GOVERNMENT OF ONTARIO

DEPARTMENT OF TRANSPORTATION
AND COMMUNICATIONS

Proposed Port Colborne Tunnel
Highway 3 - WP448-64

GEOTECHNICAL INVESTIGATIONS

ACRES CONSULTING SERVICES LIMITED
Consulting Engineers
Niagara Falls, Ontario

February 1972

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MEMORANDUM

TO: Mr. R. Oddson,
Senior Project Design Engineer,
Advanced Development Group,
Systems Design Office,
ATTENTION: Central Region,
3501 Dufferin St., Downsview.

FROM: Foundations Office,
Design Services Branch,
Central Bldg., Downsview.

DATE: March 20, 1972.

OUR FILE REF.

IN REPLY TO

SUBJECT: Proposed Crossing of Hwy. #3 and the Welland Canal at Port Colborne, Ontario.
W.P. 448-64 W.O. 71-11131

Enclosed please find the Foundation Investigation Report for the above-mentioned project. It should be noted that the report is of a preliminary nature only and that further investigation will be required when the project reaches the design stage. For your present purposes, however, we believe that the information contained in the report will be sufficient to enable you to complete your feasibility studies and prepare a reasonably accurate cost estimate. If further information is required please contact this Office.

A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER.

AGS/ao
Encl.

cc: Messrs. D. W. Farren
A. Rutka
C. R. Robertson
B. R. Davis
C. Mullerbeck (Gibb, Albery, Pullerits & Dickson)
G. C. E. Burkhardt
W. S. Leach (Pt. Colborne City Engineer)
G. Tustin (St. Lawrence Seaway - Montreal)
T. J. Kovich

Foundations Files
Documents

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1 - INTRODUCTION

Preliminary exploratory drilling for a proposed Highway 3 crossing of the Welland Canal in Port Colborne was instigated in November 1971 by the Department of Transportation and Communications. During the second week of December 1971 the Department requested Acres Consulting Services Limited to provide geotechnical services for the purpose of collating and presenting the results of the drilling program, which was then nearing completion. Drilling inspection services were provided by technicians from H. Q. Golder and Associates Ltd. and from Trow and Associates under the direction of Department personnel.

Following discussions between Acres and the Department of Transportation and Communications, the scope of the work to be undertaken by Acres was defined as follows:

(a) - To extract the factual geotechnical information from the drilling program results, collate such information, and present it in report form.

(b) - To identify, with respect to a proposed tunnel structure, factors of potential concern which would require more intensive investigation prior to carrying out detailed design. As drawings of the proposed tunnel were not available, the identification of key factors would not be related to a specific tunnel design.

Within this context, this report presents the results of the geotechnical assessment of the preliminary exploratory drilling.

2 - SUMMARY: CONCLUSIONS AND RECOMMENDATIONS

From the results of the exploratory program the following conclusions have been drawn with respect to geotechnical design considerations for the proposed tunnel:

(a) - Overburden varies from 3 feet to 25 feet in depth, and is composed of till and glacial deposits.

(b) - The general quality of the bedrock mass may be considered as Good to Excellent.

(c) - Throughgoing horizontal planes of weakness associated with bedding plane partings must be assumed to exist at all elevations, to the full depth of the exploratory drill holes. It is anticipated that residual clay minerals (mylonite) will be encountered along many of the bedding planes.

(d) - Bedrock permeabilities in the horizontal direction are generally high, in the order of 1×10^{-3} cm/sec and are affected by the presence of bedding plane partings which are open up to 4 inches in the in situ condition. In general, permeabilities along the south line were higher than at equivalent points along the north line.

(e) - From comparison of the data obtained from the south and the north investigation lines it was concluded that blast damage and stress relief effects due to canal excavation are more pronounced along the south line than along the north line.

(f) - The phenomenon of deformation of the tunnel rock cut due to rock stress relief ("rock squeeze") is considered to be a potential problem.

(g) - Gypsum was encountered in the rock strata bounding the base of the proposed tunnel cut.

(h) - Contamination of ground water with both dissolved sulphates and hydrogen sulphide was noted.

Based upon these conclusions, the following recommendations have been made:

(a) - For preliminary studies, overburden slopes of 2h:1v be used, with further soil sampling and testing undertaken prior to final design, to establish final design parameters.

(b) - Controlled perimeter blasting techniques be utilized for rock excavation associated with the tunnel structure.

(c) - For purposes of preliminary design, throughgoing horizontal planes be assumed to exist at any specified elevation, with zero cohesive strength, and with an angle of shearing resistance of 15 degrees to 20 degrees.

(d) - Further exploratory drilling, including angle holes, be undertaken prior to final design, particularly in the vicinity of proposed portals and rock plug structures.

(e) - Rock mechanics testing be undertaken prior to final design to provide quantitative data on the in situ stress levels in the bedrock.

(f) - Hydro-geological studies, including pumping tests, be undertaken prior to final design to provide data on anticipated seepage inflows to the tunnel cut, assess probability of soluting of gypsum, and on the probable disturbance to the existing ground-water regime due to tunnel construction.

(g) - Sulphate-resisting cement be used for the tunnel structure.

(h) - Adequate allowance be made for the protection of exposed materials against corrosion due to the presence of hydrogen sulphide, and further testing be carried out to determine quantitative data on the concentration of hydrogen sulphide which should be anticipated.

3 - EXPLORATORY PROGRAM

The area of investigation is shown on Plate 1, and is in Port Colborne near the entrance to the Welland Canal at Lake Erie. Investigations were conducted along two possible tunnel lines, as shown.

The general scope of the program laid out by the Department included the recovery of overburden samples from each hole; continuous core recovery within the bedrock; water-pressure testing of the uncased length of hole in 5-foot intervals; the use of a borehole television camera equipped with video-tape recording, and the placement of piezometers in selected holes. All exploratory holes were NX diameter, with NXL casing driven through the overburden and seated into bedrock, and with the holes cored to final depth using double-tube, swivel-core barrels.

The exploratory work along the north tunnel alignment consisted of five drill holes numbered BH-1 to BH-5, as shown on Plate 1, with each hole driven to a depth of approximately 100 feet. Along the south alignment, six drill holes were provided, with holes BH-6 to BH-10 being approximately 100 feet in depth and BH-11 being approximately 40 feet in depth. Table 1 lists the collar co-ordinates, elevations, and the final depths of the eleven completed drill holes.

At the time of Acres involvement, all holes on the north alignment had been completed (BH-1 to BH-5), and piezometers installed in BH-1 and BH-5. On the south alignment, BH-6 and BH-7 were near completion, and work was proceeding, using three drill rigs, on the balance of the proposed holes.

The drilling was completed under the general supervision of Acres personnel, with direct drill rig supervision carried out by H. Q. Golder and Associates Ltd. and by Trow and Associates personnel. Specific exploratory activities conducted by Acres personnel included the detailed logging of all core recovered; the use of the borehole television camera in boreholes 2, 3, 4, 6, 7, 9 and 10; the calculation of all permeability coefficients from the results of water-pressure tests; the classification and index property testing of recovered soil samples, and the chemical analyses of a limited number of water samples recovered from the drill holes and from the canal.

Table 1

BOREHOLE CO-ORDINATES, ELEVATIONS AND DEPTHS

Borehole No.	Easting (ft)	Northing (ft)	Elevation (ft)	Final Depth (ft)
1	1066440.48	15583693.03	582.86	101.00
2	1066786.70	15583835.73	582.66	100.00
3	1067300.56	15584017.54	580.64	101.50
4	1067689.55	15584175.54	580.93	103.60
5	1068285.71	15584465.77	579.67	102.00
6	1066192.32	15582432.29	582.07	101.00
7	1066891.83	15582477.01	583.97	100.30
8	1067152.52	15582483.91	579.50	101.70
9	1067521.35	15582478.29	584.48	100.80
10	1067945.80	15582465.46	582.50	100.10
11	1069022.86	15582544.29	584.88	40.00

4 - RESULTS OF EXPLORATORY PROGRAM

4.1 - General

The area under study is situated to the south of the Onondaga Escarpment. This feature is a buried erosional escarpment in the bedrock which represents the termination of southerly dipping lower Devonian strata, and which has topographic expression as a low, irregular bluff, generally with less than 30 feet of relief. The escarpment trends approximately east-west and is visible from Fort Erie to Hagersville, beyond which it is buried by glacial drift. The general area is underlain by Paleozoic sedimentary rocks, commencing with strata of lower Devonian age to the south of the escarpment, and with strata of Silurian age to the north of the escarpment. In general, a thin mantle of glacial till overlies the bedrock from the top of the escarpment to the Lake Erie shore, whereas the deep bedrock valley to the north of the escarpment is filled with glacial and post-glacial lacustrine sediments to depths in excess of 100 feet. Topographic relief in the project area is minor. The Onondaga Escarpment acts as a ground-water divide, with recharge from this area moving north to Lake Ontario and south to Lake Erie, although the regional flow pattern is modified in the vicinity of the Welland Canal.

Within this general framework, the results of the exploratory program are discussed in the following sections.

4.2 - Overburden

Fifty-six soil samples were recovered from eleven boreholes in the project area during drilling (fifty-four jar samples and two samples in Shelby tubes). These samples were initially classified visually in the field. Further classification at the Acres laboratory included standard index tests on representative samples. Fourteen samples were subjected to grain size distribution analyses, and Atterberg limits and water contents were determined for twenty samples. Tests were conducted to determine the undrained triaxial strength of two samples. The results of the index tests are summarized in Table 2, and results of grain size analyses are shown on Plates 2 and 3. Soil logs are attached to the detailed drilling logs which are appended to this report. The soil stratigraphy shown on Plates 4 and 5 were developed from these logs.

The overburden in the project area is generally shallow and, as indicated along the two lines of exploratory drilling, varies from 3.1 feet to 24.9 feet.

Within the investigation area a surficial layer was encountered, 1.5 feet to 6.5 feet thick, composed of fill and industrial residues, intermixed with clay, silt, sand, and gravel. Beneath this layer two distinct soil horizons were identified, with the upper zone consisting of clay and silty clay, with occasional pockets of peat, and varying in thickness from 4.0 feet to 18.5 feet. Deposits within this zone are considered to be probably of fluvio-glacial origin.

Immediately overlying the bedrock surface and conforming to the bedrock topography, a lower zone of clay with silty sands and gravels, probably of glacial origin, was encountered, varying from 1.0 foot to 6.5 feet in thickness.

Grain size analyses were conducted for a number of soil samples from the two soil zones, and indicated that the average clay content in the lower zone was significantly less than that in the upper zone. Results of these tests are shown plotted on Plates 2 and 3, for the upper and lower zones respectively.

The undrained shear strength of two undisturbed samples taken from the upper soil zone was measured by unconsolidated, undrained triaxial tests conducted at a confining pressure of 30 psi. The shear strengths were determined to be 2,877 psf and 4,760 psf respectively, as noted in Table 2.

The water contents for the samples tested ranged from 13.5 per cent to 34.4 per cent, which were close to, or slightly above, the plastic limit. Plasticity indices were generally in the range of 25-30 per cent, as noted in Table 2.

TABLE 2

Summary of Index Test Results for Soil

Hole No.	Sample No.	Elevation ft	Water Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Undrained Shear Strength Triaxial S_{un} psf	e_f %
2	2	580.1	24.4	54.9	24.4	30.5		
2	4	575.1	26.5	53.4	26.5	28.0		
3	3	575.6	24.9	49.2	23.4	25.8		
3	4	573.1	29.2	60.1	26.8	33.3	2,877	3.0
3	6	568.1	24.7	43.5	21.3	22.2		
4	2	578.4	24.5	52.2	25.2	27.0		
4	5	571.1	27.1	57.5	24.6	32.9		
4	6	568.4	28.0	50.1	24.0	26.2		
5	3	574.6	31.5	64.4	28.9	35.5		
5	5	569.6	30.2	53.8	23.7	30.1		
5	6	565.1	30.8	45.2	22.1	23.1		
6	3	577.0	27.5	59.3	23.5	35.8		
7	2	581.4	21.7	37.5	17.0	19.4		
7	3	578.9	30.5	48.6	23.2	25.4		
7	7	568.9	34.4	56.4	24.4	32.0		
7	9	563.9	14.6	34.1	16.9	17.7		
7	10	561.4	22.7	36.7	17.2	19.4		
8	SS-2	577.0	14.97	38.6	18.9	19.6		
8	5	569.5	26.5	62.9	26.7	36.2	4,760	4.0
8	SS-7	564.5	13.5	34.6	17.6	16.9		
10	4	574.5	26.0	51.9	23.6	28.3		
10	5	571.5	23.1	34.0	16.82	17.18		

S_{un}: is the undrained triaxial strength of an undisturbed sample tested at a confining pressure of 30 psi.

e_f: is the axial strain at failure.

4.3 - Bedrock

4.3.1 - Stratigraphy and Lithology

The project area is underlain by a series of sub-horizontal Paleozoic sedimentary strata. The geologic column, to the depth of the exploratory drilling, is given in Table 3, and is based upon the detailed geological logs for each hole. The detailed logs are appended to this report. For ease of reference, summary logs for each hole are provided on Plates 7 to 17. Geologic sections along each of the proposed alignments are shown on Plate 4 (north line) and Plate 5 (south line). The true dip of the beds, derived from sections drawn from the north to the south investigation lines, was calculated at 15 to 25 feet per mile, in a direction South 45 degrees West.

TABLE 3

GENERAL GEOLOGIC COLUMN OF THE AREA

System	Formation	Lithology	Range of Thicknesses (feet)	Permeability* Range of K-Values K = cm/sec
DEVONIAN	BOIS BLANC	Coralline Limestone	18.0 max	$0.0 - 2.5 \times 10^{-4}$
		Limestone	4.1 max	$6.0 \times 10^{-4} - 1.5 \times 10^{-3}$
		Fossiliferous Limestone	11.6 max	$0.0 - 1.8 \times 10^{-3}$
	ORISKANY	Sandstone	0.6 - 2.1	$1 \times 10^{-5} - 1.8 \times 10^{-3}$
SILURIAN	AKRON	Mottled Dolomite	11.7 - 15.0	$0.0 - 1.5 \times 10^{-3}$
		Shaly Dolomite	9.0 - 12.3	$0.0 - 1.8 \times 10^{-3}$
		Brown Porous Dolomite	11.6 - 16.1	$0.0 - 2.44 \times 10^{-3}$
		Shale, Dolomitic Shale	13.5 - 18.7	$1.0 \times 10^{-5} - 1.96 \times 10^{-3}$
	SALINA	Gypsum Rich Shale Dolomitic Shale	10.2 - (?) (end of hole)	$0.0 - 1.50 \times 10^{-3}$

All information based on borehole logs (BH-1 to BH-11) for north and south investigation lines.

*Permeability values are based on 5-foot interval water-pressure tests.

The cap rock in the investigation area consists of a lower Devonian limestone formation, known as the Bois Blanc Formation. Due to the eroded upper surface of this formation, it varies irregularly in thickness from a maximum of approximately 30 feet to a minimum of approximately 10 feet (Plates 4 and 5). The distinct depression in the bedrock surface at the western edge of the Canal on the southern exploration line (Plate 5) was not recorded prior to excavation of the Canal (Seaway Authority Drawing F-2046), and therefore may indicate either that considerable over-excavation and consequent blast damage were caused in this area during construction of the Canal, or that additional excavation was conducted in this area for some purpose. The limestone cap rock is comprised of three distinct lithological units (Table 2), these being a coralline limestone, limestone, and fossiliferous limestone. Chert is commonly present in the upper and lower units.

The base of the Bois Blanc Formation is marked by a Devonian siltstone formation known as the Oriskany Sandstone, which is bounded by erosional unconformities. Due to the presence of the unconformities, chert and glauconite are common throughout the Oriskany Formation, which varies in thickness between 0.6 foot and 2.1 feet.

Beneath the lower Devonian strata, and separated by the unconformity at the base of the Oriskany Sandstone, lie the sedimentary rocks of the Upper Silurian period. Two Silurian formations were penetrated by the exploratory drilling, the uppermost being the Bertie-Akron Dolomite. Four lithological units have been identified within this formation, and consist of an upper mottled dolomite, underlain by shaly dolomite, brown porous dolomite, and dolomitic shale. The total thickness of the Bertie-Akron Dolomite remains relatively constant across the project area at 55 feet.

