A REPORT TO
MILLFORD DEVELOPMENT LIMITED

A SOIL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

NORTHEAST OF YONGE STREET AND EAGLE STREET

TOWN OF NEWMARKET

Reference No. 0409-S004

OCTOBER 2004

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1.0 INTRODUCTION

In accordance with a letter of authorization dated August 31, 2004, from Mr. Enza Orsi, President of Millford Development Limited, a soil investigation was carried out at a property which is located northeast of Yonge Street and Eagle Street, Town of Newmarket, for a proposed Residential Development.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of the proposed project.

The findings and resulting geotechnical recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The Town of Newmarket is situated on Schomberg Lake (glacial) plain where drift has been partly eroded and filled, in places, with lacustrine clay, silt and sand.

The subject property is located on the north side of Eagle Street, just east of Yonge Street.

The site is currently an open field covered with bush and weeds. The ground surface of the tableland is relatively flat, descending gently towards the northeast to the valley bordering the northern developmental limits of the site. The bank height varies from 2.5± to 8.5± m and slopes down to the flat flood plain that contains the Western Creek, a tributary of the East Holland River. The adjacent lands are existing residential and commercial developments.

The proposed project consists of a 10-storey condominium apartment building, with 2 levels of underground parking and on-grade paved parking facilities, 51 townhouses and on-site stormwater management facilities. The project will be provided with municipal services and access roadways.

3.0 FIELD WORK

The field work, consisting of 12 boreholes to depths ranging from 4.9 to 12.7 m, was performed on September 21 and 22, 2004, at the locations shown on the Borehole Location Plan and Subsurface Profile, Drawing No. 1.

The holes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration tests, using the procedures described on the enclosed "List of Abbreviations and Terms", were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or 'N' values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the 'N' values. Split-spoon samples were recovered for soil classification and laboratory testing.

The field work was supervised and the findings recorded by a Senior Geotechnical Technician.

The elevation at each of the borehole locations was interpolated from the contours on the Topographic Survey of Part of Lots 2 and 3, Registered Plan 49, dated February 25, 2003, prepared by Young and Young Surveying Inc.

4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 12, inclusive. The revealed stratigraphy is plotted on the subsurface profile on Drawing No. 1, and the engineering properties of the disclosed soils are discussed herein.

Beneath a topsoil or topsoil fill veneer or topsoil and earth fill layers, the site is underlain predominantly by strata of sandy silt till and silty clay. In places, strata of silty sand till, fine to coarse sand, silt, sandy silt and silty clay till were encountered. An isolated layer of charcoal remains was found beneath the earth fill in the upper soil stratigraphy during sampling in 1 borehole. A second topsoil layer was found beneath the earth fill in 3 of the investigated boreholes.

4.1 Topsoil and Topsoil Fill (All Boreholes)

The revealed surficial topsoil and topsoil fill layer range in thickness from 15 to 70 cm, and a second layer of topsoil, 30 cm, 70 cm and 80 cm thick, was found underlying the earth fill in Boreholes 7, 11 and 12. The topsoil and topsoil fill are dark brown in colour, indicating that they contain appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil and topsoil fill are considered to be void of engineering values, but can be used for general landscaping purposes. Due to their humus content, they may produce volatile gases and will generate an offensive odour under anaerobic conditions. Therefore, the topsoil and topsoil fill must not be buried within the building envelopes, or deeper than 1.0 m below the exterior finished grade. This is to avoid an adverse impact on the environmental well-being of the developed areas.

As shown by the borehole findings, the topsoil and topsoil fill vary in thickness. This renders it difficult to estimate the quantity of topsoil and topsoil fill to be stripped. Diligent control of the stripping operation will be required to prevent overstripping.

4.2 **Charcoal Remains** (Borehole 4)

A layer of charcoal remains, 60 cm thick, was encountered in Borehole 4 beneath the earth fill. The charcoal is black in colour and consists of burnt organic fibrous plant material. The high water content indicates that the remains are highly compressible with very low shear strength. The organic material will likely generate volatile gases under anaerobic conditions. It is void of engineering value and must be excavated and disposed of.

4.3 **Earth Fill** (Boreholes 6, 7, 11 and 12)

The earth fill underlies the topsoil layer and measures 2.1± to 3.4± m in thickness and it is amorphous. It consists mainly of silty clay and some silty sand with variable amounts of roots and topsoil inclusions.

The obtained 'N' values range from 6 to 32, with a median of 12 blows per 30 cm of penetration, showing that the fill was loosely placed, non-uniformly compacted and has since self-consolidated.

The natural water content values of the earth fill range from 11% to 21%, with a median of 18%, showing that the fill is in a very moist to wet condition, being generally wet. The high water content is likely due to the presence of topsoil inclusions in the fill.

A grain size analysis was performed on a representative sample of the earth fill. The result is plotted on Figure 13.

One must be aware that the samples retrieved from boreholes 10 cm in diameter may not be truly representative of the geotechnical and environmental quality of the fill, and do not indicate whether the topsoil beneath the earth fill was completely stripped. This should be further assessed by laboratory testing and/or test pits.

4.4 **Sandy Silt Till and Silty Sand Till** (All Boreholes except Boreholes 7, 8 and 12)

The sandy silt till dominates the stratigraphy of the site with occasional layers of silty sand till. It consists of a random mixture of particle sizes ranging from clay to gravel, with silt and sand being the predominant fractions. The material is heterogeneous in structure, showing that it is a glacial till deposit. The tills contain occasional sand and silt seams and lenses.

The obtained 'N' values of the tills range from 14 to 100+, with a median of 100+, indicating that the relative density of the tills is compact to very dense, being generally very dense.

The water content values of the till samples were determined and the results are plotted on the Borehole Logs. The values range from 4% to 15%, with a median of 8%, showing that the tills are damp to very moist, being generally moist.

Grain size analyses were performed on 4 representative samples of the sandy silt till and 1 representative sample of the silty sand till. The results are plotted on Figures 14 and 15, respectively.

According to the above findings, the deduced soil engineering properties pertaining to the project are the following:

- High frost susceptibility and moderate water erodibility.
- Relatively low to medium permeability, with an estimated coefficient of permeability of 10^{-4} to 10^{-6}cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.07 to 0.15
2% - 6%	0.12 to 0.20
6% +	0.18 to 0.28

- Frictional soils, their shear strength is primarily derived from internal friction and is augmented by cementation. Therefore, their strength is primarily soil-density dependent.
- They will be stable in steep cuts; however, under prolonged exposure, local sheet collapse will likely occur.
- Fair pavement-supportive materials, with an estimated California Bearing Ratio (CBR) value of 8% to 10%.
- Moderate to moderately low corrosivity to buried metal, with an estimated electrical resistivity of 4,500 to 5,000 ohm/cm.

4.5 <u>Silty Clay</u> (Boreholes 3, 5, 7, 8, 9 and 12)

The silty clay was encountered beneath the topsoil and original topsoil layers and has a varved structure that indicates that the silty clay is a lacustrine deposit. The clay contains traces of sand and gravel.

The obtained 'N' values range from 12 to 100+, with a median of 19, showing that the consistency of the clay is stiff to hard, being generally very stiff. The hard clay with the 'N' value of 100+ occurs at a depth of 0.8± m in Borehole 3.

The Atterberg Limits of 2 representative samples and the natural water content values of all the samples were determined; the results are plotted on the Borehole Logs and summarized below:

Liquid Limit	26.9% and 28.2%
Plastic Limit	16.8% and 18.0%
Natural Water Content	14% to 26% (median 18%)

The above results show that the clay is a cohesive material with low plasticity. The natural water content generally lies close to its plastic limit, confirming the very stiff consistency of the clay.

Grain size analyses were performed on 2 representative samples of the silty clay. The results are plotted on Figure 16.

According to the above findings, the following engineering properties are deduced:

- High frost susceptibility and high soil-adfreezing potential.
- Low water erodibility.

- Low permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A cohesive soil, its shear strength is derived from its consistency, thus being directly dependent upon the soil moisture.
- In excavations, the clay will generally be stable in a relatively steep cut; however, prolonged exposure may lead to localized sloughing.
- A poor material to support pavement, with an estimated CBR value of 3% or less.
- Moderately high corrosivity to buried metal, with an estimated electrical resistivity of 3,500 ohm/cm.

4.6 **Silty Clay Till** (Boreholes 7 and 11)

The clay till is heterogeneous and amorphous in structure, indicating that it is a glacial deposit. In one location, the clay till was embedded in the silty clay stratum. It contains some sand to being sandy and a trace to some gravel.

Hard resistance to augering was encountered, indicating that occasional cobbles and boulders are embedded in the till.

The obtained 'N' values range from 14 to 100+, with a median of 26, indicating that the consistency of the till is stiff to hard, being generally very stiff. The hard clay till with the 'N' values of 100+ occur at a depth of 7.6± m in Borehole 11 and was likely the result of obstruction from the presence of cobbles and boulders.

The Atterberg Limits of a representative sample and the water content values of all the samples were determined. The results are plotted on the Borehole Logs and summarized below:

Liquid Limit	28.2%
Plastic Limit	17.7%
Natural Water Content	9% to 16% (median 12%)

The above results show that the till is a cohesive material with low plasticity. The natural water content lies below its plastic limit, confirming the consistency of the till as disclosed by the 'N' values.

A grain size analysis was performed on a representative sample; the result is plotted on Figure 17.

According to the above findings, the soil engineering properties pertaining to the project are given below:

- Moderate frost susceptibility and water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec, and runoff coefficients of:

Slope

0% - 2%	0.15
2% - 6%	0.20
6%+	0.28

- A cohesive-frictional soil, its shear strength is primarily derived from consistency which is inversely related to its moisture content. It contains sand; therefore, its shear strength is augmented by internal friction.
- The till will be stable in relatively steep cuts; however, prolonged exposure will allow infiltrating precipitation to saturate the soil fissures, and this may lead to localized sloughing.
- A poor material to support pavement, with an estimated CBR value of 3%.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 4,000 ohm/cm.

4.7 **Sandy Silt** (Borehole 5) and **Silt** (Borehole 12)

The silt deposits were encountered below the silty clay layers at depths of 2.1 m and 3.0 m below the ground surface. The silt contains some clay and traces of sand and gravel while the sandy silt contains traces of clay and occasional silt seams.

The obtained 'N' value of the sandy silt is 11; for the silt, the values are 28 and 45. These values indicate that the relative density of the sandy silt is generally compact, and that of the silt is compact to dense.

The natural water content values of the samples were determined, and the results are plotted on the Borehole Logs. The water content value of the sandy silt was 13%, showing that it is generally very moist. The water content values of the silt are 17% and 20%, showing that the silt is in a wet condition.

A grain size analysis was performed on a representative sample of the silt; the result is plotted on Figure 18.

Accordingly, the following engineering properties of the soils are deduced:

- High frost susceptibility, with high soil-adfreezing potential.
- High water erodibility; susceptible to migration through small openings under low to moderate seepage pressure.
- Relatively pervious, the estimated coefficients of permeability of the silt and sandy silt are 10^{-5} cm/sec and 10^{-4} cm/sec, respectively, with runoff coefficients of:

Slope	**Sandy Silt**	**Silt**
0% - 2%	0.07	0.11
2% - 6%	0.12	0.16
6% +	0.18	0.23

- The soils have a high capillarity and water retention capability.
- Fictional soils, their shear strength is density dependent. Due to their dilatancy, the strength of the wet silts is susceptible to impact disturbance; i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction in shear strength.
- In excavation, the moist silts will be stable in relatively steep cuts, while the wet silts will slough and run slowly with seepage bleeding from the cut face. They will boil with a piezometric head of 0.3 m.

- Fair pavement-supportive materials, with estimated CBR values of 10% to 15%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5,000 ohm/cm.

4.8 **Fine to Coarse Sand** (Boreholes 2 and 3)

The sand was found in the lower stratigraphy of the site underlying the sandy silt till and silty sand till deposits at depths of 10.0 m and 11.6 m below the prevailing ground surface. It contains some silt and a trace of clay and gravel.

The obtained 'N' values of the sand are 56 and 84, indicating that the relative density of the sand is very dense.

The water content values of the sand are 10% and 16%, showing that the sand is in a very moist to wet condition. Due to the pervious nature of the sand, some of the water content may have drained during sampling; therefore, the obtained natural water content values may not represent their true values.

A grain size analysis was performed on 1 representative sample of the sand. The gradation is plotted on Figure 19.

According to the above findings, the following engineering properties are deduced:

- Low to moderate frost susceptibility and high water erodibility.

- Pervious, with an estimated coefficient of permeability of 10^{-3} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.04
2% - 6%	0.09
6% +	0.13

- A frictional soil, its shear strength is derived from internal friction and is therefore directly dependent on soil density.
- In cuts, the moist sand will be stable in a relatively steep slope and the dry sand will slough readily. It will run with water seepage and boil under a piezometric head of 0.3 m.
- A fair material to support flexible pavement, with an estimated CBR value of 20%.
- Low corrosivity to buried metal, with an estimated electrical resistivity of 6,500 ohm/cm.

4.9 <u>Compaction Characteristics of the Revealed Soils</u>

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied.

As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

Table 1 - Estimated Water Content for Compaction

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Silty Clay	14 to 26 (median 18)	18	14 to 23
Silty Clay Till	9 to 16 (median 12)	16	13 to 21
Silt	17 and 20	13	8 to 17
Sandy Silt	13	12	8 to 16
Sandy Silt Till and Silty Sand Till	4 to 15 (median 8)	11	7 to 16
Fine to Coarse Sand	10 and 16	11	5 to 16

According to the above findings, the clay, sandy silt and fine to coarse sand are generally suitable for 95% or + Standard Proctor compaction. However, the silt is excessively wet and will require aeration prior to structural compaction. Aeration of the silt should be carried out during the dry, warm weather by spreading it thinly on the ground. The overall water content of the tills lies on the dry side of the optimum and will require the addition of water for structural compaction, particularly in dry, warm weather.

The tills and clay should be compacted using a heavy-weight, kneading-type roller. The silts and sand can be compacted by a smooth roller with or without vibration, depending on the water content of the soils being compacted. The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

When compacting the very stiff to hard silty clay till or dense to very dense sandy silt till on the dry side of the optimum, the compactive energy will frequently bridge over the chunks in the soil and be transmitted laterally into the soil mantle. Therefore, the lifts of these soils must be limited to 20 cm or less (before compaction). It is difficult to monitor the lifts of backfill placed in deep trenches; therefore, it is preferable that the compaction of backfill at depths over 1.0 m below the road subgrade be carried out on the wet side of the optimum. This would allow a wider latitude of lift thickness; wetting of the tills, which are generally on the dry side of optimum, will be necessary to achieve this requirement.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for pavement construction since each component of the pavement structure is to be placed under dynamic conditions which will induce the rolling action of the subgrade surface and cause structural failure of the new pavement. The foundations or bedding of the sewer and slab-on-grade, on the other hand, will be placed on a subgrade which will not be subjected to impact loads. Therefore, the structurally compacted soil mantle with the water content on the wet side or dry side of the optimum will provide an adequate subgrade for the construction.

The presence of boulders will prevent transmission of the compactive energy into the underlying material to be compacted. If an appreciable amount of boulders over

15 cm in diameter is mixed with the material, it must either be sorted, or must not be used for construction of structural backfill.

5.0 GROUNDWATER CONDITIONS

Groundwater seepage encountered during augering was recorded on the field logs. The boreholes were checked for the presence of groundwater and the occurrence of cave-in upon their completion and the levels are plotted on the Borehole Logs. The data are summarized in Table 2.

Table 2 - Groundwater Levels

	Borehole	Soil Colour Changes Brown to Grey	Seepage Encountered During Augering		Measured Groundwater/ Cave-in* Level On Completion	
BH No.	**Depth (m)**	**Depth (m)**	**Depth (m)**	**Amount**	**Depth (m)**	**El. (m)**
1	12.3	8.2	4.6	Slight	7.3	257.2
2	12.7	11.4	5.2	Slight	5.2*	260.2
3	12.7	8.2	6.4	Slight	8.2/10.4*	258.2/256.0
4	9.3	8.2	4.6	Slight	5.2*	258.9
5	9.3	9.3 +	2.6	Slight	5.5	254.8
6	6.3	6.3 +	6.1	Slight	Dry	-
7	8.1	5.8	7.6	Some	7.6	250.8
8	5.0	5.0 +	1.8	Slight	Dry	-
9	4.9	4.9 +	-	-	Dry	-
10	7.8	7.8 +	-	-	Dry	-
11	9.4	7.2	4.8	Slight	7.9	252.6
12	5.0	5.0 +	2.8	Slight	3.1*	257.0

*Cave-in level (In wet sand and silt deposits, the level generally represents the groundwater regime at the borehole location.)

Groundwater was detected at depths ranging from 5.5 to 8.2 m from the ground surface. Cave-in levels were measured at depths of 3.1 to 10.4 m from the prevailing ground level. Groundwater seepage was encountered at various depths and is mainly derived from infiltrated precipitation trapped in the fissures in the weathered soils, in the sand and silt seams and layers in the tills and clay.

The soil colour changes from brown to grey at depths ranging from 5.8 to 11.4 m below the ground surface. The brown colour indicates that the soils have oxidized. Based on the water content profile and the above information, the permanent groundwater regime generally lies in the grey soils. However, in places, the seepage level encountered in the brown soils during augering indicates that perched groundwater derived from infiltration precipitation will occur at shallow depths in wet seasons.

