 m (Relative datum)

REVIEWER: JSA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE					CONE PENETRATION "N" VALUE 10 20 30 SHEAR STRENGTH	WATER CONTENT % 10 20 30 W _p W _L	REMARKS
				TYPE	N VALUE	% WATER	% RECOVERY	RQD (%)			
0.0											
0.3	SAND: BROWN FINE SAND, SOME GRAVEL, MOIST, COMPACT			SS1	12		67				ELEVATIONS ARE RELATIVE TO THE FINISHED FLOOR ELEVATION OF THE EXISTING GARAGE (282.56 m) N 46.3583 W 79.3059 WATER IN OPEN HOLE AT 0.61 m DEPTH ON COMPLETION GSA SS2&3 37% GRAVEL 60% SAND 12% SILT 1% CLAY LSFH
0.4	SANDY SILT: GREY BROWN SANDY SILT, MOIST, COMPACT										
1.0	SAND: BROWN SAND TO GRAVELLY SAND, TRACE TO SOME SILT, TRACE FRACTURED COBBLES, MOIST TO SATURATED, DENSE TO COMPACT			SS2	40	8	46				
2.0				SS3	24	12	42				
2.2	SAND: BROWN FINE SAND, TRACE SILT, SATURATED, DENSE TO COMPACT			SS4	30		25				
3.0				SS5	16		46				
4.0											
4.9	BOREHOLE TERMINATED AT 4.9 m ON PRESUMED BEDROCK			SS6	100		46			100	
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											

JHL GEOLOGIC BW (METRIC) WITH DYNAMIC CONE PENETRATION 3080770.03 GPJ JAGGER HIMS BASIC.GDT 9/16/08

BOREHOLE NO. 3

PAGE 1 of 1

PROJECT NAME: FERONIA PATROL YARD

PROJECT NO.: 3080770.03

CLIENT: MINISTRY OF TRANSPORTATION

DATE COMPLETED: Jun. 20, 2008

BOREHOLE TYPE: 110 mm I.D HSA / 51 mm O.D SPLIT SPOON

SUPERVISOR: DCL

GROUND ELEVATION: 282.49 m (Relative datum)

REVIEWER: JSA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE					CONE PENETRATION "N" VALUE 10 20 30 SHEAR STRENGTH	WATER CONTENT % 10 20 30 W _p W _L	REMARKS
				TYPE	N VALUE	% WATER	% RECOVERY	ROD (%)			
0.0	SANDY GRAVEL: BROWN SANDY GRAVEL, SOME SILT, TRACE ASPHALT DEBRIS, MOIST, DENSE			SS1	28		46				ELEVATIONS ARE RELATIVE TO THE FINISHED FLOOR ELEVATION OF THE EXISTING GARAGE (282.56 m) N 46.3682 W 79.3059 WATER IN OPEN HOLE AT 0.76 m DEPTH ON COMPLETION GSA SS2 2% SAND 75% SILT 23% CLAY MSFH
0.7	CLAYEY SILT: GREY CLAYEY SILT, OCCASIONAL FINE TO MEDIUM SAND SEAMS, WET, FIRM			SS2	3	36	79				
1.0				SS3	3		100				
2.0				SS4	26		63				
2.2	SANDY SILT: BROWN SANDY SILT, SOME WEATHERED COBBLES, SATURATED, COMPACT			SS5	40	14	46				
2.9	SAND: REDDISH BROWN FINE TO MEDIUM SAND AND WEATHERED COBBLES, SATURATED, DENSE										
4.0											
4.3	BOREHOLE TERMINATED AT 4.3 m ON PRESUMED BEDROCK										
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											

JHL GEOLOGIC B/W (METRIC) WITH DYNAMIC CONE PENETRATION 3080770.03.GPJ JAGGER HIMMS BASIC.GDT 9/16/08

BOREHOLE NO. 4

PAGE 1 of 1

PROJECT NAME: FERONIA PATROL YARD

PROJECT NO.: 3080770.03

CLIENT: MINISTRY OF TRANSPORTATION

DATE COMPLETED: Jun. 20, 2008

BOREHOLE TYPE: 110 mm I.D HSA / 51 mm O.D SPLIT SPOON

SUPERVISOR: DCL

GROUND ELEVATION: 282.42 m (Relative datum)

REVIEWER: JSA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE					CONE PENETRATION "N" VALUE 10 20 30 SHEAR STRENGTH	WATER CONTENT % 10 20 30 W _p W _L	REMARKS
				TYPE	N VALUE	% WATER	% RECOVERY	ROD (%)			
0.0											
0.1	ASPHALT (100 mm)										ELEVATIONS ARE RELATIVE TO THE FINISHED FLOOR ELEVATION OF THE EXISTING GARAGE (282.58 m) N 46.3681 W 79.3056 WATER IN OPEN HOLE AT 2.5 m DEPTH ON COMPLETION GSA SS3 2% SAND 73% SILT 25% CLAY MSFH GSA SS5 6% SAND 80% SILT 14% CLAY HSPH
0.3	SAND: BROWN FINE SAND, SOME SILT, SOME GRAVEL, MOIST, COMPACT			SS1	22	8	54				
1.0	SILT: GREY SILT, MOIST, LOOSE TO COMPACT			SS2	10		38				
1.4	CLAYEY SILT: GREY CLAYEY SILT TO SILT SOME CLAY, TRACE SAND, TRACE RED CLAY SEAMS, WET, FIRM			SS3	3	34	100				
2.0				SS4	3		92				
2.9	SILT: GREY SILT, TRACE TO SOME CLAY, TRACE FINE SAND SEAMS, WET, VERY LOOSE			SS5	2	26	100				
4.0											
4.1	SAND: GREY SAND, SOME GRAVEL, TRACE SILT, SATURATED, COMPACT TO DENSE			SS6	30		46				
5.0											
5.8	BOREHOLE TERMINATED AT 5.8 m ON PRESUMED BEDROCK										
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											