The deepest stratum penetrated by the exploratory drill holes lies beneath the Bertie-Akron Dolomite, and belongs to the upper portion of the Salina formation. The core recovered from this formation consists principally of dolomitic shale, but includes a substantial proportion, up to 20 per cent, of gypsum in both bedded and nodular form.

4.3.2 - Engineering Geology

One measure of the engineering competence of a rock mass is the Rock Quality Designation, defined as the

ratio of the length of core recovered in pieces greater than 4 inches long to the total length of core run, expressed as a percentage. Values of RQD were calculated during drilling for all of the exploratory holes, and are plotted on the summary logs, Plates 6 to 16. From these figures it may be noted that the average RQD value is in the vicinity of 80 per cent, designating a rock of Good to Excellent quality. In general, the discontinuities encountered in the core were due to parting on bedding planes. In certain cases, weathering of shaly material had progressed along open bedding planes, resulting in local fracturing of the core, and consequent low values of RQD.

Within several of the open bedding plane partings, the presence of a silty clay infilling material was noted, although this phenomenon was apparently confined to a short depth below bedrock surface (15 feet maximum). The existence of mylonite or clay seams along bedding planes was anticipated to extend to the full depth of the exploratory holes, although evidence of this was limited, possibly due to the washing out of this material during drilling.

All fractures noted in the cores are shown in the detailed logs appended to this report. From these logs it is apparent that structural discontinuities other than those associated with the bedding planes were rarely encountered. Thus, widely spaced jointing is predicted from the drilling results, and this is consistent with exposures inspected at the R. F. Law quarry near Port Colborne.

Although no mechanical testing of core samples was conducted, it may be stated that the rock material in all of the formations penetrated was generally unweathered, hard and intact, with medium to high modulii of elasticity and medium to high compressive strengths. It is anticipated that both modulii and strengths will decrease with increasing proportion of shale or gypsum, although the variation in these properties is unlikely to be significant with respect to a tunnel structure. Where weathering was present it was minor in nature and invariably local in vertical extent. No evidence of faulting was found during this investigation.

In summary, it is anticipated that numerous horizontal planes of weakness will be encountered, and this factor must be considered in design of rock-plug dimensions and structural foundations. Other structural

discontinuities are likely to be widely spaced, and the general rock quality is considered to be Good to Excellent.

4.4 - Permeability

All exploratory holes were water-pressure tested over their uncased length utilizing 5-foot interval double packers. The total and incremental water take was measured for a range of gauge pressures, each pressure being applied for a period of 5 or six minutes. These data were reduced and utilized to calculate the average permeability in cm/sec for each 5-foot section of hole, on the basis of standard equations noted in the summary logs. The results of these calculations are plotted for each hole on the summary log sheets, Plates 6 to 16, and are summarized with respect to the lithology of the geologic column in Table 3.

The specific purpose for utilizing the Ontario Hydro borehole television camera was to investigate the in situ condition of discontinuities within the rock, particularly the degree to which such discontinuities might affect permeability. The drill holes available for inspection were numbers 2, 3 and 4 on the north line, and numbers 6, 7, 9 and 10 on the south line. Results of the camera inspection for each of the above drill holes are recorded on the relevant summary logs.

Two major conclusions stemming from the camera work were

(a) - Significant in situ openings exist within the rock, generally associated with parting across bedding planes. Openings are commonly in the range 0.5 to 1.0 inch, and occasionally up to 3 to 4 inches, with the surrounding rock generally appearing as tight and relatively impermeable. It was concluded from these studies that the horizontal permeability is probably several orders of magnitude greater than the vertical permeability, and that the calculated average permeabilities for a 5-foot interval were essentially controlled by the local bedding plane partings which occurred within the particular interval. For example, the calculated permeability in BH-6 between 54 feet and 59 feet was 1.38 by 10^{-3} cm/sec. Assuming that the measured water take for this interval was accepted entirely along the open bedding plane (0.75 inch) determined from the camera inspection, the true permeability along this bedding plane would be in the order of 5 by 10^{-1}

cm/sec, an increase by a factor of approximately 50. Balling plane permeability is clearly significant with respect to the problem of water inflow to any proposed excavation, and must be taken into account in the design.

(b) - In general terms, major bedding plane openings were significantly more common in the boreholes drilled along the south line, than the holes along the north line. This observation is supported by the permeability results calculated from the water pressure tests, and is reflected in the average permeability figures plotted on Plates 4 and 5.

As noted in Section 4.3.1, there is some evidence that the major bedrock surface depression observed on the west bank of the Canal along the south line was associated with excavation of the Canal. If this conclusion is valid, it is possible that considerable blast damage was caused to the underlying strata which, coupled with vertical stress relief, has resulted in opening across many of the bedding planes, and consequent increase in the horizontal permeability.

On Plates 4 and 5 the average permeabilities are plotted in association with the bedrock stratigraphy and lithology for each investigation line. All of the permeability results which were obtained are shown on the summary logs, Plates 6 to 16. From these data the following conclusions have been drawn:

(a) - The base of the Bois Blanc Limestone cap rock, with its associated unconformities and Oriskany Sandstone stratum, represents a continuously permeable horizon, with an average "k" value of 5.6×10^{-4} cm/sec along the south line and a value of 1.3×10^{-3} cm/sec along the north line.

(b) - The shaly dolomite unit of the Bertie-Akron Formation commonly displays permeabilities in the order of 5×10^{-4} cm/sec with slightly higher values at the top and bottom contacts of the unit and slightly lower values in the middle of the unit.

(c) - Other than the two aforementioned lithological units, the variation of permeabilities is apparently related primarily to blast damage and stress relief associated with the Canal. For the north line, permeabilities generally decrease with increasing distance from the

Canal, both vertically and horizontally. As previously noted, the south line displays generally higher permeabilities than the north line, and this effect extends to the vertical and horizontal limit of the exploratory holes.

It must be emphasized that the permeability figures determined during this exploratory program are only significant in indicating the general trends noted in this section. From these trends it is concluded that the control of seepage into proposed tunnel excavations is a major potential problem, and that it is likely to be more severe for the south alignment than for the north alignment. However, reasonably accurate determination of design seepage quantities and horizons of maximum seepage cannot be realistically undertaken from these data, but would require detailed and carefully controlled pumping tests. It is strongly recommended that such tests be undertaken prior to detailed design studies.

4.5 - Ground Water

As noted in Section 4.1, the Onondaga Escarpment acts as a ground-water divide, with the flow to the south generally moving towards Lake Erie, and locally modified by flow towards the Welland Canal. This local effect was confirmed by measurement of the elevation of the static water surface in each drill hole. The resulting ground-water surface is plotted for the north and south lines on Plate 17, which clearly indicates the gradient toward the Canal.

From the exploratory program, particularly the borehole television work, it was clear that ground-water aquifers occur at various levels within the bedrock strata, associated primarily with open bedding planes. In order to determine the piezometric levels associated with these deeper-lying open bedding planes, piezometers were placed in a number of drill holes, as shown in Table 4. Readings from these piezometers are also plotted on Plate 17, from which it is apparent that the piezometric levels increase with depth, indicating upwards flow from the deeper-lying strata towards the Canal. This phenomenon is normal and has been noted in investigations associated with other structures to the north of the Onondaga Escarpment. It is significant that, although the data are limited at the present time, there are indications that piezometric levels respond rapidly to changes in the Canal and lake water levels. This observation tends to confirm the conclusion, noted in Section 4.4, that the permeabilities associated with open bedding planes are extremely high, allowing a rapid response in piezometric level to any change in canal or lake level.

TABLE 4

PIEZOMETRIC DATA BOREHOLES NO.1-11

Borehole No.	Collar Elevation (ft)	Piezometer Interval (Depth in ft)	Date - Dec. 1 to Dec. 28 Static Water Levels (Depth in ft)	Date - Dec. 1 to Dec. 28 Piezometric Levels (Depth in ft)	Date - Dec. 29 Static Water Levels (Depth in ft)	Date - Dec. 29 Piezometric Levels (Depth in ft)	Date - Jan. 12 Static Water Levels (Depth in ft)	Date - Jan. 12 Piezometric Levels (Depth in ft)
BH-1	582.86	52.0 - 101.0	12.0	-	-	10.8	-	11.0
BH-2	582.66	None installed	11.2	-	10.7	-	10.1	-
BH-3	580.64	None installed	9.6	-	8.7	-	8.5	-
BH-4	580.93	None installed	9.6	-	8.8	-	9.4	-
BH-5	579.67	65.0 - 102.0	8.0	-	-	7.2	-	7.5
BH-6	582.07	None installed	9.5	-	9.0	-	8.4	-
BH-7	583.97	None installed	12.3	-	10.5	-	11.0	-
BH-8	579.50	(60.3 - 101.7 (26.5 - 55.3	6.9	-	-	(0.8) (6.9)	-	(5.6) (8.0)
BH-9	584.48	None installed	12.3	-	11.4	-	9.0	-
BH-10	582.50	None installed	9.2	-	9.5	-	8.8	-
BH-11	584.88	None installed	8.5	-	8.8	-	8.4	-

A limited number of water samples were obtained from the drill holes and from the Canal, and analyzed to determine the principal chemical impurities. For the drill hole samples, the results are only meaningful for the water from the tip of the hole, due to chemical mixing which occurs in the vertical water column. Typical results for the Canal water analysis and drill hole water analysis are shown on Table 5. The primary conclusion from these tests was that the direction of ground-water movement was toward the Canal and that the water associated with the Salina beds was capable of dissolving the gypsum present in these beds. The saturation concentration of $SO_4^=$ ions is approximately 1,800-2,000 ppm, depending upon the existence of other impurities. Due to the relatively short distance travelled by the ground water from the Onondaga Escarpment to the exploration area, the concentration of $SO_4^=$ ions in the Salina ground water is still relatively low, in the range of 50-850 ppm. Thus, it is deduced that the process of solutioning of the included gypsum beds and nodules is presently continuing at the site. In the event that the ground-water regime is significantly altered, such as by pumping during and after tunnel construction, the rate of solutioning could increase, leading to a potential acceleration of solution cavity formation, although the meaningful prediction of the probability of this phenomenon would require extensive hydro-geological investigations.

It was further noted that the ground water from the Salina beds contains minor amounts of hydrogen sulphide.

Although the measured sulphate concentrations would not normally warrant the use of sulphate-resisting cement for the tunnel sections, the proximity of the gypsiferous Salina formation indicates that the use of sulphate-resisting cement would be advisable.

The presence of hydrogen sulphide in the ground water should also be considered in the design of the tunnel.

5 - GEOTECHNICAL DESIGN CONSIDERATIONS

From the information obtained from the exploratory program and discussed in the preceding sections, a number of geotechnical factors have been identified which must be considered with respect to the design of a tunnel structure. These factors are summarized below:

(a) - Depth of overburden varies between 3.1 feet and 24.9 feet for the boreholes drilled, and consists primarily of fill and glacial deposits. The depth is generally greater along the south investigation line than along the north line, primarily due to a bedrock surface depression near the west side of the Canal on the south line.

As shear strength parameters were determined for only the two undisturbed samples tested, accurate stability analyses could not be performed. However, on the basis of approximate calculations, and from experience with similar soils in the area, it is considered that cut slopes of 2h:1v will probably prove to be stable and can be used for preliminary design. More detailed soil sampling and testing should be undertaken prior to final design.

(b) - Although no quantitative data concerning in situ stress conditions in the bedrock was measured, it is considered probable that such stresses will be similar to those encountered elsewhere in the Niagara region, being relatively high in the horizontal direction and in the order of 1,000 psi. Detailed examination of the core sections recovered from within the Oriskany Sandstone indicated that this formation had been subjected to high horizontal strains during its geologic history, evidenced by the alignment of cobbles included in the siltstone. If the associated stresses have not been relieved by later geological processes, then it is possible that excavation of a tunnel cut will provide the necessary relief, leading to deformation of the rock strata into the cut. This phenomenon of "rock squeeze" has been noted within the general Niagara region. It is estimated that the squeezing movements may reach 4 inches for an unrestrained condition, and this potential effect should be taken into account in the design. It is emphasized that no in situ stress measurements have been undertaken in the proposed project area, and it is recommended that a program to obtain such measurements should be instigated prior to carrying out detailed design.

(c) - Numerous horizontal discontinuities and planes of weakness were encountered in all boreholes associated with the horizontal bedding of the bedrock strata. Use of the borehole television camera confirmed that many of these discontinuities which were mapped in the core were open in the in situ condition, and carried a significant ground-water flow. In addition, the presence of clay seams or of mylonite along bedding planes is considered to be highly probable. These factors will have a major effect on the design of rock-plug structures. Detailed design of plug dimensions will require further information, particularly concerning secondary jointing, and may have to await the initial stages of construction. Nevertheless, it is concluded that continuous open horizontal planes with low shearing resistance ($\emptyset$ = 15-20 degrees) will exist at the base of any rock plug; that full canal head will act on the canal side of any plug; that the minimum uplift conditions applicable to the plug base will consist of a linear reduction from full head at the upstream end to zero at the toe, and that blast damage to the rock adjacent to the Canal will serve to reduce side restraint on the plug. With these assumptions, a minimum base width of 125 feet should be considered for rock-plug structures during preliminary studies.

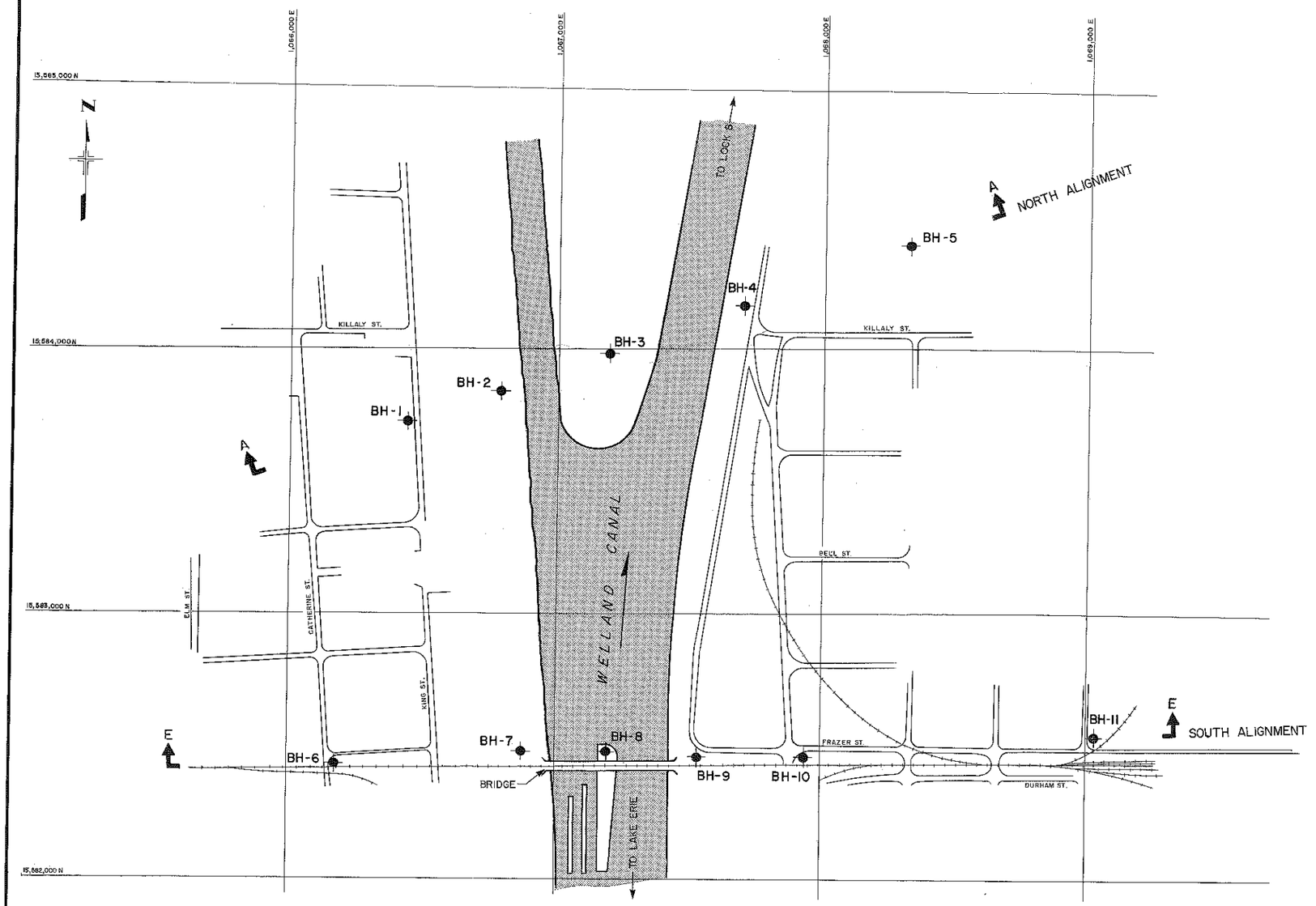
(d) - Although numerous horizontal discontinuities were encountered, these had only a minor effect on the general rock quality at the site which has been classified as Good to Excellent. Joint spacing in the recovered cores was generally greater than 10 feet, with the rock material being essentially fresh and unweathered. It is considered that controlled perimeter blasting will be necessary in excavating the rock cuts associated with a tunnel structure, and it is recommended that presplitting techniques be utilized to maintain the integrity of vertical or near vertical rock walls.