The yield of groundwater from the tills and clay, due to their low permeability, will be small and limited. The yield from the silts and sand may be appreciable and persistent depending on their extent and continuity. The water-bearing sand deposit occurs at a depth of 10.0 or + m below the prevailing ground surface in Boreholes 2 and 3. The water-bearing silt deposit occurs at a depth of 3.0± m in Borehole 12; however, its presence is localized.

It is understood that the proposed high-rise building will contain 2-levels of underground garage located in the vicinity of Boreholes 1, 2 and 3. The assumed bottom of excavation will be at a depth of 7.0± m below the prevailing ground surface, indicating that the subgrade will consist of glacial tills and will be 3.0± m above the water-bearing sand deposit. Therefore, the groundwater impact for the project construction will be minimal.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that beneath a topsoil or topsoil fill veneer or topsoil and earth fill layers, the site is underlain predominantly by strata of compact to very dense, generally very dense sandy silt till and stiff to hard, generally very stiff silty clay. Occasional strata of dense to very dense silty sand till, very dense fine to coarse sand, compact to dense silt, compact sandy silt and stiff to hard, generally very stiff silty clay till were encountered. An isolated layer of very loose charcoal remains was found beneath the earth fill of Borehole 4. The original topsoil layer was found beneath the earth fill in Boreholes 7, 11 and 12.

The sand deposit occurs at a depth of 10.0 or + m below the prevailing ground surface in Boreholes 2 and 3 and a silt deposit occurs at a depth of 3.0± m in Borehole 12. The sands are generally water bearing.

Groundwater was detected at depths ranging from 5.5 to 8.2 m from the ground surface. Perched groundwater will likely occur at a shallower depth in wet seasons.

The yield of groundwater from the tills and clay, due to their low permeability, will be small and limited. The yield from the silts and sand may be appreciable and persistent, depending on their extent and continuity.

The geotechnical findings which warrant special consideration are presented below:

1. The topsoil and topsoil fill must be stripped for the project construction. As revealed, the topsoil and topsoil fill range from 15 to 80 cm in thickness. The topsoil and topsoil fill will generate volatile gases under anaerobic conditions

and are not suitable for engineering application. For the environmental as well as the geotechnical well-being of the future development, the topsoil and topsoil fill should not be buried below a depth of 1.0 m.

2. The earth fill was randomly placed with nominal compaction and it varies in density. It is, therefore, not suitable for foundation construction. For underground services, slab-on-grade and pavement construction, the fill must be further assessed, subexcavated, sorted free of topsoil, recompacted and proof-rolled. The underlying topsoil layer must be removed for the project consruction.
3. Due to the occurrence of topsoil, topsoil fill and earth fill, the subgrade must be carefully inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to assess its suitability for bearing the designed foundations.
4. As noted, the silty clay, silt, sandy silt, sandy silt till and silty sand till are highly frost susceptible. Special measures must be incorporated into the building construction to counteract this problem.
5. The pipe joints should be leak-proof, or wrapped with a waterproof membrane. In the water-bearing sand and silt and in the tills and clay with wet sand and silt seams, the bedding material should consist of 20-mm Crusher-Run (graded) Limestone.
6. Perimeter subdrains and dampproofing of the foundation walls will be required for basement construction. The subdrains should be shielded by a fabric filter to prevent blockage by silting.
7. The sides of deep excavations in the water-bearing sand and silt will run, and the bottom will boil under a piezometric head of about 0.3 m. The excavations into these soils will require vigorous pumping from closely spaced sump-wells.

8. Excavation into the hard and very dense tills containing boulders may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 **Bank Stability** (Boreholes 1, 4 and 5)

The borehole findings show that the existing bank is underlain by strata of compact to very dense sandy silt till, compact sandy silt and stiff to very stiff silty clay.

The bank in the assessed area is well-defined and ranges in height from approximately 2.5± to 8.5± m and has an overall slope of 1 vertical:2.3 to over 10 horizontal. A site inspection revealed that the bank face is tree- and shrub-covered with no signs of seepage, sloughing or deep-seated failure. There are signs of minor undercut banks at the creek, with some evidence of erosion.

The overall long-term stability of the natural slope of the bank is primarily governed by the effective internal friction angle and to a lesser extent by the long-term cohesive strength of the revealed bank stratigraphy. The bank will be stable at a slope of 1 vertical:2.1 horizontal in the sandy silt and sandy silt till and 1 vertical:2.5 horizontal in the occurring silty clay with a safety factor of at least 1.5.

There are however, environmental factors that will weaken the bank face and may cause transitional surface slides. The inherent mechanisms that will trigger the ground slumps are described below:

- Infiltration of precipitation will gradually saturate the sand and silt seams and layers embedded in the till and clay mantles. Subsequent frost wedging in the soil mantle during freezing weather and loosening with pore pressure build-up during thawing will cause the surface to slough.
- The surficial soil on the bank generally creeps, and the zone affected depends on the slope of the bank, particularly where the bank is steeper than 1 vertical:less than 2 horizontal.

In order to prevent the occurrence of localized surface slides and to enhance the stability of the bank, the following geotechnical constraints should be stipulated:

1. The prevailing vegetative cover must be maintained, since its extraction would deprive the bank of the rooting system that is reinforcement against soil erosion by weathering. If for any reason the vegetation cover is stripped, it must be reinstated to its original, or better than its original, protective condition.
2. The leafy topsoil cover on the bank face should not be disturbed, since this provides an insulation and screen against frost wedging and rainwash erosion.
3. Grading of the land adjacent to the bank must be such that concentrated runoff is not allowed to drain onto the bank face. Landscaping features, which may cause runoff to pond at the top of the bank as well as frequent

lawn watering which will saturate the crown of the bank, must not be permitted.

Where development is carried out near the top of the bank there are other factors to be considered, i.e. possible human environmental abuse, such as soil saturation from maintenance of landscaping features, stripping of topsoil or vegetation and dumping of loose fill over the bank.

The overall existing slope is at 1 vertical:2.3 or + horizontal. Cross-sections have been plotted across several representative areas of the site. The Cross-Sections A-A, B-B, C-C, D-D and E-E along the slope are plotted on Drawing Nos. 2 to 6, inclusive, and their locations are shown on Drawing No. 1. The area in the proximity of Cross-Section B-B is of concern because the toe of the slope is situated adjacent to the creek. Due to minor active erosion undercutting the bank, an erosion allowance of 7 m is applied from the toe of the bank. A geotechnically stable gradient at 1 vertical:2.1 horizontal is drawn in this cross-section from the setback point to the ground surface of the bank. The top of the bank lies behind this gradient, therefore the slope is considered geotechnically stable.

Based on the above, the top of bank, as established by Lake Simcoe Conservation Authority, is considered to be geotechnically stable.

The lot grading should be designed to prevent concentrated run-off along the top of the bank such as discharge from side-yard swales.

The above recommendations are subject to the approval of Lake Simcoe Region Conservation Authority.

6.2 Foundations

Ten-Storey Condominium Apartment Building (Boreholes 1 to 3, inclusive)

According to the borehole findings, the normal spread and strip footings for the building foundations must be placed below the topsoil onto sound natural soil. Assuming the proposed founding level lies at a depth of 7.0 m or + below the prevailing ground surface to accommodate the 2 levels of underground parking, the subgrade of the founding levels will consist of very dense sandy silt till and silty sand till. A Maximum Allowable Soil Pressure of 800 kPa is recommended for the design of the proposed building at the assumed founding level.

For shallow foundations, the normal strip and spread footings should be placed below the topsoil onto sound sandy silt till. Maximum Allowable Soil Pressures of 400 kPa and 800 kPa are recommended for the design of the footings. The suitable founding levels generally lie at depths of 1.0 or + m and 2.5 or + m, respectively, below the prevailing ground surface.

Townhouses (Boreholes 6 to 12, inclusive).

Normal spread and strip footings for the house foundations should be founded below the topsoil, topsoil fill and earth fill onto sound natural soil, or on engineered fill. As a guide, a Maximum Allowable Soil Pressure of 150 kPa is recommended for the design of the house footings. The appropriate founding levels, as inferred by the borehole findings, are presented in Table 3.

Table 3 - Founding Levels

	Recommended Maximum Allowable Soil Pressure and Suitable Founding Level	
	150 kPa	
Borehole No.	**Depth (m)**	**El. (m)**
6	4.0 or +	259.5 or -
7	4.6 or +	253.8 or -
8	1.0 or +	256.1 or -
9	1.0 or +	266.5 or -
10	1.0 or +	264.5 or -
11	3.8 or +	256.7 or -
12	2.6 or +	257.5 or -

The existing earth fill can be upgraded to and/or replaced with engineered fill. Furthermore, cut and fill may be required for lot grading and it is generally more practical and economical to place engineered fill for normal footing construction.

The requirements and procedures for engineered fill construction are discussed in Section 6.3.

The footings should meet the requirements specified in the Ontario Building Code.

Foundations exposed to weathering, and in unheated areas, must be protected against frost action by a minimum earth cover of 1.2 m.

Due to the occurrence of topsoil, topsoil fill and earth fill, the footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that the condition of the footing subgrade is compatible with the foundation design requirements.

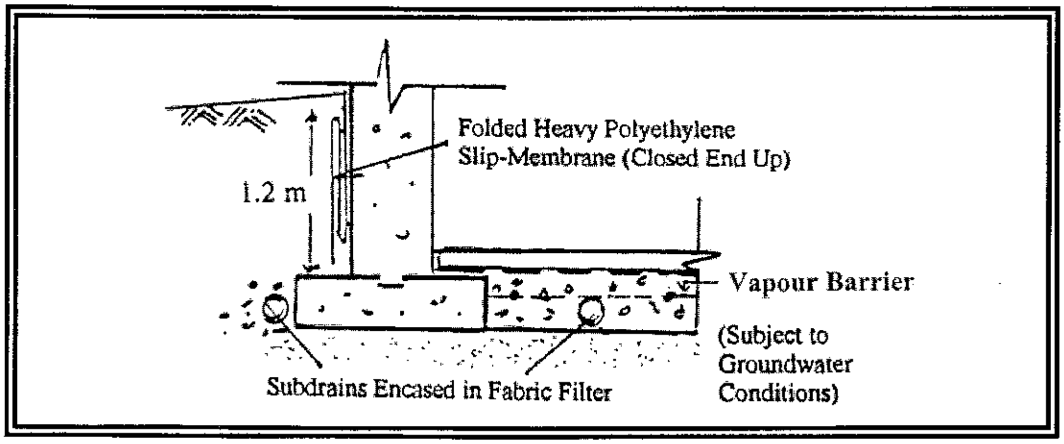
The buildings must be designed to resist a minimum earthquake force calculated using the following:

F - Foundation Factor	1.0
v - Zonal Velocity Ratio	0.05

Perimeter subdrains and dampproofing of the foundation walls will be required in order to provide a dry basement. All the subdrains should be encased in a fabric filter to protect them against blockage by silting.

The silty clay, silt, sandy silt, sandy silt till and silty sand till are highly frost susceptible and have high soil-adfreezing potential. In order to alleviate the risk of frost damage, the basement and foundation walls must be constructed of concrete and either backfilled with non-frost-susceptible pit-run granular, or shielded with a polyethylene slip-membrane. The requirements for this should be assessed at the time of footing construction. The recommended scheme is illustrated in Diagram 1.

Diagram 1 - Frost Protection Measures (Foundations)



6.3 **Engineered Fill**

Where earth fill is required to raise the site or where cut and fill may be required for lot grading, it is generally economical to place engineered fill for normal footing, sewer and road construction. Furthermore, the existing earth fill can be upgraded to and/or replaced by engineered fill. The engineering requirements for a certifiable fill for road construction, municipal services, and footings designed with a 150 kPa Maximum Allowable Soil Pressure are presented below:

1. All of the topsoil and topsoil fill must be removed, and the subgrade surface must be inspected and proof-rolled prior to any fill placement. The existing earth fill must be subexcavated, sorted free of topsoil and debris, aerated and properly recompacted. The subexcavated inorganic earth fill can be aerated and used as engineered fill material.
2. Inorganic soils must be used and they must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to

the proposed finished lot grade and/or road subgrade. The soil moisture must be properly controlled on the wet side of the optimum. If the house foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.

3. If imported fill is to be used, the hauler is responsible for its environmental quality and must provide a document to certify that the material is free of hazardous contaminants.
4. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
5. The engineered fill must extend over the entire graded area, and the fill envelope must be clearly and accurately defined in the field and precisely documented by qualified surveyors. Foundations partially on engineered fill must be properly reinforced and designed by a structural engineer to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soil and engineered fill.
6. The engineered fill must not be placed during the period from late November to early April, when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
7. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
8. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim

construction, environmental degradation and/or disturbance by the footing excavation.

9. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of excavation and/or to inspect the reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification

10. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundations must be properly reinforced and designed by the structural engineer for the project. The total and differential settlements of 25 mm and 15 mm, respectively, should be considered in the design of the foundations founded on engineered fill. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.4 <u>Underground Garage and Slab-On-Grade</u> (High-Rise Building)

For the underground garage, the perimeter garage walls should be designed to sustain a lateral earth pressure calculated using the soil parameters stated in Section 6.11 and any applicable surcharge loads adjacent to the proposed buildings must also be considered in the design of the basement walls.

The subgrade for the slab-on-grade of the underground garage will likely consist of very dense sandy silt till or silty sand till. A Modulus of Subgrade Reaction of 40 MPa/m can be used for the design of the floor slab. The floor slab-on-grade should be constructed on a granular base 20 cm thick, consisting of 20-mm Crusher-Run Limestone, or equivalent, compacted to 100% or + of its Standard Proctor dry density.

Perimeter subdrains encased in a fabric filter will be required. The perimeter underground garage walls should be dampproofed and provided with synthetic sheet drains, or backfilled with free-draining granular to prevent the ponding of surface water against the basement walls. As noted, perched groundwater may occur at a shallow depth. The perched groundwater yield is expected to be small and limited; however, in order to drain the accumulation of groundwater, a subdrain system consisting of 100-mm filter-sleeved weepers with 5 to 10 m spacing, depending on the amount of groundwater, should be installed at a depth of about 400 mm below the underside of the slab, and the subdrains should drain into the storm sewer or sump-wells. A vapour barrier should be provided at the crown level of the floor subdrains to prevent the emission of excessive water vapour. This can be further assessed during construction.

At the garage entrances, the subgrade should be properly insulated, or the subgrade material should be replaced with 1.0 m of non-frost-susceptible granular material and should be provided with subdrains. This will minimize frost action in this area where vertical ground movement cannot be tolerated. The floor at the entrances and in areas of close proximity to air shafts, should be insulated, and the insulation should extend 5.0 m internally. This measure is to prevent frost action induced by cold wintry drafts.

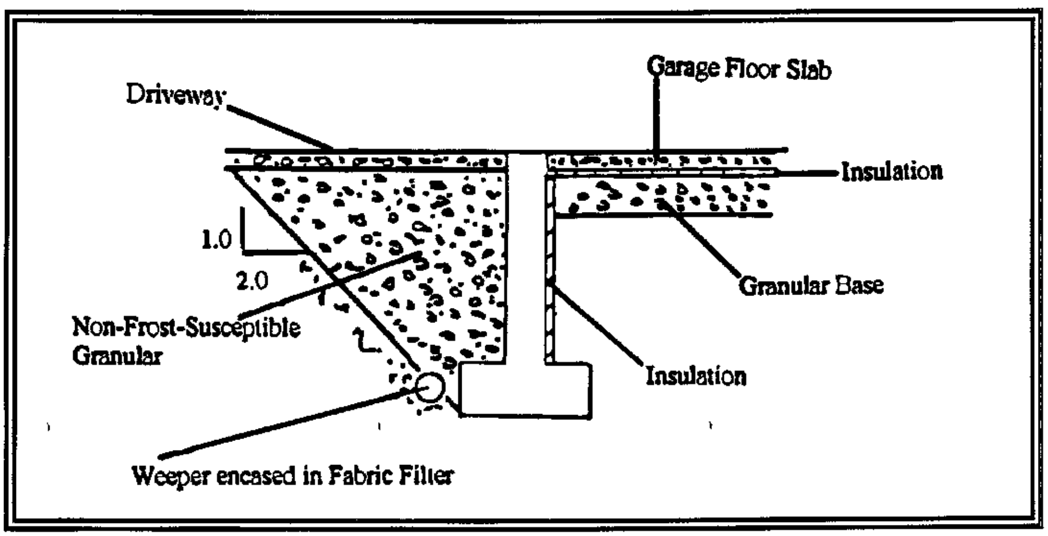
6.5 Garages, Driveways and Landscaping

In areas where the silty clay, silt and sandy silt till occur at a shallow depth, one must realize that the ground will heave during the cold weather and is susceptible to rainwash erosion.

The driveway at entrances to the garages must be backfilled with non-frost-susceptible granular material, with a frost taper at a slope of 1 vertical:2 horizontal.

The garage floor slab and interior garage foundation walls must be insulated with 50-mm Styrofoam, or equivalent. The recommended scheme is illustrated in Diagram 2.

Diagram 2 - Frost Protection Measures (Garage)



The slab-on-grade in open areas should be designed to tolerate frost heave, and the grading around the slab-on-grade must be such that it directs runoff away from the structure.

In areas where ground movement due to frost heave cannot be tolerated, the floor slab and interlocking stone pavement must be constructed on a free-draining granular base, at least 1.0 m thick, with proper drainage which will prevent water from ponding in the granular base.

6.6 Underground Services

The subgrade for the underground services should consist of sound natural soil or uniformly compacted organic-free earth fill.

A Class 'B' bedding is recommended for construction of the underground services. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent. In order to minimize the migration of groundwater through the bedding material, trench plugs consisting of impervious silty clay or concrete should be provided where wet sand and silt subgrade is encountered.

