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PRELIMINARY FOUNDATION INVESTIGATION REPORT

MTO FERRY DOCKS AT LEAMINGTON, KINGSVILLE AND PELEE ISLAND
TOWNSHIPS OF MERSEA, GOSFIELD SOUTH AND PELEE ISLAND
DISTRICT 31, CHATHAM
WORK ORDER NUMBER: 01-33-001
PURCHASE ORDER NUMBER: 3005-A-000218
GEO CRES NUMBER 40J2-57

Submitted to:

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February 26, 2003

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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Morrison Hershfield Limited on behalf of The Ministry of Transportation Ontario (MTO) to carry out a preliminary foundation investigation at the Leamington and Kingsville Ferry Docks, Ontario. No foundation investigation was to be carried out at the Pelee Island Dock.

The purpose of the foundation investigation is to determine the subsurface soil and groundwater conditions in the areas of interest by drilling a series of boreholes and the digging of selected testpits at both sites. The preceding work was supplemented by a program of laboratory testing carried out on selected soil samples obtained from the boreholes and testpits. The terms of reference for the scope of work are outlined in Golder Associates Ltd. proposal P14-2732 dated July 24, 2002.

2.0 SITE DESCRIPTION

2.1 Site Location

The Leamington ferry dock site is located along the southerly extension of Erie Street South in the Town of Leamington, Ontario. The present ferry dock was constructed in 1993/1994 when the original wharf (which includes the access road, restaurant/warehouse, timber crib and armour stone breakwall to the north) was widened to the east. The expanded docking facilities were created to improve the shipping operations to Pelee Island. The present docking complex extends approximately 300 metres out from shore, comprises an asphalt pavement surface and at the waters edge is enclosed by steel sheet piling with a concrete cap. Pelee Island Transportation Service currently operates the dock facility.

The Kingsville ferry dock site is located at the southerly extension of Lakeview Avenue in the Town of Kingsville, Ontario. The present ferry dock is situated east of and replaced the former docking facility at the south end of the original east pier which contains the Kingsville fishing operations building. The current ferry dock complex extends approximately 300 metres out from shore, comprises an asphalt pavement surface and is enclosed at the south and west sides by steel sheet piling with a concrete cap. An armour stone breakwall protects the east side the dock.

2.2 Site Physiography

The Towns of Kingsville and Leamington are both located in the physiographic region of southwestern Ontario known as the St. Clair Clay Plain. The base soils at the two subject sites are characteristically described as comprising of extensive deposits of glacio lacustrine clays. The massive clay stratum is generally considered to have a till-like structure exemplified by a random distribution of coarser particles throughout the stratum and a general lack of stratification. In the Kingsville and especially the Leamington area, the clay plain is overlain by small discontinuous morainic deposits (consisting mainly of sand and sand and gravel). Available mapping for the subject areas indicates the overburden thickness to be in the order of 17 and 34 metres at the Kingsville and Leamington dock sites respectively.

The Kingsville and Leamington docks have been constructed out into Lake Erie a considerable distance south of the current shoreline. This has been accomplished by mass filling to raise the grade in the Lake Erie bed.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between September 11 and 20, 2002 during which time a total of fifteen (15) boreholes and four testpits were advanced at the two ferry dock sites. Boreholes L1 to L9 were drilled at the Leamington dock site while boreholes K1 to K6 were drilled at the Kingsville dock. Each of the boreholes was drilled just inland of the concrete cap of the steel sheet pile wall of the ferry dock using hollow stem augers assisted by washboring methods wherever necessary. The boreholes were extended to depths between 9.8 and 11.3 metres below the existing ground surface. All of the boreholes were drilled using conventional soil sampling and drilling equipment supplied and operated by a specialist drilling contractor.

One borehole at the Leamington site and two boreholes at the Kingsville ferry dock sites were deleted from the field drilling program as access to the drill locations was not available.

Two testpits were also excavated at each of the two ferry dock sites. The testpits were excavated using a rubber tired backhoe supplied and operated by a local excavating contractor. The testpits were excavated immediately behind the cap of the steel sheet pile wall and were terminated at depths of between 1.7 and 2.4 metres below existing grade.

The boreholes and testpits are shown in plan on the attached Borehole Location Plans, Figures 1 and 2.

After augering through the existing pavement structure, standard penetration testing and soil sampling was, wherever possible, carried out at selected intervals of depth in each of the boreholes using 35 millimetre, inside diameter, split spoon sampling equipment. Dynamic cone penetration testing was also carried out in the lower portion of borehole L8 to better define the insitu condition of the deeper soils. All of the soil samples obtained were, following field identification, placed in individually labeled containers and brought to our Windsor office for further examination and laboratory testing.

Representative samples of the major soil horizons exposed in the testpits were obtained and brought to our Windsor office. The attached Photographs 1 to 7 provide a pictorial view of typical conditions exposed in each of the testpits excavated at the two ferry dock sites.

The soil stratigraphy encountered in the boreholes and testpits is shown in detail on the appended Records of Boreholes and Records of Testpits. The results of the field and laboratory testing are shown on the respective borehole and testpit logs and on Figures 5 to 14 inclusive.

The field drilling and testpitting operations were continuously supervised by experienced geotechnical members of our engineering staff who also determined the ground surface elevation at each of the testhole locations, logged the boreholes and testpits and cared for the soil samples obtained. The ground surface elevation at the borehole and testpit locations have been referenced to temporary benchmarks provided by Callon Dietz. The bench mark elevations provided are understood to be referenced to Imperial Great Lakes Datum (IGLD).

Each of the boreholes and testpits was tied into UTM reference coordinates (i.e. northing and easting).

Groundwater conditions were observed in the open boreholes and testpits throughout the field drilling/testpitting operations and upon completion of sampling.

All of the testpits were backfilled in mechanically compacted loose lifts using the materials excavated during the excavation process. The boreholes were backfilled using a bentonite-cement mix, lean concrete and/or granular fill materials.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface soil and groundwater conditions encountered in the boreholes and testpits advanced at the Leamington and Kingsville ferry dock sites are shown on the attached Records of Boreholes, Records of Testpits and on Figures 5 to 14 inclusive.

The soil boundaries indicated on the Records of Boreholes and Records of Testpits are inferred from non-continuous sampling and from observations of the resistance to borehole/testpit advance. These boundaries typically represent the transition from one soil type to another and do not necessarily represent exact planes of geological change. Further, the subsurface conditions will vary between and beyond the testhole locations.

4.2 Site Stratigraphy

A detailed description of the subsurface soil and groundwater conditions encountered in the boreholes and testpits advanced at the two ferry dock sites under investigation are described on the Record of Borehole and Record of Testpit sheets following the text of this report.

In general the subsurface conditions encountered in the testholes advanced at both sites was similar. To summarize, below the existing pavement structure and/or near surface granular fill materials, the boreholes encountered rock fill overlying strata of very loose to dense fine-grained granular soils. Two of the boreholes at the Leamington dock site were terminated in soft silty clay encountered below the fine-grained granular deposits. Except for one borehole, all of the boreholes at the Kingsville dock site were terminated in very dense sandy silt till and/or hard silty clay/clayey silt till. The following sections provide a generalized description of the various soil horizons encountered at both sites.

4.2.1 Leamington Dock

The subsurface conditions encountered in the nine boreholes and two testpits advanced at the Leamington dock site were variable and differed in plan as well as with depth. In general, the subsurface soil comprised of the existing asphalt pavement structure overlying typically 0.3 metres of sand fill, 0.6 metres of crushed stone fill (clear stone size) and 1.5 to 4.2 metres of rock fill (cobble size) underlain by very loose to compact fine sand to sandy silt. Boreholes L1 and L7 were terminated in soft silty clay encountered below the fine grained granular soils at a depth of about 11 metres below the dock surface.

In areas where some rehabilitation work to the dock surface was previously carried out, the upper, approximately 2 metres of the original dock construction immediately behind the concrete cap wall appears to have been replaced with a well graded granular type fill material placed on a geotextile separation fabric.

4.2.1.1 Existing Pavement Structure and Fill Materials

Boreholes L2 to L7 were drilled in existing paved areas and encountered between 130 and 180 millimetres of asphalt overlying between about 180 and 305 millimetres of granular base materials.

Boreholes L1, L8 and L9 were drilled in previously repaired areas and encountered some 0.4 to 2.1 metres of Granular "A" type fill materials at ground surface underlain by and/or containing a geotextile separation fabric. Standard penetration testing carried out in the Granular "A" type fill materials yielded "N" values ranging between 8 and 26 blows per 0.3 metres.

Beneath the existing pavement structure in boreholes L2 to L7 and the granular base materials in borehole L9, some 0.7 to 1.8 metres of very loose to dense sand and crushed stone fill (clear stone size materials) was found. In general, the upper, typically 0.2 to 0.8 metres of the fill was of a sand composition overlying the coarser clear stone size materials. The presence of a geotextile separation fabric between the sand and clear stone fill materials was not detected in the boreholes. The results of standard penetration testing carried out in the sand and crushed stone fill materials yielded "N" values ranging between 4 and 31 blows per 0.3 metres. The water content of the sand, crushed stone and Granular "A' type fill materials tested varied between about 2 and 22 per cent with the majority of the values being in the 5 to 15 per cent range.

The attached Figures 7 to 11 present the results of laboratory grading analyses carried out on typical samples of the sand and crushed stone (clear stone sized) fill materials recovered from selected boreholes and testpits advanced at the site.

Underlying the Granular "A" type fill materials in boreholes L1 and L8 and the sand and/or clear stone fill materials in the remaining boreholes and testpits, rock fill was encountered. The thickness of the rock fill at the borehole locations varied between about 1.7 and 4.4 metres. On the basis of the conditions exposed in the testpits, the rock fill can generally be described as comprising 150 to 200 millimetre sized stone and contains varying amounts of sand and/or layers. Although not encountered in the shallow testpits, it is possible that some larger size rock fragments may be present in the rock fill. Standard Penetration testing carried out in the rock fill materials yielded "N" values ranging between 5 and 59 blows per 0.3 metres of penetration indicating a loose to very dense state of packing.

Grain size distribution curves for selected samples of the rock fill recovered in boreholes L2 and L3 are shown on Figure 6. The samples were obtained with the standard 35 mm inside diameter split spoon sampler and as such, the gradation shown is not considered to be truly representative of the coarser size materials existing in the rock fill.

4.2.1.2 Fine Sand to Sandy Silt

Underlying the rock fill materials, all of the boreholes encountered fine grained granular soils ranging in composition from fine sand to sandy silt containing occasional shells and organic pockets/zones. The presence of occasional cobbles in the upper portion of the fine grained granular soils has been inferred based on the resistance to augering and/or sampling. .

Measured "N" values obtained in the fine sand to sandy silt soils ranged from 2 to 23 blows per 0.3 metres of penetration indicating a very loose to compact state of packing. The results of dynamic cone penetration testing carried out at depth in borehole L8 confirms the relative state of packing of the fine sand to sandy silt materials.

Grain size distribution curves for selected samples of the fine sand to sandy silt materials recovered in boreholes L1 and L9 are shown on the Grain Size Distribution sheet on Figure 5.

The water content of selected samples of the fine sand to sandy silt materials obtained in the boreholes varied between about 19 and 38 per cent.

4.2.1.3 Silty Clay

Boreholes L1 and L7 were terminated in soft silty clay encountered below the rock fill materials. The two measured "N" values obtained in the silty clay were 4 blows per 0.3 metres.

4.2.1.4 Groundwater Conditions

Water levels were noted during drilling and measured in the open boreholes upon completion of the sampling/testing/drilling operations as detailed on the Record of Borehole sheets. The groundwater levels measured in the boreholes and testpits varied between about elevations 173.6 and 174.5 metres or some 1.5 to 2.4 metres below the top of the existing dock surface. The water level at the site is considered to be directly influenced and governed by the level in Lake Erie. It should be noted that groundwater levels will fluctuate seasonally depending on the level of the water in the lake.

4.2.2 Kingsville Dock

The subsurface conditions encountered in the six boreholes and two testpits advanced at the Kingsville dock site were variable and differed in plan as well as with depth. In general, the subsurface soils comprised of the existing asphalt pavement structure and typically 0.4 to

1.1 metres of fine sand to silty fine sand fill containing some clear stone and/or rock fragments, overlying between about 2.9 and 5.0 metres of rock fill (cobble size). The rock fill is underlain by strata of soft to very stiff clayey silt and compact to very dense fine sand to sandy silt. The latter soils are at depth underlain by very dense sandy silt till and/or hard clayey silt till. In areas where some rehabilitation work to the dock surface has previously been carried out, the upper, approximately 0.7 to 1.4 metres of the original dock construction (i.e. immediately behind the concrete cap wall) appears to have generally been replaced with a well graded granular type fill material placed on and/or containing a geotextile separation fabric.

4.2.2.1 Existing Pavement Structure and Fill Materials

Boreholes K4 and K5 were drilled in existing paved areas and encountered between 130 and 165 millimetres of asphalt overlying between about 180 and 340 millimetres of granular base materials.

Boreholes K1 to K3 and K6 were drilled in previously repaired areas and encountered some 0.7 to 1.4 metres of granular fill materials. The granular fill varied in composition from Granular "A" type fill materials, fine sand and silty fine sand fill to crushed stone (clear stone sized) fill. There is evidence that a geotextile separation fabric was provided during the repair work. Standard penetration testing carried out in the granular fill materials yielded "N" values ranging between 16 and greater than 50 blows per 0.3 metres.

The water content of the sand, crushed stone and Granular "A' type fill materials tested varied between about 4 and 23 per cent.

The attached Figures 8 to 11 present the results of laboratory grading analyses carried out on typical samples of the sand and crushed stone (clear stone sized) fill materials recovered from the two testpits excavated at the site.

Underlying the sand, clear stone and Granular "A" type fill materials, the boreholes and testpits encountered rock fill. The thickness of the rock fill at the borehole locations varied between about 2.9 and 5.0 metres. On the basis of the conditions exposed in the testpits, the rock fill can generally be described as comprising 150 to 200 millimetre sized stone and contains varying amounts of sand pockets and/or layers. Although not encountered in the shallow testpits, it is possible that some larger size rock fragments may be present in the rock fill. Standard Penetration testing carried out in the rock fill materials yielded "N" values ranging between 8 and 118 blows per 0.3 metres of penetration indicating a loose to very dense state of packing.

Grain size distribution curves for selected samples of the rock fill recovered in boreholes K1 and K6 are shown on Figures 12 and 14. The samples were obtained with the standard 35 millimetre inside diameter split spoon sampler and as such, the gradation shown is not considered to be truly representative of the coarser size materials existing in the rock fill.

4.2.2.2 Fine Sand to Sandy Silt

Underlying the rock fill materials, all of the boreholes encountered fine grained granular soils ranging in composition from fine sand to sandy silt containing occasional shells and organic pockets/zones. The presence of occasional cobbles in the upper portion of the fine-grained granular soils has been inferred based on the resistance to augering and/or sampling.

Measured 'N' values obtained in the fine sand to sandy silt soils ranged from 3 to 42 blows per 0.3 metres of penetration with the values generally being in the 25 to 35 blows per 0.3 metre range indicating a compact to dense state of packing. The water content of selected samples of the fine sand to sandy silt materials obtained in the boreholes varied between about 10 and 31 per cent.

Grain size distribution curves for selected samples of the fine sand to sandy silt materials recovered in boreholes K1 and K6 are shown the Grain Size Distribution sheet on Figure 13.