(e) - The results of water-pressure testing are discussed in Section 4.4, in which it is noted that the control of seepage into proposed tunnel excavations is considered to be a key potential problem. The data obtained from the geological investigations to date indicate that high permeabilities are associated with bedding plane openings and with particular lithological units, notably the Oriskany Sandstone. It is recommended that pumping tests be conducted prior to undertaking detailed design of the tunnel structure.

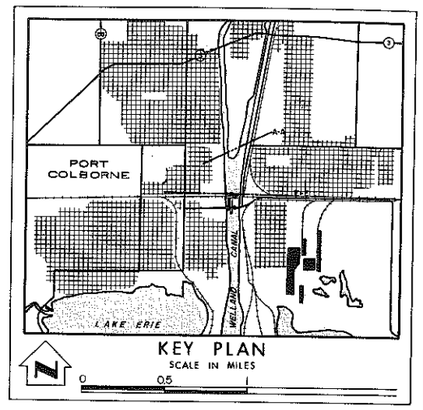
(f) - Chemical analyses of a limited number of water samples were conducted, although it was recognized that the results could not be directly utilized in a quantitative sense due to vertical chemical mixing of water in the drill holes. Nevertheless, the analyses do indicate that ground water associated with aquifers in the Salina Formation contains $SO_4^=$ due to solutioning of gypsum from this formation. It is considered that the use of sulphate-resisting cement for the tunnel structure would be advisable.

(g) - The current rate of gypsum solutioning from the Salina Formation and the effect of modification of the ground water regime due to a tunnel structure are factors of potential significance to design of the tunnel, particularly with respect to anticipated settlements. In order to provide quantitative data on these factors, a study of the regional ground-water regime, with particular attention to ground-water chemistry, will be required and must be undertaken at an early stage to enable the results to be applied to the tunnel design.

(h) - The presence of hydrogen sulphide gas in the ground water was detected by observation of drill rod discoloration, and by the odor of the ground water. In general, it appeared that H_2S was associated primarily with water from the Salina Formation. Quantitative measurements of H_2S concentrations were not undertaken as the equipment required for the necessary down-hole separation of the relevant ground-water aquifers, sampling and chemical analysis, was not available. From previous experience at the Townline Road/Rail Tunnel beneath the Welland Canal, it was tentatively concluded that H_2S concentrations were less than 5 ppm. Nevertheless, from the experience of the Seaway Authority at other projects in the Port Colborne area, it is considered important that adequate allowance be made in the design of the tunnel to protect against corrosion of exposed metal and other materials. Detailed testing for H_2S concentrations should be conducted prior to final design, and could be incorporated in the pumping test program recommended under Item (e).



PLAN



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation.

NO.	ELEVATION	CO-ORDINATES NORTHING	CO-ORDINATES EASTING
1	582.86	15583693.03	1066440.48
2	582.66	15583835.73	1066786.70
3	580.64	15584017.54	1067300.56
4	580.93	15584175.54	1067689.55
5	579.67	15584455.77	1068285.71
6	582.07	15582432.29	1066192.32
7	583.97	15582477.01	1066891.83
8	579.50	15582483.91	1067152.52
9	584.48	15582478.29	1067521.35
10	582.50	15582465.46	1067945.80
11	584.88	15582544.29	1069022.86

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

0 400 800
SCALE IN FEET

REVISIONS	DATE	BY	DESCRIPTION

ACRES CONSULTING SERVICES LIMITED

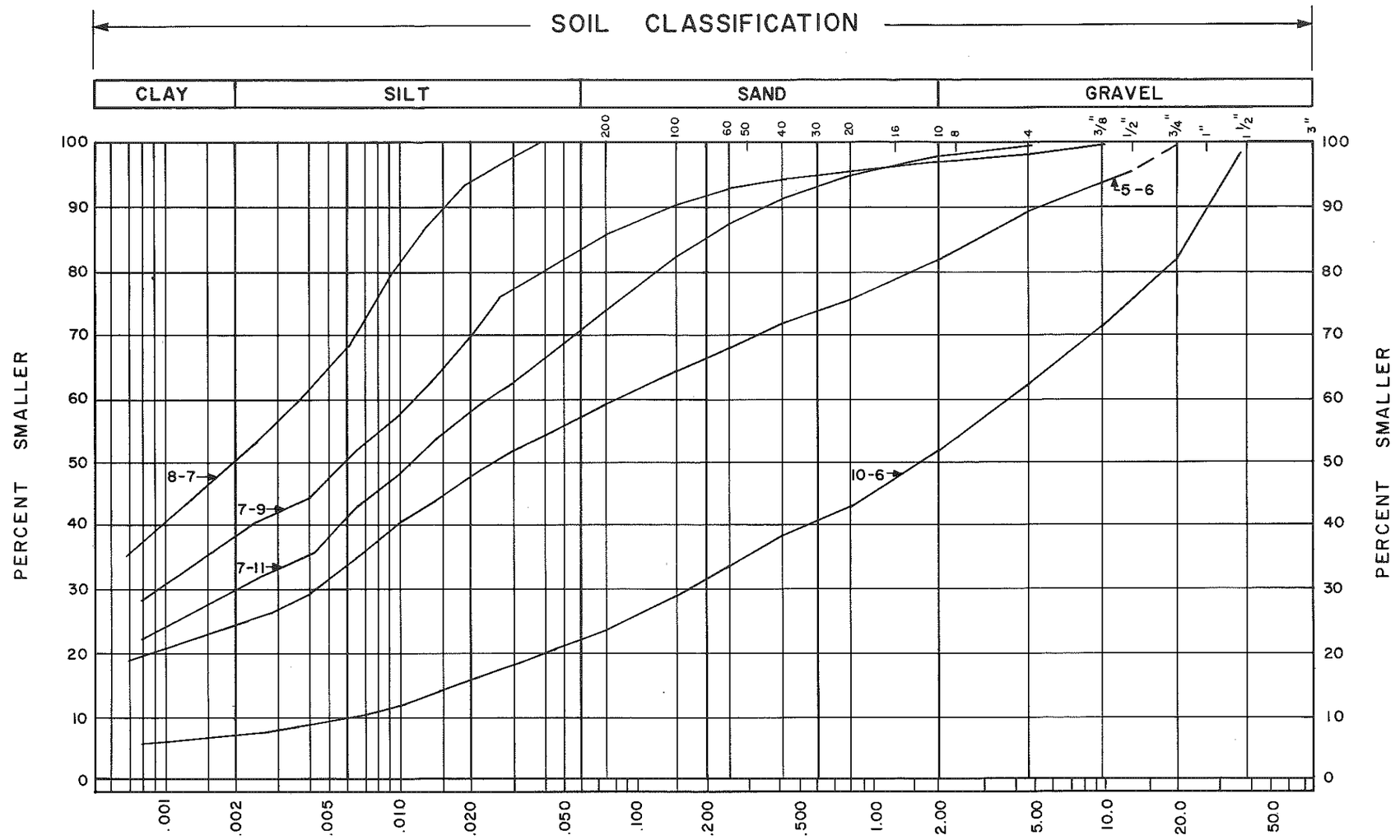
DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH — FOUNDATION OFFICE

PORT COLBORNE TUNNEL
PLAN OF INVESTIGATION AREA

HIGHWAY NO. 3 DIST. NO. 4
CO. WELLAND
TWP. LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. J.M.M.	CHECKED B.K.	W.P. NO. 448-64	DRAWING NO. 1
DRAWN R.C.	CHECKED D.A.	JOB NO. P 2955	
DATE FEBRUARY, 1972		SITE NO.	BRIDGE DRAWING NO.
APPROVED ACRES CONSULTING SERVICES LIMITED		CONT. NO.	



LEGEND

10 - 6 BOREHOLE No. 10
SAMPLE No. 6

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

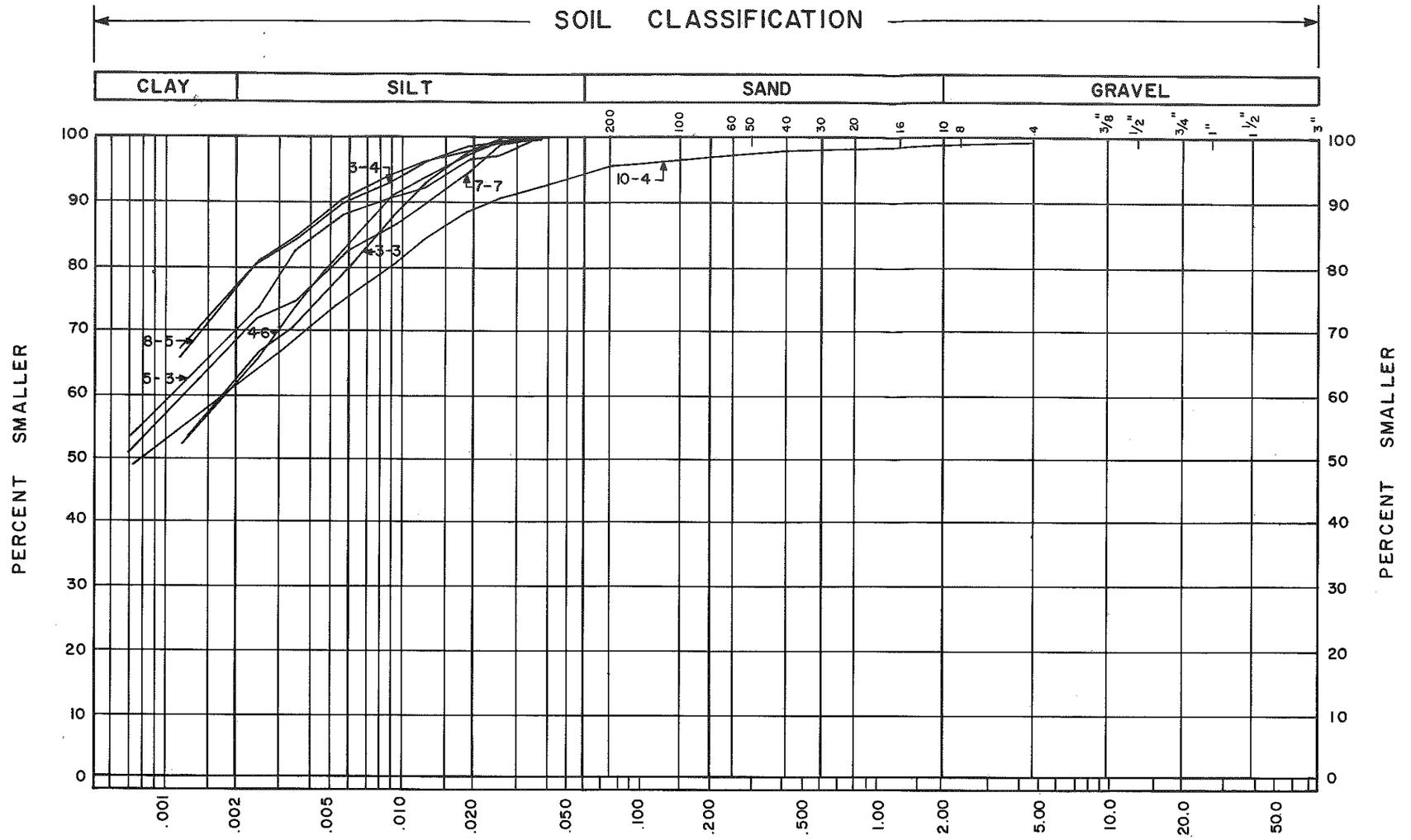
PORT COLBORNE TUNNEL

GRAIN SIZE DISTRIBUTION LOWER SOIL HORIZON

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 3



LEGEND

10 - 4 BOREHOLE No. 10
SAMPLE No. 4

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

GRAIN SIZE DISTRIBUTION UPPER SOIL HORIZON

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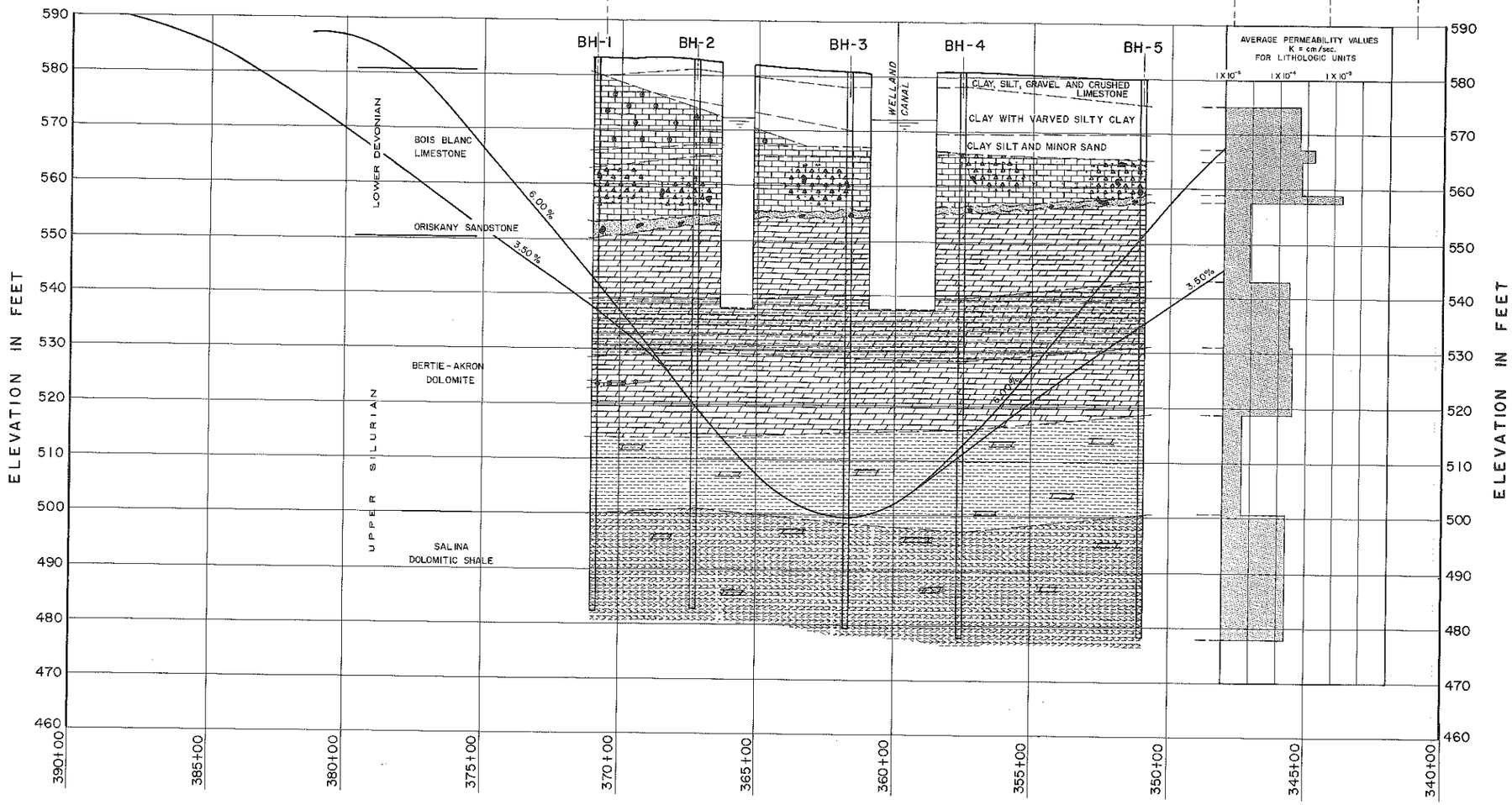
FEBRUARY 1972

PLATE 2



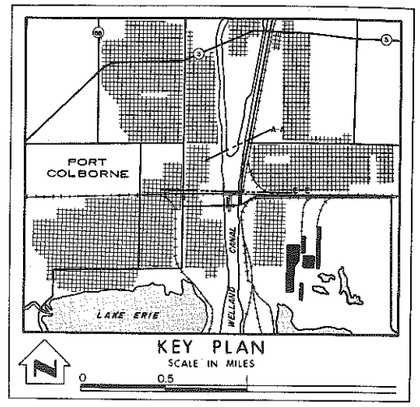
SECTION A-A

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

0 20 40
VERT. SCALE IN FEET

0 400 800
HORIZ. SCALE IN FEET



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation.