The pipes should be connected by leak-proof joints, or the joints should be wrapped with a waterproof membrane to prevent subgrade migration.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness equal to the diameter of the pipe should be in place at all times after completion of the pipe installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent silting.

Since the silty clay has moderately high corrosivity to buried metal, the water main should be protected against corrosion. In determining the mode of protection, an electrical resistivity of 3,500 ohm/cm should be used. This, however, must be confirmed by testing the soil along the water main alignment at the time of sewer construction.

6.7 **Trench Backfilling**

The backfill in the trenches should be compacted to at least 95% of its maximum Standard Proctor dry density. In the zone within 1.0 m below the road subgrade, the material should be compacted with the water content 2% to 3% drier than the optimum, and the compaction should be increased to at least 98% of the respective maximum Standard Proctor dry density. This is to provide the required stiffness for pavement construction. In the lower zone, the compaction should be carried out on the wet side of the optimum; this allows a wider latitude of lift thickness.

In normal construction practice, the problem areas of ground settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns. In areas which are inaccessible to a heavy compactor, sand backfill should be used. Unless compaction of the backfill is carefully performed, the interface of the native soils and the sand backfill will have to be flooded for a period of at least 1 day.

The narrow trenches should be cut at 1 vertical:2 or + horizontal so that the backfill can be effectively compacted. Otherwise, soil arching will prevent the achievement of proper compaction. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

One must be aware of the possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the *in situ* soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.
- In areas where the underground services construction is carried out during winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1 vertical:

1.5 + horizontal, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.

- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector, i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section. In areas where groundwater movement is expected in the sand fill mantle, seepage collars should be provided.

6.8 Pavement Design

Where the pavement is to be built on structural slabs, such as the underground garage rooftop, a sufficient granular base and adequate drainage must be provided to prevent frost damage to the pavement. A waterproof membrane must be placed above the structural slab exposed to weathering to prevent water leakage, as well as to protect the reinforcing steel bars against brine corrosion.

The recommended pavement structure to be placed on top of the underground garage is presented in Table 4.

Table 4 - Pavement Design (Roof of Underground Garage)

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	65	HL-8
Granular Base	250	20-mm Crusher-Run Limestone
Granular Sub-base	100	Free-Draining Sand Fill

The granular bases should be compacted to 100% of their maximum Standard Proctor dry density.

For the on-grade portion of the parking lot and local roads, the recommended pavement structure is given in Table 5.

Table 5 - Pavement Design (On-Grade Parking Lot)

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	65	HL-8
Granular Base	100	20-mm Crusher-Run Limestone
Granular Sub-base Parking Access Road	 250 350	50-mm Crusher-Run Limestone

The granular base and sub-base should be compacted to 100% or + of their maximum Standard Proctor dry density. The earth backfill within the zone 1.0 m below the pavement must be compacted to 98% or + of its maximum Standard Proctor dry density, with the moisture content 2% to 3% drier than the optimum.

The subgrade will suffer a strength regression if water is allowed to saturate the mantle. The following measures should, therefore, be incorporated in the construction procedures and road design:

- If the road construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Lot areas adjacent to the roads should be properly graded to prevent ponding of large amounts of water. Otherwise, the water will seep into the subgrade mantle and induce a regression of the subgrade strength, with costly consequences for the pavement construction.
- Prior to the placement of the granular bases, the subgrade should be proof-rolled, and any soft spots should be rectified.
- If the roads are to be constructed during the wet seasons and the subgrade is softened, the granular sub-base should be thickened. In extreme cases, the top 0.8 m of the subgrade should be replaced by compacted granular material, or the granular bases should be strengthened by geogrid reinforcement in the Crusher-Run Limestone.
- Fabric filter-encased curb subdrains backfilled with free-draining granular material will be required to prevent infiltrating precipitation from seeping into the granular bases, inflicting frost damage on the flexible pavement, and they should be connected to the catch basins and storm manholes in the paved areas.

6.9 Sidewalk, Interlocking Stone Pavement and Landscaping

Interlocking stone pavement and the sidewalks in areas which are sensitive to frost-induced ground movement, such as entrances, must be constructed on a free-draining non-frost-susceptible granular material such as Granular 'B'. It must extend to 1.2 m below the slab or pavement surface and be provided with positive drainage such as weeper subdrains connected to manholes or catch basins. Alternatively, the sidewalk and the interlocking stone pavement should be properly insulated with 50-mm Styrofoam, or equivalent.

6.10 Stormwater Management Facilities

At the time of the preparation of the report, the location of the proposed stormwater management pond was not yet finalized. The subsoils of the proposed stormwater management pond will likely consist of compact to very dense sandy silt till or silty sand till, stiff to hard silty clay till, stiff to very stiff silty clay, or compact to dense silts.

The designed water level has yet to be determined. Due to the low to relatively low permeability of the silty clay, silty clay till and sandy silt till, the seepage of groundwater into the pond constructed in the tills will likely be equal to or less than the amount of water lost through evaporation. The impact on the storage volume of the pond will be minimal. However, the silty sand till and silts are more pervious. This indicates that the water lost by seepage through the strata will have an impact on the effective storage capacity of the pond. In order to minimize this impact where the banks and bottom of the pond consist of silts and silty sand till, an impermeable geosynthetic membrane or clay liner, 1.0 m thick, compacted to achieve at least 95% of its maximum Standard Proctor dry density, should be placed above this stratum. This can be further assessed during excavation.

Alternatively, geosynthetic clay liners can be used, such as High Density Polyethylene (HDPE), Reinforced Polyethylene (RPE) or Geosynthetic Clay Liners (GLSs), all three manufactured by Layfield, or Bentofix Thermal Lock for Geosynthetic Clay Liners manufactured by Terrafix Geosynthetic Inc.

The *in situ* silty clay and silty clay till are suitable for construction of the berms; however, in a submerged condition, the clays will flatten to their angle of repose which is about 16° from the horizontal. The clay berms below the normal water level should be flattened to 1 vertical:4 or + horizontal.

The coefficient of permeability and the infiltration rate of the encountered soils are given in Table 6.

Table 6 - Coefficient of Permeability and Infiltration Rate

Soil	Coefficient of Permeability (cm/sec)	Infiltration Rate (min/cm)
Silty Clay and Silty Clay Till	10^{-6}	80
Sandy Silt Till	10^{-5} to 10^{-6}	40 to 60
Silty Sand Till and Silt	10^{-4} to 10^{-5}	20 to 35

For construction of the berms, the topsoil and topsoil fill must be stripped, and the surface of the subgrade should be proof-rolled prior to filling. The berms should consist of silty clay or silty clay till material. The on-site clay and silty clay till can be used for this purpose, and must be compacted to 95% or + of their maximum Standard Proctor dry density. The berms should be sloped at 1 vertical: 4 or + horizontal below the normal water level, and 1 vertical:3 horizontal above the normal water level.

The side slopes and top of the berms should be sodded for protection against rainwash erosion. At the normal water level, the edge of the pond should be shielded by rip-rap for protection against wave action.

One should be aware that minor maintenance might be required after rapid draw-down as the water recedes from a high water level to the normal level.

The footings for all control structures for the stormwater management system must be placed onto the natural sound soils. Maximum Allowable Soil Pressures of 150 to 800 kPa are recommended for use in their design depending on the locations and founding levels of the structures. The footings must be placed below the frost depth of 1.2 m, or the scouring depth, whichever is deeper.

The footing subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, prior to concrete pouring to ensure its conformity to the design.

Additional boreholes should be carried out when the design and location of the pond are determined.

6.11 Soil Parameters

The recommended soil parameters for the project design are given in Table 7.

Table 7 - Soil Parameters

Unit Weight and Bulk Factor			
	Unit Weight (kN/m^3)	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compacted**
Tills	22.0	1.33	1.05
Silty Clay	21.0	1.30	1.03
Sand and Silts	20.5	1.25	1.00
Lateral Earth Pressure Coefficients			
	Active K_a	**At Rest K_o**	**Passive K_p**
Silty Clay Till and Clay	0.35	0.45	2.86
Sandy Silt Till, Silty Sand Till, Sand and Silts	0.30	0.40	3.33
Coefficients of Friction			
Between Concrete and Sound Natural Soils		0.4	
Between Concrete and Granular Base		0.6	

Table 7 - Soil Parameters (Cont'd)

Runoff Coefficients

Slope	Sand	Sandy Silt	Silt	Sandy Silt Till and Silty Sand Till	Silty Clay and Silty Clay Till
0% - 2%	0.04	0.07	0.11	0.07 to 0.15	0.15
2% - 6%	0.09	0.12	0.16	0.12 to 0.20	0.20
6% +	0.13	0.18	0.23	0.18 to 0.28	0.28

Coefficients of Permeability (cm/sec)

Silty Clay and Silty Clay Till	10^{-6}
Sandy Silt Till and Silty Sand Till	10^{-4} to 10^{-6}
Silt	10^{-5}
Sandy Silt	10^{-4}
Sand	10^{-3}

Maximum Allowable Soil Pressure For Thrust Block Design

Sound Natural Soil	100 kPa

6.12 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91.

Excavations in excess of 1.2 m should be sloped at 1 vertical:1 horizontal for stability.

For excavation purposes, the types of soils are classified in Table 8.

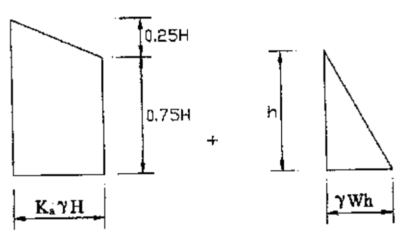
Table 8 - Classification of Soils for Excavation

Material	Type
Sound Tills and Clay	2
Earth Fill, Silts and Sand above groundwater	3
Silts and Sand below groundwater	4

In the tills and clay with wet sand and silt seams, the sides of excavations above groundwater may suffer localized sloughing or side collapse. Therefore, they must be sloped at 1 vertical:at least 1 horizontal for stability.

If shoring is required for braced excavation, it should be designed using the lateral earth pressure diagram shown below.

Diagram 3 - Lateral Earth Pressure (Tills)



h - Height of Water, if any

H - Height of Excavation

γ - Bulk Unit Weight = 22 kN/m^3

$K_a = 0.35$

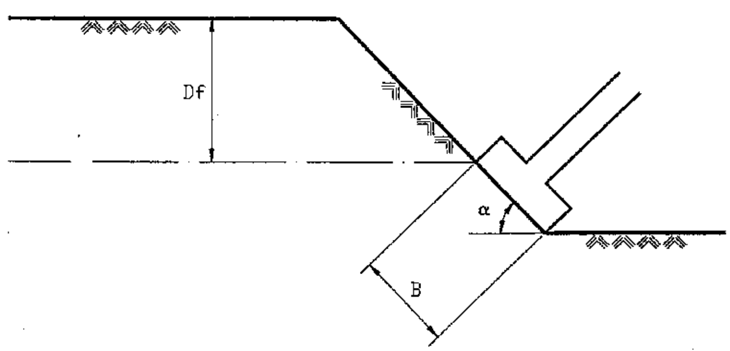
γ_w - Weight of Water

If tiebacks are to be used for the shoring structure, the anchors should be embedded into the very stiff to hard and compact to very dense tills. An average undrained shear strength of 40 kPa after reduction factor can be used for the design of the anchorage embedded in the tills. All the tieback anchors should be proof-loaded to at least 133% of the design load, and at least 1 full scale test should be carried out on 1 anchor.

If rakers instead of tiebacks are to be used, they should be designed using the recommended Soil Bearing Pressure given in Table 9.

Table 9 - Soil Pressure for Rakers

Angle of Raker Inclination (α)	Recommended Soil Pressure (kPa) Dense to Very Dense Tills	
	Df/B=0	**Df/B=1**
30°	500	680
45°	450	620
60°	400	570



Where excavations are carried out in the water-bearing sand and silts, the possibility of flowing sides and bottom boiling dictates that the ground be predrained, either by pumping from closely spaced sump-wells (excavations shallower than 0.5 m below the groundwater) or, if necessary, by the use of a well-point dewatering system (excavations deeper than 0.5 m into the groundwater table). In order to provide a stable subgrade for the services or foundation construction, the groundwater should be depressed to at least 0.5 m below the subgrade. As noted, the water-bearing sand deposit occurs at a depth of 10.0 or + m and the water-bearing silts appear to be localized; therefore extensive dewatering for the project construction is likely unneccessary.

Prospective contractors should assess the *in situ* subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the intended bottom of excavation. These test pits should be allowed to remain open for a period of at least 4 hours to assess the pit wall conditions.

7.0 LIMITATIONS OF REPORT

It should be noted that no tests have been carried out to determine whether environmental contaminants are present in the soils. Therefore, this report deals only with a study of the geotechnical aspects of the proposed project.

This report was prepared by Soil Engineers Ltd. for the account of Millford Development Limited, and for review by their designated consultants and government agencies. The material in it reflects the judgement of Wing S. Lam, B.A.Sc., and Ho-Yin Chiu, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

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LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report are as follows:

1. SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core with size and percentage of recovery
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash Sample

2. PENETRATION RESISTANCE/'N'

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter 90° point cone driven by a 140-pound hammer falling 30 inches.
Plotted as _______

Standard Penetration Resistance or 'N' value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.
Plotted as 'O'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

3. SOIL DESCRIPTION

a) Cohesionless Soils:

'N' (Blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

b) Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (Blows/ft)	Consistency
Less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

c) Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 - Field vane test in borehole
The number denotes the sensitivity to remoulding.

△ - Laboratory vane test

□ - Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength.

METRIC CONVERSION FACTORS

1 ft. = 0.3048 metres	1 inch = 25.4 mm
1 lb. = 0.453 kg	1 ksf = 47.88 kN/m^2

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JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Water Content (%)
264.5	Ground Surface				
0.0	**30cm TOPSOIL**	1	DO	14	8
	Compact to very dense	2	DO	40	6
		3	DO	40	9
		4	DO	100+	7
	SANDY SILT, Till	5	DO	80	7
		6	DO	100+	11
	traces of clay and gravel occ. silt seams	7	DO	56	10
	brown --- grey	8	DO	100+	7
		9	DO	100+	7
254.5 10.0	*Cont'd on Fig. 1A*				

Shear Strength (kN/m2): 50, 100, 150, 200

Atterberg Limits: Wp, WL

Penetration Resistance (blows/0.3m): 10, 30, 50, 70, 90

Water Content (%): 5, 15, 25, 35, 45

Depth Scale (m): 0 – 10

WATER LEVEL: W.L. @ El. 257.2 m on completion

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1A

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. Depth (m)	SOIL DESCRIPTION (Cont'd)	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	Depth Scale (m)	Shear Strength (kN/m2) × 50 100 150 200 × / Penetration Resistance (blows/0.3m) ○ 10 30 50 70 90 ○	Atterberg Limits Wp ⊢—⊣ WL / Water Content (%) ● 5 15 25 35 45 ●	WATER LEVEL
254.5								
10.0	Very dense							
		10	DO	100+			7	
	SANDY SILT, Till				11			
					12		7	
252.2		11	DO	100+				
12.3	END OF BOREHOLE							
					13			
					14			
					15			
					16			
					17			
					18			
					19			
					20			

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Water Content (%)
265.4	Ground Surface				
0.0	25cm TOPSOIL	1	DO	31	14
	Brown, dense to very dense	2	DO	45	8
		3	DO	100+	8
	SANDY SILT, Till	4	DO	100+	7
		5	DO	100+	7
	a tr. of clay a tr. to some gravel	6	DO	100+	7
		7	DO	100+	9
258.4 7.0	Brown, very dense **SILTY SAND, Till** a tr. of clay a tr. to some gravel occ. silt and sand lenses occ. cobbles and boulders	8	DO	85	9
		9	DO	80	13
255.4 10.0	*Cont'd on Fig. 2A*				