4.2.2.3 Clayey Silt

Layers of soft to very stiff clayey silt were encountered below the rock fill in borehole K3 and at depth in Borehole K2. The thickness of the clayey silt varied between 0.9 and 1.6 metres at the borehole locations. The measured "N" values obtained in the clayey silt ranged from 3 to 23 blows per 0.3 metres. The average water content of the clayey silt samples tested was about 28 per cent.

4.2.2.4 Sandy Silt Till and Clayey Silt Till

Except for Borehole K2 all of the boreholes drilled at the Kingsville site were terminated in very dense sandy silt till or hard clayey silt till. Measured "N" values obtained in the sandy silt/clayey silt till materials ranged from 33 to 96 blows per 0.3 metres. The water content of samples of the till materials tested varied from about 11 to 14 per cent.

4.2.2.5 Groundwater Conditions

Water levels were noted during drilling and measured in the open boreholes upon completion of the sampling/testing operations as detailed on the Record of Borehole sheets. The groundwater levels measured in the boreholes and testpits varied between about elevations 173.9 and 174.1 metres or some 1.9 to 2.1 metres below the top of the existing dock surface. The water level at the site is considered to be directly influenced and governed by the level in Lake Erie. It should be noted that groundwater levels will fluctuate seasonally depending on the level of the water in the lake.

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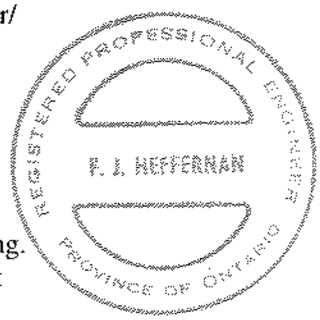

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PART B

PRELIMINARY FOUNDATION DESIGN REPORT
MTO FERRY DOCKS AT LEAMINGTON, KINGSVILLE AND PELEE ISLAND
TOWNSHIPS OF MERSEA, GOSFIELD SOUTH AND PELEE ISLAND
DISTRICT #31 CHATHAM
WORK ORDER NUMBER: 01-33-001
PURCHASE ORDER NUMBER: 3005-A-000218
GEO CRES NUMBER 40J2-57

5.0 PRELIMINARY ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations for the geotechnical aspects related to the preliminary design of the rehabilitation works proposed at the Leamington, Kingsville and Pelee Island ferry docks. The preliminary engineering recommendations provided herein are based on our interpretation of the factual information obtained during the investigation, project data and relevant ferry dock design details (i.e. drawings and information) provided to us. It should be noted that the interpretation of our findings and the preliminary recommendations provided herein are intended for use by the design engineer only. Where comments are made on construction they are provided only to highlight those aspects of construction which could potentially affect the design of the project. Contractors bidding on or undertaking any work at the site(s) should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

Our professional services for this assignment address only the geotechnical (physical) aspects of the subsurface conditions at the site(s). The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site(s) of materials from off-site sources are outside the terms of reference of this report and have not been investigated or addressed.

It is understood that the present ferry dock systems at the Kingsville, Leamington and Pelee Island sites were constructed in about 1993/1994. The construction comprised an expansion of the original pier configuration for the purpose of improving the shipping operations. Review of the available "as-built" and/or design drawings provided to us, indicates that the construction of the Kingsville and Leamington ferry docks was carried out in substantially a similar manner and essentially involved first constructing a rock fill berm around the periphery of the new dock, followed by driving of a steel sheet wall along the outside toe of the berm and then infilling the area contained between the sheeting and the existing dock complex. The top of the steel sheet piling is supported by deadman anchors constructed in the backfill behind the wall. A concrete cap (i.e. coping) has also been provided at the top of the steel sheet piling to provide additional reinforcing to the wall.

All indications are that the rock fill berm was constructed by placing quarry run rock on the lake bed to create a working platform upon which the pile driving and/or other construction equipment could operate to install the sheet piling. Additional rock and/or crushed stone fill was used to backfill the steel sheet piling. Crushed stone fill (i.e. clear stone sized) was used to top and cover the inland portion of the rock berm. At the Kingsville ferry dock site, mainly rock and crushed stone fill was used to create the new ferry dock complex. At the Leamington ferry dock site, a large portion of the remaining backfill comprised select sand fill, dredged and/or approved materials. Final construction at both the Kingsville and Leamington dock sites comprised placement of 130 millimetres of asphalt and 150 millimetres of Granular "A" base materials laid on the prepared crushed rock, select sand fill, dredged and/or approved fill subgrade.

From discussions with Pelee Island Transportation Service (who are the present ferry dock operators), it is understood that the newly constructed pavement directly behind the dock wall experienced settlement almost immediately after completion of construction. The areas of settlement were irregular in shape and generally occurred at random locations. The attached Figures 3 and 4 show the approximate locations of the present and formerly repaired settlement areas at the Kingsville and Leamington ferry dock sites. The surface subsidence has resulted in an uneven pavement which has required regular maintenance to fill the depressed areas. Indications are that the movement was most pronounced during the early periods following construction. The settlement continues to the present although to a lesser degree and thus requires on-going maintenance. Based on the preceding it has been requested that an investigation be undertaken to investigate the probable cause(s) of the subsidence and to recommend potential remedial measures to mitigate the problem. To assist the TPM in the overall investigation process, Golder Associates Ltd. has been retained to carry out a preliminary foundation investigation to determine the subsurface soil and groundwater conditions at the site(s). The soils information obtained, together with project data/drawings and our understanding of the project requirements has been used to investigate the probable cause(s) of the subsidence and to provide preliminary engineering recommendations to mitigate the problem.

5.1.1 Summary of Subsurface Soil and Groundwater Conditions

The subsurface soil and groundwater conditions encountered in the boreholes and testpits advanced at the Kingsville and Leamington ferry dock sites were similar. To summarize, below the existing pavement structure, the subsoils typically comprised of 0.7 to 2.1 metres of granular/sand and/or crushed stone fill materials and some 1.6 to 5.0 metres of rock fill overlying strata of very loose to dense fine grained granular soils. Two of the deeper boreholes at the Leamington dock site were terminated in soft silty clay encountered below the fine grained granular soils. At the Kingsville ferry dock site, all of the boreholes, except one, were terminated in very dense sandy silt till and/or hard silty clay till.

The groundwater level at the two sites investigated was typically at about elevation 174.0 metres or some 2.0 metres below the dock pavement surface and basically corresponded to the water level in Lake Erie at the time of the investigation.

5.1.2 General Comments and Field Observations

The following summarizes some of the key features observed during excavation of the testpits. The items are presented in point form below:

- The testpits excavated through and/or beside granular surfaced repaired areas characteristically encountered Granular "A" type materials underlain by a geotextile separation fabric.
- The Granular "A" type fill materials are generally underlain by crushed stone (i.e. clear stone sized) fill materials.
- Testpits excavated through the existing, unrepaired asphalt pavement encountered variable amounts of sand fill overlying crushed stone (i.e. clear stone sized) fill materials down to approximately the lake water level, below which rock fill was found. The sand fill thickness in the testpits was greatest furthest away from the steel sheet pile wall. Correspondingly, the thickness of crushed stone fill decreased moving further away from the wall. This detail is clearly visible from the attached Photographs 1 and 7.
- The presence of a geotextile separation fabric(s) was not observed in any of the testpits excavated in the original pavement areas and it appears that the individual granular fill layers (becoming coarser with depth) were placed directly on top of one another.
- A void was visible below the concrete cap of the steel sheet pile wall at each of the testpit locations.

Based on preliminary information provided to us at the progress meeting(s), it is our understanding that the existing steel sheet pile wall is presently in an overall stable condition exhibiting no major openings of the interlocks (either at depth or directly below the concrete cap). Also, there is no evidence of significant scour having taken place in front of the wall. Indications are that the present steel sheet pile wall has performed satisfactorily to date.

5.2 Identification of Probable Cause(s) of Problem

The results of this investigation indicate that the present dock complex was created by the placement of several, generally discontinuous, layers of fill materials on top of the original Lake bed. There is no evidence to indicate that a geotextile fabric was used to separate the materials to avoid migration of fine materials into the underlying coarser grained clear stone and rock fill layers. This migration of sand appears to have occurred as the testholes showed signs of sand accumulation in the clear stone and/or rock fill. Further, there is evidence that some of the rock fill has penetrated into the loose, mainly fine grained granular soils, comprising the lake bed bottom. The migration of the fine sand fill materials into the underlying coarser stone and rock fill materials is considered to be the prime cause of the observed surface settlement at the Kingsville and Leamington ferry dock sites.

As detailed on the attached Figures 3 and 4, the most prominent areas of surface settlement are confined to the areas directly behind the concrete cap wall of the steel sheet piling. Indications at the Leamington site are that further inland and farther away from the wall, the amounts of clear stone and rock fill reduces and the fill materials are expected to chiefly comprise select sand fill and/or dredged fill materials. In these areas therefore there is less potential for settlement caused by migration of the sand fill materials into the deeper coarser clear stone and rock fill. Also, the areas further removed from the dock face, would be expected to be less prone to dynamic effects caused by ship docking operations and wave action compared to the areas abutting the concrete dock wall. All of the preceding indicators would suggest that the areas well removed from the face of wall are less prone to settlement and this is confirmed by the fact that there are no obvious signs of surface settlement here. It is our opinion therefore that fluctuations in the Lake Erie water level and dynamic loads (producing ground vibrations) induced by the ships during docking and wave action, are the prime triggering mechanisms which have caused migration of the finer fill materials into the underlying clear stone and/or rock fill layers resulting in the observed surface settlement.

No information is currently available to indicate how the concrete cap was constructed on top of the steel sheet piling. It is believed that after the area was brought up to the design grade, the concrete for the cap of the steel sheet pile wall was cast directly on top of the exposed fill surface. It is quite conceivable that the fill materials used to support the concrete during casting of the cap wall may not have been thoroughly compacted possibly as a result of space constraints, ground water problems and the like. This would have contributed to the settlement problems being experienced directly behind the wall and possibly also explains the reason why a void was detected below the concrete cap in each of the testpits excavated at the Kingsville and Leamington dock sites.

5.3 Potential Restoration Options

Several potential restoration and/or upgrading options have been considered for implementation at the two sites. The potential restoration options discussed at the December 5, 2002 progress meeting are listed in point form below and discussed briefly in the following paragraphs:

a) carry out cosmetic repairs and patching to the settled areas,
b) reinstate the settled areas by conventional excavating and backfilling techniques,
c) implement a grouting program to fill the voids and stabilize the fill materials, and
d) construct a structural pier cap to bridge the settlement prone areas.

Option a) could, depending on the operational requirements imposed by Pelee Island Transportation Service, be considered. This option does not however, address and deal with the cause of the problem but rather reacts to the occurrence of settlement. In principle this option would be similar to that which is currently being carried out in that any areas which are identified as warranting repair can be either filled with imported granular materials and/or topped with an asphaltic concrete mix. This option would, depending on the severity of the settlements, require regular future maintenance but takes away the need for major initial capital expenditures.

Assuming only limited amounts of settlement are taking place, then the use of an interlocking brick surface layer could be considered. This surface layer would be more resilient and better able to resist surface deformations compared to conventional bituminous layers such as used previously at the site. Also, the brick could be removed to allow levelling of the area should appreciable amounts of movement occur.

Option b) will require a considerable amount of earth work to implement. It is expected that a strip, at least 3 metres wide, would need to be excavated behind the wall extending the full length of the problem area(s) and will likely involve excavating along the entire length of the sheet pile wall at both sites (or some 150 to 200 metres). This operation would entail removing the existing pavement structure and underlying fill materials down to the rock fill materials or to about a depth of about 2 metres below the present dock surface. The materials removed would need to be replaced with well compacted granular borrow surrounded by a geotextile separation fabric. To avoid interference with the tie back anchors and the potential for damage to the geotextile laid directly on the rock fill, a well graded granular separation layer is recommended. This layer should be at least 0.5 metres in thickness and comprise of 0.50 millimetre crushed rock meeting OPSS Granular 'B' - Type II materials. The remainder of the backfill should comprise of approved granular materials compacted to at least 98 per cent of standard Proctor maximum dry density. This repair option will need to be properly staged to avoid disturbance/damage to the tie back anchors. Also, the void below the concrete cap of the steel sheet pile wall will need to be effectively backfilled.

Option c) the use of a grouting program to fill the voids and to stabilize the fill materials behind the wall has also been considered. This repair option is considered to be not only very difficult to implement effectively but may also be cost prohibitive. This method of stabilization requires specialized equipment and an experienced qualified construction team. Although a conscientious effort can be made to properly grout the subsurface, there is no guarantee that the work can been successfully carried out due to the large number of variables involved. A major concern is that the grout will flow from the repair area to the pervious fill throughout the dock resulting in excessive quantities of grout. If this repair method is to be considered further then it is recommended that a trial grouting program be carried out to determine the practicality and effectiveness of the grouting work.

To avoid continued operational problems being experienced by Pelee Island Transportation Service due to the development of new settlement areas and/or existing ones continuing, consideration could be given to Option d) by constructing a structural concrete slab (i.e. pier cap) to bridge the settlement prone areas directly at the rear of the wall. The pier cap could be supported on either conventional foundations and/or mini piles. If this repair option is to be considered further, we would be pleased to provide geotechnical engineering design recommendations for the work once the actual pier cap founding details have been established (such as the type, location and founding depth).

To summarize, only Option d) would provide some reasonable assurance that the rehabilitated areas would not be prone to any appreciable amount of future settlement. The draw back of this option though is that the rehabilitation work would be quite costly and potentially difficult to construct. The remaining options, although less expensive to implement, strictly represent a cosmetic fix and do not guarantee that the completed works will not be prone to any future settlement.

From a geotechnical perspective, Option b) would be the recommended course of action as it would reduce the potential for future subsidence caused by infiltration of fine materials above the former rock berm into the coarse stone matrix. It does not, however, eliminate the potential for movement associated with the fine lake bed materials moving up into the rock fill and/or the rock fill materials being pushed into the soft/loose lake bed sediments.

GOLDER ASSOCIATES LTD.