NO.	ELEVATION	CO-ORDINATES NORTHING	CO-ORDINATES EASTING
1	582.86	15583693.03	1066440.48
2	582.66	15583835.73	1066786.70
3	580.64	15584017.54	1067300.56
4	580.93	15584175.54	1067689.55
5	579.67	15584465.77	1068285.71

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS			
DATE	BY	DESCRIPTION	

ACRES CONSULTING SERVICES LIMITED

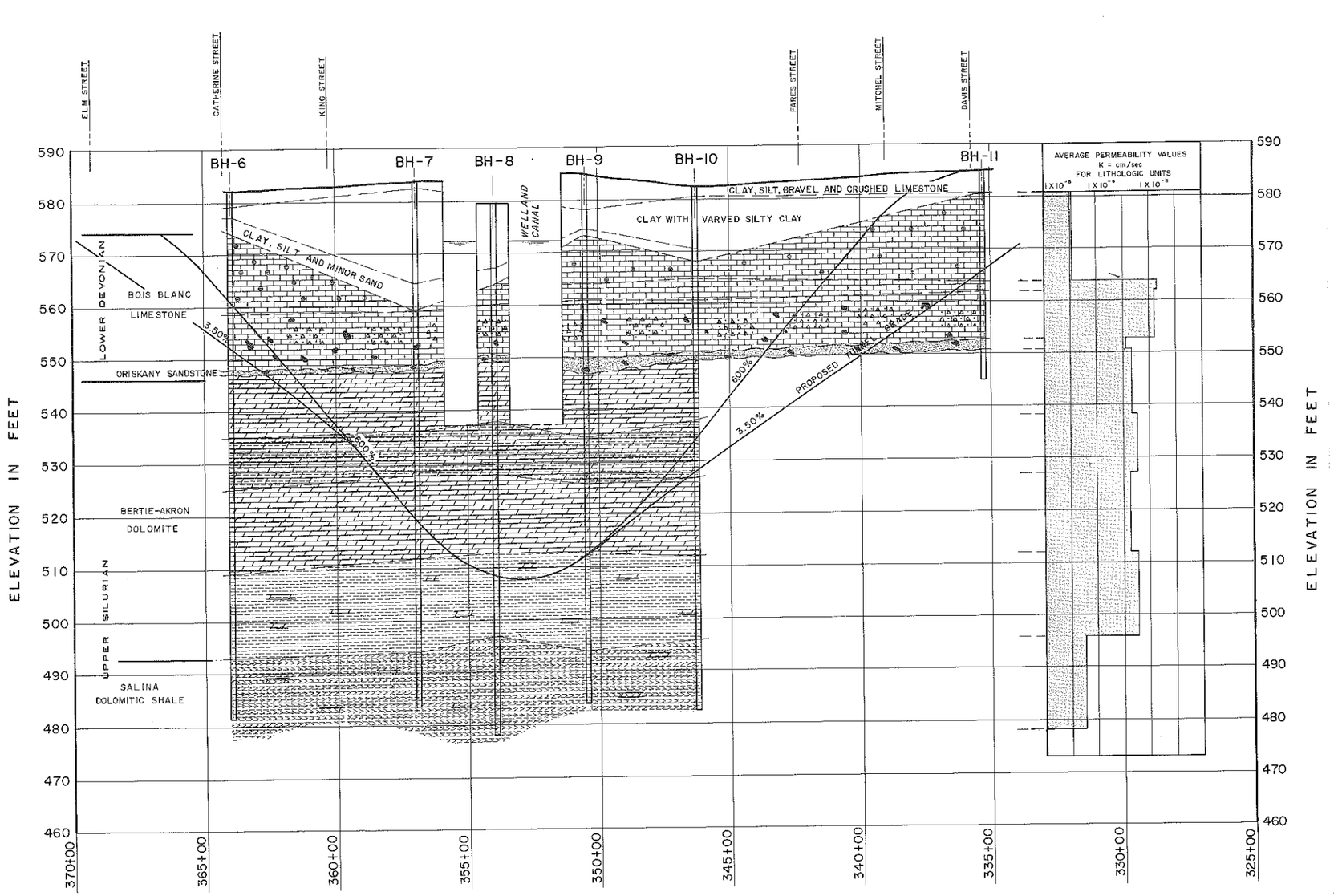
DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH — FOUNDATION OFFICE

PORT COLBORNE TUNNEL
GEOLOGIC SECTION - NORTH LINE

HIGHWAY NO. 3 DIST. NO. 4
CO. WELLAND
TWP. LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. M.U	CHECKED D.M.	W.P. NO. 448-64	DRAWING NO. 4
DRAWN M.U	CHECKED	JOB NO. P 2955	
DATE FEBRUARY 1972		SITE NO.	BRIDGE DRAWING NO.
APPROVED ACRES CONSULTING SERVICES LIMITED		CONT. NO.	



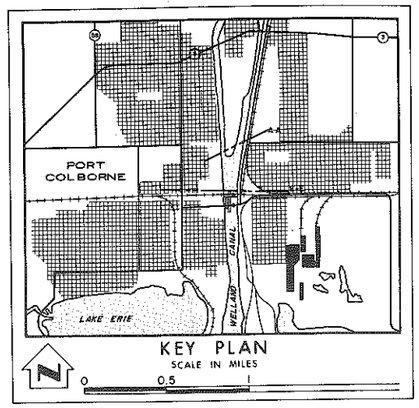
SECTION E-E

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

0 20 40
VERT. SCALE IN FEET

0 400 800
HORIZ. SCALE IN FEET



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation.

NO.	ELEVATION	CO-ORDINATES NORTHING	EASTING
6	582.07	15582432.29	1066192.32
7	583.97	15582477.01	1066891.83
8	579.50	15582483.91	1067152.52
9	584.48	15582478.29	1067521.35
10	582.50	15582465.46	1067945.80
11	584.88	15582544.29	1069022.86

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error

REVISIONS DATE	BY	DESCRIPTION

ACRES CONSULTING SERVICES LIMITED

DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH —— FOUNDATION OFFICE

PORT COLBORNE TUNNEL
GEOLOGIC SECTION - SOUTH LINE

HIGHWAY NO. 3 DIST. NO. 4
CO. WELLAND
TWP. LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. M.N.	CHECKED M.C.	W.P. NO. 448-64	DRAWING NO. 5
DRAWN	CHECKED	JOB NO. P 2955	
DATE FEBRUARY 1972		SITE NO.	BRIDGE DRAWING NO.
APPROVED ACRES CONSULTING SERVICES LIMITED		CONT. NO.	

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
		SOFT MOTTLED DARK BROWN CLAY MIXED WITH CRUSHED LIMESTONE
5		CORALLINE CHERTY LIMESTONE; DARK GREY, FINE TO MEDIUM GRAINED, CRYSTALLINE ROCK, CHERTY, ABUNDANT CORALS
10		CORALLINE LIMESTONE; BROWNISH GREY, MEDIUM GRAINED, CRYSTALLINE ROCK, SHALE PARTINGS, ABUNDANT CORALS, DISTINCTLY BEDDED
15		
20		LIMESTONE; MEDIUM BROWN, FINE GRAINED, SHALY, SILTY, DISTINCTLY BEDDED, WELL CONSOLIDATED
		ROCK FRACTURED
25		FOSSILIFEROUS CHERTY LIMESTONE; MEDIUM GREY, FINE GRAINED, CHERTY, SILTY, ABUNDANT FOSSILS, DISTINCTLY BEDDED, SHALE PARTINGS
30		SILTSTONE; BROWNISH GREY, FINE GRAINED CHERTY, GLAUCONITIC
		ROCK FRACTURED
35		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, WAVY BEDDING, MINOR SHALE PARTINGS
40		
45		SHALY DOLOMITE; MEDIUM BROWN; FINE GRAINED, FINELY LAMINATED, WELL CONSOLIDATED
50		
55		ROCK FRACTURED (FOOTAGE: 54'-6.5" TO 55'-3.5")
		BROWN POROUS DOLOMITE; MEDIUM BROWN, FINE GRAINED, POROUS, SHALE LAMINATIONS, CHEMICAL WEATHERING
60		CORALLINE LIMESTONE
65		
70		SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, DISTINCTLY BEDDED, DENSE
75		
80		
85		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, GYPSUM IN NODULAR AND FIBROUS FORM, MINOR AMOUNT OF HYDROGEN SULPHIDE, POROUS LOCALLY, DOLOMITIC IN PARTS
90		
95		NO TAKE
100		
105	END OF HOLE	

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

1. PERMEABILITY CALCULATED USING TEST RESULTS SUPPLIED FROM FIELD:

$$K = \frac{Q}{2\pi LH} \ln \frac{L}{r} \quad (L > 10r)$$

WHERE: K = PERMEABILITY
Q = CONSTANT RATE OF FLOW INTO WALL OF HOLE
L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}}$ X 100

(CALCULATED IN FIELD)

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DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

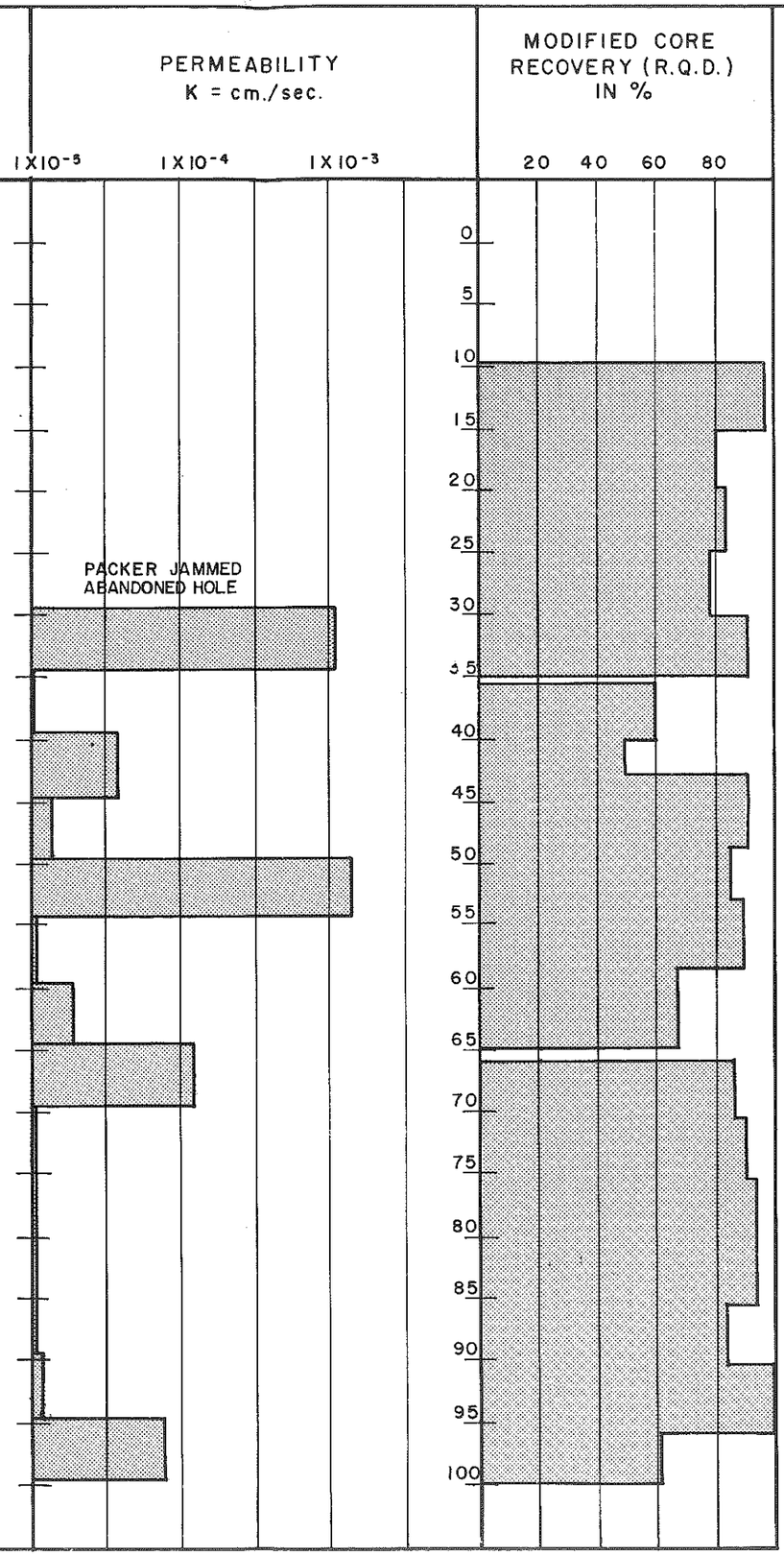
BOREHOLE LOG DRILL HOLE No. 1

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 6

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		INDUSTRIAL RESIDUE WASTE LAYERS OF BROWN, REDDISH BROWN AND LIGHT BROWN CLAY WITH CHARCOAL GREY ORGANIC SILT LAYERS.
10		VERY STIFF DARK AND LIGHT REDDISH BROWN PLASTIC CLAY WITH SILT LAYERS
15		CORALLINE LIMESTONE; MEDIUM BROWN, FINE TO MEDIUM GRAINED, DISTINCTLY BEDDED CRYSTALLINE ROCK
20		LIMESTONE; BROWN, FINE GRAINED, SHALY, SILTY *VOID; (FOOTAGE: 17'-7", OPENING: 0.5")*
25		FOSSILIFEROUS CHERTY LIMESTONE; MEDIUM GREY, FINE TO MEDIUM GRAINED, SILTY, ABUNDANT CHERT NODULES
30		SILTSTONE; MEDIUM BROWN, FINE TO MEDIUM GRAINED GLAUCONITIC, CHERTY IN PARTS
35		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, FINELY LAMINATED, SHALE PARTINGS
40		
45		ROCK FRACTURED SHALY DOLOMITE; MEDIUM BROWN, FINE GRAINED, FINELY LAMINATED
50		
55		BROWN POROUS DOLOMITE; MEDIUM BROWN, FINE TO MEDIUM GRAINED, THIN SHALE LAMINATIONS, POROUS LOCALLY
60		
65		*ROCK FRACTURED (FOOTAGE: 64'-0" TO 66'-3.5")*
70		SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, DISTINCTLY BEDDED
75		
80		
85		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, GYPSUM IN NODULAR AND FIBROUS FORM, MINOR AMOUNT OF HYDROGEN SULPHIDE, POROUS LOCALLY
90		
95		
100		
105	END OF HOLE	



LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

1. PERMEABILITY CALCULATED USING TEST RESULTS SUPPLIED FROM FIELD:

$$K = \frac{Q}{2\pi LH} \ln \frac{L}{r} \quad (L > 10r)$$

WHERE: K = PERMEABILITY
Q = CONSTANT RATE OF FLOW INTO WALL OF HOLE
L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}}$ X 100

(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

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DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG
DRILL HOLE No. 2