Shear Strength (kN/m2): 50, 100, 150, 200

Penetration Resistance (blows/0.3m): 10, 30, 50, 70, 90

Atterberg Limits: W_p, W_L

Water Content (%): 5, 15, 25, 35, 45

Depth Scale (m): 0–10

WATER LEVEL: Cave-In @ El. 260.2 m on completion

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2A

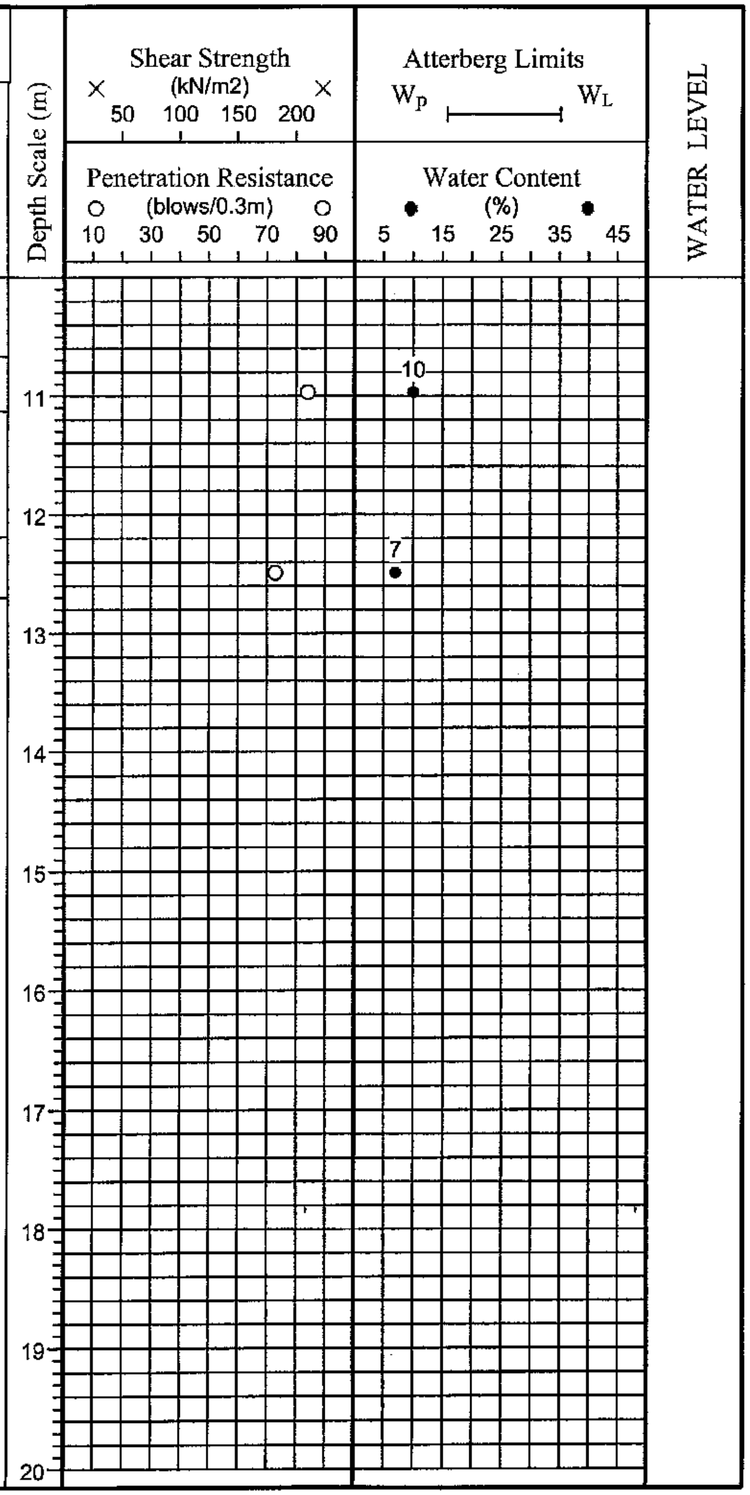
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. Depth (m) 255.4	SOIL DESCRIPTION (Cont'd)	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
10.0	Brown, very dense **FINE TO COARSE SAND** traces of clay and silt	10	DO	84
254.0 / 11.4	Grey, very dense **SANDY SILT, Till** traces and clay and gravel	11	DO	73
252.7 / 12.7	**END OF BOREHOLE**			



Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

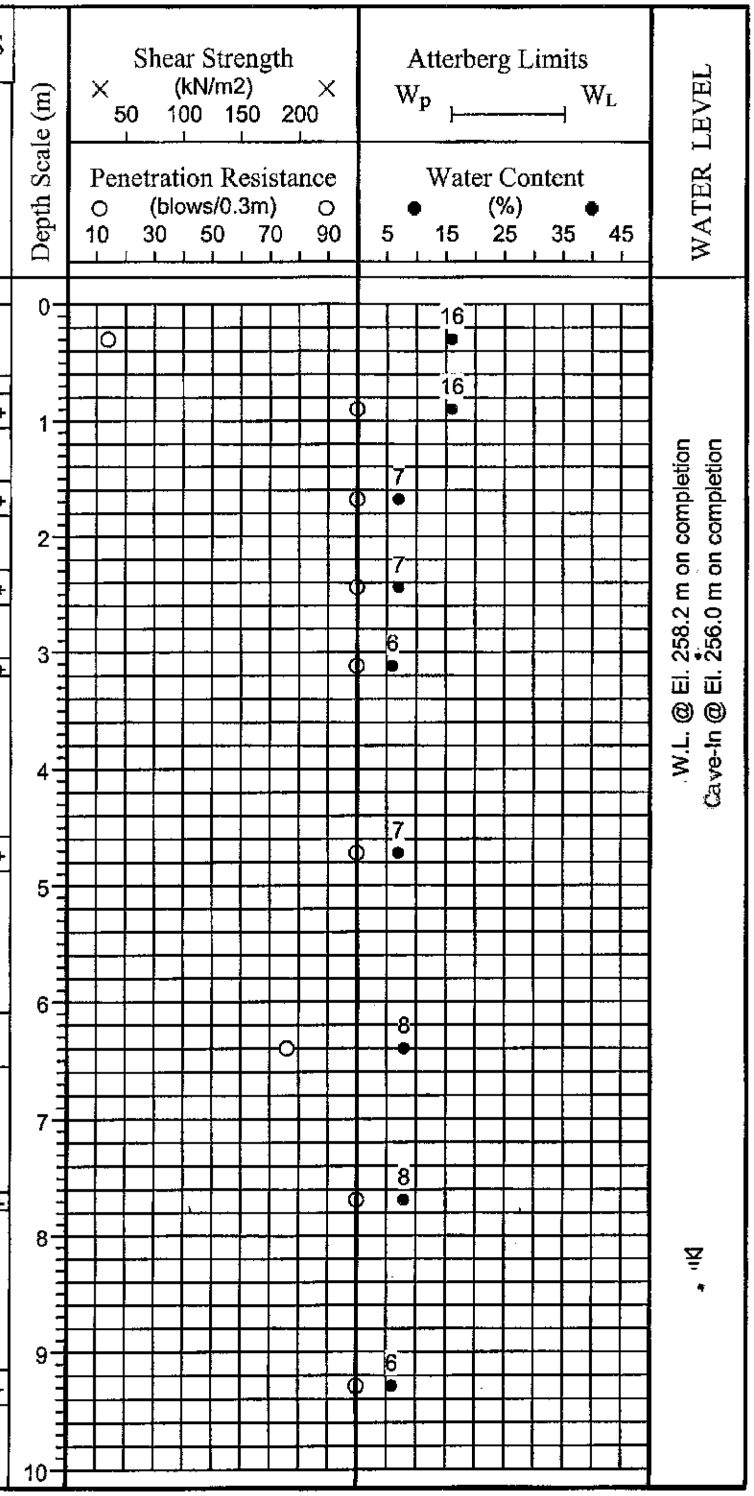
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value
266.4	Ground Surface			
0.0	**30cm TOPSOIL**	1	DO	14
	Brown, hard **SILTY CLAY** a tr. of gravel	2	DO	100+
265.2 / 1.2	Very dense **SANDY SILT, Till**	3	DO	100+
		4	DO	100+
		5	DO	100+
		6	DO	100+
	a tr. of clay, a tr. to some gravel, occ. sand and silt seams	7	DO	76
	brown / grey	8	DO	100+
		9	DO	100+
256.4 / 10.0	*Cont'd on Fig. 3A*			



Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3A

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. / Depth (m)	SOIL DESCRIPTION (Cont'd)	Sample Number	Type	N-Value	Water Content (%)
256.4 / 10.0	**SANDY SILT, Till**	10	DO	100+	15
254.8 / 11.6	Brown, very dense **FINE TO COARSE SAND** traces of clay, silt and gravel	11	DO	56	16
253.7 / 12.7	**END OF BOREHOLE**				

Shear Strength (kN/m2): 50, 100, 150, 200

Penetration Resistance (blows/0.3m): 10, 30, 50, 70, 90

Atterberg Limits: W_p, W_L

Water Content (%): 5, 15, 25, 35, 45

Depth Scale (m): 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

WATER LEVEL

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	Water Content (%)	WATER LEVEL
264.1	Ground Surface					
0.0 / 263.4	**TOPSOIL, Fill**	1	DO	7	17	
0.7 / 262.8	**CHARCOAL REMAINS**	2	DO	2	23	
1.3	Compact to very dense	3	DO	20	6	
		4	DO	100+	4	
		5	DO	100+	7	
	SANDY SILT, Till					Cave-In @ El. 258.9 m on completion
		6	DO	100+	10	
		7	DO	94	10	
	traces of clay and gravel occ. sand and silt seams					
	brown	8	DO	100+	8	
	grey					
254.8		9	DO	100+	8	
9.3	**END OF BOREHOLE**					

Shear Strength (kN/m2) × 50 100 150 200 ×

Penetration Resistance (blows/0.3m) ○ 10 30 50 70 90 ○

Atterberg Limits W_P W_L

Water Content (%) ● 5 15 25 35 45 ●

Depth Scale (m) 0–10

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth (m)	Water Content (%)
260.3	Ground Surface					
0.0	15cm TOPSOIL				0	
	Brown, stiff to very stiff SILTY CLAY a tr. of sand	1	DO	13		18
		2	DO	26	1	15
		3	DO	23		16
258.2 / 2.1	Brown, compact SANDY SILT a tr. of clay occ. silt seams	4	DO	11	2	13
257.4 / 2.9	Brown, compact to very dense SANDY SILT, Till a tr. to some clay a tr. of gravel	5	DO	15	3	12
		6	DO	31		8
		7	DO	40		8
		8	DO	100+		9
251.0 / 9.3	END OF BOREHOLE	9	DO	100+		7

WATER LEVEL: W.L. @ El. 254.8 m on completion

Shear Strength (kN/m2): 50, 100, 150, 200

Penetration Resistance (blows/0.3m): 10, 30, 50, 70, 90

Atterberg Limits: W_p — W_L

Water Content (%): 5, 15, 25, 35, 45

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

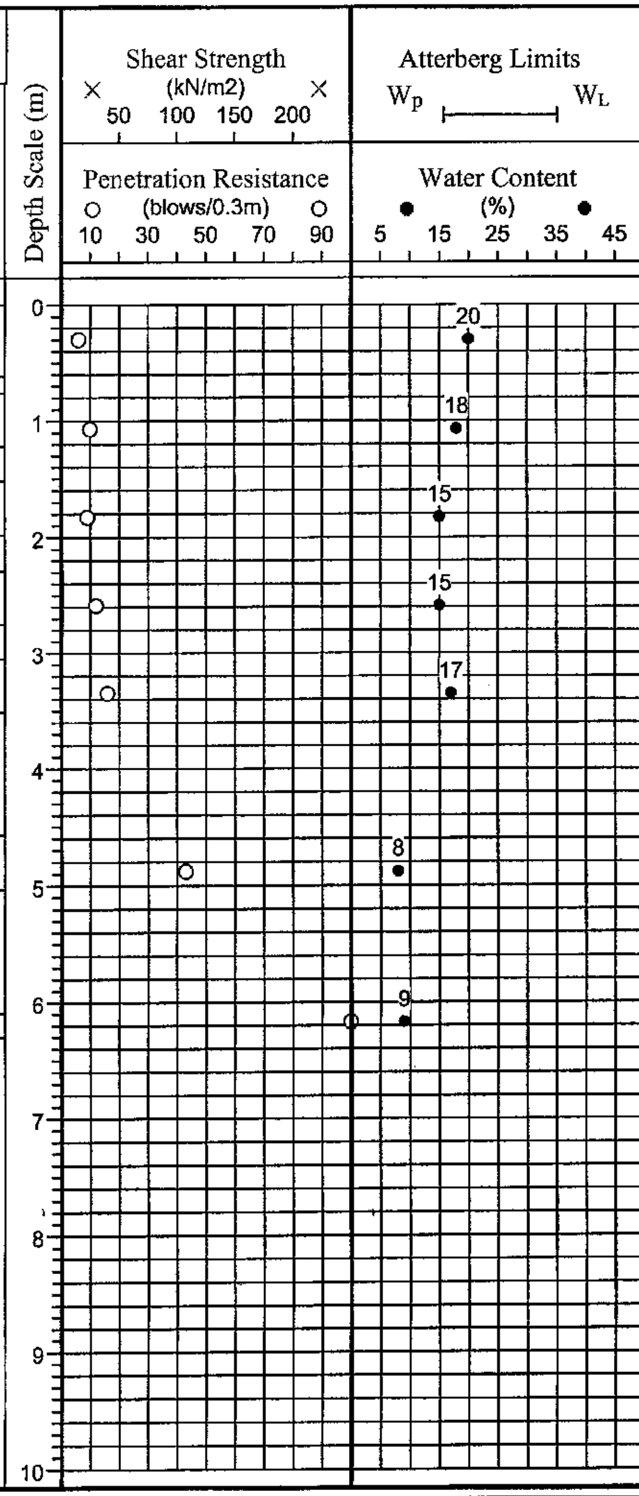
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value
263.5	Ground Surface			
0.0	**15cm TOPSOIL**			
	Brown **SILTY CLAY, Fill** occ. roots, plant materials, topsoil inclusions	1	DO	6
		2	DO	10
		3	DO	9
		4	DO	12
259.9 / 3.6		5	DO	16
	Brown, dense **SILTY SAND, Till** traces of clay and gravel	6	DO	43
258.1 / 5.4	Brown, very dense **SANDY SILT, Till** a tr. of clay, some gravel	7	DO	100+
257.2 / 6.3	**END OF BOREHOLE**			



WATER LEVEL: Dry on completion

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

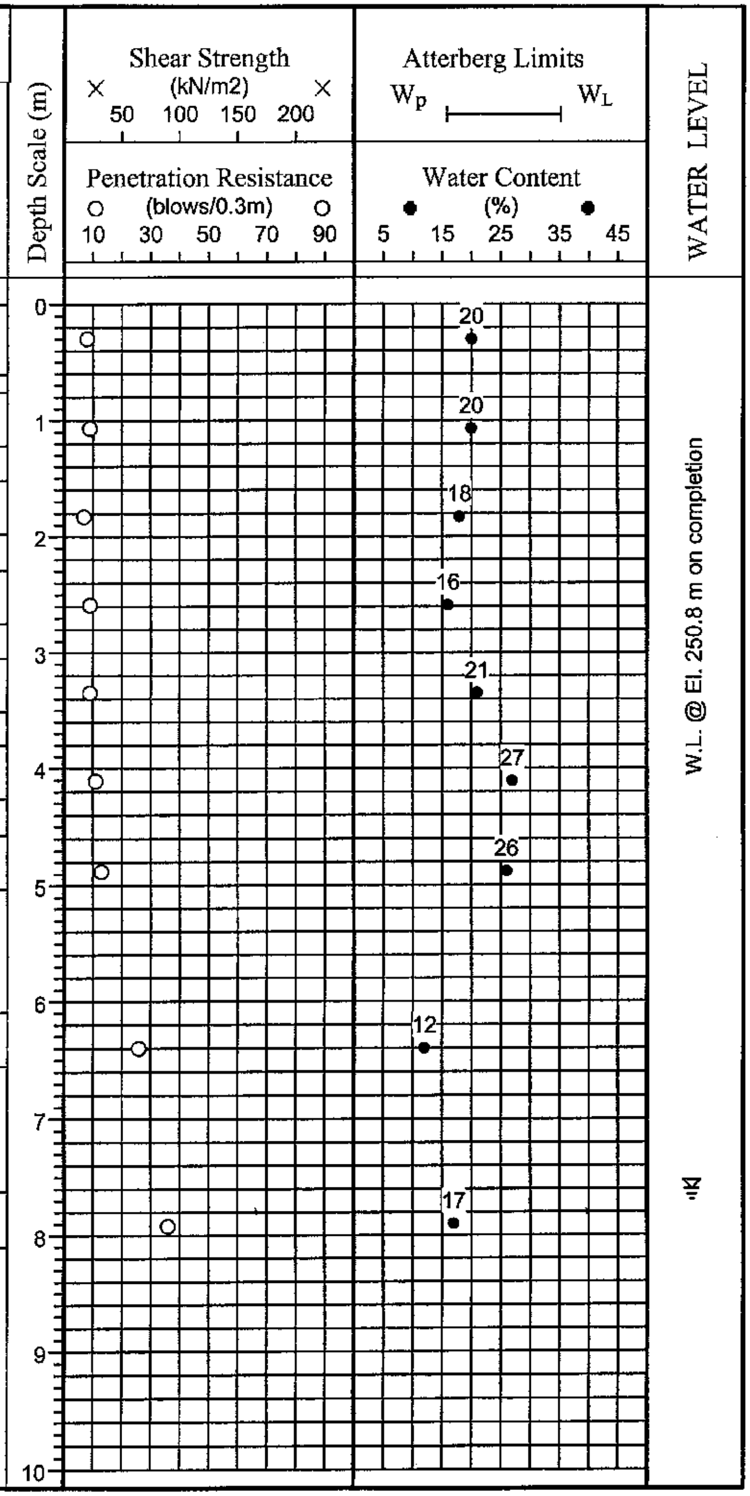
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value
258.4	Ground Surface			
0.0	25cm TOPSOIL	1	DO	8
	Brown	2	DO	9
	SILTY CLAY, Fill	3	DO	7
	occ. roots	4	DO	9
254.8		5	DO	9
3.6	TOPSOIL occ. roots	6	DO	11
254.0 / 4.4	Stiff to hard	7	DO	13
	SILTY CLAY brown --- grey			
	silty clay till layer ----	8	DO	26
250.3		9	DO	36
8.1	END OF BOREHOLE			



Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Water Content (%)	WATER LEVEL
257.1	Ground Surface					
0.0	**41cm TOPSOIL**	1	DO	12	22	Dry on completion
	Brown, stiff to very stiff	2	DO	16	18	
	SILTY CLAY	3	DO	13	20	
		4	DO	19	16	
	traces of sand and gravel occ. sand lenses	5	DO	21	21	
252.1		6	DO	18	23	
5.0	**END OF BOREHOLE**					