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PROVINCE OF ONTARIO

HD/ASP/FJH:hd

N:\ACTIVE\4200\021-4216 MTO FERRY DOCKS LTON KINGSVILLE\DRFT RPT-021010-MTO FERRY DOCKS-PART A-HD-SE.DOC

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole", on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS	auger sample
CS	chunk sample
DO	drive open
DS	Denison type sample
FS	foil sample
RC	rock core
ST	slotted tube
TO	thin-walled, open
TP	thin-walled, piston
WS	wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight-weight, hammer

PH sampler advanced by hydraulic force

PM sampler advanced by manual force

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	"N" Blows/0.3 m or Blow/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

	"Cu"	
Consistency	kPa	psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	combined analysis, sieve and hydrometer[1]
Q	undrained triaxial[2]
R	consolidated undrained triaxial[2]
S	drained triaxial
U	unconfined compression
V	field vane test
Chem	chemical analysis

NOTES:

1. Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
2. Undrained triaxial tests in which pore pressures are measured are shown as Q or R.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$
e = base of natural logarithms 2.7183
$\log_e$ a or ln a, natural logarithm of a
$\log_{10}$ a or log a, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
m	mass
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress (σ is also used)
τ	shear stress
ε	linear strain
ε_{sy}	shear strain
υ	Poisson's ration (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_p)I_p$
I_C	consistency index - $(w_L - w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
κ	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta\log_{10}\sigma'$
c_v	coefficient of consolidation
T_F	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	in terms of effective stress $\tau_f = c' + \sigma' \tan\phi$
c'	effective cohesion intercept	
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = cu + \sigma\tan\phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653751N, 367367E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (SOLID STEM, HOLLOW STEM)
COMPILED BY T.M.
DATUM Geodetic
DATE September 13, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.95	GROUND SURFACE						
0.00	FILL, granular base, with filter fabric; Loose to compact; Grey Brown to Brown	1	AS	-			
		2	SS	8			
		3	SS	26	Water level approx. elev. 174		
173.82 / 2.13	FILL, rock (cobble size), some sand layers/ inclusions; Compact; Grey to Brown	4	SS	16			
173.05 / 2.90	FILL, silty sand, some rock fragments, occ. grey to black organic inclusions; Very dense; Grey Brown to grey	5	SS	59			
172.60 / 3.35							
172.14 / 3.81	FILL, rock (cobble size), some sand; Very Dense; Grey to Brown						
	FINE SAND to SILTY FINE SAND, trace gravel; Loose to compact; Brown Grey to Grey	6	SS	5			0 85 10 5
		7	SS	10			
		8	SS	4			
		9	SS	11			
		10	SS	23			
		11	SS	4			
164.92 / 11.13	SILTY CLAY, some sand; Soft; Grey Brown						
	End of Borehole						

Elevation scale: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTES:
Water level in Borehole at about elev. 173.97m upon completion of drilling on Sept. 13, 2002.

Borehole drilled in repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L2

 METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653738N, 367361E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 13, 2002 - September 16, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.92	PAVEMENT SURFACE							
0.00	ASPHALT							
0.14	FILL, granular base							
0.33	FILL, fine sand, trace silt, some crushed rock at depth, Loose, Brown	1	AS	-			○	
174.85 / 1.07	FILL, crushed rock (clear stone), some sand, Loose to dense, Grey	2	SS	5		175		
		3	SS	31		174		
173.82 / 2.10	FILL, fine sand, trace silt, cobbles in sand layers, with some black organic inclusions, Very dense to dense, Brown	4	SS	52	▽		○	38 48 14 0
172.72 / 3.20	FILL, rock (cobble size), with silty sand layers, Dense, Grey	5	SS	39		173		
172.26 / 3.66	FINE SAND to SILTY FINE SAND, occ. black organic inclusions, trace gravel, occ. shells, Loose to very loose, Grey Brown to Grey	6	SS	9		172		
		7	SS	3		171	○	
		8	SS	9		170		
		9	SS	6		169, 168	○	
		10	SS	8		167	○	
166.16 / 9.75	End of Borehole							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTES:
Water seepage into borehole encountered at about elev. 173.63m during drilling on Sept. 16, 2002.

Borehole drilled in existing settled pavement area.

Encountered buried electrical wires at a depth of about 1.5m during drilling.

$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

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Windsor, Ontario

RECORD OF BOREHOLE No L3

 METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653721N, 367353E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 16, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.96	PAVEMENT SURFACE					
0.00	ASPHALT					
0.14	FILL, granular base	1	AS	-		
175.53 / 0.43	FILL, fine sand, trace silt, occ. gravel Brown					
0.61	FILL, crushed rock (clear stone), with some sand layers/ intermixing Loose Brown	2	SS	4		
174.59 / 1.37	FILL, rock (cobble size), with some sand layers/ inclusions Compact to dense Grey Brown to Grey	3	SS	>30	▽ (174.0)	
		4	SS	21		
		5	SS	32		53 39 8 0
172.15 / 3.81	FILL, fine sand to silty fine sand, with rock fragments, occ. black organic inclusions Loose Black to Grey	6	SS	9		
171.63 / 4.33	FINE SAND to SILTY FINE SAND, occ. black organic pockets/ staining Loose to compact Grey to Black	7	SS	11		
		8	SS	5		
		9	SS	6		
		10	SS	8		
		11	SS	5		
164.84 / 11.13	End of Borehole					

NOTES:
Water level in borehole at about elev. 174.00m upon completion of drilling on Sept. 16, 2002.

Borehole drilled in (sound) existing pavement area.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (175 to 165); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L4

METRIC

PROJECT 021-4216			
G.W.P. 01-33-001	LOCATION 4653725N, 367338E		ORIGINATED BY C.C.
DIST #31	HWY N/A	BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)	COMPILED BY T.M.
DATUM Geodetic	DATE September 11, 2002 - September 16, 2002		CHECKED BY H.D.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
175.86	PAVEMENT SURFACE
0.00	ASPHALT
0.15	FILL, granular base
0.33	FILL, fine sand, trace silt, some rock fragments Compact Brown
174.70 / 1.16	FILL, rock (cobble size) Compact Grey Brown
174.34 / 1.52	FILL, fine sand, trace silt, some rock fragments Compact Brown
1.68	FILL, rock (cobble size), some sand layers, occ. grey black organic pockets/ staining Compact Grey to Brown
171.44 / 4.42	FINE SAND to SILTY FINE SAND, trace silt, some rock fragments near surface, occ. black organic inclusions/ pockets Very loose to compact Grey brown to grey
166.11 / 9.75	End of Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES
1	AS	-
2	SS	20
3	SS	23
4	SS	25
5	SS	20
6	SS	7
7	SS	7
8	SS	10
9	SS	3

GROUND WATER CONDITIONS: water level symbol at about elev. 174 (▽).

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:
Initial Borehole L4 terminated at about elevation 173.9m upon encountering buried electrical conduit.

Water seepage into borehole encountered at about elev. 175.16m during drilling on Sept. 16, 2002.

+³, ×³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

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Windsor, Ontario

RECORD OF BOREHOLE No L5

 METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653709N, 367327E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 16, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.95	PAVEMENT SURFACE						
0.00	ASPHALT						
0.13 / 175.52	FILL, granular base	1	AS	-			
0.43 / 175.19	FILL, fine sand, trace silt, some gravel/ rock fragments Brown						
0.76	FILL, crushed rock (clear stone) some sand Loose Grey Brown	2	SS	9		175	80 17 3 0
174.58 / 1.37	FILL, rock (cobble size), some sand layers/ inclusions Compact to loose Grey to Brown	3	SS	20	▽	174	
		4	SS	16		173	
		5	SS	9			
		6	SS	13		172	
171.53 / 4.42	FINE SAND to SILTY FINE SAND, some rock fragments near surface, occ. black peat/ organic silt seams/ layers Compact to loose Grey to Brown Grey	7	SS	16		171	
						170	
		8	SS	4		169	
		9	SS	3		168	
						167	
		10	SS	5		166	
164.82 / 11.13	End of Borehole	11	SS	3		165	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTES:
Water level in borehole at about elev. 174.02m upon completion of drilling on Sept. 16, 2002.

Borehole drilled in paved, repaired area.

+³, ×³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L6

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653698N, 367320E
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
DATUM Geodetic
DATE September 17, 2002
ORIGINATED BY C.C.
COMPILED BY T.M.
CHECKED BY H.D.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
175.88	PAVEMENT SURFACE
0.00	ASPHALT
175.40 / 0.18	FILL, granular base, Grey
0.48 / 0.61	FILL, fine sand and gravel, Brown
174.72 / 1.16	FILL, fine sand, trace silt, occ. gravel, Compact, Brown
1.37	FILL, crushed rock (clear stone), some sand, Compact, Grey Brown
	FILL, rock (cobble size), some sand layers/ inclusions, Compact to dense, Grey Brown to Grey
170.85 / 5.03	FINE SAND to SILTY FINE SAND, trace silt, some rock fragments near surface, occ. grey black organic pockets/ zones, Very loose to compact, Grey to Grey Brown
166.13 / 9.75	End of Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS	-	
2	SS	17	
3	SS	30	
4	SS	10	
5	SS	16	
6	SS	20	91 7 2 0
7	SS	16	
8	SS	5	
9	SS	2	
10	SS	4	

GROUND WATER CONDITIONS: water level symbol at approx. elev. 174

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

NOTES:
Water level in borehole at about elev. 173.95m upon completion of drilling on Sept. 17, 2002.

Borehole drilled in existing pavement area (nonrepaired).

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L7

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653669N, 367314E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 17, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)
175.91	PAVEMENT SURFACE						
0.07	ASPHALT						
175.43 / 0.48	FILL, granular base	1	AS	-			o
	FILL, fine sand, mixed with clear stone and gravel Loose Brown	2	SS	8		175	o
174.72 / 1.19	FILL, sand and gravel, with asphalt fragments Grey and Black Loose						
1.37	FILL, rock (cobble size), some sand layers/ inclusions Compact to dense Grey Brown to Grey	3	SS	10	▽	174	
		4	SS	14		173	
		5	SS	13			
		6	SS	10		172	o
		7	SS	>30		171	
170.12 / 5.79	FINE SAND to SANDY SILT, trace clay, occ. grey black organic zones/ inclusions Loose to very loose Grey					170	
		8	SS	7		169	
		9	SS	3		168	
						167	
		10	SS	5		166	
165.12 / 10.79	SILTY CLAY, trace sand Soft Brown	11	SS	4		165	
164.78 / 11.13	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:
Water seepage into borehole encountered at about elev. 173.96m during drilling on Sept. 17, 2002.

Borehole drilled in existing settled pavement area.

+3, ×3: Numbers refer to Sensitivity
○3% STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L8

METRIC

PROJECT	021-4216		
G.W.P.	01-33-001	LOCATION	4653654N, 367310E
DIST	#31 HWY N/A	BOREHOLE TYPE	POWER AUGER (HOLLOW STEM and WASH BORING)
DATUM	Geodetic	DATE	September 12, 2002

ORIGINATED BY C.C.
COMPILED BY T.M.
CHECKED BY H.D.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
175.93	GROUND SURFACE	
0.00	FILL, granular base, with filter fabric Loose to compact Grey Brown to Brown	Fill
173.80 / 2.13	FILL, rock (cobble size), some sand layers/ inclusions Loose to compact Grey Brown to grey	Fill
170.44 / 5.49	SILTY FINE SAND, with some rock fragments, occ. grey black organic zones/ inclusions Loose Grey Brown	Silty sand
169.38 / 6.55	End of Soil Sampling	
168.00 / 7.93	Start of Dynamic Cone Test	
165.26 / 10.67	End of Borehole	

SAMPLES

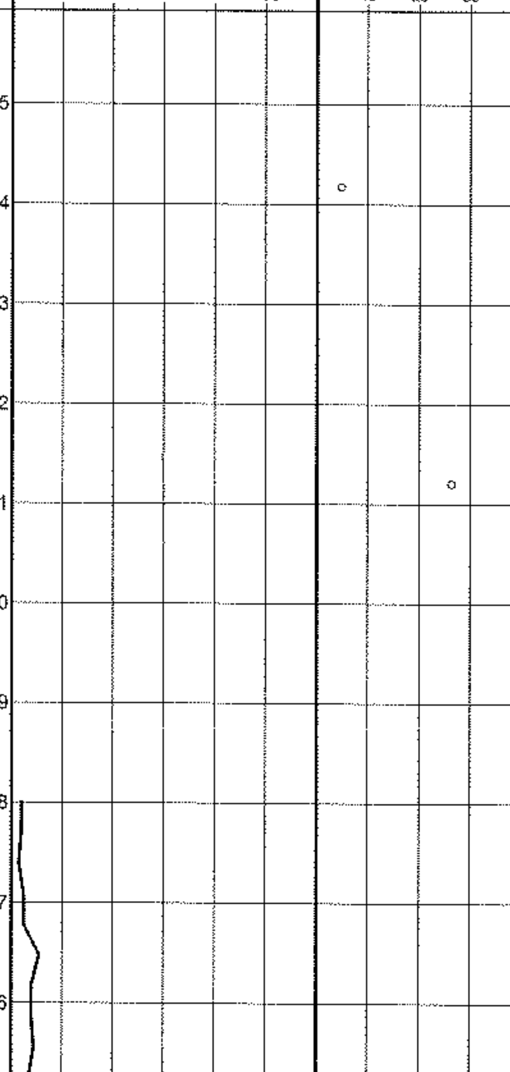
NUMBER	TYPE	"N" VALUES
1	AS	-
2	SS	10
3	SS	22
4	SS	5
5	SS	10
6	SS	10
7	SS	24
8	SS	6

GROUND WATER CONDITIONS: water level symbol at approx. elev. 173.9

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100



PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:
Water seepage into borehole encountered at about elev. 173.90m during drilling on Sept. 12, 2002.

Borehole drilled in repaired area.

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No L9

METRIC

PROJECT 021-4216

G.W.P. 01-33-001 LOCATION 4653637N, 367296E ORIGINATED BY C.C.

DIST #31 HWY N/A BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) COMPILED BY T.M.

DATUM Geodetic DATE September 11, 2002 - September 18, 2002 CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.97	GROUND SURFACE					
0.00	FILL, granular base	1	AS	-		
175.54 / 0.43	FILL, fine sand, trace silt, occ. gravel, Brown					
175.21 / 0.76	FILL, granular subbase, Loose, Brown	2	SS	8		
174.90 / 1.07						
174.51 / 1.46	FILL, fine sand, occ. gravel/ rock fragments, Loose, Brown	3	SS	30	▽ (elev. 174.01)	
	FILL, crushed rock (cobble size), some sand layeres/ inclusions, Dense to loose, Grey Brown to Grey	4	SS	10		
		5	SS	24		
		6	SS	9		
		7	SS	21		
170.48 / 5.49	FINE SAND to SILTY FINE SAND, trace silt, occ. grey black organic zones/ inclusions, Compact to very loose, Grey Brown to Brown					
		8	SS	11		0 79 14 7
		9	SS	8		
		10	SS	2		
166.22 / 9.75	End of Borehole					

Elevation scale: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30 (Sample 2: approx. 7%)

UNIT WEIGHT γ kN/m³

NOTES:
Water level in borehole at about elev. 174.01m during drilling on Sept. 18, 2002.

Borehole drilled in repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653836N, 356683E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
COMPILED BY T.M.
DATUM Geodetic
DATE September 18, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.96	GROUND SURFACE					
0.00	FILL, granular base, with layers of brown silty fine sand, geotextile at about 0.9 m depth; Very dense; Grey Brown	1	AS	-		
		2	SS	>50		
174.80 / 1.16	FILL, rock (cobble size), some sand layers/ inclusions; Compact to very dense; Grey Brown	3	SS	118	▽	
		4	SS	11		
		5	SS	12		
		6	SS	23		
		7	SS	8		53 39 8 0
170.47 / 5.49	SILTY FINE SAND to SANDY SILT; Dense to very dense; Grey Brown	8	SS	39		0 62 38 0
		9	SS	30		
		10	SS	59		
165.90 / 10.06	SANDY SILT TILL, trace to some clay and gravel, occ. cobbles; Very dense; Grey	11	SS	73		
164.84 / 11.13	End of Borehole					

Elevation scale: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

NOTE:
Water level in Borehole at about elev. 174.13m during drilling Sept. 18, 2002

Borehole drilled in repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K2

METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653829N, 356673E ORIGINATED BY R.W.W.
DIST #31 HWY N/A BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY T.M.
DATUM Geodetic DATE September 19, 2002 CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES
175.95	GROUND SURFACE			
0.00	FILL, granular base, with geotextile @ 0.3m, Grey Brown	1	AS	-
175.34 / 0.61	FILL, fine sand to silty fine sand mixed rock fragments, Brown	2	SS	20
174.73 / 0.76 / 1.22	FILL, crushed rock (clear stone), with layers of silty fine sand, with geotextile, Compact, Brown to Grey	3	SS	23
	FILL, rock (cobble size), with layers/pockets of silty fine sand, Compact, Grey Brown	4	SS	13
		5	SS	11
		6	SS	12
		7	SS	18
170.16 / 5.79	SILTY FINE SAND, Very loose, Grey Brown			
169.64 / 6.31	CLAYEY SILT, some sand, occ. grey black organic inclusions, Soft to very stiff, Grey	8	SS	3
168.09 / 7.86	SILTY FINE SAND to FINE SAND, occ. grey black organic pockets, Compact, Grey	9	SS	23
		10	SS	25
166.20 / 9.75	End of Borehole			

Groundwater level symbol at approx. elev. 174 (between samples 3 and 4).