JHL GEOLOGIC BAY (METRIC) WITH DYNAMIC CONE PENETRATION 3080770.03.GPJ JAGGER HIMES BASIC.GDT 9/16/08

BOREHOLE NO. 5

PAGE 1 of 1

PROJECT NAME: FERONIA PATROL YARD

PROJECT NO.: 3080770.03

CLIENT: MINISTRY OF TRANSPORTATION

DATE COMPLETED: Jun. 21, 2008

BOREHOLE TYPE: 110 mm I.D HSA / 51 mm O.D SPLIT SPOON

SUPERVISOR: DCL

GROUND ELEVATION: 282.60 m (Relative datum)

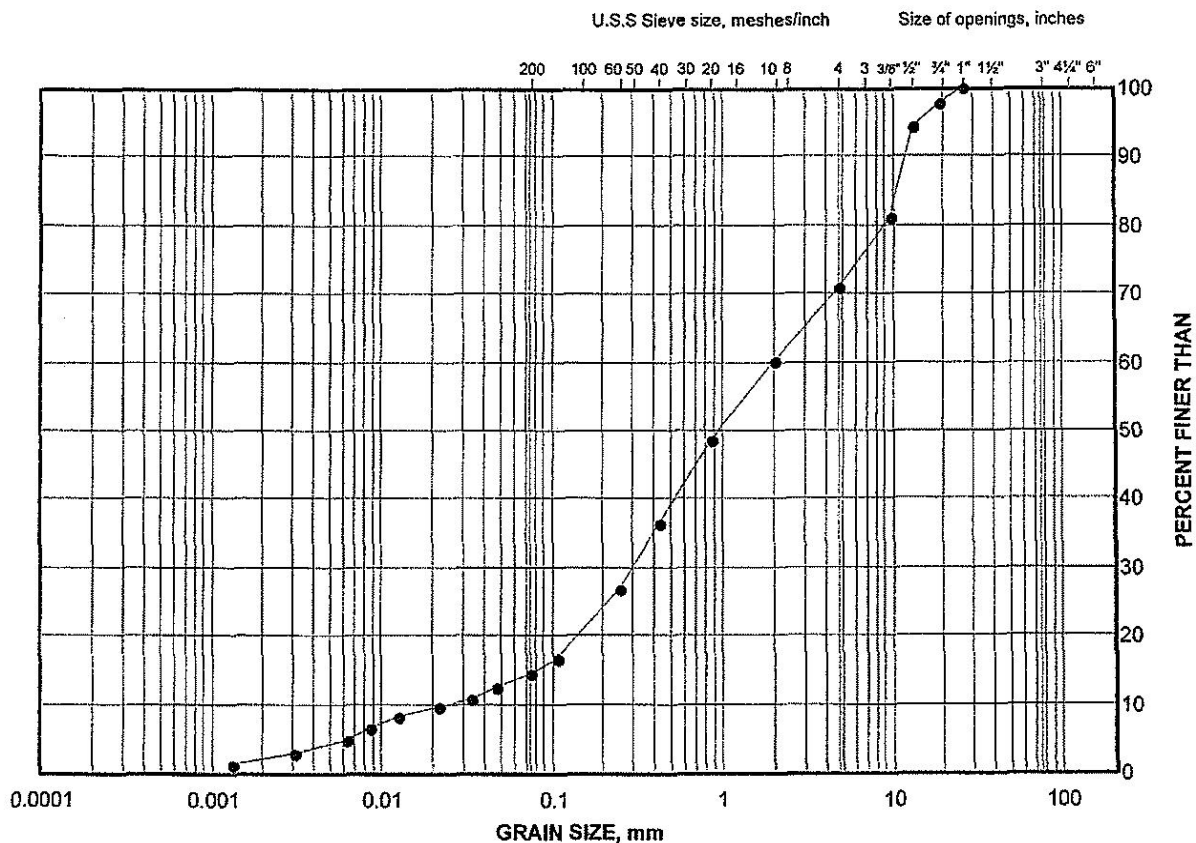
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DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE					CONE PENETRATION "N" VALUE 10 20 30 SHEAR STRENGTH	WATER CONTENT % 10 20 30 W _p W _L	REMARKS
				TYPE	N VALUE	% WATER	% RECOVERY	ROD (%)			
0.0	ASPHALT (75mm)										ELEVATIONS ARE RELATIVE TO THE FINISHED FLOOR ELEVATION OF THE EXISTING GARAGE (282.56 m) N 46.3879 W 79.3060 GSA SS1 15% GRAVEL 78% SAND 6% SILT LSFH GSA SS3 1% SAND 68% SILT 31% CLAY MSFH WATER IN OPEN HOLE AT 2.7 m DEPTH ON COMPLETION
0.1	GRAVELLY SAND; BROWN GRAVELLY SAND, TRACE SILT, MOIST, COMPACT			SS1	9	7	50				
0.7	SILT TO CLAYEY SILT; GREY SILT TRACE CLAY TO CLAYEY SILT, TRACE SAND, MOIST/APL, COMPACT TO LOOSE OR VERY STIFF TO FIRM			SS2	16		50				
1.0				SS3	7	32	92				
2.0				SS4	4		83				
3.0	SILT; GREY SILT, SOME SAND, WET, LOOSE			SS5	4		4				
4.0	SAND; GREY FINE SAND, SOME TO TRACE GRAVEL, TRACE TO SOME SILT, TRACE TO SOME FRACTURED COBBLES, SATURATED, COMPACT			SS6	20	13	50				
5.0											BOREHOLE TERMINATED AT 6.1 m ON PRESUMED BEDROCK
6.0				SS7	100		8			100	
6.1											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											