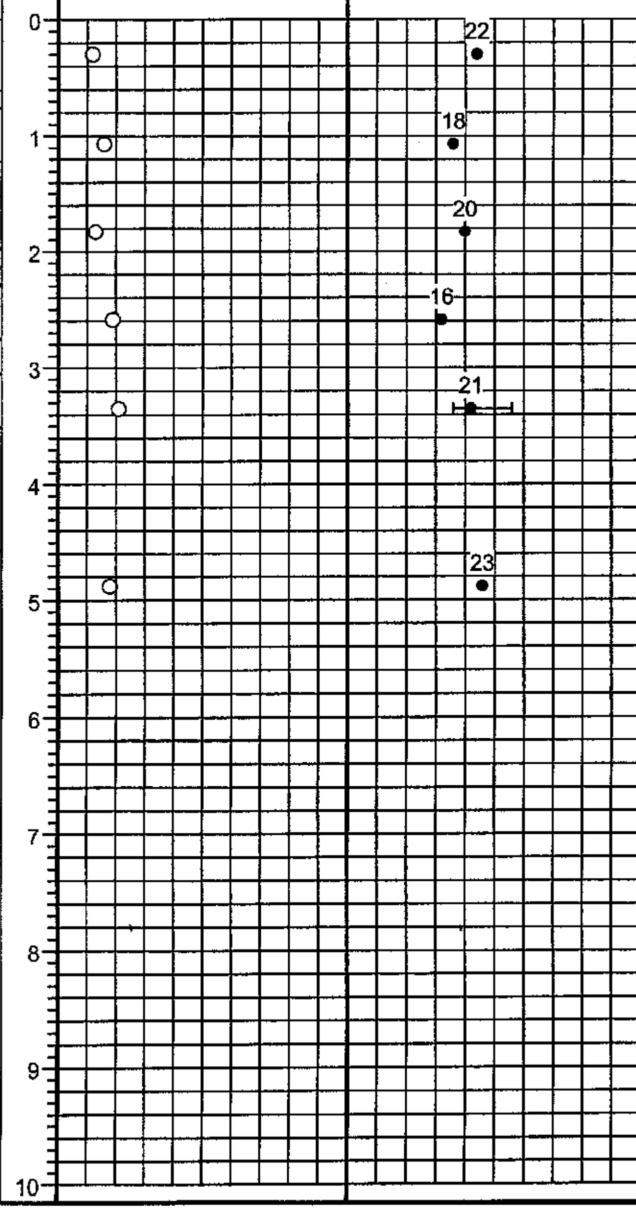
Depth Scale (m): 0–10

Shear Strength (kN/m2) × 50 100 150 200 ×

Penetration Resistance (blows/0.3m) ○ 10 30 50 70 90 ○

Atterberg Limits W_p W_L

Water Content (%) ● 5 15 25 35 45 ●



Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

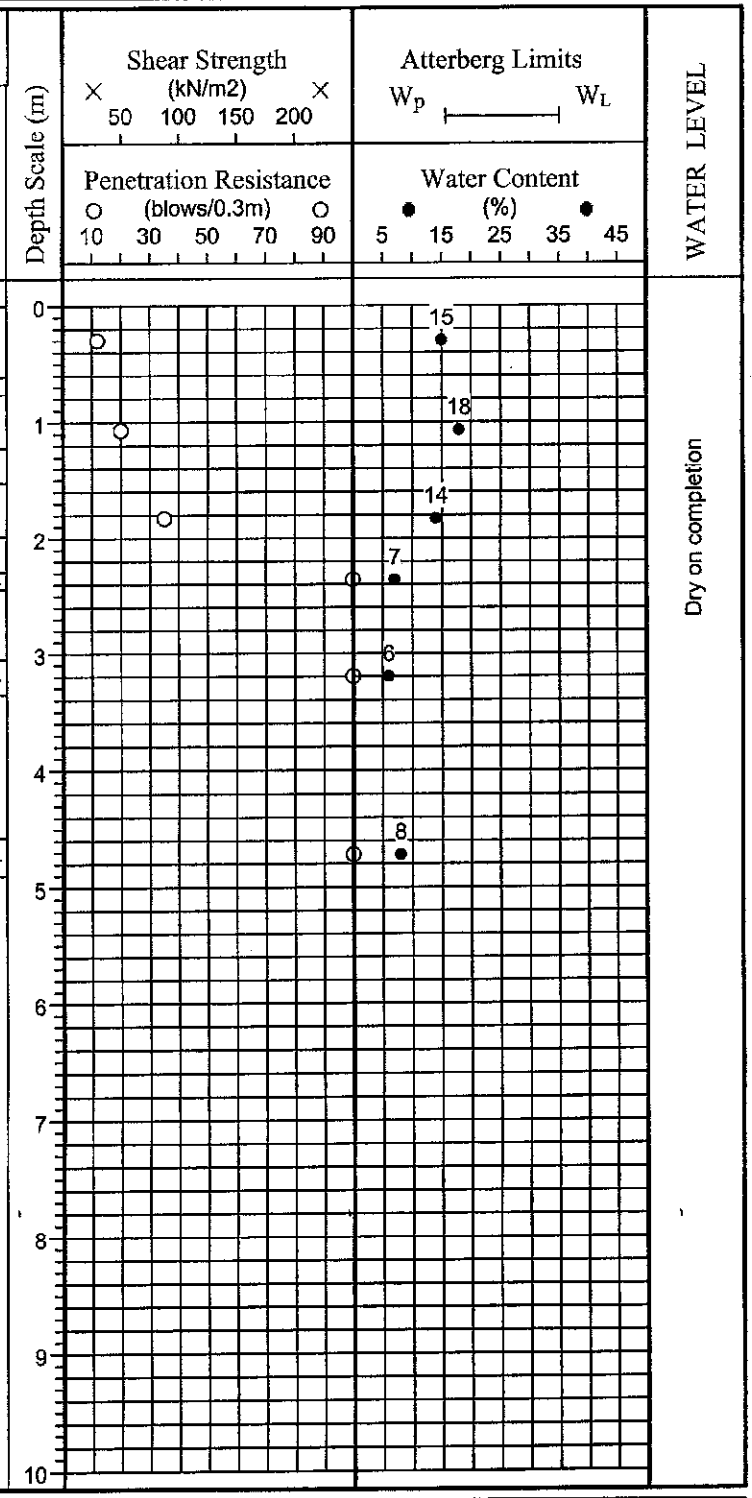
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 21, 2004

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
267.5	Ground Surface			
0.0	**25cm TOPSOIL**	1	DO	12
	Brown, stiff to hard **SILTY CLAY** a tr. of gravel	2	DO	20
		3	DO	35
265.4 / 2.1	Brown, very dense **SANDY SILT, Till** tr. to some clay and gravel	4	DO	100+
		5	DO	100+
		6	DO	100+
262.6 / 4.9	**END OF BOREHOLE**			



Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 10

JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Water Content (%)	WATER LEVEL
265.5	Ground Surface					
0.0	**30cm TOPSOIL**	1	DO	14	12	Dry on completion
	Brown, compact to very dense	2	DO	33	8	
		3	DO	35	8	
		4	DO	75	9	
	SANDY SILT, Till	5	DO	100+	7	
		6	DO	100+	8	
	traces of clay and gravel	7	DO	100+	8	
257.7 / 7.8		8	DO	100+	7	
	END OF BOREHOLE					

Shear Strength (kN/m2): 50 100 150 200

Penetration Resistance (blows/0.3m): 10 30 50 70 90

Atterberg Limits W_p W_L

Water Content (%): 5 15 25 35 45

Depth Scale (m): 0 1 2 3 4 5 6 7 8 9 10

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 11

FIGURE NO.: 11

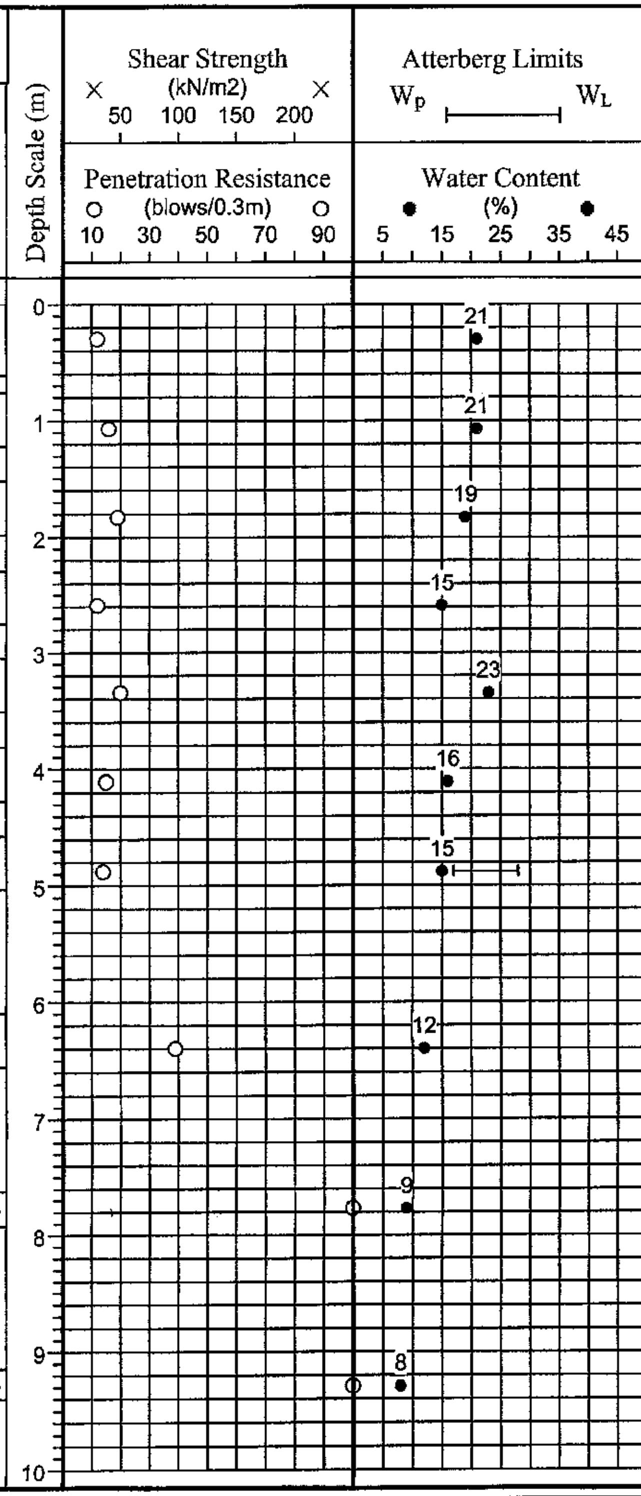
JOB DESCRIPTION: Proposed Residential Development

JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. / Depth (m)	SOIL DESCRIPTION	Sample Number	Sample Type	N-Value
260.5	Ground Surface			
0.0	**15cm TOPSOIL**	1	DO	12
	Brown **SILTY CLAY, Fill** occ. roots, topsoil inclusions some sand	2	DO	16
		3	DO	19
257.6		4	DO	12
2.9	**TOPSOIL** occ. roots	5	DO	20
256.9 / 3.6	Stiff to hard **SILTY CLAY, Till** some sand to sandy a tr. to some gravel occ. cobbles and boulders brown --- grey	6	DO	15
		7	DO	14
		8	DO	39
252.1		9	DO	100+
8.4	Grey, very dense **SANDY SILT, Till** some clay and gravel			
251.1		10	DO	100+
9.4	**END OF BOREHOLE**			



WATER LEVEL: W.L. @ El. 252.6 m on completion

Soil Engineers Ltd.

JOB NO.: 0409-S004

LOG OF BOREHOLE NO.: 12

FIGURE NO.: 12

JOB DESCRIPTION: Proposed Residential Development

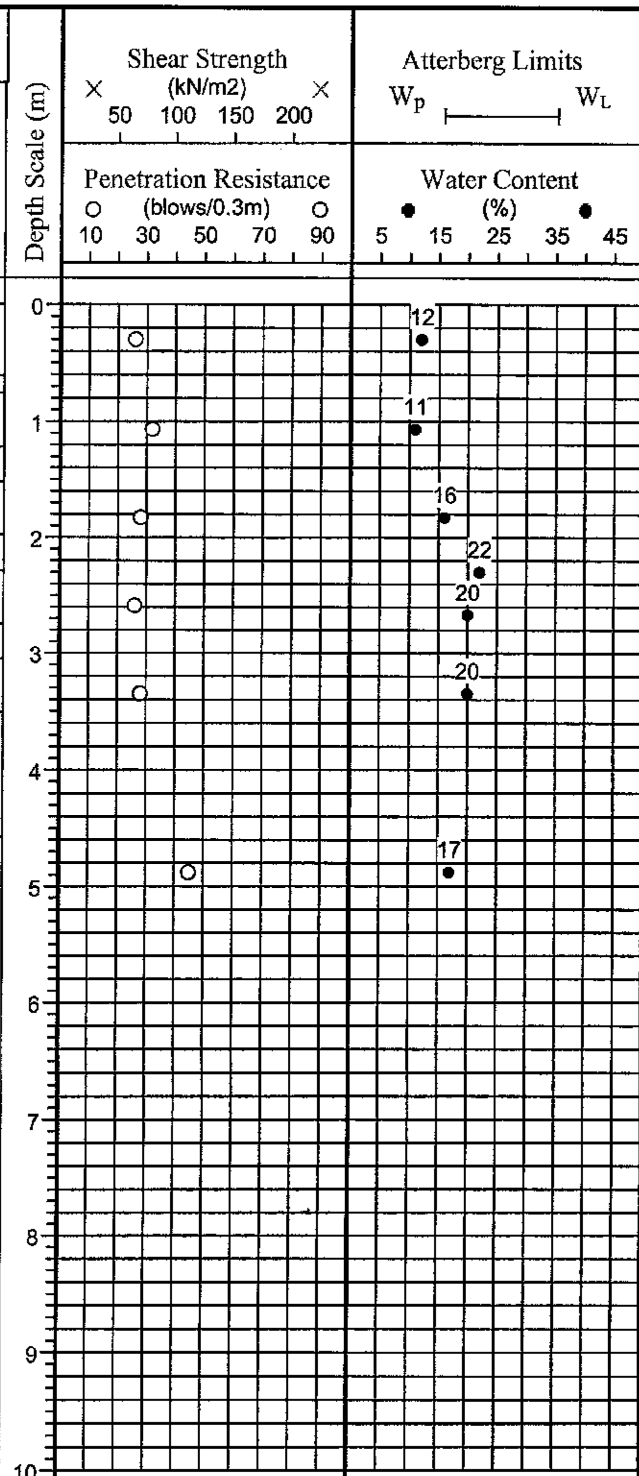
JOB LOCATION: NE of Yonge St./Eagle St., Town of Newmarket

METHOD OF BORING: Flight-Auger

DATE: September 22, 2004

Elev. / Depth (m)	SOIL DESCRIPTION
260.1	Ground Surface
0.0	**20cm TOPSOIL** Brown **SILTY CLAY, Fill**
257.8 / 2.3	**TOPSOIL**
257.5 / 2.6	Brown, very stiff **SILTY CLAY**
257.1 / 3.0	Brown, compact to dense **SILT** some clay traces of sand and gravel
255.1 / 5.0	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value
1	DO	26
2	DO	32
3	DO	28
4	DO	26
5	DO	28
6	DO	45



WATER LEVEL
Cave-In @ El. 257.0 m on completion

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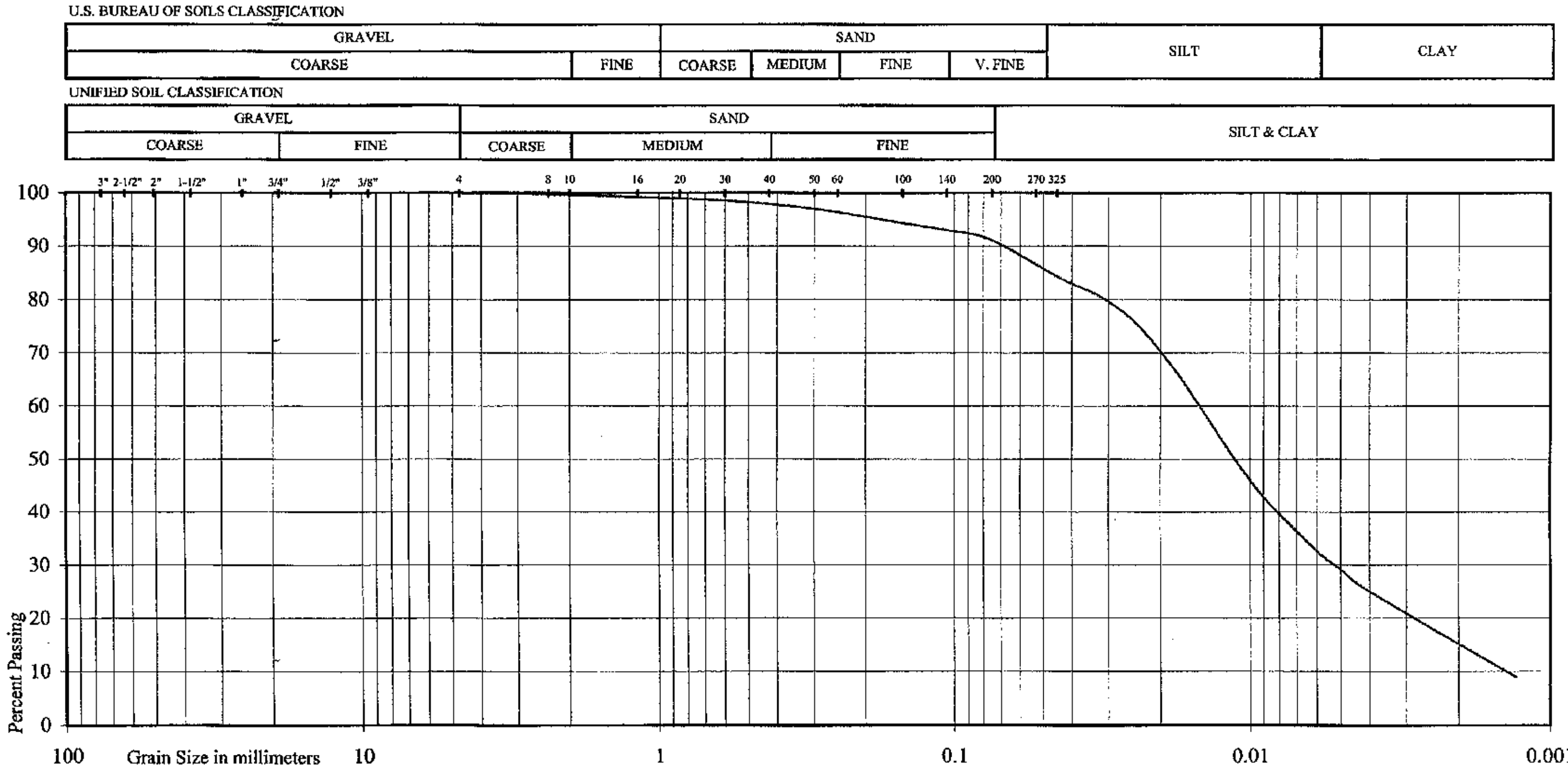
GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