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:
Water level in Borehole at about elev. 173.92m during drilling on Sept. 19, 2002

Borehole drilled in a repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity $○^{3\%}$ STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K3

 METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653845N, 356668E ORIGINATED BY R.W.W.
DIST #31 HWY N/A BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY T.M.
DATUM Geodetic DATE September 19, 2002 CHECKED BY H.D.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
175.97	GROUND SURFACE				
0.00	FILL, granular base, with geotextile @ depth	1	AS	-	
175.63 / 0.34	FILL, silty fine sand, some rock fragments, Brown	2	AS	-	
175.30 / 0.67	FILL, rock (cobble size), with some sand inclusions/ layers, Loose to dense, Grey Brown	3	SS	26	
		4	SS	8	▽ (elev. ~174)
		5	SS	36	
		6	SS	12	
		7	SS	8	
		8	SS	6	
170.48 / 5.49	CLAYEY SILT, some sand partings/ seams, with occ. grey black organic inclusions, Soft, Grey Brown				
169.57 / 6.40	SANDY SILT to SILTY FINE SAND, Very loose to dense, Grey Brown	9	SS	3	
		10	SS	32	
		11	SS	36	
165.61 / 10.36	SANDY SILT TILL, Very dense, Grey Brown	12	SS	96	
164.69 / 11.28	End of Borehole				

Elevation scale: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:
Water seepage into borehole encountered at about elev. 173.94m during drilling Sept. 19, 2002

Borehole drilled in a repaired area.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K4

METRIC

PROJECT	021-4216		
G.W.P.	01-33-001	LOCATION	4653866N, 356672E
DIST	#31 HWY N/A	BOREHOLE TYPE	POWER AUGER (HOLLOW STEM)
DATUM	Geodetic	DATE	September 20, 2002

ORIGINATED BY C.C.
COMPILED BY T.M.
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
176.00	PAVEMENT SURFACE					
0.00	ASPHALT					
0.16	FILL, granular base		1	AS	-	
175.49 / 0.51	FILL, fine sand, some rock fragments; Compact; Brown		2	SS	24	
0.76	FILL, rock (cobble size), some sand inclusions/ layers; Compact to very dense; Grey Brown		3	SS	24	▽ (approx. elev. 174.07)
			4	SS	21	
			5	SS	28	
			6	SS	58	
170.21 / 5.79	SANDY SILT TILL, some sand and gravel, occ. silt seams; Compact; Grey		7	SS	27	
168.99 / 7.01	FINE SAND, trace silt; Dense; Grey		8	SS	32	
167.47 / 8.53	CLAYEY SILT TILL, some sand and gravel; Hard; Grey		9	SS	63	
166.25 / 9.75	End of Borehole					

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTE:
Water level in Borehole at about elev. 174.07m during drilling Sept. 20, 2002

Borehole drilled in a settled pavement area.

+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K5

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653900N, 356678E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (SOLID STEM, HOLLOW STEM)
COMPILED BY T.M.
DATUM Geodetic
DATE September 18, 2002
CHECKED BY H.D.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
175.98	PAVEMENT SURFACE
0.00	ASPHALT
0.13	FILL, granular base
0.30	FILL, crushed rock, mixed with brown silty fine sand, aluminum can and pieces of clay brick; Compact; Brown
175.22 / 0.76	FILL, rock (cobble size), occ. brick fragments, some sand; Compact to Loose; Grey Brown
172.32 / 3.66	SILTY FINE SAND to FINE SAND, some rock fragments near surface, occ. grey black organic inclusions; Compact; Grey Brown
170.49 / 5.49	SILTY FINE SAND to SANDY SILT; Dense; Grey
167.44 / 8.53	CLAYEY SILT TILL, some sand and gravel; Hard; Grey
166.23 / 9.75	End of Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES
1	AS	-
2	SS	21
3	SS	8
4	SS	19
5	SS	24
6	SS	14
7	SS	21
8	SS	37
9	SS	42
10	SS	63

GROUND WATER CONDITIONS: ▽ at about elev. 174

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:
Water level in Borehole at about elev. 173.97m during drilling on Sept. 18, 2002

Borehole drilled in a settled pavement area.

$+^3, \times^3$: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

ON_MOT 021-4216.GPJ ON_MOT.GDT 2/24/03 DATA INPUT:

Golder Associates
Windsor, Ontario

RECORD OF BOREHOLE No K6

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
DIST #31 HWY N/A
DATUM Geodetic
LOCATION 4653922N, 356676E
BOREHOLE TYPE POWER AUGER (HOLLOW STEM)
DATE September 20, 2002
ORIGINATED BY C.C.
COMPILED BY T.M.
CHECKED BY H.D.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.01	GROUND SURFACE					
0.00	FILL, granular base, with silty fine sand layers and asphalt fragments, filter fabric at 0.3m. Compact, grey	1	AS	-		
		2	SS	16		
174.64 / 1.37	FILL, rock (cobble size), with sand layers/ inclusions. Compact to dense. Grey Brown	3	SS	30	∇ (approx. 174.09)	
		4	SS	11		
		5	SS	14		
		6	SS	16		41 42 17 0
170.52 / 5.49	SILTY FINE SAND to SANDY SILT. Compact. Grey	7	SS	25		2 34 64 0
		8	SS	22		
167.48 / 8.53	SILT to SANDY SILT. Dense. Grey					
166.56 / 9.45	CLAYEY SILT TILL, some sand and gravel. Hard. grey	9	SS	33		
		10	SS	81		
164.88 / 11.13	End of Borehole					

Column headings also include: STRAT PLOT; ELEVATION SCALE (175 to 165); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

NOTES:
Water level in Borehole
at about elev. 174.09m
during drilling on Sept. 20, 2002

Borehole drilled in a repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF TEST PIT No TP L1

 METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653645N, 367309E ORIGINATED BY RW
DIST #31 HWY N/A BOREHOLE TYPE BACKHOE DUG 1.22 x 2.44 x 2.13m COMPILED BY BG
DATUM Geodetic DATE September 13, 2002 CHECKED BY

ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
176.43	PAVEMENT SURFACE												
0.00	(ASPHALT)												
176.28 / 0.15	(FILL), Granular base Grey, brown		1	CS				o					
176.13 / 0.30	(FILL), Crushed rock (Clear stone), some sand inclusions/ layers Grey, brown						176						
			2	CS			175	o		89	8	3	0
174.91 / 1.52	(FILL), rock (Cobble size) Grey, brown		3	CS		▽							
174.30 / 2.13	END OF TEST PIT												

NOTES:
Water seepage into Test pit encountered at about elev. 174.5m during excavation on Sept. 13, 2002

Test Pit sides caving below elev. 176.1m during excavation.

25 to 50mm void below asphalt in east half of test pit

Void below concrete cap

West half of test pit encountered some 0.9m of sand (FILL) overlying clear stone.
See figure 9 for grain size of sand fill.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF TEST PIT No TP L2

METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653705N, 367343E ORIGINATED BY RW
DIST #31 HWY N/A BOREHOLE TYPE BACKHOE DUG 0.91 x 1.83 x 1.68m COMPILED BY BG
DATUM Geodetic DATE September 13, 2002 CHECKED BY

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
175.90	PAVEMENT SURFACE												
175.81 / 0.00	(ASPHALT)												
0.09	(FILL), Granular base Grey, brown		1	CS				o					
175.41 / 0.49	(FILL), Crushed rock (Clear stone), with black geotextile surround Grey, brown						175						
			2	CS				o		86	9	5	0
174.36 / 1.52	(FILL), Crushed rock, (Cobble size) Brown - grey		3	CS				o					
174.22 / 1.68	END OF TEST PIT												

NOTES:

Test pit dry during excavation on Sept. 13, 2002

Test Pit sides caving below about elev. 175.4m during excavation.

Void below concrete cap.

North half of test pit encountered some 1.0m of sand (FILL) overlying the crushed rock (cobble size) material
See Figure 11 for grain sise.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF TEST PIT No TP K1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653843N, 356669E ORIGINATED BY RW
DIST #31 HWY N/A BOREHOLE TYPE BACKHOE DUG 1.71 x 3.66 x 2.29m COMPILED BY BG
DATUM Geodetic DATE September 19, 2002 CHECKED BY

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
175.97	GROUND SURFACE													
0.00	(FILL), Granular base, geotextile at 0.2m and 0.8m Grey, brown		1	CS					o					
175.21 / 0.76	(FILL), Crushed rock, (Clear stone) Grey, brown		2	CS			175		o		85	12	3	0
174.96 / 1.01	(FILL), rock, (Cobble size) Grey, brown		3	CS		▽	174		o					
173.68 / 2.29	END OF TEST PIT													

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

Water seepage into test pit encountered at about elev. 174.0m during excavation on Sept. 19, 2002

Test Pit sides caving below about elev 175.7m during excavation

Void present below concrete cap

East portion of test pit encountered asphalt at ground surface, underlaying by 0.2m of granular base and some 0.7m of sand (FILL) overlain the clear stone fill, (no geotextile present)
See Figure 16 for grainsize of sand fill.

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates
Windsor, Ontario

RECORD OF TEST PIT No TP K2

METRIC

PROJECT 021-4216
G.W.P. 01-33-001 LOCATION 4653921N, 356674E ORIGINATED BY RW
DIST #31 HWY N/A BOREHOLE TYPE BACKHOE DUG 0.91 x 2.29 x 2.44m COMPILED BY BG
DATUM Geodetic DATE September 19, 2002 CHECKED BY

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
176.01	PAVEMENT SURFACE											
0.00	(ASPHALT)											
175.86 / 0.15	(FILL), Granular base, geotextile Grey, brown	1	CS				o					
175.68 / 0.33	(FILL), fine sand, occ. rock fragments Brown	2	CS				o		2	92	6	0
175.03 / 0.98	(FILL), Crushed rock (Clear stone) Grey, brown	3	CS			175	o		90	9	2	0
174.58 / 1.43	(FILL), rock (Cobble size) Grey, brown	4	CS		▽	174						
173.57 / 2.44	END OF TEST PIT											

NOTES:

Water seepage into test pit encountered at about elev. 174.0m during excavation on Sept. 19, 2002

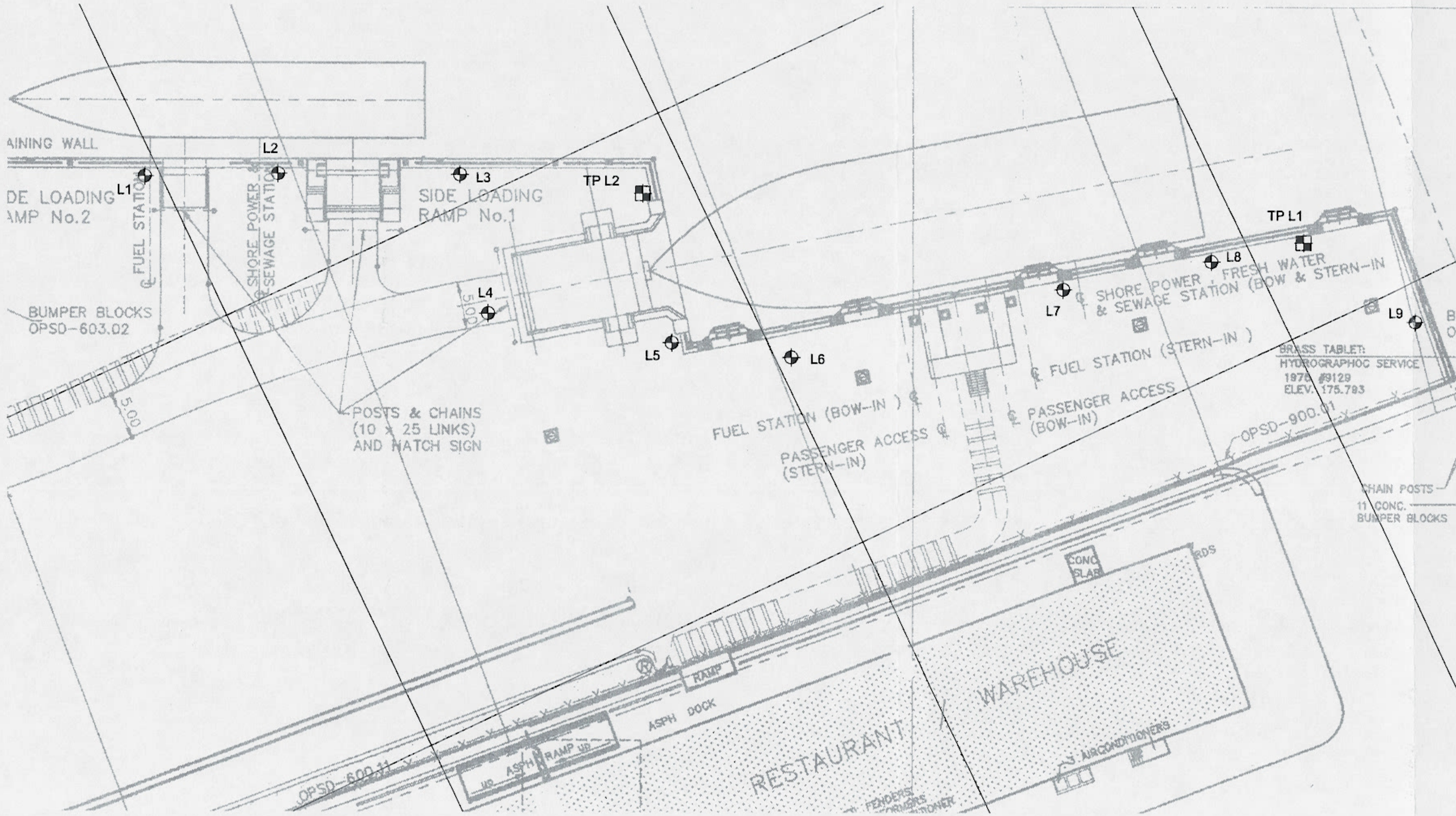
Test Pit sides caving below about elev. 175.0m during excavation

Void present below concrete cap

East portion of test pit excavated in repaired area and encountered some 1.04m of granular fill, overlying the clear stone fill

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE



METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

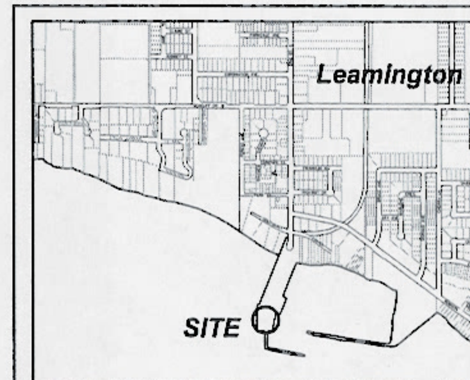
DIST No. 31 HWY. N/A
CONT. No.
WP No. 01-33-001