JHL GEOLOGIC B/W (METRIC) WITH DYNAMIC CONE PENETRATION 3080770.03.GPJ JAGGER HIMS BASIC.GDT 9/16/08

GRAIN SIZE DISTRIBUTION

FIGURE



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	1	1 & 2	0.00 -0.90

REMARKS
3080770.03

Project Number: 08-1116-0015

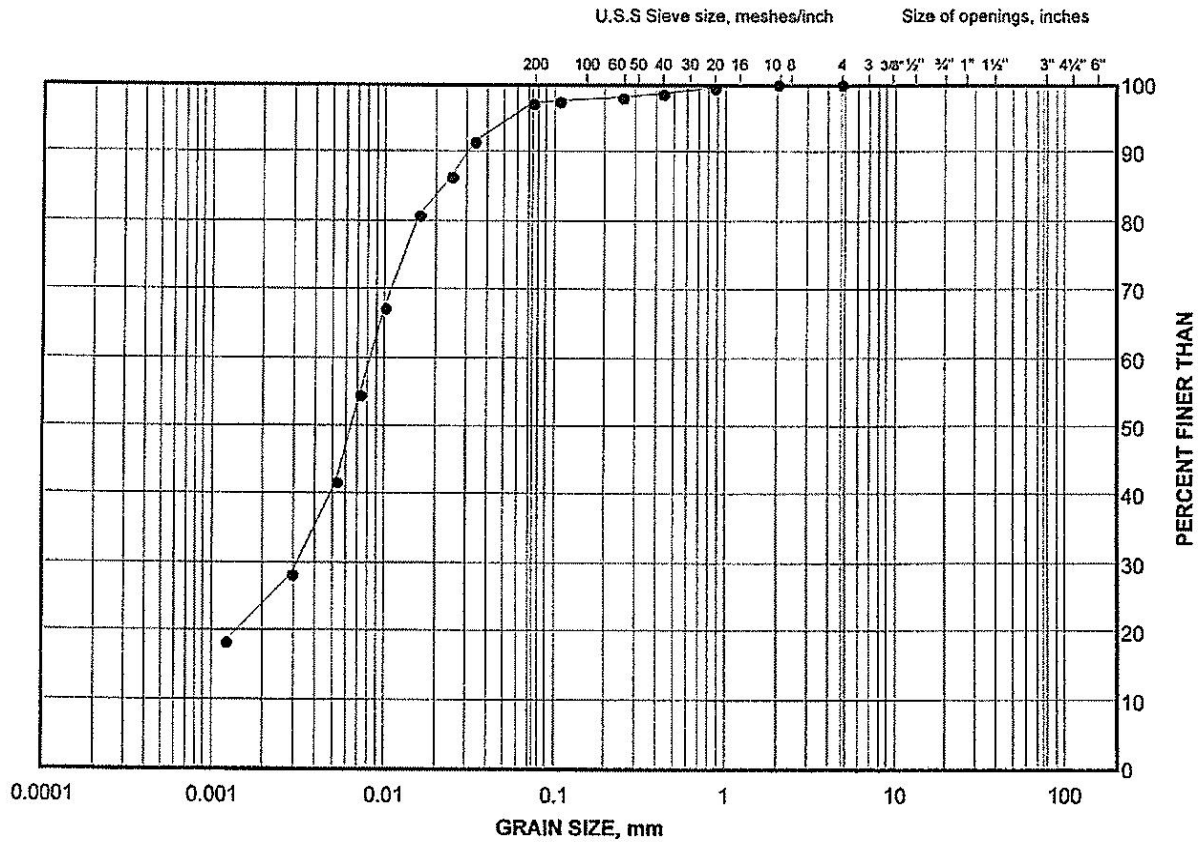
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Golder Associates

Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	1	3 & 4	1.50 - 2.90

REMARKS
3080770.03

Project Number: 08-1116-0015

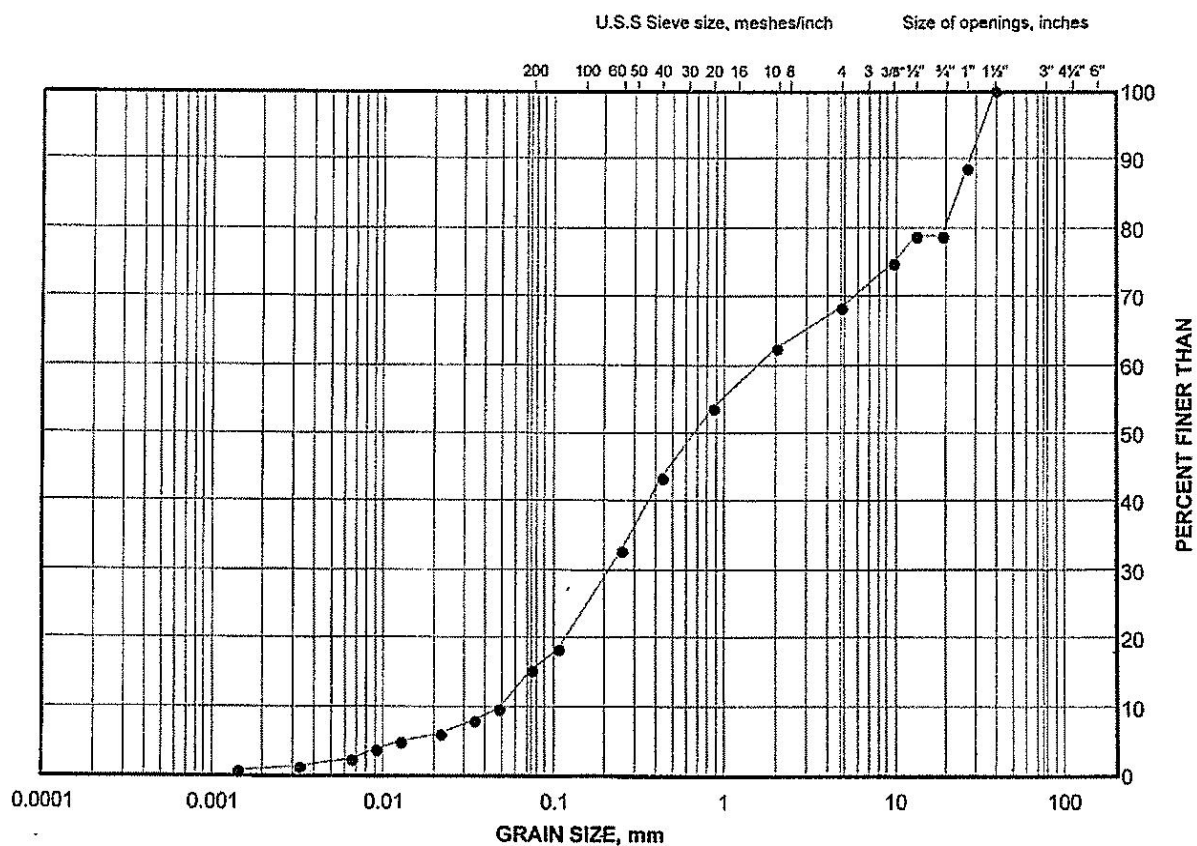
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Golder Associates

Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	2	2 & 3	0.80 - 2.10

REMARKS
3080770.03

Project Number: 08-1116-0015

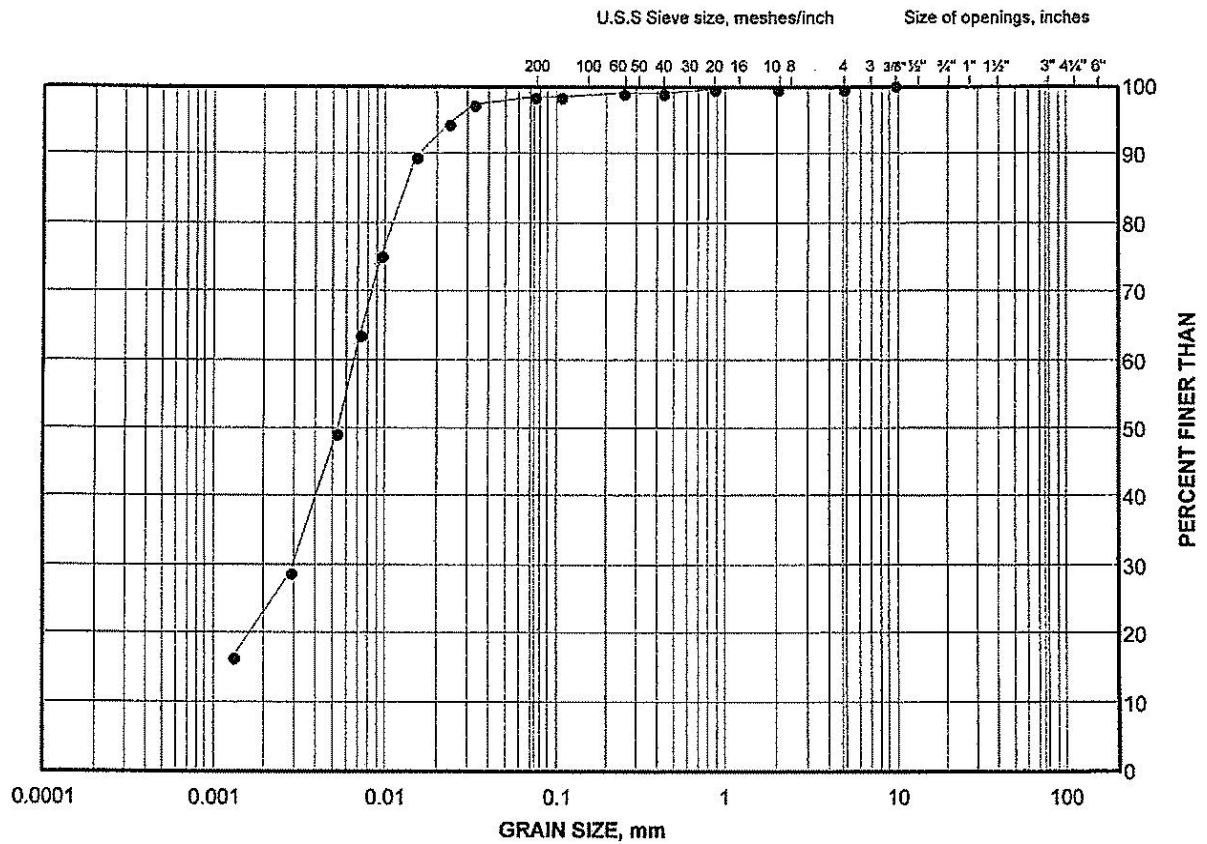
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Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	3	2	0.80 - 1.40

REMARKS
3080770.03

Project Number: 08-1116-0015

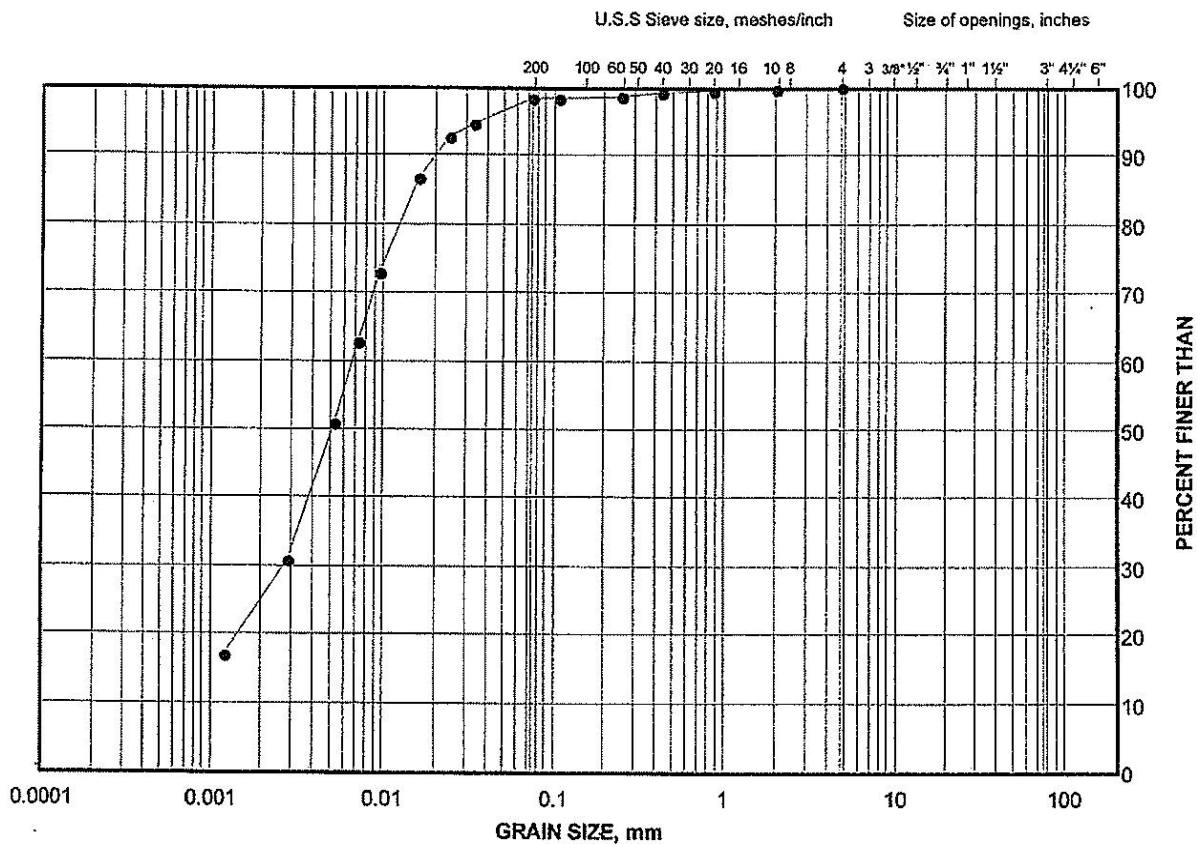
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GRAIN SIZE DISTRIBUTION