Project:	Proposed Residential Development	Liquid Limit (%) =	-
Location:	NE of Yonge St./Eagle St., Town of Newmarket	Plastic Limit (%) =	-
Borehole No:	11	Plasticity Index (%) =	-
Sample No:	2	Moisture Content (%) =	-
Depth (m):	1.1	Estimated Permeability	
Elevation (m):	259.4	(cm./sec.) =	10^{-6}

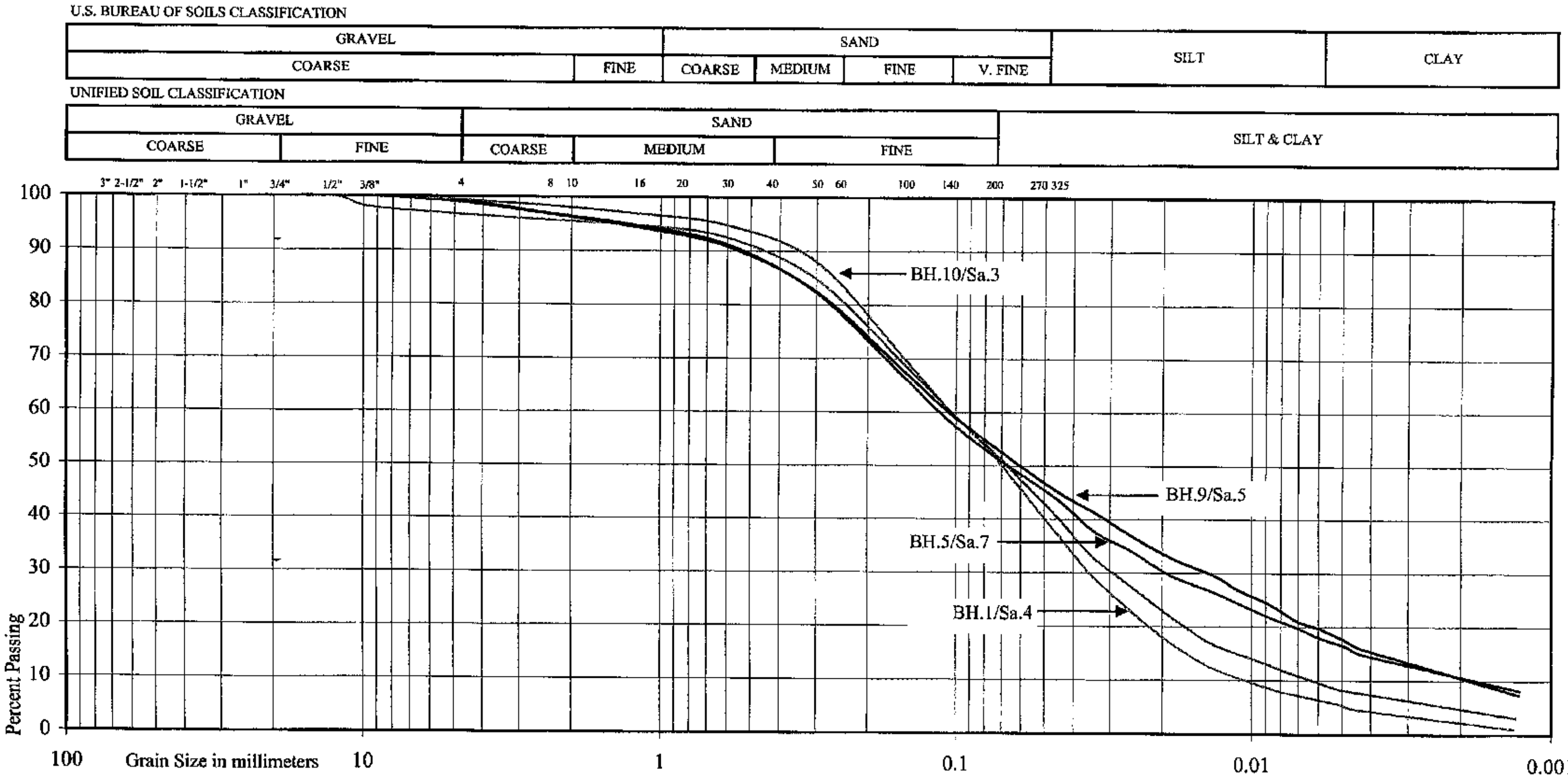
Classification of Sample [& Group Symbol]: SILTY CLAY, Fill

Figure: 13

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



Project:	Proposed Residential Development			
Location:	NE of Yonge St./Eagle St., Town of Newmarket			
Borehole No:	1	5	9	10
Sample No:	4	7	5	3
Depth (m):	2.4	6.4	3.2	1.8
Elevation (m):	262.1	253.9	264.3	263.7

BH./Sa.	1/4	5/7	9/5	10/3
Liquid Limit (%) =	-	-	-	-
Plastic Limit (%) =	-	-	-	-
Plasticity Index (%) =	-	-	-	-
Moisture Content (%) =	-	-	-	-
Estimated Permeability (cm./sec.) =	10^{-5}	10^{-6}	10^{-6}	10^{-5}

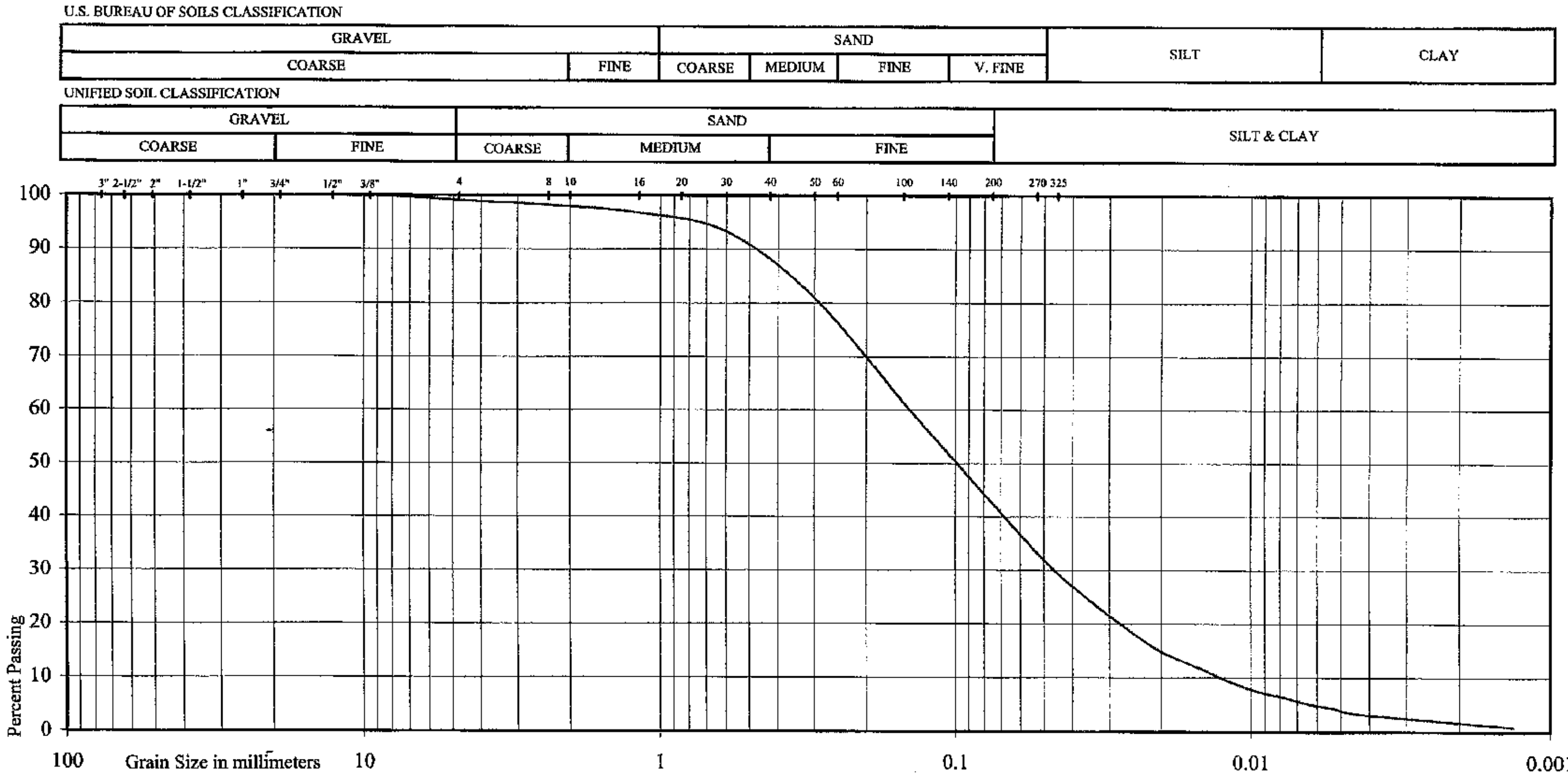
Classification of Sample [& Group Symbol]: SANDY SILT, Till
a tr. to some clay, a tr. of gravel

Figure: 14

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



Project: Proposed Residential Development

Location: NE of Yonge St./Eagle St., Town of Newmarket

Borehole No: 6

Sample No: 6

Depth (m): 4.9

Elevation (m): 258.6

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = -

Estimated Permeability (cm./sec.) = 10^{-4}

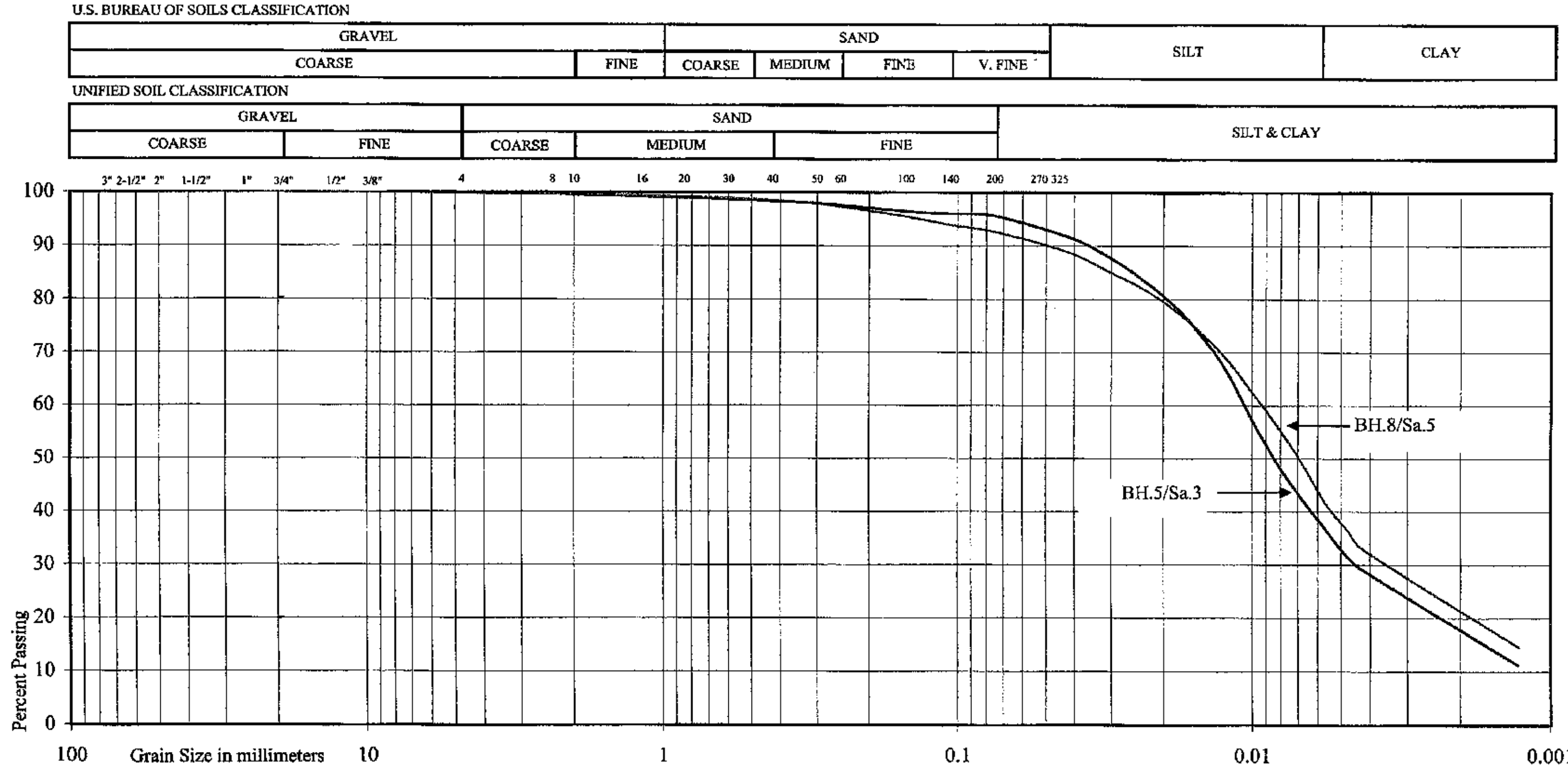
Classification of Sample [& Group Symbol]:	SILTY SAND, Till traces of clay and gravel

Figure: 15

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



BH./Sa.	5/3	8/5
Liquid Limit (%) =	26.9	28.2
Plastic Limit (%) =	16.8	18.0
Plasticity Index (%) =	10.1	10.2
Moisture Content (%) =	16	21
Estimated Permeability (cm./sec.) =	10^{-6}	

Project:	Proposed Residential Development	
Location:	NE of Yonge St./Eagle St., Town of Newmarket	
Borehole No:	5	8
Sample No:	3	5
Depth (m):	1.8	3.3
Elevation (m):	258.5	253.8

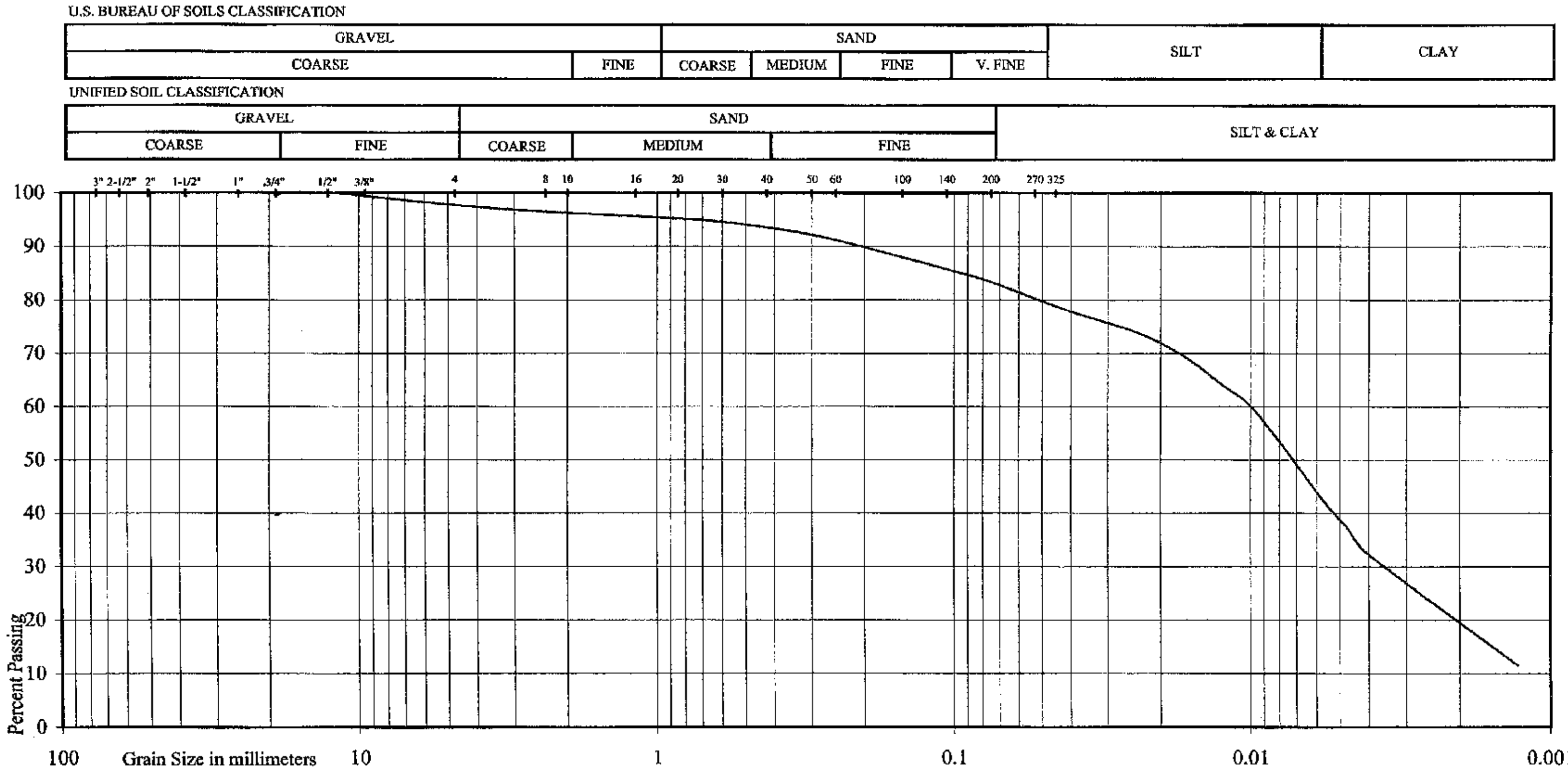
Classification of Sample [& Group Symbol]: SILTY CLAY
a tr. of sand