LEAMINGTON FERRY DOCK
LEAMINGTON, ONTARIO
TEST HOLE LOCATIONS

SHEET

Golder Associates — Golder Associates Ltd.
WINDSOR, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY MORRISON HERSHFIELD ENTITLED SITE SERVICES



KEY PLAN

LEGEND

- Borehole
- Test Pit

No.	ELEVATION (metres)	LOCATION	
		NORTHING	EASTING
L1	175.95	4653751	367367
L2	175.92	4653738	367361
L3	175.96	4653721	367353
L4	175.86	4653725	367338
L5	175.95	4653709	367327
L6	175.88	4653698	367320
L7	175.91	4653669	367314
L8	175.93	4653654	367310
L9	175.97	4653637	367296
TP L1	176.43	4653645	367309
TP L2	175.90	4653705	367343

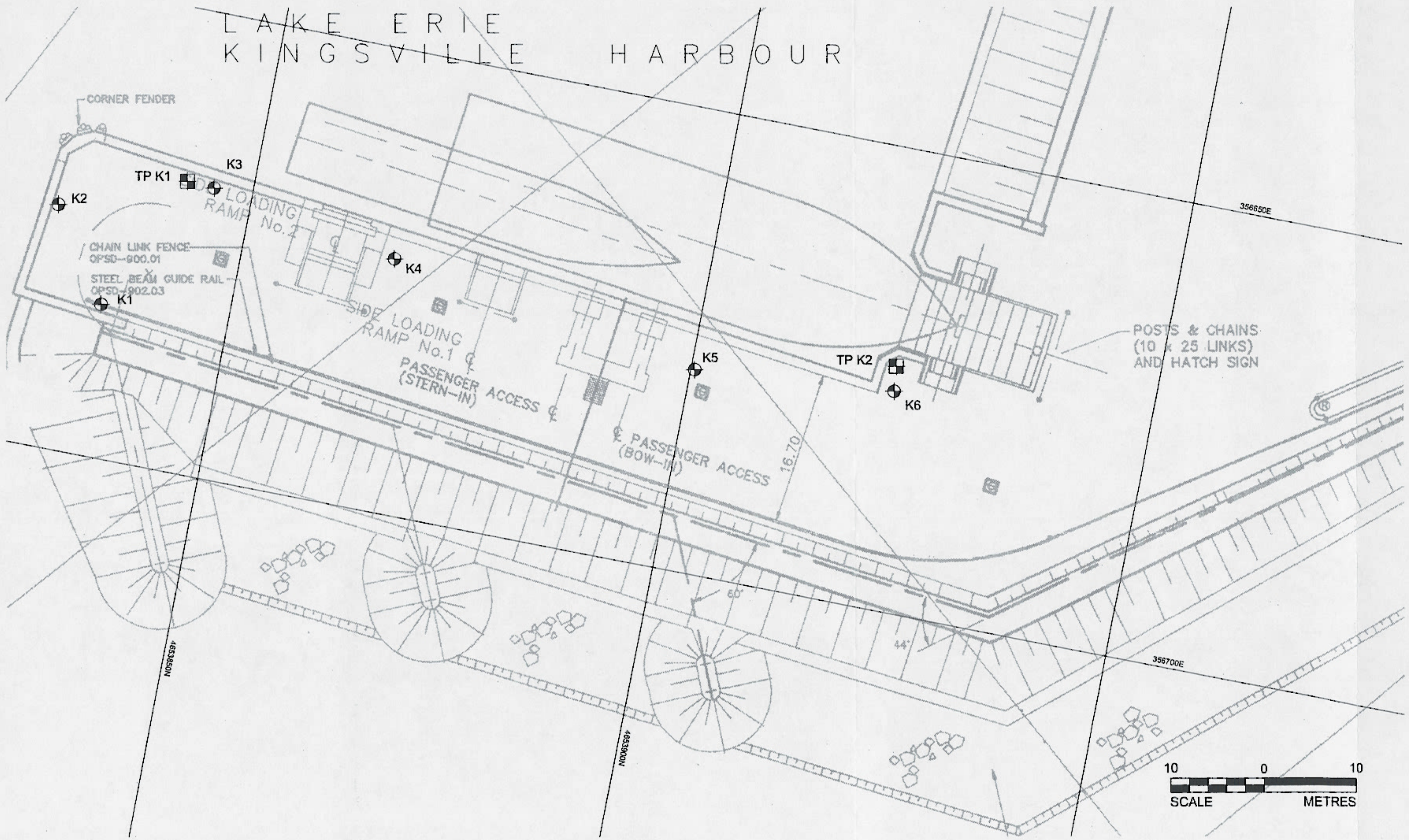
NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY. No.		PROJECT NO.: 021-4216	
SUBM'D. –	CHKD: –	DATE: OCT. 2002	
DRAWN: T.M.	CHKD. H.D.	APPD.	DWG. 1

001323223D001.DWG



METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST No. 31 HWY. N/A
CONT. No.
WP No. 01-33-001

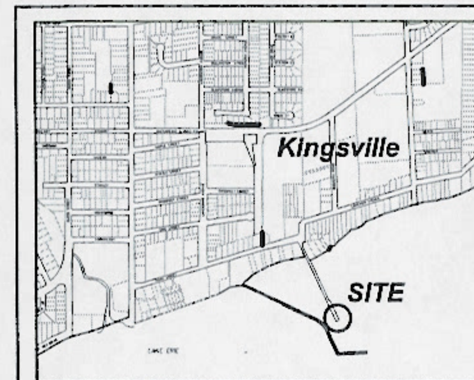
KINGSVILLE FERRY DOCK
KINGSVILLE, ONTARIO
TEST HOLE LOCATIONS

SHEET

Golder Associates

Golder Associates Ltd.
WINDSOR, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY MORRISON HERSHFIELD ENTITLED SITE SERVICES



KEY PLAN

LEGEND

- Borehole
- Test Pit

No.	ELEVATION (metres)	LOCATION	
		NORTHING	EASTING
K1	175.96	4653836	356683
K2	175.95	4653829	356673
K3	175.97	4653845	356668
K4	176.00	4653866	356672
K5	175.98	4653900	356678
K6	176.01	4653922	356676
TP K1	175.97	4653843	356669
TP K2	176.01	4653921	356674

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY. No.		PROJECT NO.: 021-4216	
SUBM'D. –	CHKD: –	DATE: OCT. 2002	
DRAWN: T.M.	CHKD. H.D.	APPD.	DWG. 2

00132223D001.DWG

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST No. 31 HWY. N/A
CONT. No.
WP No. 01-33-001

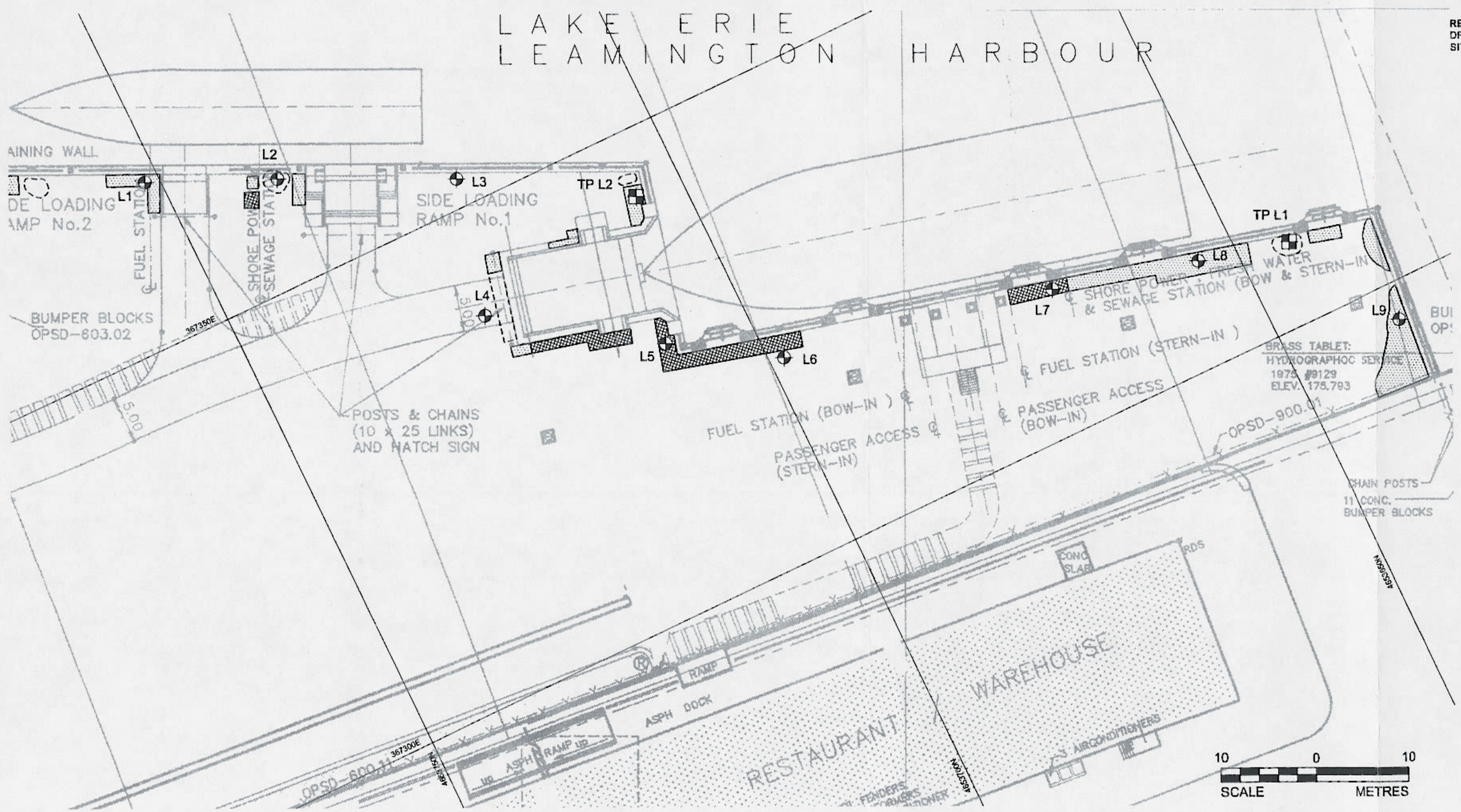
LEAMINGTON FERRY DOCK
LEAMINGTON, ONTARIO
PAVEMENT SETTLEMENT LOCATIONS

SHEET

Golder Associates

Golder Associates Ltd.
WINDSOR, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY MORRISON HERSHFIELD ENTITLED SITE SERVICES



10 0 10
SCALE METRES

LEGEND

- Borehole
- Test Pit
- Granular Repaired Surface
- Repaired Asphalt
- Depressed Asphalt

No.	ELEVATION (metres)	LOCATION	
		NORTHING	EASTING
L1	175.95	4653751	367367
L2	175.92	4653738	367361
L3	175.96	4653721	367353
L4	175.86	4653725	367338
L5	175.95	4653709	367327
L6	175.88	4653698	367320
L7	175.91	4653669	367314
L8	175.93	4653654	367310
L9	175.97	4653637	367296
TP L1	176.43	4653645	367309
TP L2	175.90	4653705	367343

NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY. No.		PROJECT NO.: 021-4216	
SUBM'D. –	CHKD: –	DATE: OCT. 2002	
DRAWN: T.M.	CHKD. H.D.	APPD.	DWG. 3

00132322D001.DWG

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST No. 31 HWY. N/A
CONT. No.
WP No. 01-33-001

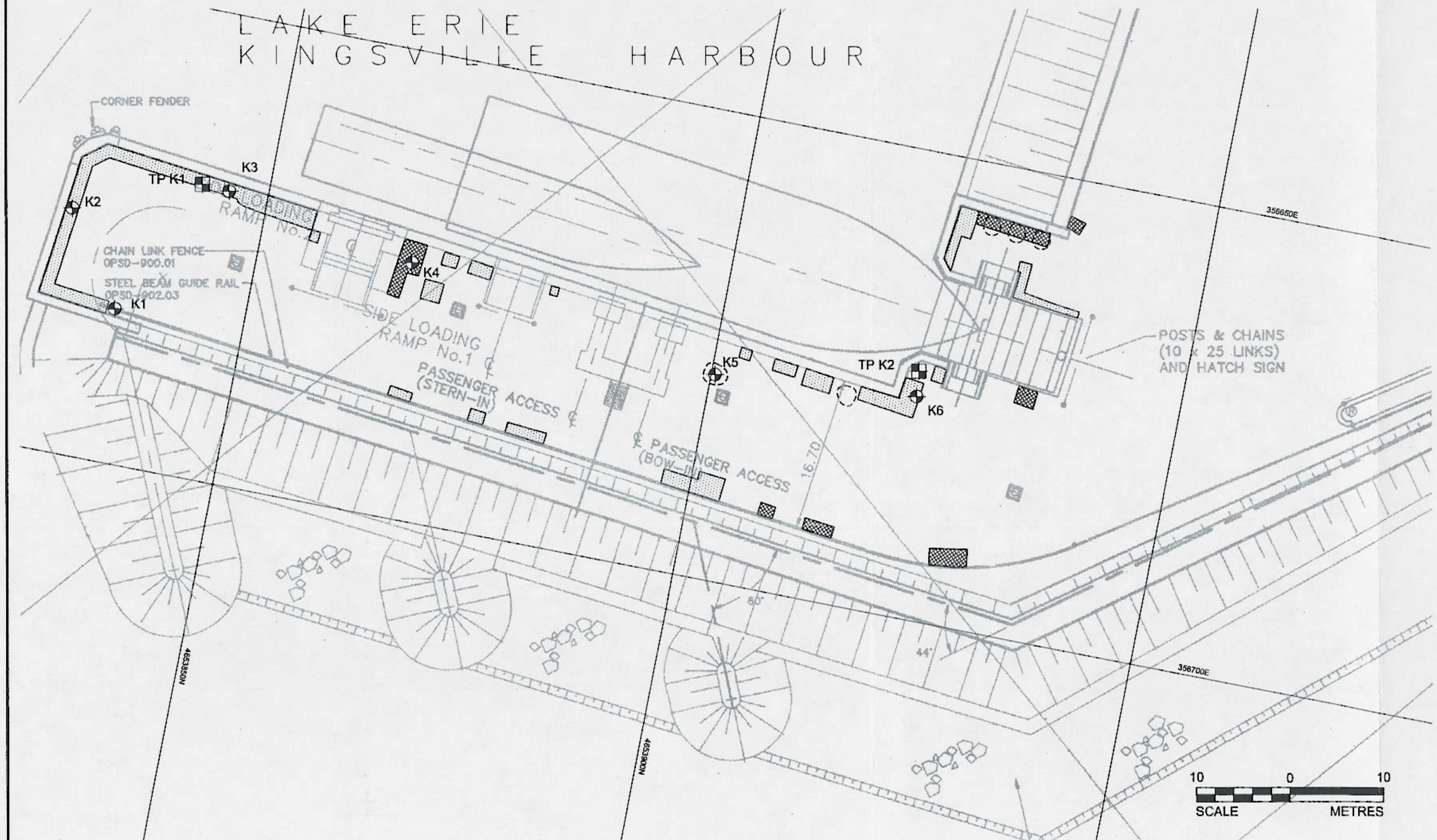
KINGSVILLE FERRY DOCK
KINGSVILLE, ONTARIO
PAVEMENT SETTLEMENT LOCATIONS

SHEET

Golder Associates

Golder Associates Ltd.
WINDSOR, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY MORRISON HERSHFIELD ENTITLED SITE SERVICES