FIGURE



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	4	3	1.50 - 2.10

REMARKS
3080770.03

Project Number: 08-1116-0015

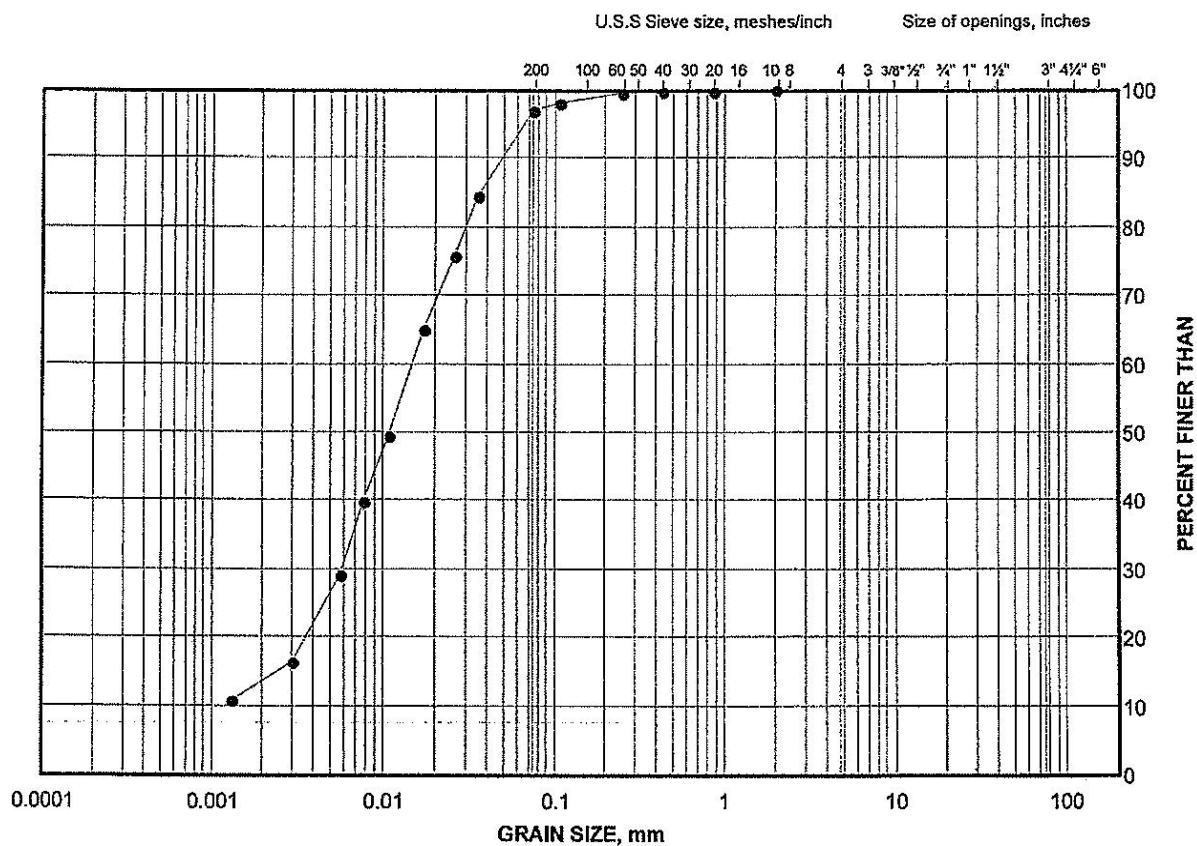
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Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	4	5	3.10 - 3.70