Figure: 16

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



Project:	Proposed Residential Development	Liquid Limit (%) =	28.2
Location:	NE of Yonge St./Eagle St., Town of Newmarket	Plastic Limit (%) =	17.7
Borehole No:	11	Plasticity Index (%) =	10.5
Sample No:	7	Moisture Content (%) =	15
Depth (m):	4.9	Estimated Permeability	
Elevation (m):	255.6	(cm./sec.) =	10^{-6}

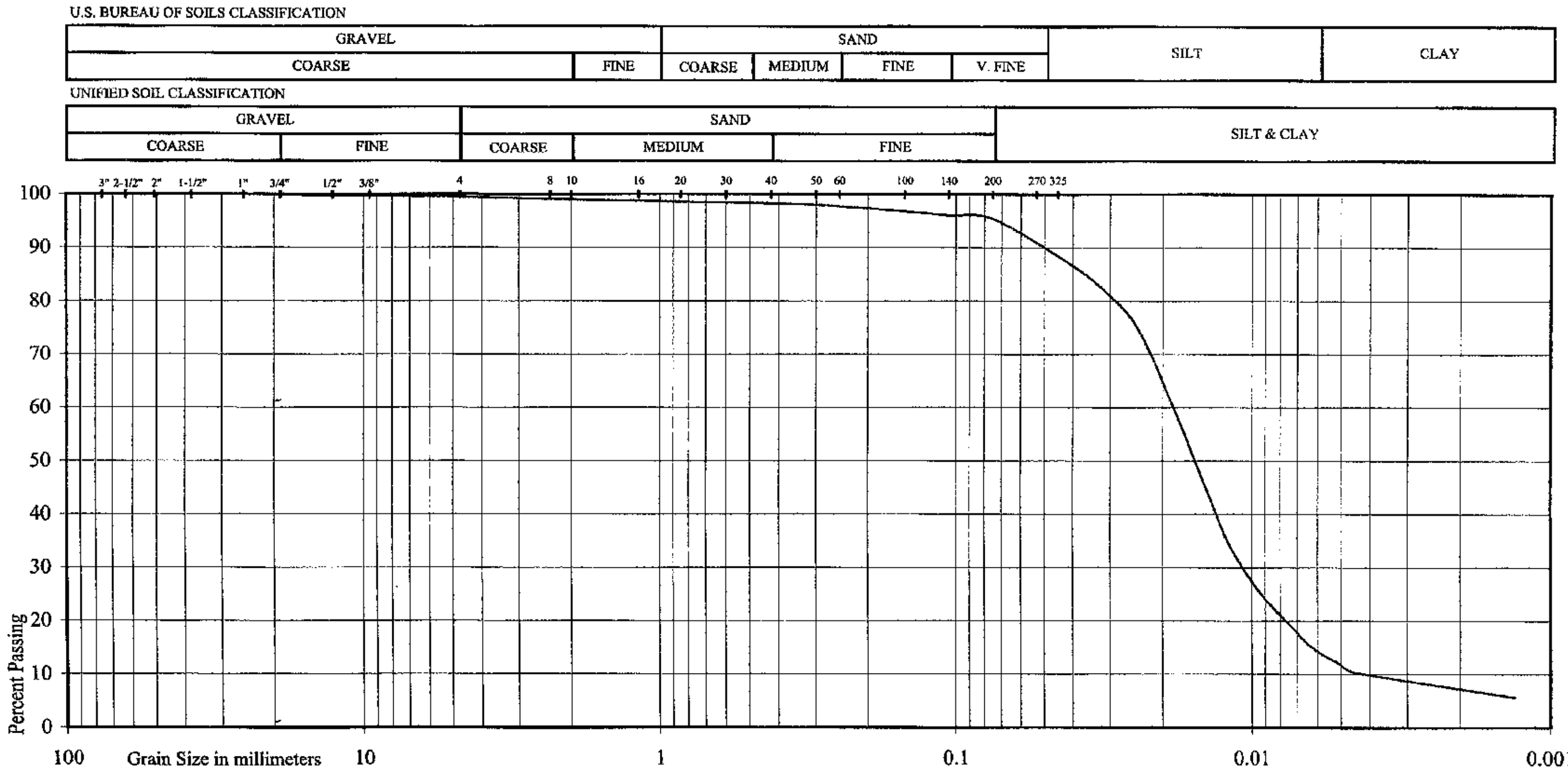
Classification of Sample [& Group Symbol]: SILTY CLAY, Till
some sand, a tr. of gravel

Figure: 17

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004



Project:	Proposed Residential Development	Liquid Limit (%) =	-
Location:	NE of Yonge St./Eagle St., Town of Newmarket	Plastic Limit (%) =	-
Borehole No:	12	Plasticity Index (%) =	-
Sample No:	5	Moisture Content (%) =	-
Depth (m):	3.3	Estimated Permeability	
Elevation (m):	256.8	(cm./sec.) =	10^{-5}

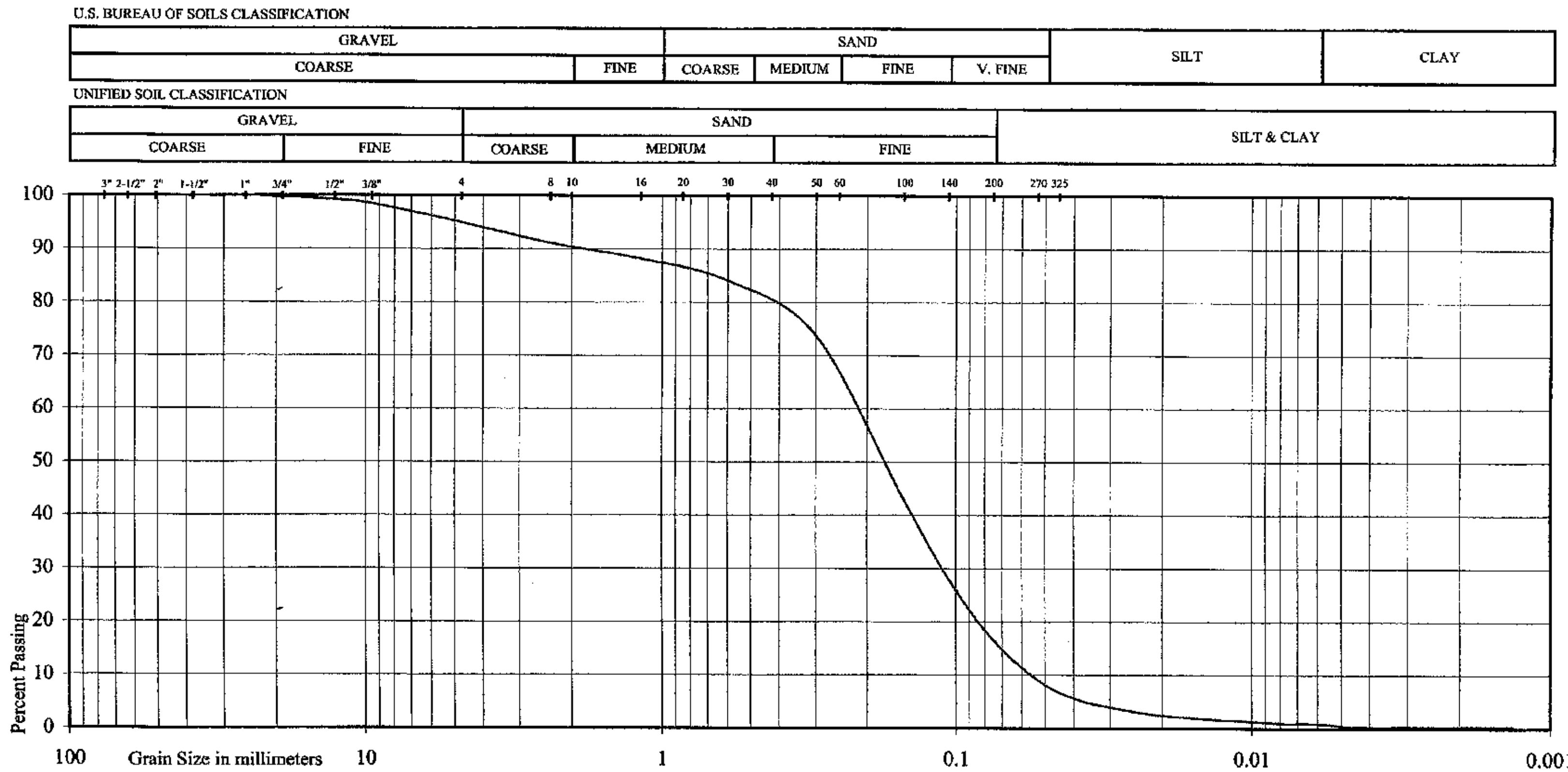
Classification of Sample [& Group Symbol]:	SILT some clay, traces of sand and gravel

Figure: 18

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 0409-S004

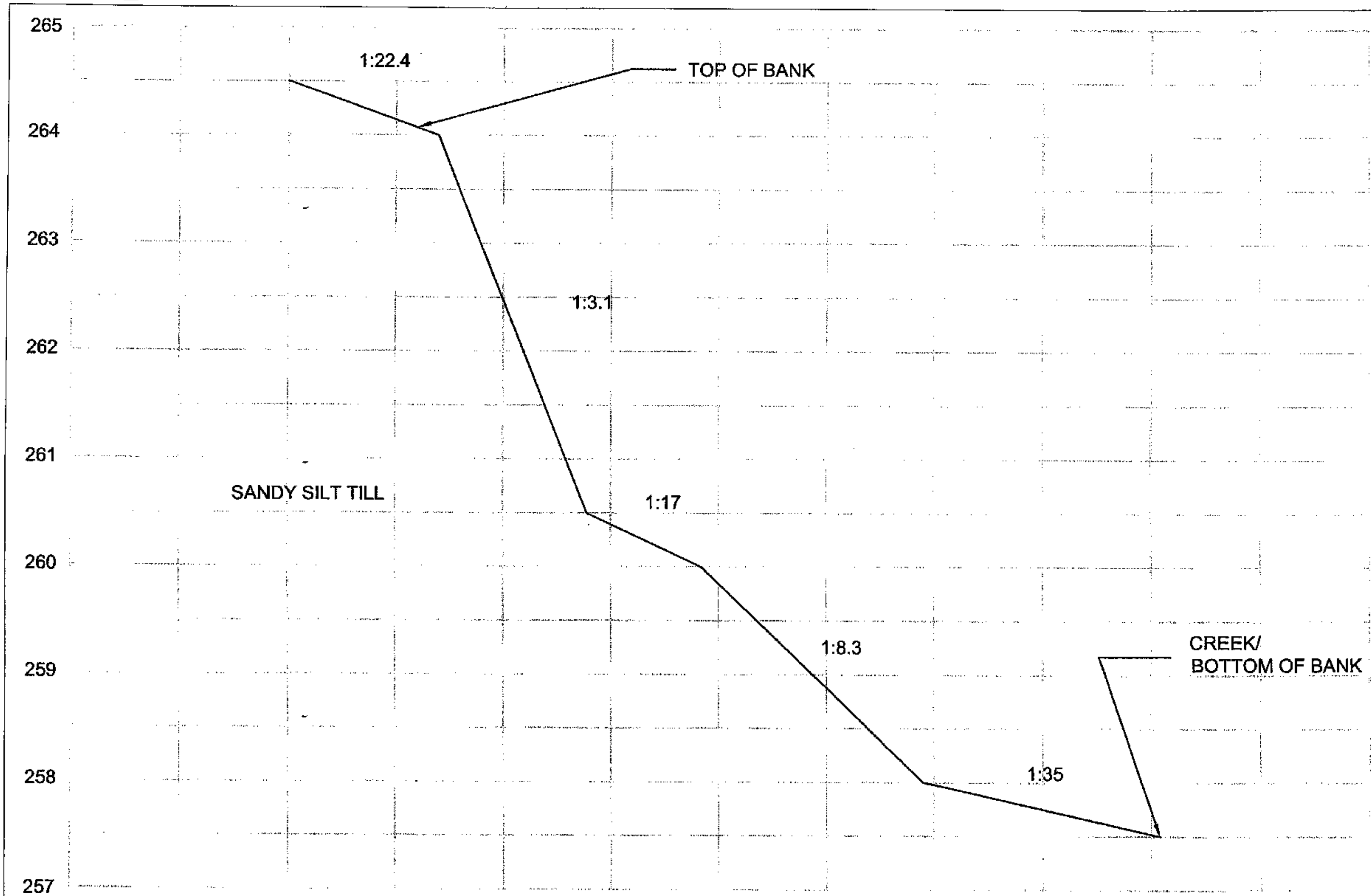


Project:	Proposed Residential Development	Liquid Limit (%) =	-
Location:	NE of Yonge St./Eagle St., Town of Newmarket	Plastic Limit (%) =	-
Borehole No:	3	Plasticity Index (%) =	-
Sample No:	11	Moisture Content (%) =	-
Depth (m):	12.5	Estimated Permeability	
Elevation (m):	253.9	(cm./sec.) =	10^{-3}

Classification of Sample [& Group Symbol]: FINE TO COARSE SAND
some silt, traces of clay and gravel

Figure: 19

Soil Engineers Ltd.

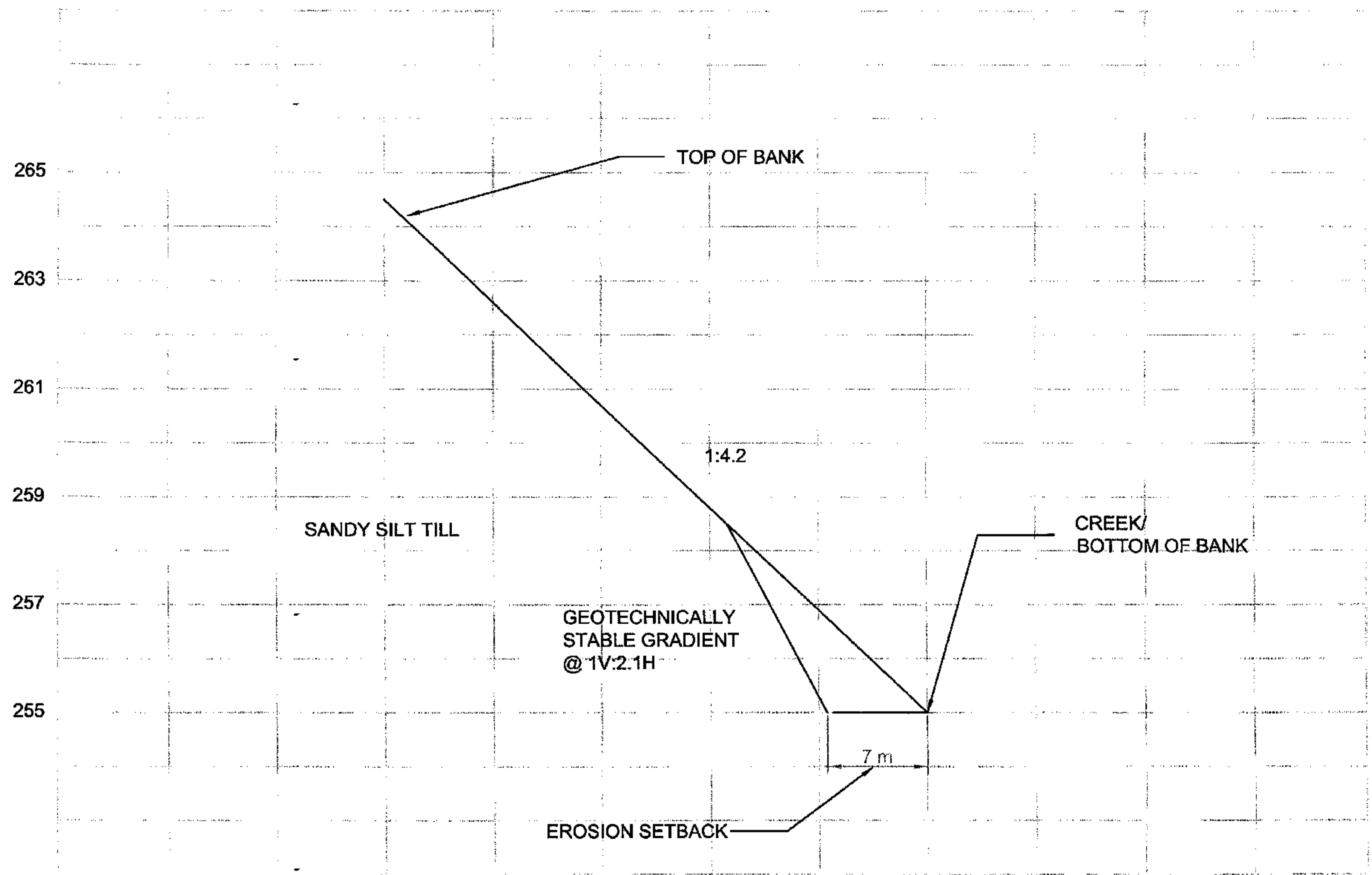


SCALE: HORIZ. 1:400
VERT. 1:50

CROSS-SECTION A-A

REF. NO. 0409-S004
DRAWING NO. 2

Soil Engineers Ltd.