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 7

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		STIFF MOTTLED BROWN AND REDDISH BROWN SILTY CLAY AND CRUSHED LIMESTONE
10		STIFF BROWN AND REDDISH BROWN CLAY WITH GREY AND GREYISH BROWN SILT
15		STIFF BROWN MOTTLED SILTY CLAY WITH LIGHT GREY SILT LAYERS
20		VERY STIFF THIN LAMINATIONS OF CLAY AND SILT
25		LIMESTONE; MEDIUM BROWN, FINE GRAINED, SHALY, SILTY, FINELY LAMINATED, COHESIVE ROCK.
30		FOSSILIFEROUS LIMESTONE; MEDIUM GREY, FINE TO MEDIUM GRAINED, CHERTY, SILTY, ABUNDANT FOSSILS
35		SILTSTONE; BROWNISH GREY, FINE GRAINED, CHERTY, GLAUCONITIC
40		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, SHALE PARTINGS, EXTREMELY COHESIVE
45		SHALY DOLOMITE; MEDIUM BROWN, FINE GRAINED THIN SHALE LAMINATIONS
50		
55		BROWN POROUS DOLOMITE; MEDIUM BROWN, FINE GRAINED THIN SHALE LAMINATIONS, POROUS LOCALLY
60		
65		SHALE; DARK GREY, FINE GRAINED, DOLOMITE IN PARTS, DISTINCTLY BEDDED
70		
75		
80		
85		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, FIBROUS FORM OF GYPSUM PARTLY FILLS THE BEDDING JOINT, NODULAR GYPSUM OCCURS LOCALLY, DOLOMITIC IN PARTS
90		
95		
100		
105	END OF HOLE	

PERMEABILITY K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

← NOT TESTED (0.3')

← NO TAKE

← NOT TESTED (0.6')

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

1. PERMEABILITY CALCULATED USING TEST RESULTS SUPPLIED FROM FIELD:

$$K = \frac{Q}{2\pi LH} \ln \frac{L}{r} \quad (L > 10r)$$

WHERE: K = PERMEABILITY
Q = CONSTANT RATE OF FLOW INTO WALL OF HOLE
L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}} \times 100$

(CALCULATED IN FIELD)

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 3

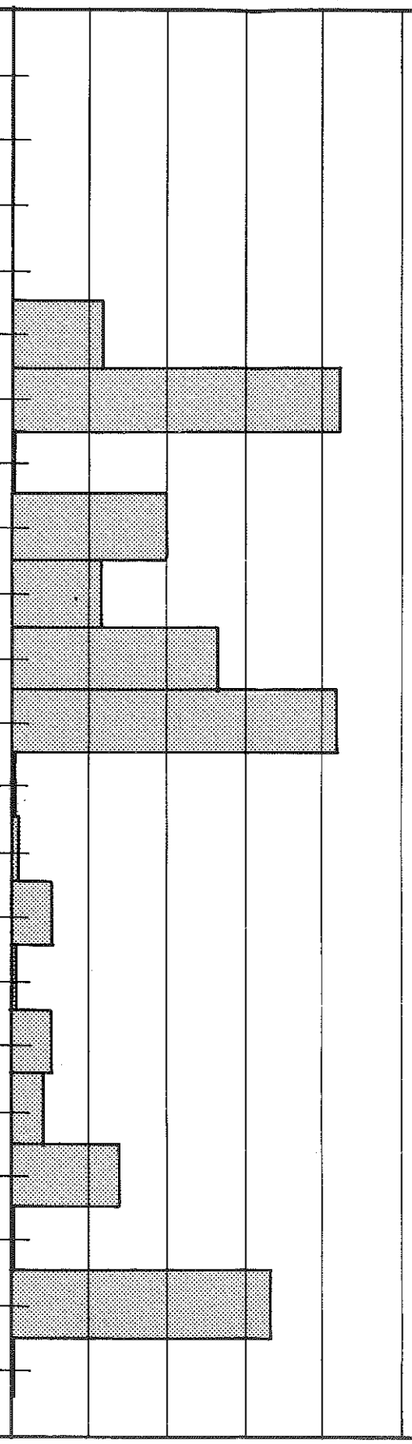
ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

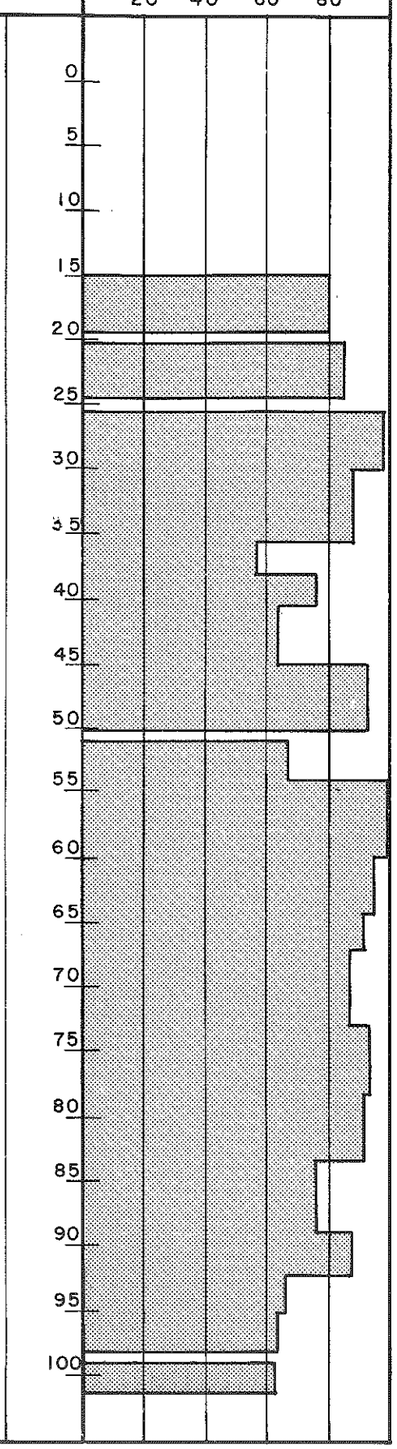
PLATE 8

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		MIXTURE OF GRAVEL, DARK GREY SILT AND BROWN CLAY
10		STIFF YELLOWISH BROWN, REDDISH BROWN AND CHARCOAL GREY CLAY WITH SILT LAYERS
15		VERY STIFF VARVED CLAY STIFF LAMINATED REDDISH BROWN CLAY
20		FOSSILIFEROUS LIMESTONE; MEDIUM GREY, FINE TO MEDIUM GRAINED, CHERTY, SILTY, ABUNDANT FOSSILS
25		*VOID (FOOTAGE 24'-7", OPENING; 2.5")*
30		SILTSTONE; MEDIUM BROWN, FINE TO MEDIUM GRAINED, CHERTY, GLAUCONITIC, FRACTURED. MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, SHALE PARTINGS, WELL CONSOLIDATED
35		
40		*VOID (FOOTAGE 38'-3", OPENING; 0.4")*
45		SHALY DOLOMITE; MEDIUM BROWN, FINE GRAINED, THIN SHALE LAMINATIONS, DISTINCT BEDDING, WELL CONSOLIDATED
50		*VOID (FOOTAGE 50'-10", OPENING; 0.75")*
55		BROWN POROUS DOLOMITE; MEDIUM BROWN, FINE GRAINED, THIN SHALE LAMINATIONS (> 0.1" THICK) POROUS, WEATHERED LOCALLY
60		
65		SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, DISTINCTLY BEDDED, WELL CONSOLIDATED.
70		
75		
80		
85		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED SHALE, NODULAR AND FIBROUS FORM OF GYPSUM, MINOR AMOUNT OF HYDROGEN SULPHIDE, WEATHERED LOCALLY.
90		
95		
100		
105	END OF HOLE	

PERMEABILITY
K = cm./sec.



MODIFIED CORE RECOVERY (R.Q.D.) IN %



LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

1. PERMEABILITY CALCULATED USING TEST RESULTS SUPPLIED FROM FIELD:

$$K = \frac{Q}{2\pi LH} \ln \frac{L}{r} \quad (L > 10r)$$

WHERE: K = PERMEABILITY
Q = CONSTANT RATE OF FLOW INTO WALL OF HOLE
L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}} \times 100$

(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 4

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 9

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		MIXTURE OF CRUSHED LIMESTONE AND SOFT WET SILTY CLAY
		MEDIUM STIFF BROWN CLAYEY SILT
10		LAYERS OF BROWN AND GREYISH BROWN CLAY
		LAMINATED BROWN AND REDDISH BROWN CLAY
15		
20		FOSSILIFEROUS LIMESTONE; MEDIUM GREY, FINE GRAINED, CHERTY, SILTY, FOSSILIFEROUS, BEDDING WAVY IN SHAPE, FEW SHALE PARTINGS, WELL CONSOLIDATED ROCK
25		ROCK FRACTURED (FOOTAGE; 22'-8.4" TO 22'-9.6")
		SILTSTONE; BROWNISH GREY, FINE TO MEDIUM GRAINED, CHERTY, GLAUCONITIC
30		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED OCCASIONAL SHALE PARTINGS, WELL CONSOLIDATED ROCK
35		
40		SHALY DOLOMITE; MEDIUM BROWN, FINE GRAINED, DISTINCTLY BEDDED, FINELY LAMINATED
45		
50		BROWN POROUS DOLOMITE; MEDIUM BROWN, FINE GRAINED, FINELY LAMINATED, POROUS LOCALLY, CHEMICAL WEATHERING
55		
60		
65		ROCK FRACTURED (FOOTAGE; 61'-11" TO 62'-3")
		SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, DISTINCTLY BEDDED, WELL CONSOLIDATED
70		
75		
80		
85		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, GYPSUM IN NODULAR AND FIBROUS FORM, DOLOMITIC IN PARTS, POROUS LOCALLY, MINOR CHEMICAL WEATHERING
90		
95		
100		
105	END OF HOLE	

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

← NO TAKE

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

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L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}} \times 100$

(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 5

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 10

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	LOOSE, DAMP, FINE TO COARSE SAND AND GRAVEL CONTAMINATED WITH INDUSTRIAL WASTE
5		SOFT BROWNISH GREY CLAYEY SILT
		SOFT BROWN SILTY CLAY AND CLAYEY, SANDY SILT
10		CORALLINE CHERTY LIMESTONE; BROWNISH GREY, FINE TO MEDIUM GRAINED CRYSTALLINE ROCK, SHALY, CHERTY, ABUNDANT CORALS, SHALE PARTINGS
15		
20		LIMESTONE; BROWNISH GREY, FINE GRAINED, SHALY, SILTY
		VOID (FOOTAGE: 22'-7", OPENING: 0.75").
25		FOSSILIFEROUS CHERTY LIMESTONE; LIGHT BROWNISH GREY, FINE GRAINED CHERTY, SILTY, ABUNDANT FOSSILS, SHALE PARTINGS
30		
35		*VOID (FOOTAGE: 34'-3", OPENING: ~ 3")*
		SILTSTONE; MEDIUM BROWN FINE GRAINED, SHALY, CHERTY, GLAUCONITIC, DISTINCT BEDDING, FRACTURED
40		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, NUMEROUS SHALE PARTINGS
45		*VOID (FOOTAGE: 43'-7", OPENING: 0.5")*
50		*VOID (FOOTAGE: 48'-1", OPENING: 0.75")*
		SHALY DOLOMITE; MEDIUM GREY, FINE GRAINED, DISTINCTLY BEDDED, SHALE LAMINATIONS, ROCK FRACTURED LOCALLY
55		
60		*VOID (FOOTAGE: 56'-8", OPENING: 0.75")*
65		BROWN POROUS DOLOMITE; LIGHT BROWN, FINE TO MEDIUM GRAINED, POROUS, SHALE PARTINGS, CHEMICAL WEATHERING
70		
		IRREGULAR FRACTURE (FOOTAGE: 69'-5", OPENING: ~1" MAX.)
75		*HORIZONTAL OPENING (FOOTAGE: 72'-7", OPENING: 0.5"-0.75")*
		SHALE; DARK GREY, FINE GRAINED, DISTINCTLY BEDDED, SHALE PARTINGS
80		
		OPEN FRACTURE (FOOTAGE: 79'-3", OPENING: 0.25"-0.50")
85		
90		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, DISTINCTLY BEDDED, SHALE PARTINGS, DOLOMITIC IN PARTS, GYPSUM IN NODULAR AND FIBROUS FORM
95		
100		
105	END OF HOLE	

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

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L = LENGTH OF HOLE PRESSURIZED = 5.3 FEET
r = RADIUS OF DRILL HOLE = 1.5 INCHES
H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF +4 INCH CORE}}{\text{LENGTH OF CORE RUN}} \times 100$
(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

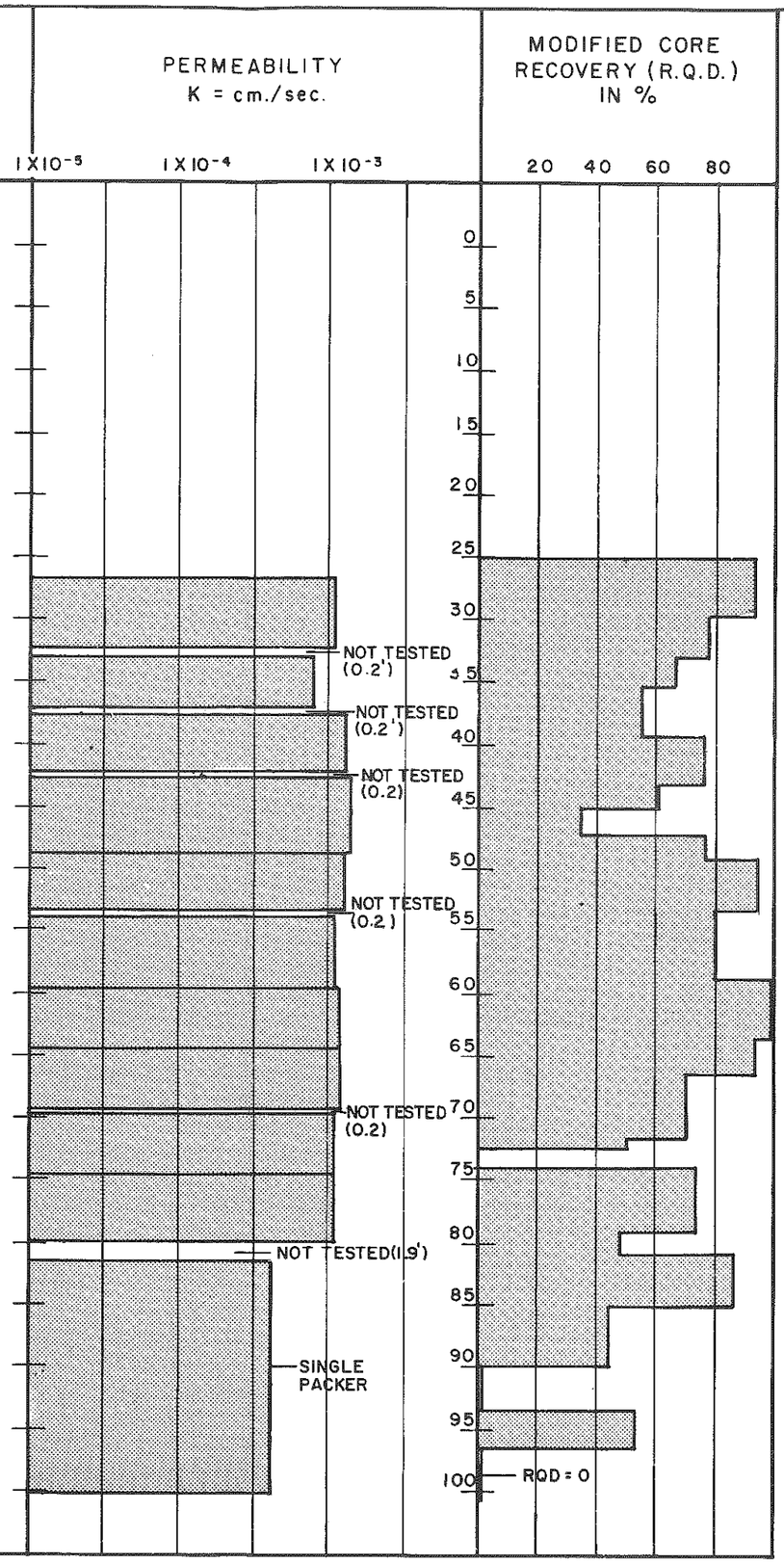
BOREHOLE LOG DRILL HOLE No. 6

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 11

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
		LOOSE, BROWNISH GREY GRAVELLY, SANDY SILT
5		SOFT TO STIFF LAYERS OF BROWN, REDDISH BROWN AND GREYISH BROWN CLAY
10		MIXTURE OF PEAT AND SOFT LAYERED CLAY
15		BROWN AND GREYISH BROWN SOFT REMOULDED CLAY WITH PIECES OF DECOMPOSED WOOD
20		SOFT, BROWN CLAY WITH VERTICAL FISSURES
25		SOFT, LAMINATIONS OF BROWN, REDDISH BROWN AND GREYISH BROWN CLAY MIXED WITH SILTY SAND
		VOID (FOOTAGE: 26'-6", OPENING: ~ 1")
30		FOSSILIFEROUS CHERTY LIMESTONE; MEDIUM GREY, FINE GRAINED, SHALY, CHERTY, COHESIVE ROCK
35		*VOID (FOOTAGE: 35'-3", OPENING: 0.5")*
		SILTSTONE; MEDIUM BROWN, FINE GRAINED, SHALY, CHERTY, MINOR AMOUNT OF GLAUCONITIC SAND, IRREGULAR FRACTURES
40		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, MOTTLED DOLOMITE, SHALE PARTINGS
45		*VOID (FOOTAGE: 43'-4", OPENING: ~ 0.5")*
		VOID (FOOTAGE: 46'-7", OPENING: ~ 1")
50		SHALY DOLOMITE; MEDIUM GREY, FINE GRAINED, DISTINCTLY BEDDED, SHALE LAMINATIONS, SHALE PARTINGS, WELL CONSOLIDATED ROCK
55		
60		BROWN POROUS DOLOMITE; LIGHT BROWN, FINE TO MEDIUM GRAINED, POROUS SHALE PARTINGS, CHEMICAL WEATHERING
65		
70		
75		SHALE; DARK GREY, FINE GRAINED, DISTINCTLY BEDDED, DOLOMITIC IN PARTS, FRACTURED LOCALLY
80		
85		
90		
95		ROCK FRACTURED
		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, FRACTURED LOCALLY
100		ROCK FRACTURED
105	END OF HOLE	



LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

1. PERMEABILITY CALCULATED USING TEST RESULTS SUPPLIED FROM FIELD:

$$K = \frac{Q}{2\pi LH} \ln \frac{L}{r} \quad (L > 10r)$$

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H = DIFFERENTIAL HEAD OF WATER AT ELEVATION OF TEST

2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}}$ X 100

(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

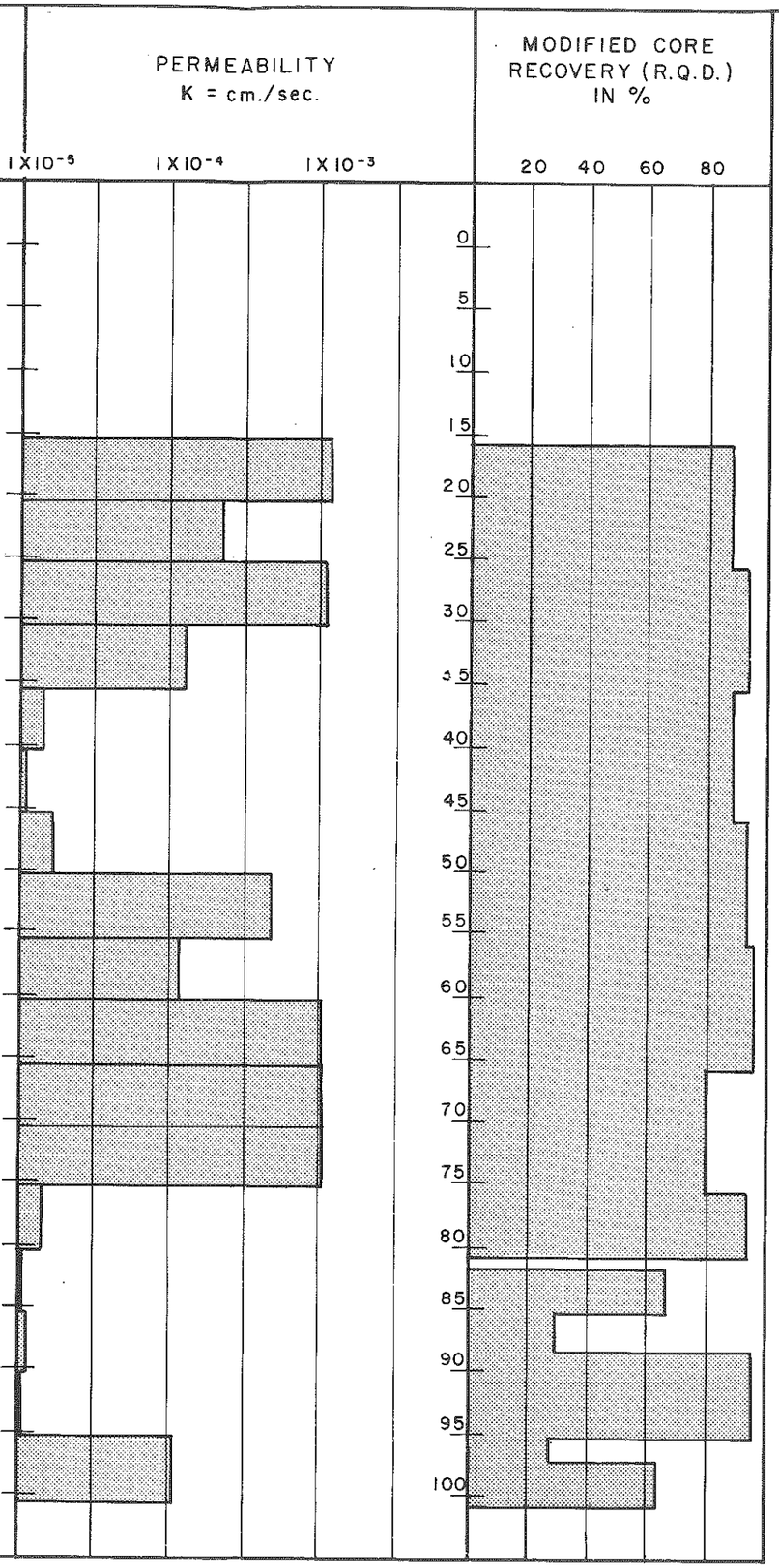
BOREHOLE LOG DRILL HOLE No. 7

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 12

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		DARK GREY ORGANIC CLAYEY SANDY SILT
		HARD BROWN SILTY CLAY WITH FINE GRAVEL
10		HARD, DARK BROWN TO BLACK PEAT
		STIFF BROWN SILTY CLAY
15		HARD BROWN SILTY CLAY
20		LIMESTONE; DARK GREY, FINE GRAINED, FINELY LAMINATED, WELL CONSOLIDATED
25		FOSSILIFEROUS CHERTY LIMESTONE; DARK GREY, FINE GRAINED, CHERTY, WAVY SHAPED BEDDING, COHESIVE ROCK
30		ROCK FRACTURED
		SHALY CHERTY SANDSTONE; BROWNISH GREY, FINE TO MEDIUM GRAINED, CHERTY, SHALY SANDSTONE, MINOR AMOUNT OF GLAUCONITIC SAND
35		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, SHALE PARTINGS, WELL CONSOLIDATED ROCK
40		
45		SHALY DOLOMITE; BROWNISH GREY, FINE GRAINED, DISTINCTLY BEDDED, FINELY LAMINATED, DENSE
50		
55		BROWN POROUS DOLOMITE; LIGHT BROWN, FINE GRAINED, SHALE PARTINGS, POROUS LOCALLY, CHEMICAL WEATHERING ALONG THE BEDDING PLANE
60		
65		
70		ROCK FRACTURED
		SHALE; DARK GREY, FINE GRAINED, DISTINCTLY BEDDED, DOLOMITIC IN PARTS, CONTAINS MINOR AMOUNTS OF HYDROGEN SULPHIDE, WELL CONSOLIDATED
75		
80		
85		ROCK FRACTURED
		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, GYPSUM IN NODULAR AND FIBROUS FORM, POROUS LOCALLY, CHEMICAL WEATHERING, DOLOMITIC IN PARTS
90		
95		
100		ROCK FRACTURED (FOOTAGE; 96'-3.5" TO 98'-6")
105	END OF HOLE	



LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

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(CALCULATED IN FIELD)

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ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 8

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 13

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		GREY SILT, FINE SAND AND FINE GRAVEL
		BROWN SILT, FINE SAND AND FINE GRAVEL
10		SOFT TO FIRM BROWN SILTY CLAY
		VOID (FOOTAGE: 11'-11", OPENING: ~0.5")
15		CORALLINE CHERTY LIMESTONE; MEDIUM BROWNISH GREY, FINE TO MEDIUM GRAINED, CRYSTALLINE ROCK, THICK BEDDED, CORALLINE, SHALY IN PARTS, CHERTY
20		
		LIMESTONE; BROWNISH GREY, FINE GRAINED, SHALY, SILTY, MEDIUM DARK GREY WEATHERING
25		
		FOSSILIFEROUS CHERTY LIMESTONE; MEDIUM LIGHT GREY, FINE GRAINED, CHERTY, SILTY, FOSSILIFEROUS, VERY COHESIVE ROCK
30		
35		
		SILTSTONE; MEDIUM GREY, FINE GRAINED, CHERTY, SHALY GLAUCONITIC GREEN SAND, IRREGULAR BEDDING
40		*OPEN FRACTURE (FOOTAGE: 37'-1", OPENING: ~0.75") MAXIMUM*
45		MOTTLED DOLOMITE; LIGHT BROWN, FINE GRAINED, BUFF TO BROWN WEATHERING, NUMEROUS SHALE PARTINGS
		VOID (FOOTAGE: 46'-7", OPENING: ~0.1")
50		
		SHALY DOLOMITE; MEDIUM LIGHT BROWN, FINE GRAINED, THIN SHALE LAMINATIONS, DISTINCTLY BEDDED
55		
60		BROWN POROUS DOLOMITE; LIGHT BROWN, FINE GRAINED, POROUS (PORES ~ 0.3" DIAMETER MAXIMUM) THIN SHALE LAMINATIONS, CHEMICAL WEATHERING
65		
70		
75		SHALE; DARK GREY, FINE GRAINED, DISTINCTLY BEDDED, DOLOMITIC IN PARTS, WELL CONSOLIDATED ROCK
80		
85		
90		
95		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, POROUS LOCALLY, GYPSUM IN NODULAR AND FIBROUS FORM, DOLOMITIC INPARTS
100		
105	END OF HOLE	

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

←NO TAKE

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
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(CALCULATED IN FIELD)

3. SLOPED LETTERING INDICATES BOREHOLE T.V. CAMERA STUDY

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 9

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 14

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	
5		GREY FINE SAND TO MEDIUM GRAVEL
		DARK BROWN TO BLACK PEAT WITH SOME MEDIUM GREY CLAYEY SILT
10		STIFF VARVES OF MEDIUM GREY SILTY CLAY WITH OCCASIONAL SILT LENSES
15		LIGHT BROWN, FINE SILTY SAND AND GRAVEL
20		CORALLINE CHERTY LIMESTONE; MEDIUM BROWNISH GREY, FINE TO MEDIUM GRAINED, CRYSTALLINE ROCK, THICK BEDDED, CORALLINE, CHERTY, SHALE PARTINGS
		LIMESTONE; BROWNISH GREY, FINE GRAINED, SHALY SILTY, FRACTURED LOCALLY.
25		FOSSILIFEROUS CHERTY LIMESTONE; MEDIUM LIGHT GREY, FINE GRAINED, THIN SHALE PARTINGS (< 0.2" THICK) FOSSILIFEROUS
30		
35		SILTSTONE; MEDIUM GREY, FINE GRAINED, GREEN CHERT, GLAUCONITIC
40		MOTTLED DOLOMITE; LIGHT BROWN, FINE GRAINED, BROWN WEATHERING, SHALE PARTINGS (< 0.2" THICK)
45		*VOID (FOOTAGE: 44'-7", OPENING: 0.5")*
50		SHALY DOLOMITE; MEDIUM LIGHT BROWN, FINE GRAINED, FINELY LAMINATED, WELL CONSOLIDATED
55		*VOID (FOOTAGE: 54'-4", OPENING: 1")*
60		BROWN POROUS DOLOMITE; LIGHT BROWN, FINE GRAINED, POROUS, MINOR CHEMICAL WEATHERING GYPSUM CRYSTALS FILL THE CAVITIES LOCALLY
65		
70		*VOID (FOOTAGE: 70'-1", OPENING: 0.25" MAXIMUM)*
75		SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, DISTINCTLY BEDDED, DENSE
80		
85		
90		GYPSUM RICH SHALE; DARK GREY, FINE GRAINED, DOLOMITIC IN PARTS, GYPSUM IN NODULAR AND FIBROUS FORM
95		
100		
	END OF HOLE	
105		

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
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(CALCULATED IN FIELD)

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ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG DRILL HOLE No. 10

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 15

DEPTH FROM SURFACE IN FEET	SOIL OR ROCK TYPE	REMARKS
0	TOP OF HOLE	SOFT BROWN CLAYEY SILT WITH INDUSTRIAL WASTE
		BROWN SILTY CLAY WITH FRAGMENTS OF SHALE
5		CORALLINE CHERTY LIMESTONE; BROWN, FINE GRAINED, CRYSTALLINE ROCK, SHALY, CHERTY, CORALLINE, SHALE PARTINGS
10		
15		
20		
		SILT SEAM (FOOTAGE: 21'-1.2" TO 21'-3.6")
25		LIMESTONE; BROWNISH GREY, FINE GRAINED, SHALY, SILTY, SHALE PARTINGS
		FOSSILIFEROUS CHERTY LIMESTONE; LIGHT GREY, FINE GRAINED, CHERTY, SILTY, ABUNDANT FOSSILS, SHALE PARTINGS
30		
		ROCK FRACTURED (FOOTAGE: 33'-1.8" TO 33'-3.6")
35		SILTSTONE; MEDIUM BROWN, FINE GRAINED, SHALY, CHERTY, GREEN GLAUCONITIC SAND, FRACTURED & JOINTED ROCK
		MOTTLED DOLOMITE; BROWNISH GREY, FINE GRAINED, SHALE PARTINGS (<0.2"), VERY COHESIVE ROCK
40		
	END OF HOLE	
45		
50		
55		
60		
65		
70		
75		
80		
85		
90		
95		
100		
105		

PERMEABILITY
K = cm./sec.

1X10⁻⁵ 1X10⁻⁴ 1X10⁻³

MODIFIED CORE RECOVERY (R.Q.D.) IN %

20 40 60 80

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

LEGEND

- LIMESTONE
- DOLOMITE
- SILTSTONE, SANDSTONE
- SHALE
- CHERT
- CONGLOMERATE
- GYPSUM
- CORALS
- FOSSILIFEROUS
- UNCONFORMITY

NOTES

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2. R.Q.D. = $\frac{\text{LENGTH OF + 4 INCH CORE}}{\text{LENGTH OF CORE RUN}}$ X 100
(CALCULATED IN FIELD)

ACRES

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

PORT COLBORNE TUNNEL

BOREHOLE LOG
DRILL HOLE No. 11

ACRES CONSULTING SERVICES LIMITED

FEBRUARY 1972

PLATE 16

APPENDIX 1

DETAILED DRILLING REPORTS

BH-1 to BH-11

SOIL LOGS; ROCK LOGS; FRACTURE LOGS

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-1

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. November 24 , 19 71

FINISHED .M. November 29 , 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used

ROCK CORE DIAM.

LOCATION: LATITUDE 15583693.03N ELEVATIONS: DATUM CGD

DEPARTURE 1066440.48E DRILL PLATFORM -

BEARING - GROUND SURFACE 582.86 ft

INITIAL DIP 90° ROCK SURFACE 578.96 ft

OTHER DIPS - BOTTOM OF HOLE 481.86 ft

WATER TABLE 572.06 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 3.9	Mottled Clay	Soft mottled dark brown clay mixed with crushed limestone	1	AQ		0.5 1.0 1.5 2.0		
3.9			2	AQ		2.5 3.0 3.5 3.9		
3.9		Bedrock						

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED R P Benson

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-1

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. November 24, 19 71

FINISHED .M. November 29, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM.