REMARKS
3080770.03

Project Number: 08-1116-0015

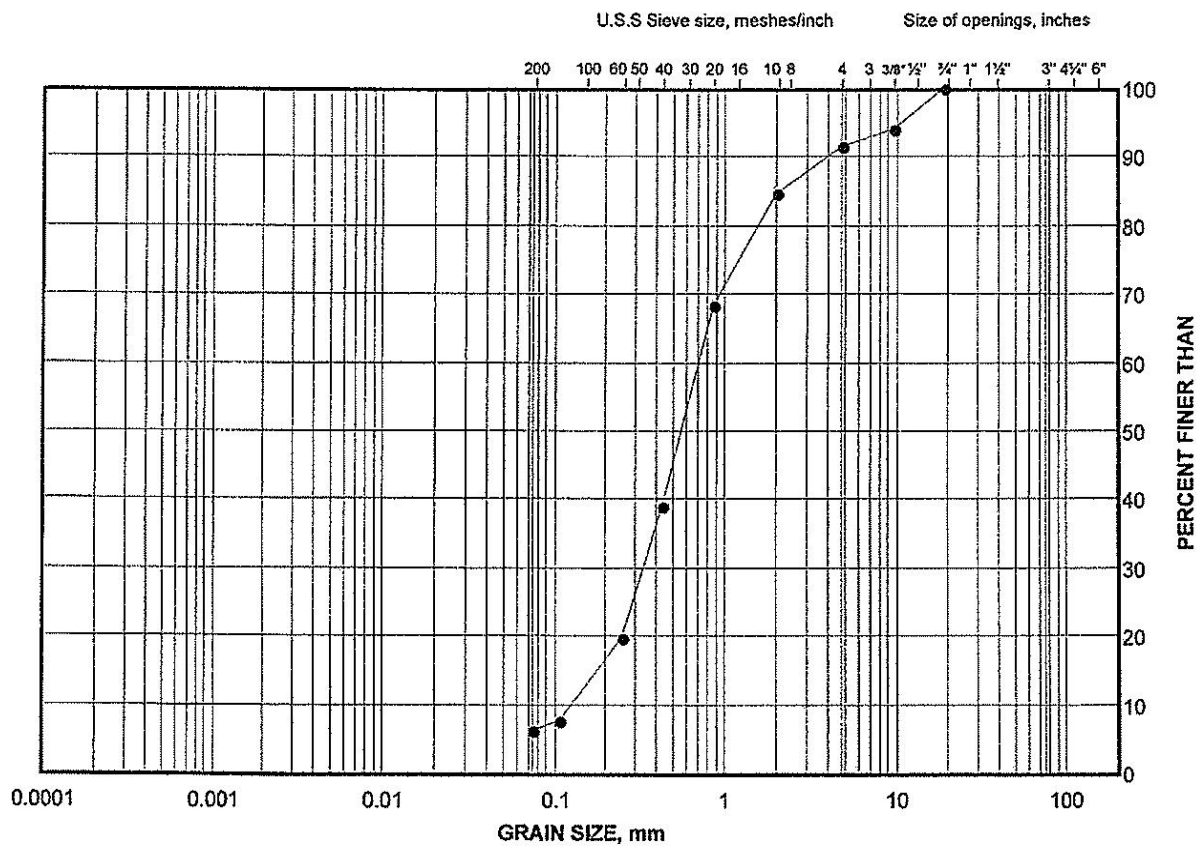
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Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	5	1	0.00 - 0.60

REMARKS
3080770.03

Project Number: 08-1116-0015

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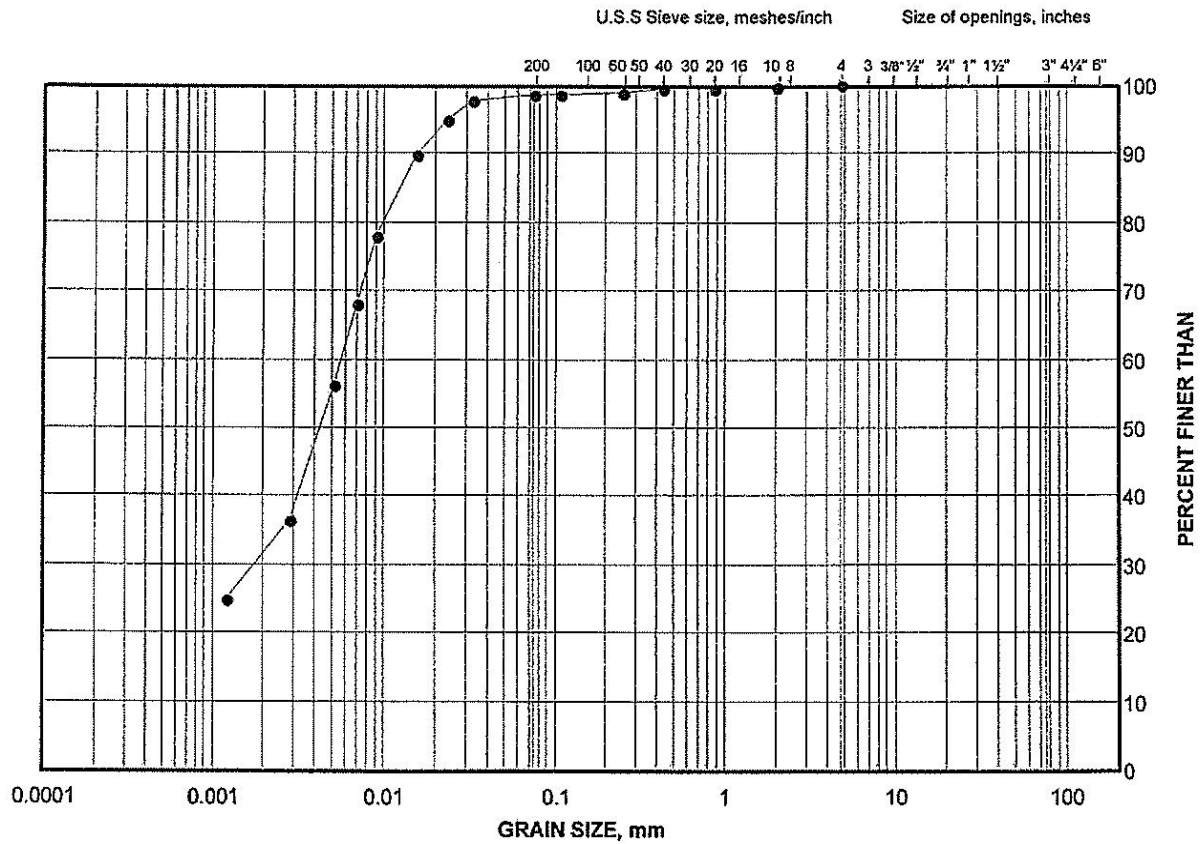
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Date: 09-Jul-08