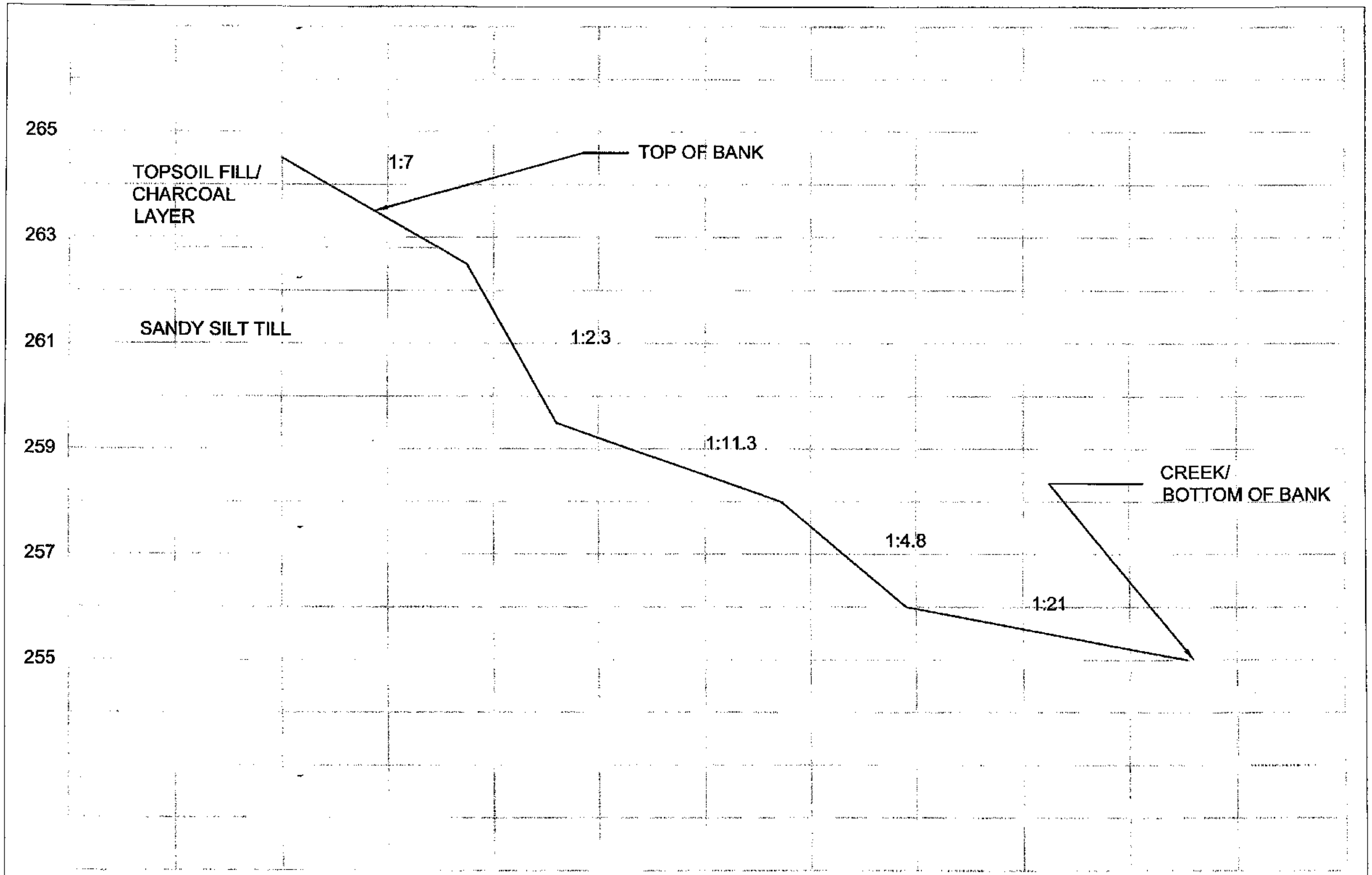


CROSS-SECTION B-B

SCALE: HORIZ. 1:400
VERT. 1:100

REF. NO. 0409-S004
DRAWING NO. 3

Soil Engineers Ltd.

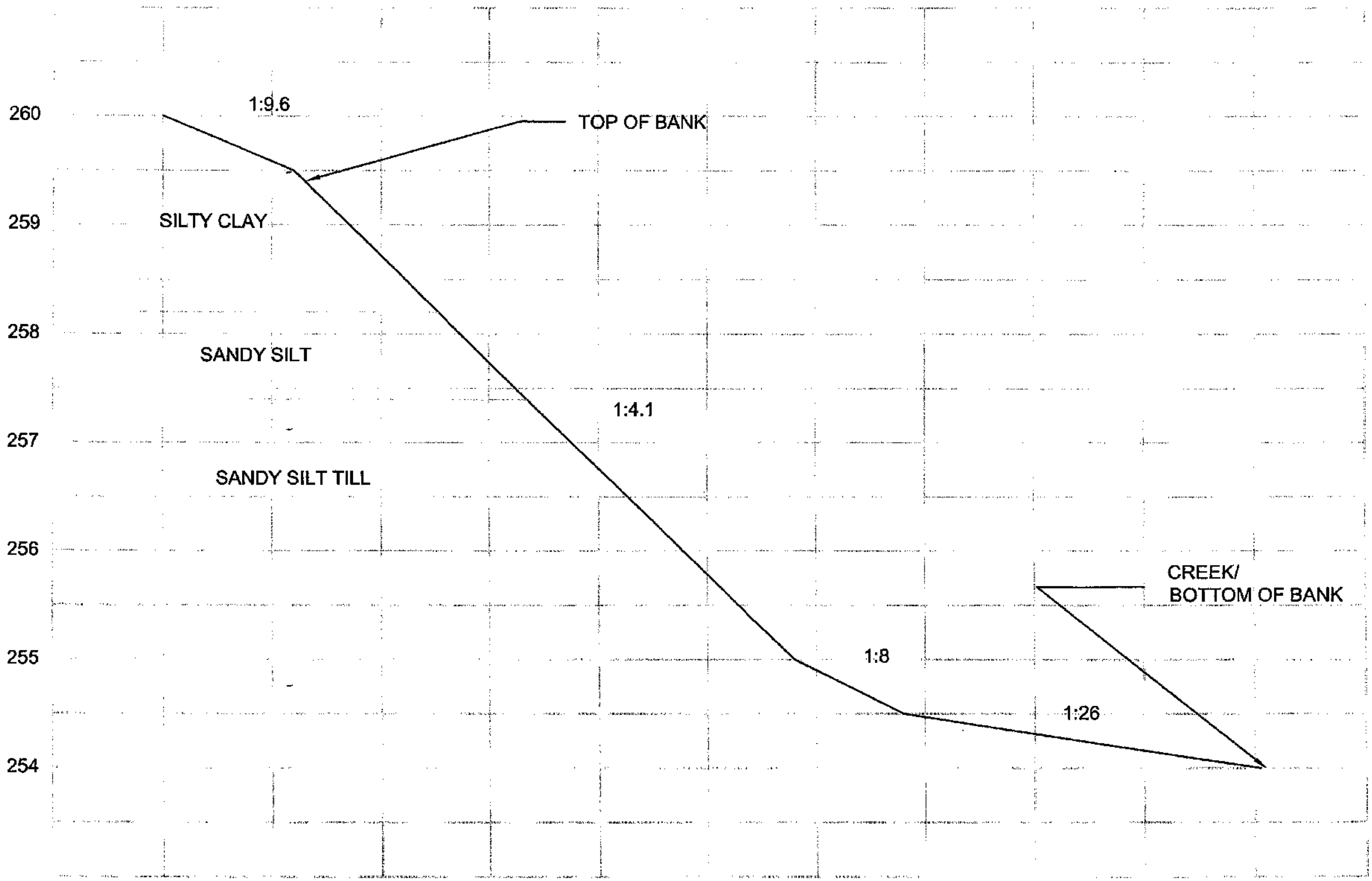


SCALE: HORIZ. 1:400
VERT. 1:100

CROSS-SECTION C-C

REF. NO. 0409-S004
DRAWING NO. 4

Soil Engineers Ltd.

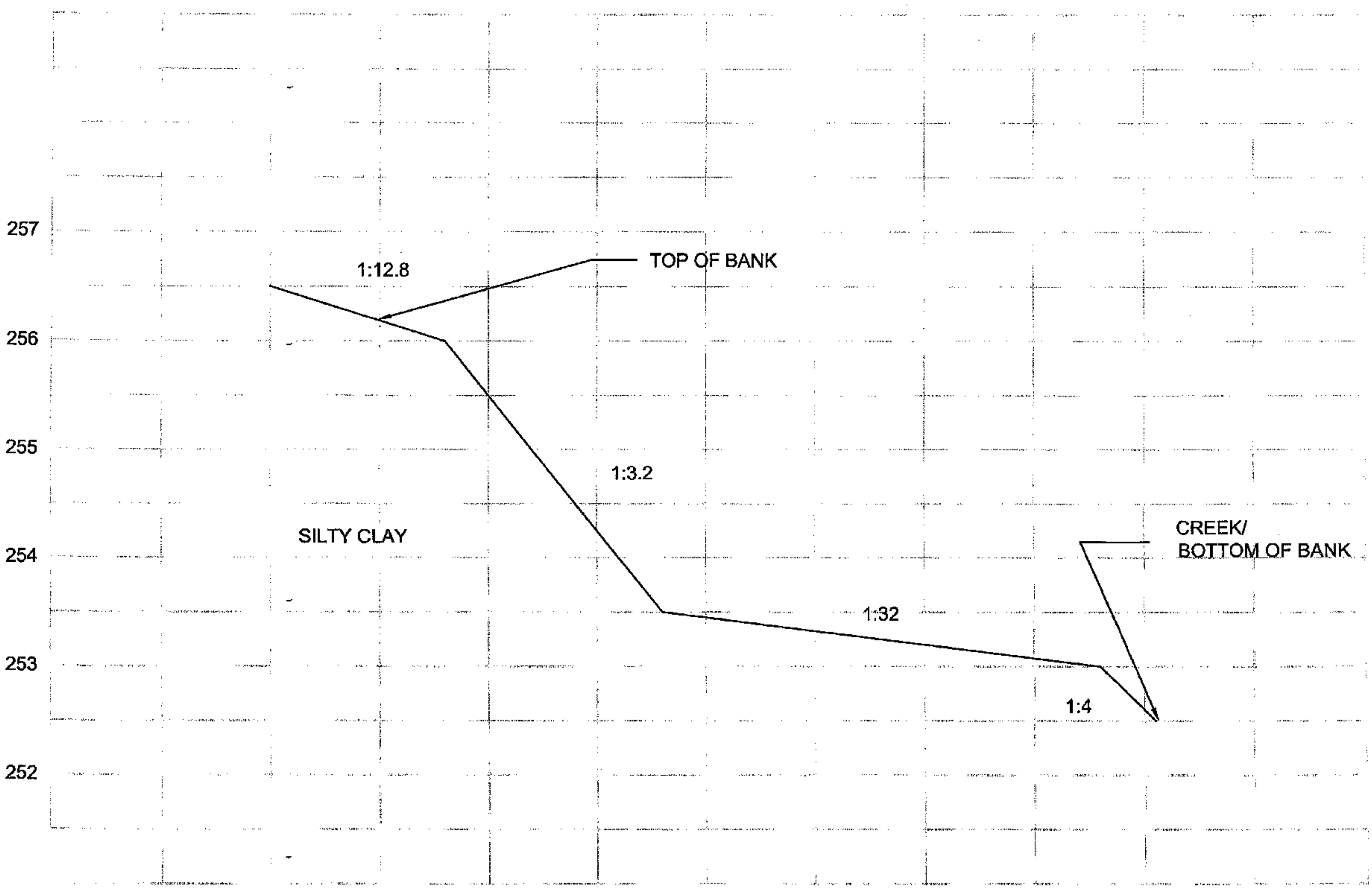


SCALE: HORIZ. 1:200
VERT. 1:50

CROSS-SECTION D-D

REF. NO. 0409-S004
DRAWING NO. 5

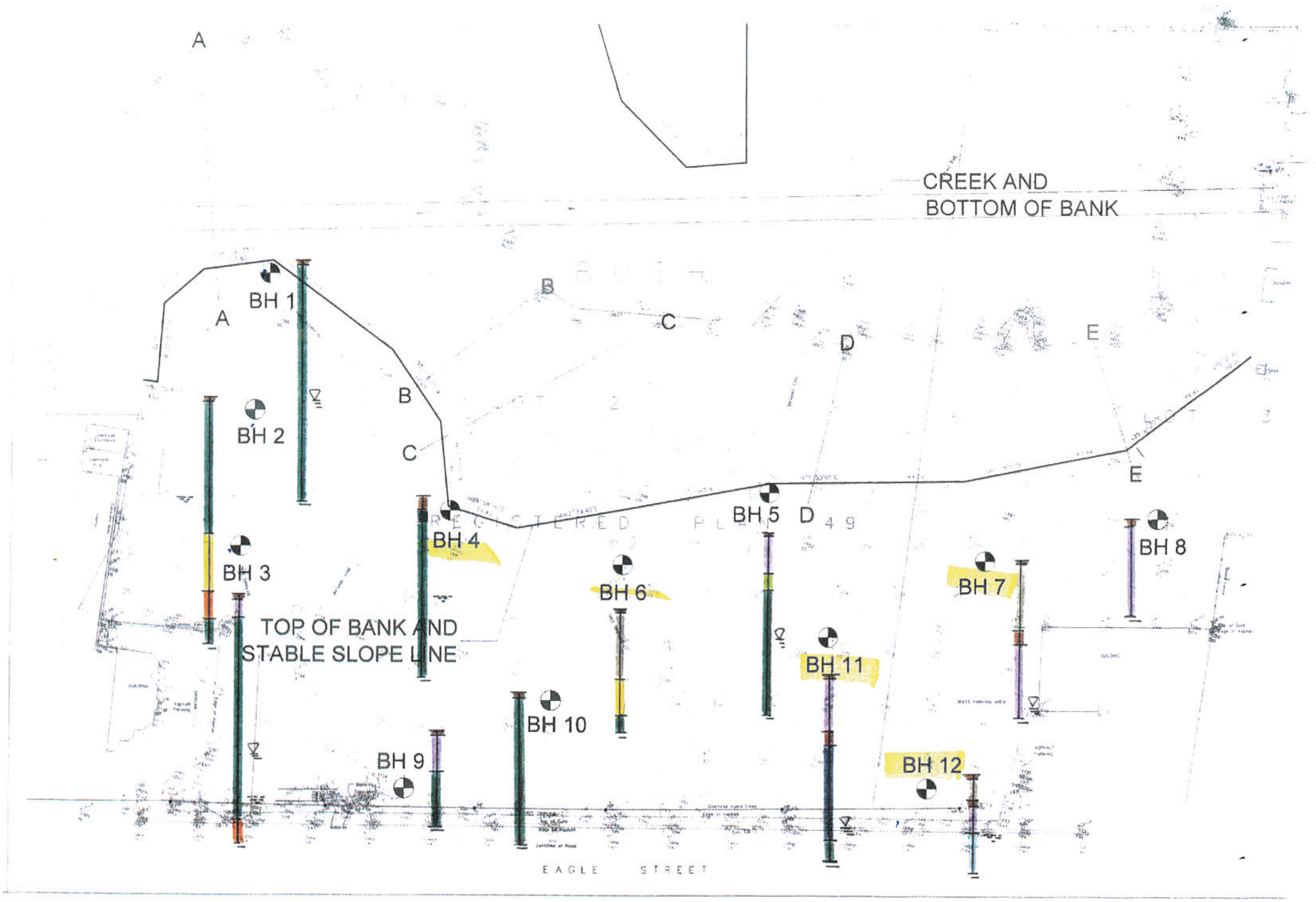
Soil Engineers Ltd.



SCALE: HORIZ. 1:200
VERT. 1:50

CROSS-SECTION E-E

REF. NO. 0409-S004
DRAWING NO. 6



LEGEND

- TOPSOIL/TOPSOIL FILL
- EARTH FILL
- CHARCOAL REMAINS
- SANDY SILT TILL
- SILTY SAND TILL
- SANDY SILT
- FINE TO COARSE SAND
- SILTY CLAY
- SILT
- SILTY CLAY TILL
- WATER LEVEL
- CAVE-IN

BOREHOLE LOCATION PLAN AND SUBSURFACE PROFILE

Ref. No. 0409-S004
Date: October 2004
Drawing No. 1
Scale: Horiz. - 1: 1000 Vert. - 1:200

SOIL ENGINEERS LTD.