LEGEND

- Borehole
- Test Pit
- Granular Repaired Surface
- Repaired Asphalt
- Depressed Asphalt

No.	ELEVATION (metres)	LOCATION	
		NORTHING	EASTING
K1	175.96	4653836	356683
K2	175.95	4653829	356673
K3	175.97	4653845	356668
K4	176.00	4653866	356672
K5	175.98	4653900	356678
K6	176.01	4653922	356676
TP K1	175.97	4653843	356669
TP K2	176.01	4653921	356674

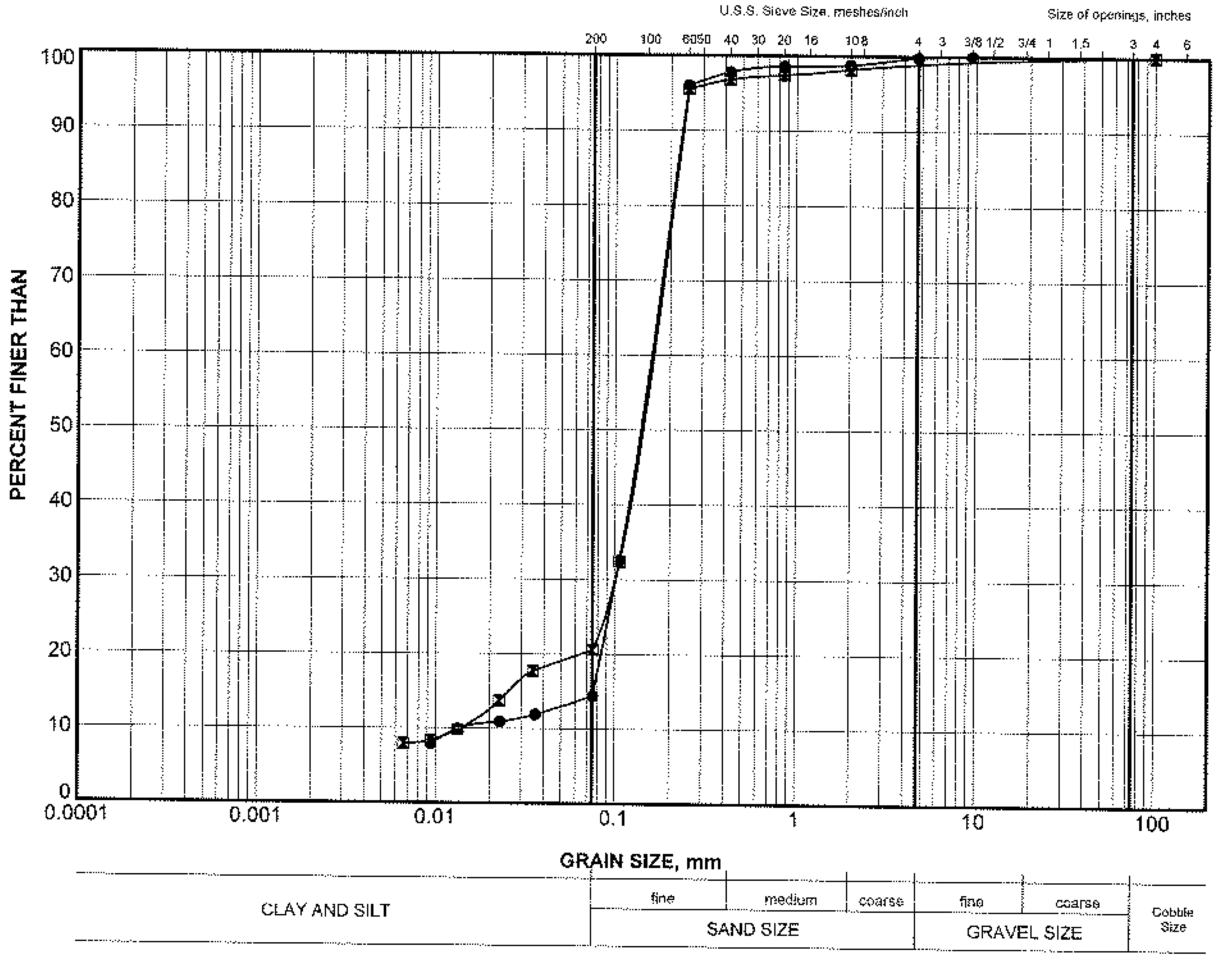
NOTES
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No.

HWY. No.		PROJECT NO.: 021-4216	
SUBM'D. –	CHKD: –	DATE: OCT. 2002	
DRAWN: T.M.	CHKD. H.D.	APPD.	DWG. 4

00132322300001.DWG



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	L1	6	172.0
⊠	L9	8	169.7

PROJECT

LEAMINGTON FERRY DOCK
LEAMINGTON, ONTARIO

TITLE

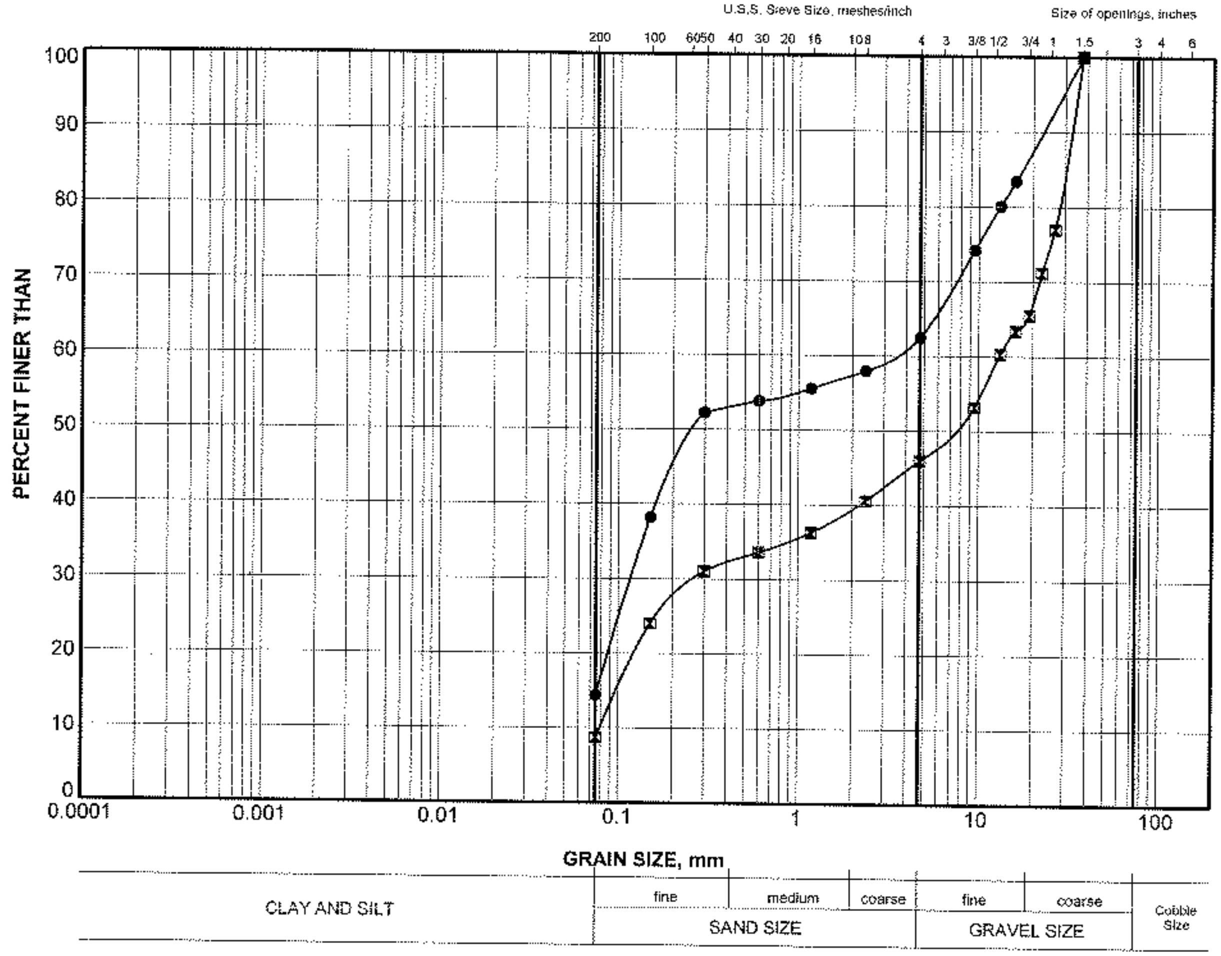
GRAIN SIZE DISTRIBUTION CURVE

SILTY FINE SAND to FINE SAND

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No.	021-4216.GPJ
			SCALE N/A	REV.
DRAWN	T.M.	10-11-02	FIGURE 5	
CHECK	[signature]	10-11-02		

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	L2	4	173.5
⊠	L3	5	172.8

PROJECT

LEAMINGTON FERRY DOCK
LEAMINGTON, ONTARIO

TITLE

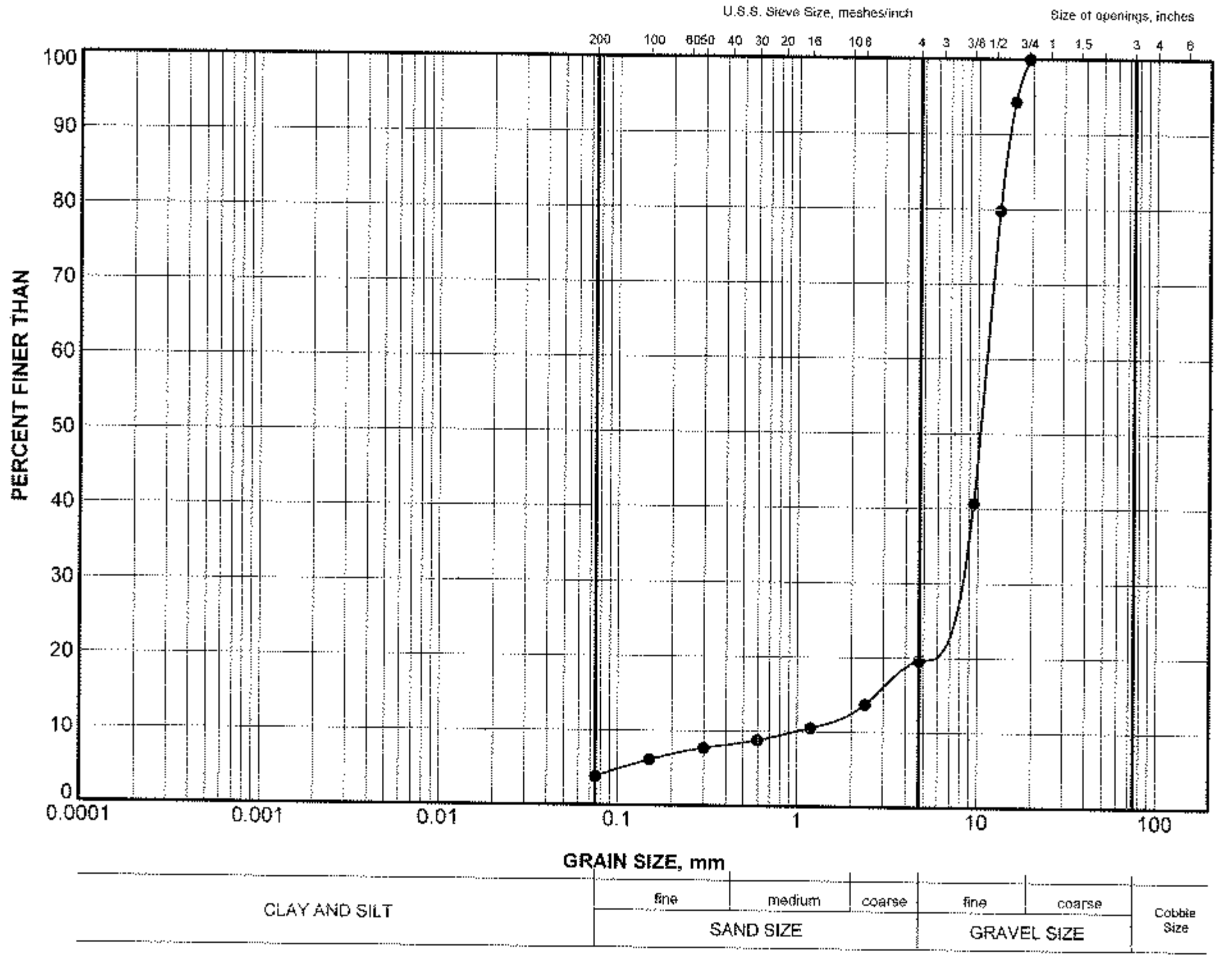
GRAIN SIZE DISTRIBUTION CURVE

FILL, rock with sand

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No.	021-4216.GPJ
			SCALE N/A	REV.
DRAWN	T.M.	10-11-02	FIGURE 6	
CHECK		10-11-02		

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	L5	2	175.0

PROJECT

LEAMINGTON FERRY DOCK
LEAMINGTON, ONTARIO

TITLE

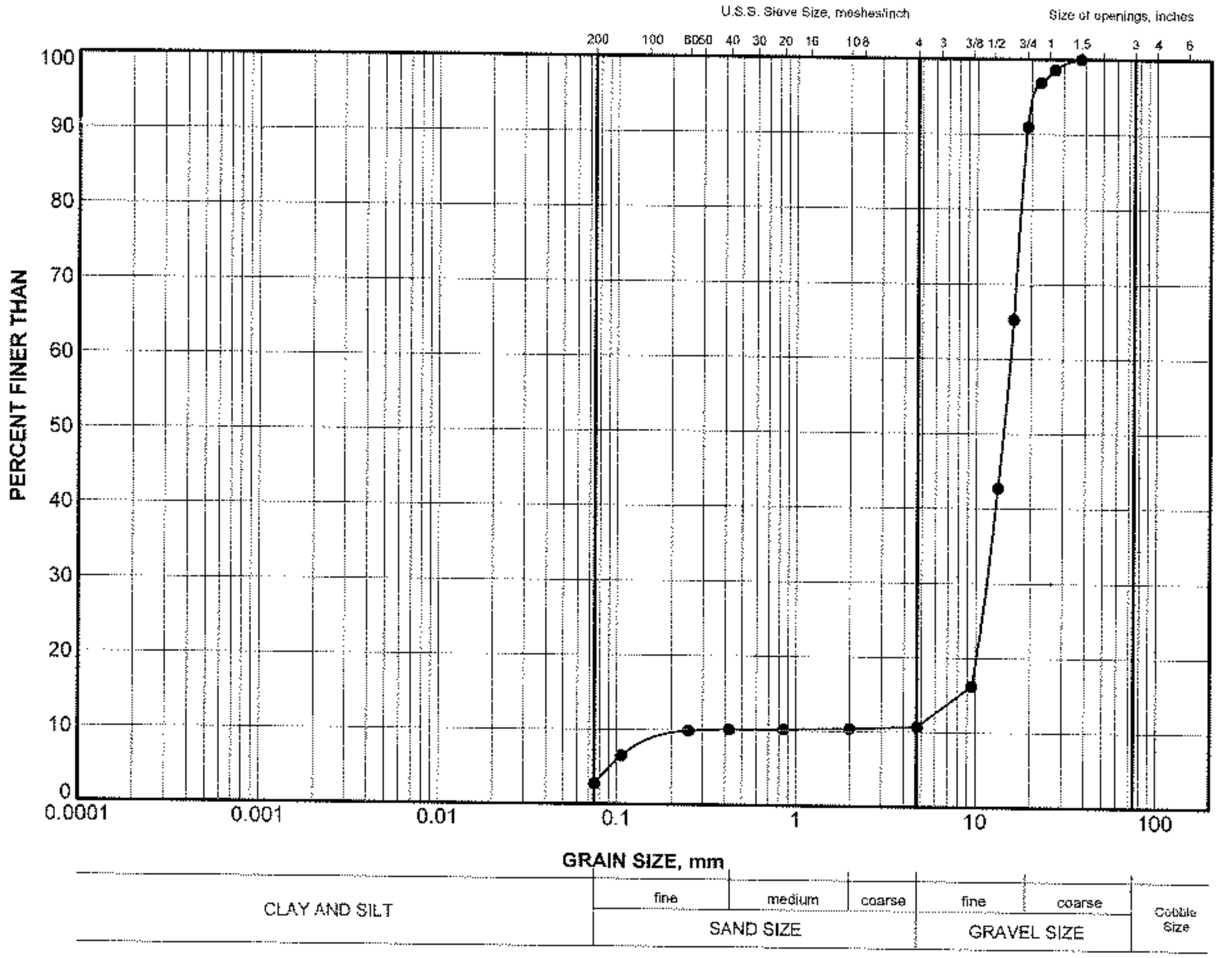
GRAIN SIZE DISTRIBUTION CURVE

FILL, crushed rock (clear stone)