GRAIN SIZE DISTRIBUTION

FIGURE




LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	5	3	1.50 - 2.10

REMARKS
3080770.03

Project Number: 08-1116-0015

Checked By: 

Golder Associates

Date: 09-Jul-08

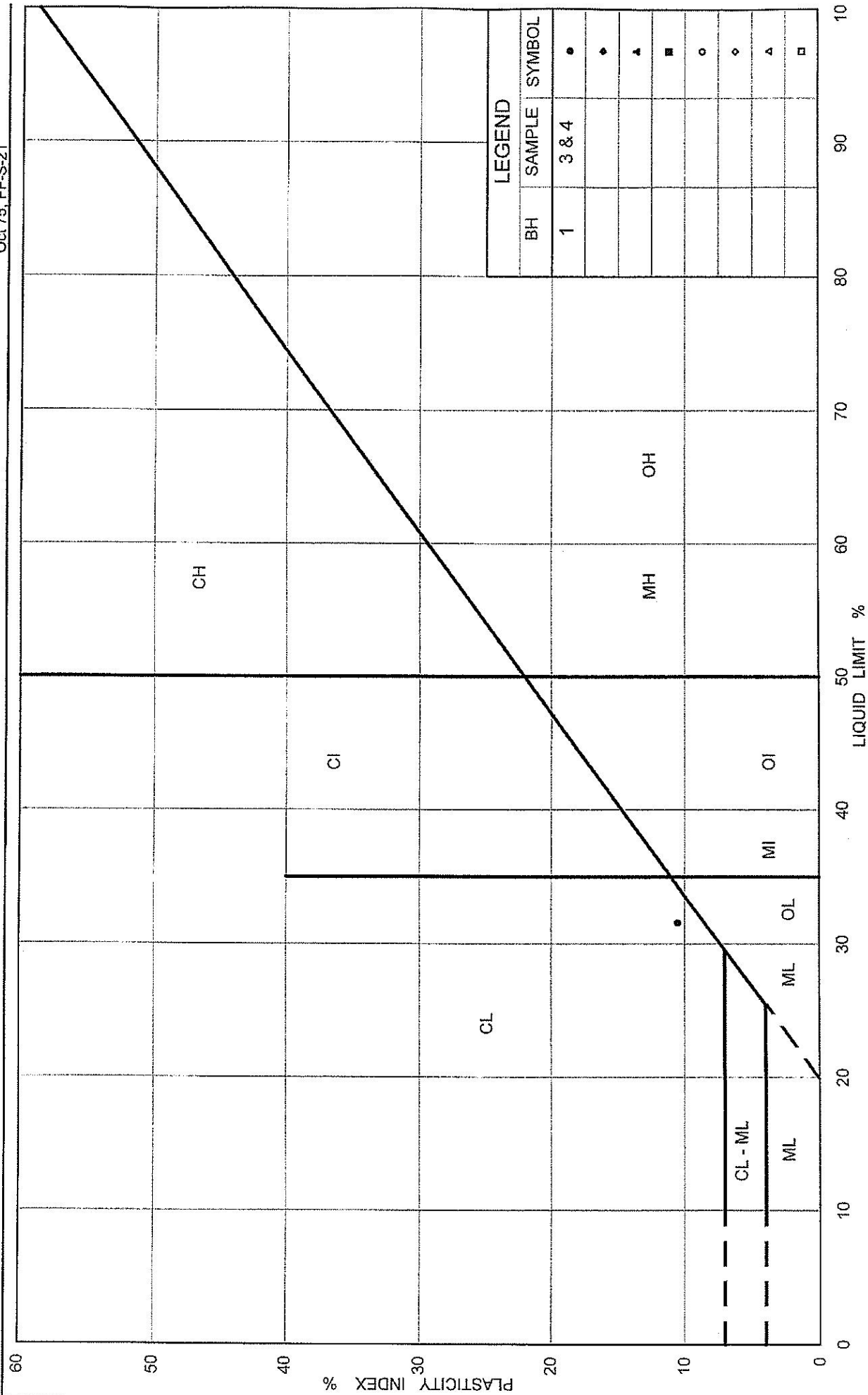
TABLE 1

SUMMARY OF ATTERBERG DETERMINATIONS

ASTM D 4318-05

PROJECT NUMBER	08-1116-0015
PROJECT NAME	Jagger Hims / Lab Testing / 3080770.03
DATE TESTED	July, 2008

Borehole No.	Sample No.	Depth (ft)	Depth (m)	Atterberg Limits LL, PL, PI
1	3 & 4	5.0-9.5	1.52-2.90	LL=31.6, PL=21.1, PI=10.5



PLASTICITY CHART

Ministry of Transportation



Ontario

Figure No.

Project No. 08-1116-0015

Checked By: *[Signature]*