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15583693.03N ELEVATIONS: DATUM CGD

DEPARTURE 1066440.48E DRILL PLATFORM

BEARING GROUND SURFACE 582.86 ft

INITIAL DIP 90° ROCK SURFACE 578.96 ft

OTHER DIPS - BOTTOM OF HOLE 481.86 ft

WATER TABLE 572.06 ft

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.0 to 3.9		Overburden	
3.90 to 6.10	Coralline Cherty Limestone	Dark grey, fine to medium grained, crystalline rock, brownish grey chert nodules, abundant corals.	
6.10 to 16.20	Coralline Limestone	Brownish grey, medium grained, crystalline rock, distinctly bedded locally, shaly occasionally, abundant corals, minor shale partings.	
16.20 to 19.80	Limestone	Medium brown, fine grained, distinctly bedded, shaly, silty, well consolidated, cohesive.	
19.80 to 30.65	Fossiliferous Cherty Limestone	Medium grey, fine grained, distinctly bedded, cherty, silty, abundant fossils, shale partings locally.	
30.65 to 32.40	Siltstone	Brownish grey, fine grained, green glauconitic sand, brown chert, badly fractured rock.	

INSPECTOR A.H. Tilk

LOGGED BY M. Walia

APPROVED

DATE January, 1972

FORM NO. 91-C

H. G. ACRES LIMITED - CONSULTING ENGINEERS

NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 2, Tunnel/Bridge HOLE No. BH-1

SITE Port Colborne SHEET No. 2 OF 2

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
32.40 to 44.50	Mottled Dolomite	Brownish grey, fine grained, dolomite mottled, bedding wavy in shape, shale partings with minor openings.	
44.50 to 55.30	Shaly Dolomite	Medium brown, fine grained, finely laminated, distinctly bedded.	
55.30 to 68.95	Brown Porous Dolomite	Medium brown, fine grained, finely laminated, well consolidated rock, porous (pores 5 mm maximum in diameter). Coralline limestone embedded from 58.90 to 59.60. feet	
68.95 to 83.40	Shale	Dark grey, fine grained, dolomitic in parts, dense, distinctly bedded, occasional presence of evaporite along the bedding plane (77.4', gypsum (< .5 mm thick)).	
83.40 to 101.0	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, 20 per cent gypsum in the rock in nodular and fibrous form along the bedding plane, minor amount of muscovite, porous locally, chemically weathered, minor amount of hydrogen sulphide present in the rock.	
101.0		End of borehole	

FORM NO. 91-6

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-1

SITE Port Colborne SHEET NO. 1 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION												MUTUAL ANGLE
			SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Wavy	Opening mm	
3.60	Open joint	40°		x	x					C	Gy			2	
4.55	Open joint	65°		x	x					C	Gy			.5	
5.10	Joint, partly filled with clay	45°		x	x					C	Gy			.5	
5.25	Open joint	40°		x	x					C	Gy			1	
5.60	Joint	65°												-	
5.75	Joint	70°												-	
5.75 to 6.70	Rock fractured								x	CHBr					
7.10 to 7.25	Rock fractured								x						
8.15	Joint	60°			x	x									
8.40 to 8.60	Rock fractured								x						
9.55	B joint	90°			x									.5	
11.25	B joint	90°		x		x								.5	

C = CARBONATE H = HEMATITE K = CHLORITE ++Br = BROWN +Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-1

SITE Port Colborne SHEET NO. 2 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Waxy	Opening mm	MUTUAL ANGLE
18.45 to 18.76	Rock fractured	Var					x								
25.0	Joint	75°		x		x				C	Gy			1	
27.4	Joint	70°		x		x				C	Br			1	
29.6	Joint, exhibits minor chemical weathering along the joint face				x	x				C	Br			1	
31.65 to 32.20	Rock fractured														
40.40 to 40.70	Rock fractured														
49.50	B joint	Vert.		x		x									
55.30 to 57.20	Rock fractured, the fracture occurs sub-parallel to the core axis and is partly filled with calcareous material														
58.90 to 59.60	Rock fractured	Var.					x								
62.80	Rock fractured												x		

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-1

SITE Port Colborne SHEET NO. 3 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Wavy	Opening mm	MUTUAL ANGLE
69.70 to 70.25	Rock fractured--mostly along bedding												x		
83.85	B joint--partly filled with gypsum	90°		x		x				G	W			.5	
84.3	Joint	90°		x		x				G	W			.5	
84.5															
87.25 to 87.40	Rock fractured	Var													
92.5	Joint	70°		x		x				G	W			.5	
93.65	Joint	90°			x	x				G	W			1	
99.65	B joint--partly filled with gypsum	85°		x		x				G	W			.5	
100.33 to 100.48	Rock fractured	Var						x							
101.00	End of hole														

G = Gypsum W = White
B Joint = Bedding Joint
B Shale Parting = Shale parting along Bedding
Var = Variable
CH = Chert

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-2

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. November 23, 1971

FINISHED .M. December 9, 1971

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used

ROCK CORE DIAM.

LOCATION: LATITUDE 15583835.73N DEPARTURE 1066786.70E BEARING – INITIAL DIP 90° OTHER DIPS –

ELEVATIONS: DATUM CGD DRILL PLATFORM – GROUND SURFACE 582.66 ft ROCK SURFACE 579.86 ft BOTTOM OF HOLE 482.66 ft WATER TABLE 571.96 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 1.5	Contaminated brown clay	Charcoal grey industrial residue waste with some brown clay and limestone fragments	1	AQ		0.5 1.0 1.5		
1.5 to 4.0	Clay with organic silt layers	Layers of brown, reddish-brown and light brown clay with charcoal grey organic silt layers	2	AQ		2.5 3.0 4.0		
4.0 to 7.5	Clay with silt layers	Very stiff layers of dark and light reddish-brown plastic clay and some silt layers	3	AQ		5.0 6.5		
7.5 to 9.8	Clay with silt layers	Very stiff layers of plastic reddish-brown clay with layers of silt	4	AQ		7.5 8.0 8.5 9.0		
9.8		Bedrock						

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-2

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. November 23, 19 71

FINISHED .M. December 9, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. -

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15583835.73N DEPARTURE 1066786.70E BEARING - INITIAL DIP 90° OTHER DIPS -

ELEVATIONS: DATUM CGD DRILL PLATFORM - GROUND SURFACE 582.66 ft ROCK SURFACE 579.86 ft BOTTOM OF HOLE 482.66 ft WATER TABLE 571.96 ft

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 9.80		Overburden	
9.80 to 15.60	Coralline Limestone	Medium brown, fine to medium grained, crystalline rock, distinctly bedded, shaly locally, abundant corals, well consolidated.	
15.60 to 17.60	Limestone	Brown, fine grained, shaly, silty, distinctly bedded, sharp contacts with overlying and underlying beds.	
17.60 to 27.90	Fossiliferous Cherty Limestone	Medium grey, fine grained, cherty, silty, abundant fossils, well consolidated.	
27.90 to 28.80	Siltstone	Medium brown, fine to medium grained, cherty, glauconitic, fractured locally.	
28.80 to 43.50	Mottled Dolomite	Brownish grey, fine grained, cherty, bedding wavy in shape, minor shale partings, cohesive.	

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED A Berger

DATE January, 1972

FORM NO. 91-C

H. G. ACRES LIMITED - CONSULTING ENGINEERS

NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-2

SITE Port Colborne SHEET No. 2 OF 2

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
43.50 to 53.10	Shaly Dolomite	Medium brown, fine grained, finely laminated, shaly in parts, minor shale partings.	
53.10 to 68.10	Brown Porous Dolomite	Medium brown, fine to medium grained, occasional shale laminations, porous, chemically weathered rock.	
68.10 to 81.00	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, well consolidated, dense.	
81.00 to 100.00	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts; gypsum occurs in nodular and fibrous form, slightly porous locally, minor amount of hydrogen sulphide, well consolidated rock.	
100.00		End of borehole.	

FORM NO. 91-0

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-2

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
10.1	B shale parting	70°		x		x				Gy			.5		
16.0 to 16.3	Rock fractured						x								
16.85 to 17.10	Fracture	5°			x		x	x		C	Gy			.5	
17.25	Open fracture *	Var						x						5	
17.60	Fracture *	Var						x						10	
19.40	Fracture *	Var						x						8	
23.05	B shale parting	25°		x		x				C	Gy			.5	
28.40 to 28.50	Fracture							x							
41.1 to 41.4	Fractured rock							x							
43.4	B shale parting												x		
52.2	B shale parting												x		

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-2

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
64.0 to 66.3	Fractured rock						x								
84.55	B shale parting - partly filled with gypsum	80°		x		x				G	W		.5		
100.0	End of borehole														

G = Gypsum W = White
B Joint = Bedding Joint
B Shale Parting = Shale parting along Bedding
* = T.V. Camera Study
Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-3

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. December 7, 19 71

FINISHED .M. December 15, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM.

ROCK CORE DIAM.

LOCATION: LATITUDE 15584017.54N DEPARTURE 1067300.56E BEARING – INITIAL DIP 90° OTHER DIPS –

ELEVATIONS: DATUM CGD DRILL PLATFORM – GROUND SURFACE 580.64 ft ROCK SURFACE 566.94 ft BOTTOM OF HOLE 479.14 ft WATER TABLE 571.94 ft

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.5	Mottled silty clay	Stiff mottled brown and reddish-brown silty clay mixed with crushed limestone	1	AQ		0.5 1.0 1.5		
2.5 to 5.0	Clay with silt	Stiff brown and reddish-brown clay with grey and greyish-brown silt and charcoal industrial waste	2	AQ		2.5		
5.0 to 10.0	Mottled silty clay	Stiff brown mottled silty clay and dark brown, light brown and reddish-brown clay, with light grey silt layers	3 4	AQ BO		5.0 7.5		
10.0 to 13.7	Laminated clay and silt	Very stiff thin laminations of brown clay and silt	5 6	AQ AQ		10.0 12.5		
13.7		Bedrock						

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR B. Clarke

LOGGED BY M. Walia

APPROVED A Berger

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-3

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 7, 19 71

FINISHED .M. December 15, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. -

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15584017.54N DEPARTURE 1067300.56E BEARING - INITIAL DIP 90° OTHER DIPS -

ELEVATIONS: DATUM CGD DRILL PLATFORM - GROUND SURFACE 580.64 ft ROCK SURFACE 566.94 ft BOTTOM OF HOLE 479.14 ft WATER TABLE 571.94 ft

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.0 to 13.7		Overburden	
13.7 to 14.0	Limestone	Medium brown, fine grained, shaly, silty, well laminated, cohesive rock.	
14.0 to 25.3	Fossiliferous Cherty Limestone	Medium grey, fine grained, cherty, silty, abundant fossils, fractured locally.	
25.3 to 26.5	Siltstone	Brownish grey, fine grained, green glauconitic sand, cherty, partings along the bedding plane.	
26.5 to 40.5	Mottled Dolomite	Brownish grey, fine grained, wavy indistinct bedding, shale partings, silt seams from 31.50 feet to 31.65 feet, cohesive rock.	
40.5 to 51.8	Shaly Dolomite	Medium brown, fine grained, thin shale laminations, distinctly bedded, fractured locally.	

INSPECTOR B. Clarke

LOGGED BY M. Walia

APPROVED A F Berger

DATE January, 1972

FORM NO. 91 C

H. G. ACRES LIMITED - CONSULTING ENGINEERS

NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-3

SITE Port Colborne SHEET No. 2 OF 2

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
51.8 to 65.1	Brown Porous Dolomite	Medium brown, fine grained, thin wavy shale laminations, porous, chemically weathered.	
65.10 to 82.10	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, fractured locally, weak along the bedding plane.	
82.10 to 101.50	Gypsum Rich Shale	Dark grey, fine-grained, dolomitic in parts, gypsum in nodular and fibrous form, fractured locally, chemically weathered occasionally.	
101.50		End of borehole.	

FORM NO. 91-6

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-3

SITE Port Colborne SHEET NO. 1 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION													MUTUAL ANGLE
			SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm		
23.0 to 24.9	Rock fractured						x									
29.1	B joint	80°		x		x										
31.1	B joint	80°		x		x										
38.0	B joint	80°		x		x										
38.7	B joint	80°		x		x										
40.4	B joint	80°		x		x										
42.65 to 42.73	Fracture along the bedding	Var											x	.2		
46.55 to 47.20	Series of fractures parallel to bedding plane	87°		x		x				D	Gy					
50.45	B joint *	85°		x		x				D	Gy			2		
51.80	B joint	80°		x		x				D	Gy			.1		
53.00 to 53.80	Fracture	15°			x		x	x								

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT (CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-3

SITE Port Colborne SHEET NO. 2 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION												MUTUAL ANGLE
			SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	
53.80	Joint--partly weathered along the joint face	50°		x		x				D	Gy			1	
57.55	Open joint	30°		x		x				D	Gy			1	
57.75	B joint	80°		x		x				D	Gy			1	
60.50	Fracture	Var			x		x	x		D	Br			.5	
61.90	Fracture, sub-parallel to the bedding plane				x									3	
62.00	Fractures*	90°					x							5	
63.15	Joint	25°			x	x								-	
65.15 to 65.60	Fractures, mostly along the bedding plane *												x	5	
66.25	Open joint	30°		x		x				D	Br			.5	
66.25 to 66.50	Fracture	Var			x		x	x							
73.25	Open fracture *	90°												3	
83.90	Bedding joint partly filled with gypsum	90°		x		x				G	W			.2	

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-3

SITE Port Colborne SHEET NO. 3 OF 3

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
87.00 to 87.40	Fracture	Var						x							
91.15 to 91.25	Fracture	Var						x							
91.85	Joint, partly filled with gypsum	65°		x		x				G	W			5	
92.10	Joint, partly filled with gypsum	63°		x		x				G	W			5	
94.15	Joint	10°	x			x				C	Gy			5	
94.30 to 94.70	Fractured rock due to jointing														
97.4 to 97.6	Fracture	Var						x		G	W				
99.2	Open joint	40°			x	x				G	W			1	
100.15	B joint	90°		x		x								1	
101.5	End of borehole														

Var = Variable
D = Dolomite W = White
G = Gypsum * = TV Camera Study
S = Shale

B Joint=Bedding Joint, B Shale Parting=Shale parting along bedding
C = CARBONATE H = HEMATITE K = CHLORITE ++Br = BROWN +Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-4

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M.December 1, 19 71
FINISHED .M.December 6, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15584175.54N
DEPARTURE 1067689.55E
BEARING –
INITIAL DIP 90°
OTHER DIPS –

ELEVATIONS: DATUM CGD
DRILL PLATFORM –
GROUND SURFACE 580.93 ft
ROCK SURFACE 566.13 ft
BOTTOM OF HOLE 477.33 ft
WATER TABLE 572.03 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.5	Gravel Silt and clay	A mixture of quarried gravel, organic dark grey silt and medium brown clay with tiny roots	1	AQ		0.5 1.0 1.5		
2.5 to 9.9	Layers of clay and silt	Stiff layers of yellowish-brown, reddish-brown and charcoal grey clay with silt layers	2	AQ		2.5 3.0 7.0		
9.9 to 11.4	varved clay	Very stiff varved clay	5	AQ		9.9 10.5 11.0 11.4		
11.4 to 14.8	Laminated clay	Stiff laminated reddish-brown clay	6	AQ		12.5 13.0 13.5 14.0		
14.8		Bedrock						

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR A. H. Tilk
LOGGED BY M. Walia
APPROVED
DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT: Highway No. 3, Tunnel/Bridge HOLE No. BH-4

SITE: Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 1, 19 71

FINISHED .M. December 6, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. -

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15584175.54N ELEVATIONS: DATUM CGD

DEPARTURE 1067689.55E DRILL PLATFORM -

BEARING - GROUND SURFACE 580.93 ft

INITIAL DIP 90° ROCK SURFACE 566.13 ft

OTHER DIPS - BOTTOM OF HOLE 477.33 ft

WATER TABLE 572.03 ft

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.0 to 14.80		Overburden	
14.80 to 24.45	Fossiliferous cherty limestone	Medium grey, fine grained, chery, silty, abundant fossils, rock fractured locally.	
24.45 to 26.15	Cherty siltstone	Medium brown, fine to medium grained, glauconitic, cherty, fractured rock.	
26.15 to 41.15	Mottled dolomite	Brownish grey, fine grained, wavy indistinct bedding, shale partings, well consolidated and extremely cohesive rock	
41.15 to 53.40	Shaly dolomite	Medium brown, fine grained, finely laminated, distinctly bedded.	
53.40 to 65.00	Brown porous dolomite	Medium brown, fine grained, finely laminated, porous, chemically weathered.	