Golder Associates
WINDSOR, ONTARIO

PROJECT No.	021-4216	FILE No.	021-4216.GPJ
		SCALE	N/A REV.
DRAWN	T.M.	10-11-02	
CHECK	[signature]	10-11-02	FIGURE 7

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	TP L1	2	175.1

PROJECT

LEAMINGTON FERRY DOCK
LEAMINTON, ONTARIO

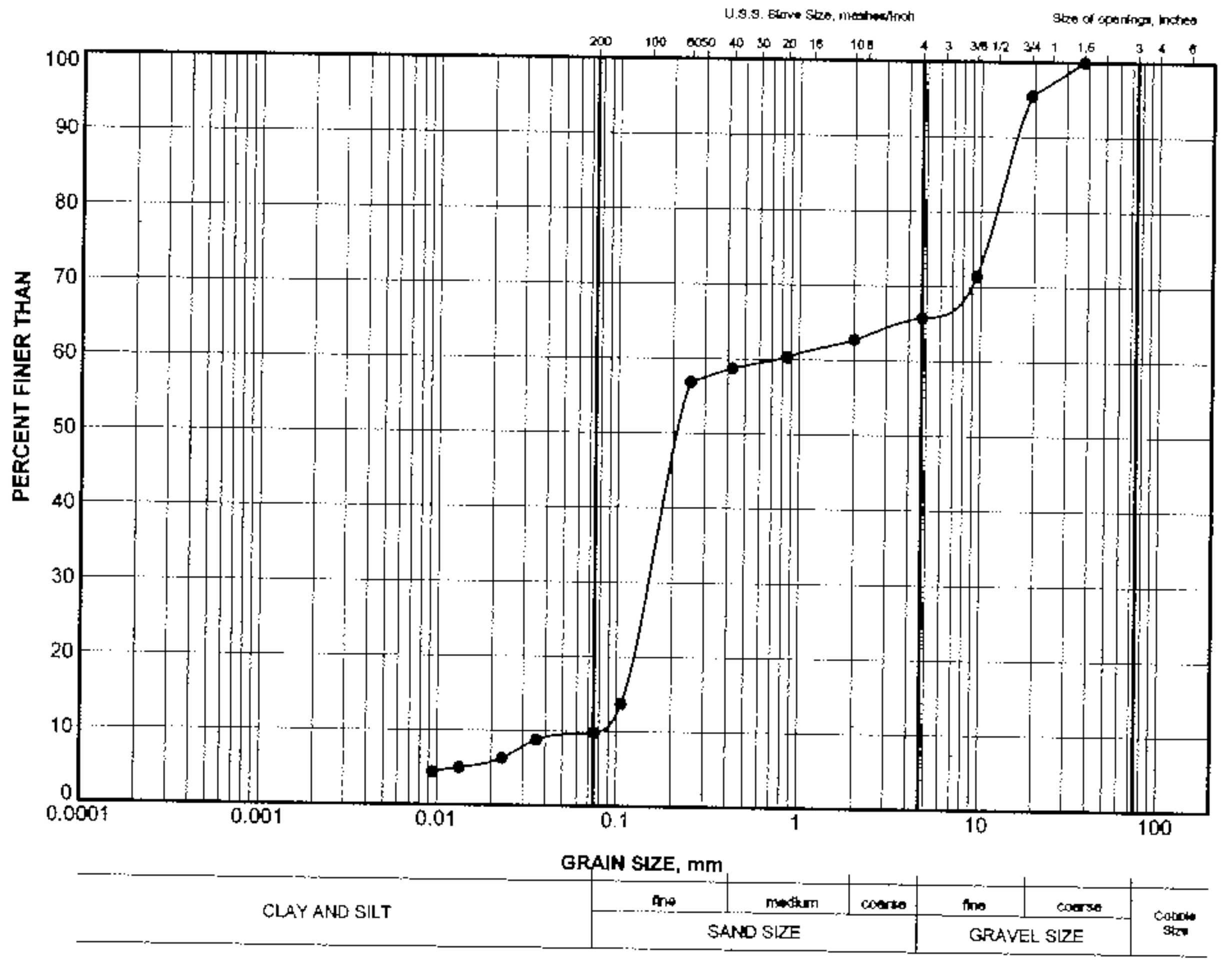
TITLE

GRAIN SIZE DISTRIBUTION CURVE

FILL, crushed rock (clear stone)

Golder Associates WINDSOR, ONTARIO	PROJECT No.		021-4216	FILE 021-4216 TEST PITS.GPJ
				SCALE N/A REV.
	DRAWN	T.M.	10-11-02	FIGURE 8
	CHECK		10-11-02	

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	TP L1	3	175.0

PROJECT

LEAMINGTON FERRY DOCK
LEAMINTON, ONTARIO

TITLE

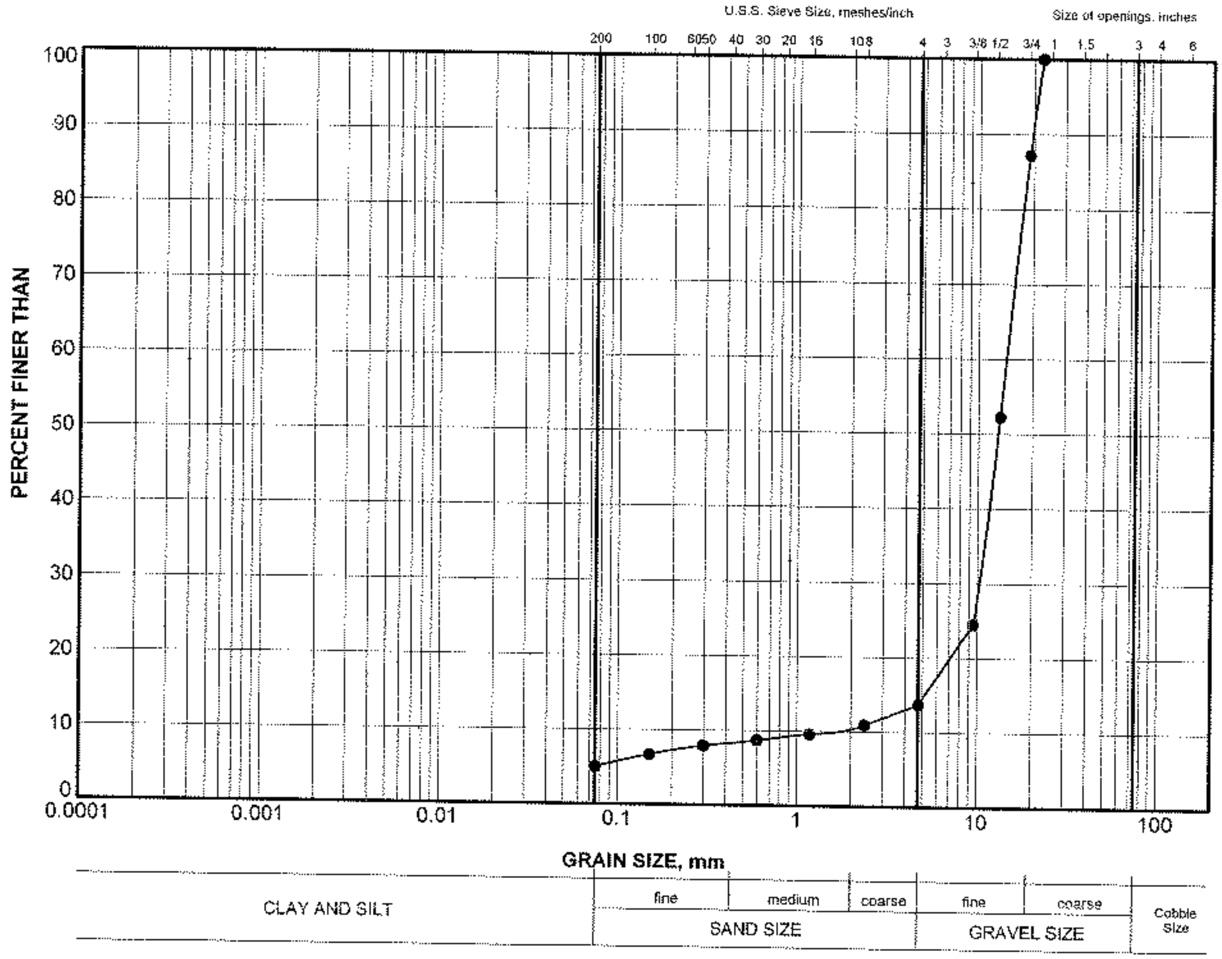
GRAIN SIZE DISTRIBUTION CURVE

FILL, sand some crushed rock

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	RLEM-4216 TEST PITS.GPJ
			SCALE N/A REV.
DRAWN	T.M.	10-11-02	FIGURE 9
CHECK		10-11-02	

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	TP L2	2	174.3

PROJECT

LEAMINGTON FERRY DOCK
LEAMINTON, ONTARIO

TITLE

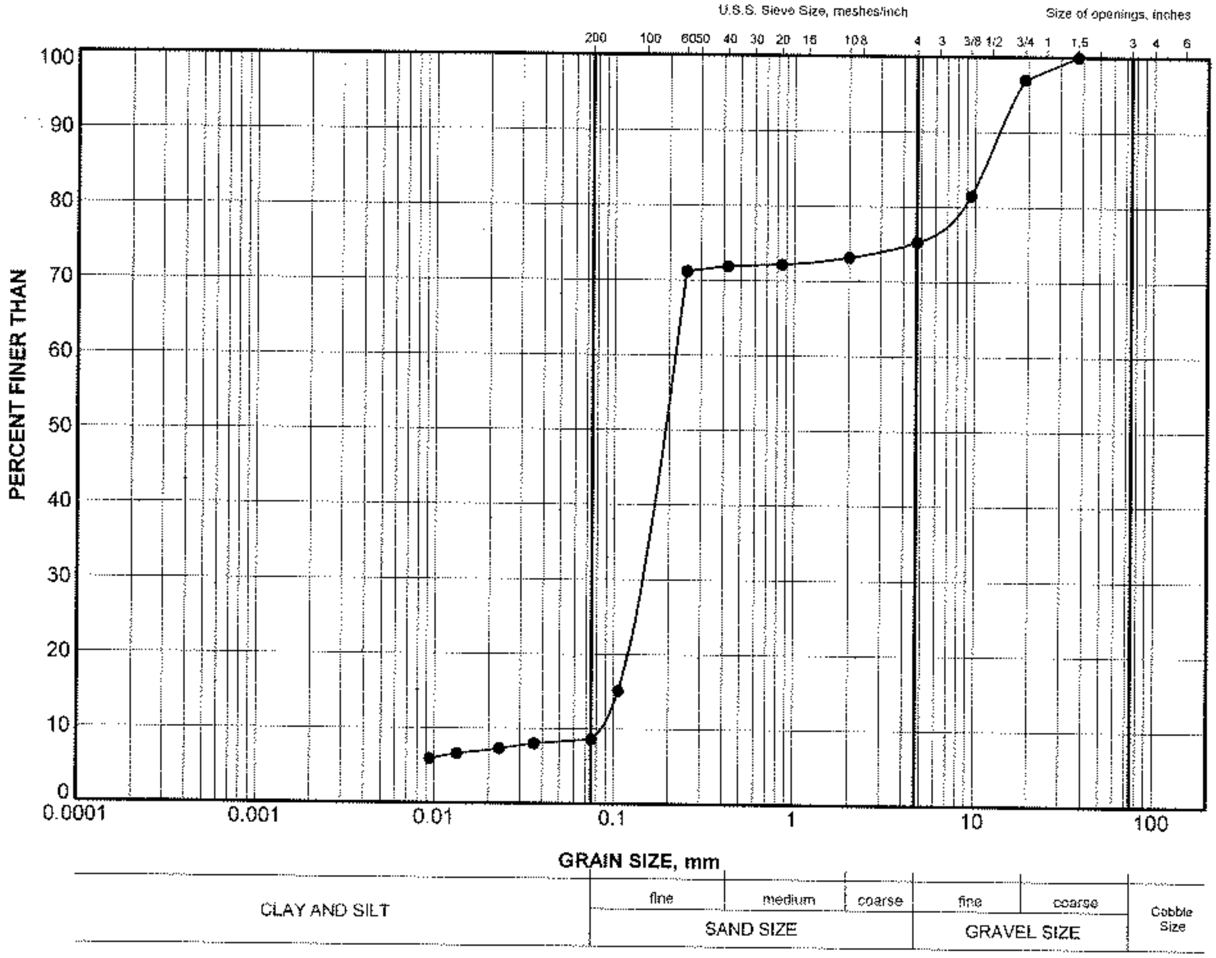
GRAIN SIZE DISTRIBUTION CURVE

FILL, crushed rock (clear stone)

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No. 021-4216 TEST PITS.GPJ
			SCALE N/A REV.
DRAWN	T.M.	10-11-02	
CHECK	[signature]	10-11-02	FIGURE 10

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	TP L2	North End	175.9

PROJECT

LEAMINGTON FERRY DOCK
LEAMINTON, ONTARIO

TITLE

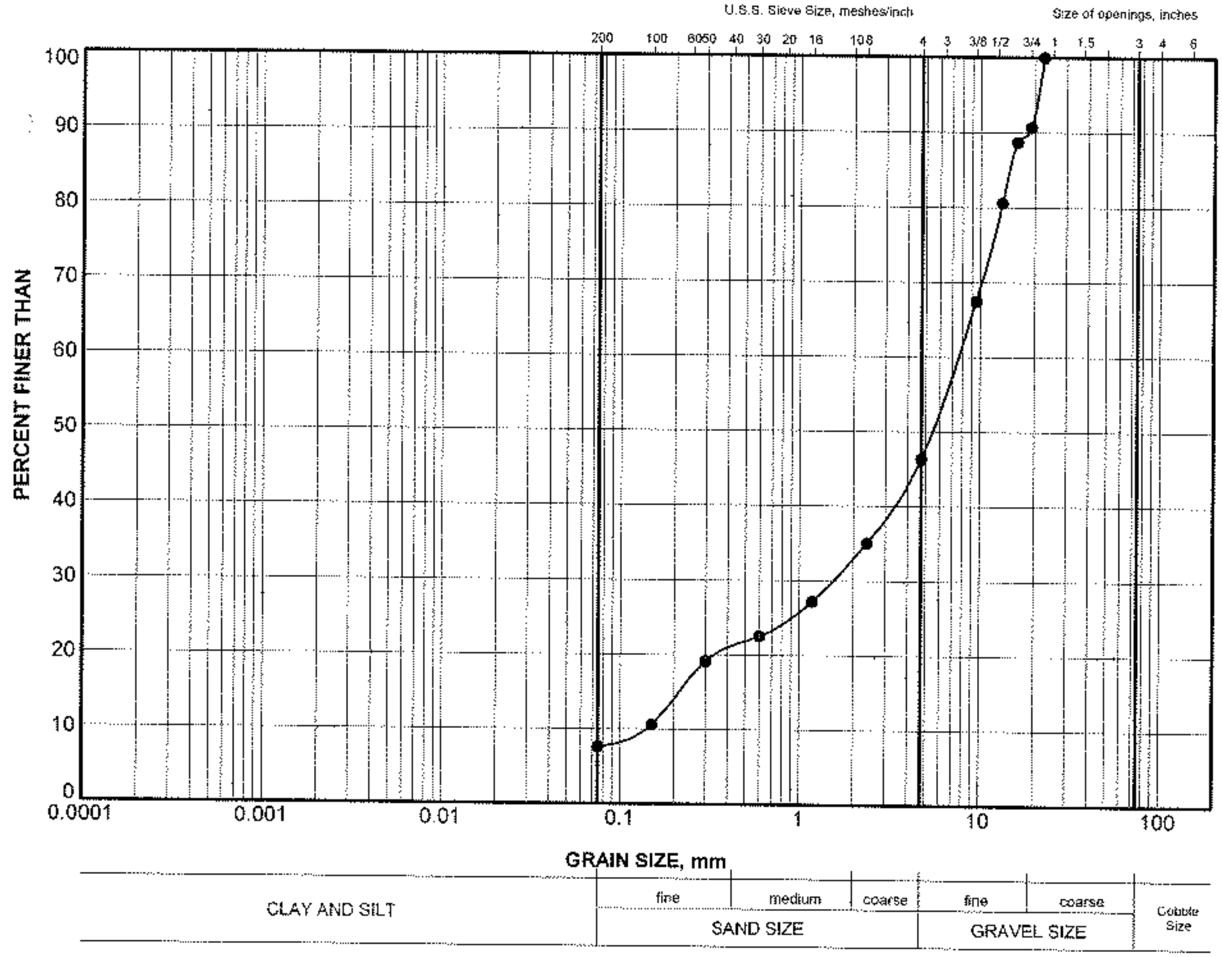
GRAIN SIZE DISTRIBUTION CURVE

FILL, sand, some crushed rock

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No. 021-4216 TEST PITS.GPJ
			SCALE N/A REV.
DRAWN	T.M.	10-11-02	
CHECK		10-11-02	FIGURE 11

LDN_MTO_NEW_GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	K1	7	171.2

PROJECT

KINGSVILLE FERRY DOCK
KINGSVILLE, ONTARIO

TITLE

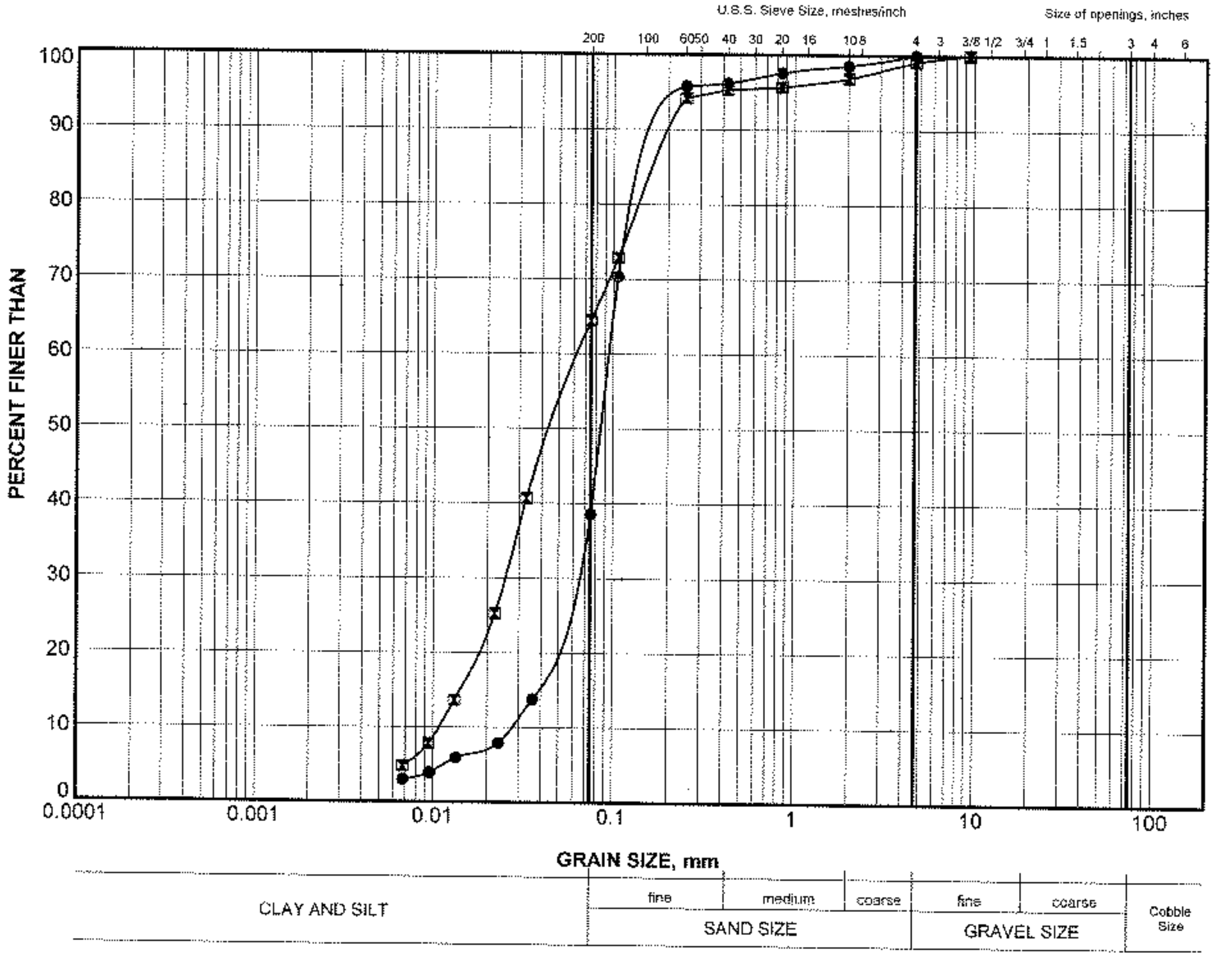
GRAIN SIZE DISTRIBUTION CURVE

FILL, rock with sand

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No.	021-4216.GPJ
			SCALE N/A	REV.
DRAWN	T.M.	10-11-02		
CHECK	[signature]	10-11-02	FIGURE 12	

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	K1	8	169.6
⊠	K6	7	171.2

PROJECT

KINGSVILLE FERRY DOCK
KINGSVILLE, ONTARIO

TITLE

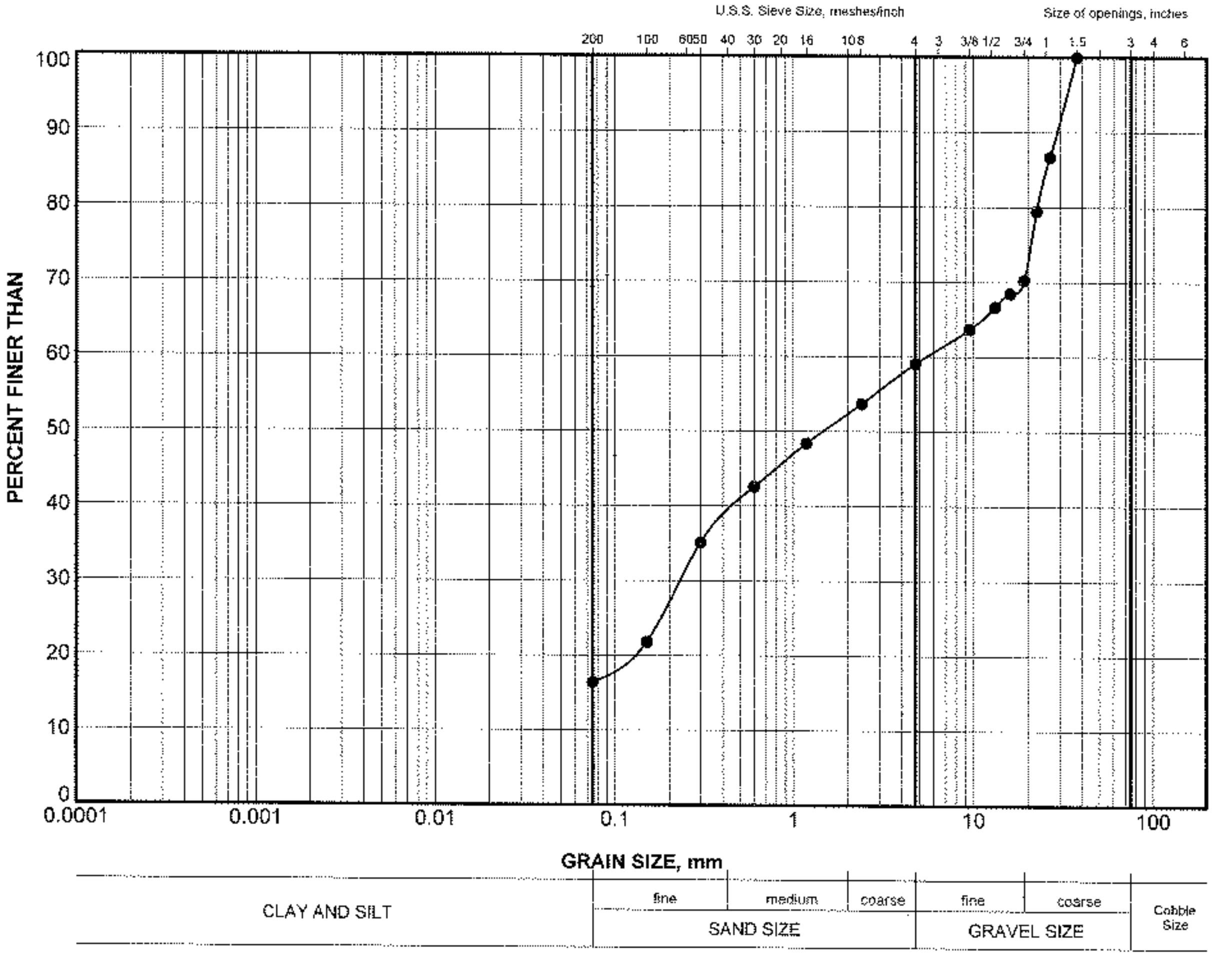
GRAIN SIZE DISTRIBUTION CURVE

SILTY FINE SAND to SANDY SILT

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No.	021-4216.GPJ	
			SCALE	N/A	REV.
DRAWN	T.M.	10-11-02			
CHECK		10-11-02	FIGURE 13		

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	K6	6	172.0

PROJECT

KINGSVILLE FERRY DOCK
KINGSVILLE, ONTARIO

TITLE

GRAIN SIZE DISTRIBUTION CURVE

FILL, rock with sand

Golder Associates
WINDSOR, ONTARIO

PROJECT No.		021-4216	FILE No. 021-4216.GPJ
			SCALE N/A REV.
DRAWN	T.M.	10-11-02	
CHECK		10-11-02	FIGURE 14

LDN_MTO_NEW GLDR_LDN.GDT

Test Pit Photographs

TEST PIT 1 – LEAMINGTON FERRY DOCK

Test Pit Photographs

TEST PIT 1 – LEAMINGTON FERRY DOCK

TEST PIT 1 – LEAMINGTON FERRY DOCK

Test Pit Photographs

TEST PIT 2 – LEAMINGTON FERRY DOCK

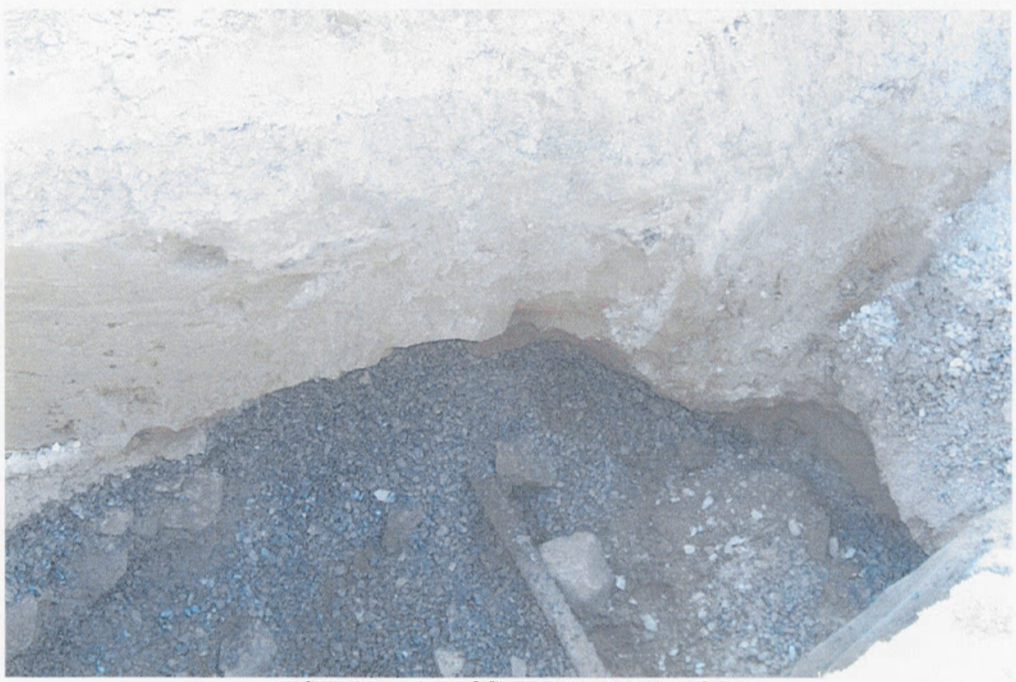
TEST PIT 2 – LEAMINGTON FERRY DOCK

Test Pit Photographs

TEST PIT 1 – KINGSVILLE FERRY DOCK

Test Pit Photographs

TEST PIT 1– KINGSVILLE FERRY DOCK



TEST PIT 1– KINGSVILLE FERRY DOCK

Test Pit Photographs

TEST PIT 2– KINGSVILLE FERRY DOCK

Test Pit Photographs

TEST PIT 1 – LEAMINGTON FERRY DOCK