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED A. Berger

DATE January, 1972

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955.00

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-4

SITE Port Colborne SHEET No. 2 OF 2

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
65.00 to 83.40	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, dense.		
83.40 to 103.60	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum in nodular and fibrous form, porous locally, chemically weathered occasionally.		
103.60		End of borehole.		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Port Colborne, Highway 3 Tunnel/Bridge HOLE NO BH-4

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Wavy	Opening mm	MUTUAL ANGLE
15.6 to 15.85	Fracture exhibits chemical weathering*						x	x		C	Gy			5	
16.2 to 16.7	Fracture exhibits chemical weathering along the fracture face						x	x		C	Gy			1	
20.1 to 20.4	Fracture, partly filled with calcareous material	5						x		C	Gy			1	
24.4 to 24.6	Fractured rock*							x						60	
24.9 to 25.2	Fractured rock*							x						5	
30.9	Fracture*	90						x						3	
31.05	B shale parting												x		
31.50	B shale parting												x		
38.0	Fracture*							x						5	
38.1 to 38.4	Fractured rock sub-parallel to the bedding plane*	90		x				x						10	
39.0	Fracture*	90						x						4	
50.90 to 51.20	Fractured rock sub-parallel to the bedding plane*	90			x	x								18	

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communication (Ontario) JOB NO P-2955

PROJECT Port Colborne Highway 3, Tunnel/Bridge HOLE NO BH-4

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Wavy	Opening mm	MUTUAL ANGLE
54.60	Open Joint	70		x		x				C	Br			3	
59.3	Fracture*	90												2.5	
63.0	Fracture*	Vert												1	
63.5	Fracture*	Vert			x			x						1	
78.40	Fracture														
83.40	B Joint	Vert		x		x				G	W			1	
84.0	B Joint partly filled with gypsum	Vert		x		x				G	W			.5	
97.0 to 97.2	Fractured Rock*						x							1	
97.65 to 97.80	Fractured Rock*						x								
103.60	End of borehole														

S = Shale W = White
G = Gypsum * = TV Camera Study
D = Dolomite
B Joint = Bedding Joint
B Shale parting = Shale parting along bedding

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-5

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 1, 19 71

FINISHED .M. December 7, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. none used

ROCK CORE DIAM.

LOCATION: LATITUDE 15584465.77N ELEVATIONS: DATUM CGD

DEPARTURE 1068285.71E DRILL PLATFORM -

BEARING - GROUND SURFACE 579.67 ft

INITIAL DIP 90° ROCK SURFACE 564.17 ft

OTHER DIPS - BOTTOM OF HOLE 477.67 ft

WATER TABLE 571.67 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 5.0	Silty clay	Mixture of crushed quarried limestone and soft wet silty clay	1	AQ		0.5 1.0 1.5 2.0		
			2	AQ		2.5 3.0 3.5 4.0 4.5		
5.0 to 8.0	Clayey silt	Medium stiff brown clayey silt	3	AQ		5.0 5.5 6.0 6.5 7.0		
8.0 to 10.0	Layered clay	Layers of brown, reddish-brown and greyish-brown clay	4	AQ		8.0 8.5 9.0 10.0		

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR V. Katic

LOGGED BY M. Walia

APPROVED A P Bengson

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-5

SITE Port Colborne SHEET No. 2 OF 2

DEPTH, feet	SOIL TYPE	DESCRIPTION; COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RET'D	
10.0 to 15.5	Laminated clay	Stiff, laminated brown and reddish-brown clay	5	AQ		10.0 11.0 12.0		
			6	AQ		14.5 15.3		
15.5		Bedrock						

FORM NO 91-B

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Department of Transportation and Communications (Ontario) — JOB No. P2955

PROJECT: Highway No. 3, Tunnel/Bridge — HOLE No. BH-5

SITE: Port Colborne — SHEET No. 1 OF 2

CONTRACTOR: Longyear — STARTED A.M. December 1, 19 71

FINISHED P.M. December 7, 19 71

METHOD OF DRILLING: SOIL Auger — CASING DIAM. -

ROCK Diamond Drill — CORE DIAM. NXL

LOCATION: LATITUDE 15584465.77N — DEPARTURE 1068285.71E — BEARING - — INITIAL DIP 90° — OTHER DIPS -

ELEVATIONS: DATUM CGD — DRILL PLATFORM - — GROUND SURFACE 579.67 ft — ROCK SURFACE 564.17 ft — BOTTOM OF HOLE 477.67 ft — WATER TABLE 571.67 ft

DEPTH Feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.0 to 15.5		Overburden	
15.5 to 22.2	Fossiliferous Cherty Limestone	Medium grey, fine grained, cherty, silty, abundant fossils, distinctly bedded, few shale partings, well consolidated.	
22.2 to 23.9	Siltstone	Brownish grey, fine to medium grained, cherty, glauconitic, distinctly bedded, fractured locally.	
23.9 to 37.0	Mottled Dolomite	Brownish grey, fine grained, indistinctly bedded, wavy shale partings, well consolidated.	
37.0 to 48.3	Shaly Dolomite	Medium brown, fine grained, finely laminated, distinctly bedded, well consolidated.	

INSPECTOR V. Katic

LOGGED BY M. Walia

APPROVED [signature]

DATE January, 1972

FORM NO. 91-C

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-5

SITE Port Colborne SHEET No. 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
48.3 to 61.25	Brown Porous Dolomite	Medium brown, fine grained, finely laminated, porous locally, chemically weathered.		
61.25 to 78.50	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, dense, fractured locally.		
78.50 to 102.00	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, gypsum occurs in nodular and fibrous forms, porous locally due to chemical leaching of gypsum, fractured locally.		
102.00		End of Borehole		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO. P2955

PROJECT Port Colborne Hwy 3, Tunnel/Bridge HOLE NO. BH-5

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
16.6 to 16.7	Fractured rock						x								
22.7 to 22.8	Fractured rock	Var.					x								
30.6	B joint			x		x								1	
31.05	Fracture	90°					x							1	
31.40	B joint			x		x								1	
40.55 to 40.90	Fracture	0°-5°			x			x						.5	
44.50 to 44.55	Fracture	Var						x							
61.90 to 62.25	Rock fractured							x							
74.90	Fracture	70°			x			x							
81.90	B shale parting	90°			x					C	Gy	x		5	
92.80 to 92.90	Rock fractured	Var.			x			x							

C = CARBONATE H = HEMATITE K = CHLORITE S=Shale ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT (CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P2955

PROJECT Port Colborne Hwy 3, Tunnel/Bridge HOLE NO BH-5

SITE Port Colborne SHEET NO 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	MUTUAL ANGLE
95.80 to 95.90	Rock fractured	Var		x			x						
100.80 to 100.90	Rock fractured	Var		x			x						
102.0	End of Borehole												

S = Shale G = Gypsum
B Joint = Bedding Joint
B Shale Parting = Shale parting along bedding
Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE S=Shale ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-6

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. December 9, 1971
FINISHED .M. December 14, 1971

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15582432.29 N
DEPARTURE 1066192.32 E
BEARING --
INITIAL DIP 90°
OTHER DIPS --

ELEVATIONS: DATUM CGD
DRILL PLATFORM -
GROUND SURFACE 582.07 ft
ROCK SURFACE 574.17 ft
BOTTOM OF HOLE 481.07 ft
WATER TABLE 573.07 ft

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 3.0	Sand and Gravel	Loose, damp, fine to coarse sand and gravel with some charcoal industrial waste contamination.	1	AQ		0.5 1.0 1.5 2.0		
3.0 to 5.0	Clayey Silt with Pebbles	Soft dark brownish grey clayey silt, occasional pebble and yellowish brown fine sand	2	AQ		3.0 3.5 4.0 4.5 5.0		
5.0 to 7.9	Silty clay	Soft medium brown silty clay and gravelly, clayey, sandy silt.	3	AQ		5.0 5.5 6.0 6.5 7.0		
7.9		Bedrock						

SAMPLING METHOD
* A — SPLIT TUBE
B — THIN WALL TUBE
C — PISTON SAMPLER
D — CORE BARREL
E — AUGER
F — WASH

SHIPPING CONTAINER
N — INSERT
O — TUBE
P — WATER CONTENT TIN
Q — GLASS JAR
R — CLOTH BAG
S — PLIOFILM BAG
Z — DISCARDED

INSPECTOR V. Katic
LOGGED BY M. Walia
APPROVED [signature]
DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-6

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. Dec. 9, 19 71

FINISHED .M. Dec. 14, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM.

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582432.29 N
DEPARTURE 1066192.32 E
BEARING --
INITIAL DIP 90°
OTHER DIPS --

ELEVATIONS: DATUM CGD
DRILL PLATFORM -
GROUND SURFACE 582.07 ft
ROCK SURFACE 574.17 ft
BOTTOM OF HOLE 481.07 ft
WATER TABLE 573.07 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 7.90		Overburden	
7.90 to 21.05	Coralline Cherty Limestone	Brownish grey, fine to medium grained, crystalline rock, cherty, shaly, abundant corals, shale partings.	
21.05 to 23.15	Limestone	Brownish grey, fine grained, shaly, silty, distinctly bedded, cohesive rock. A silt seam runs from 22.60ft to 22.65 ft.	
23.15 to 34.00	Fossiliferous Cherty Limestone	Light brownish grey, fine grained, cherty, silty, abundant fossils, shale partings.	
34.00 to 34.60	Siltstone	Medium brown, fine grained, shaly, cherty, glauconitic sand, distinctly bedded, badly fractured rock .	
34.60 to 47.00	Mottled Dolomite	Brownish grey, fine grained, wavy indistinct bedding, nodular green chert from 34.60 to 35.10, cohesive rock	

INSPECTOR V. Katic

LOGGED BY M. Walia

APPROVED

DATE January, 1972

FORM NO. 91-C

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-6

SITE Port Colborne SHEET No. 2 OF 2

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
47.00 to 56.75	Shaly Dolomite	Medium grey, fine grained, distinctly bedded, finely laminated, fractured locally.		
56.75 to 71.05	Brown Porous Dolomite	Light brown, fine grained, porous, chemically weathered, shale partings, finely laminated.		
71.05 to 88.40	Shale	Dark grey, fine grained, dense, dolomitic in parts, distinctly bedded, shale partings, porous dolomite from 79.45 to 79.90.		
88.40 to 101.00	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum in nodular and fibrous form, fractured locally.		
101.00		End of Borehole.		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge (Ontario) HOLE NO BH-6

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
7.95	Fracture				x			x	C	Gy			1		
8.45	Fracture	Var			x			x	C	Gy			1		
8.90 to 9.00	Rock fractured				x			x	C	Gy					
9.10 to 9.50	Rock fractured	Var			x			x	C	Gy					
10.00 to 10.10	Rock fractured			x			x								
13.60	Fracture sub-horizontal*			x				x					3		
14.00	B shale parting*			x					S	Gy		x			
14.60	B shale parting			x					S	Gy		x			
14.85	B shale parting			x					S	Gy		x			
15.80	Fracture, sub-horizontal*	90°		x					S	Gy			6		
17.20	B shale parting			x					S	Gy		x			
21.30	Fracture sub-horizontal	90°		x		x			S	Gy			12		
22.60	Open Fracture*	90°		x		x			SL	Gy			18	max	x
25.20	Open fracture*			x					S	Gy		x	25		
28.25	Fracture*			x					S	Gy		X	3		
30.10	B shale parting			x					S	Gy		x			

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO. BH-6

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
30.60	B shale parting			x					S	Gy		x	3		
34.25	Rock fractured. Void, substantial flow of water*			x			x		CTGr				75		
43.65	Void, noticeable flow of water*			x			x						12		
44.85	B shale parting*	90°		x									1		
46.85	Fracture*	90°		x									2		
48.10	Fracture, flow of water*	90°			x								18		
52.00	Minor fracturing*	90°		x			x								
56.70	Fracture, substantial flow of water*						x						18		
64.85	B shale parting*	90°					x						3		
69.40	Fracture*						x						25	max	
72.60	Fracture, sub-horizontal*	90°											18	max	
79.25	Open fracture*						x						12	max	
98.25	Fracture			x			x								
101.00	End of Borehole														

CT = Chert Gr = Green
G = Gypsum W = White
S = Shale SL = Silt
* = T.V. camera study
Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-7

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 10, 19 71
FINISHED .M. December 14, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15582477.01N DEPARTURE 1066891.83 E BEARING -- INITIAL DIP 90° OTHER DIPS --

ELEVATIONS: DATUM CGD; DRILL PLATFORM -; GROUND SURFACE 583.97 ft; ROCK SURFACE 559.07 ft; BOTTOM OF HOLE 483.67 ft; WATER TABLE 573.47 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE*	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 1.5	Organic Sandy silt	Loose, dry, dark brownish grey, gravelly sandy silt. (Organic)	1	AQ		0.0 0.5 1.0 1.5		
1.5 to 7.5	Distorted layered clay	Soft to medium stiff, distorted layers of brown, reddish brown greyish brown clay	2	AQ		2.5 3.0 3.5 4.0		
			3	AQ		5.0 5.5 6.0 6.5		
7.5 to 9.0	Peat with layered clay	Mixture of charcoal organic peat with decomposed wood and soft layered clay	4	AQ		7.5 8.0 8.5 9.0		
9.0 to 16.5	Remoulded clay	Brown and greyish brown soft remoulded clay with pieces of decomposed wood.	5	AQ		10.0 10.5 11.0 11.5		
			6	AQ		12.5 13.0 13.5 14.0 14.5		

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR A. H. Tilk
LOGGED BY M. Walia
APPROVED
DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-7

SITE Port Colborne SHEET No. 2 OF 2

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RET'D	
			7	AQ	15.0 15.5 16.0 16.5			
16.5 to 20.0	Fissured Clay	Soft to medium brown, reddish brown and grey brown clay with vertical fissures	8	AQ	17.5 18.0 18.5 19.0			
20.0 to 24.9	Clay mixed with silty sand	Soft to medium stiff laminations of brown reddish brown and greyish brown clay mixed with silty fine sand.	9	AQ	20.0 20.5 21.0			
			10	AQ	22.5 23.0 23.5 24.0			
24.9		Bedrock						

FORM NO 91-B

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No BH-7

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. Dec. 10, 1971
FINISHED .M. Dec. 14, 1971

METHOD OF DRILLING: SOIL Auger CASING DIAM. —
ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582477.01 N. ELEVATIONS: DATUM CGD
DEPARTURE 1066891.83 E DRILL PLATFORM —
BEARING —— GROUND SURFACE 583.97 ft
INITIAL DIP 90° ROCK SURFACE 559.07 ft
OTHER DIPS —— BOTTOM OF HOLE 483.67 ft
WATER TABLE 573.47 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 24.90		Overburden	
24.90 to 34.90	Fossiliferous Cherty Limestone	Medium grey, fine grained, cherty, silty, distinctly bedded, abundant fossils, cohesive rock.	
34.90 to 35.65	Siltstone	Medium brown, fine grained, shaly, silty, minor amount of glauconitic sand, porous locally.	
35.65 to 47.45	Mottled Dolomite	Brownish grey, fine grained, shale partings, well consolidated rock, fractured locally.	
47.45 to 56.40	Shaly Dolomite	Medium grey, fine grained, distinctly bedded, finely laminated, well consolidated rock, weak along the bedding plane.	
56.40 to 72.50	Brown Porous Dolomite	Light brown, fine to medium grained, bedding wavy in shape, porous locally, shale partings, chemically weathered.	

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED

DATE January, 1972

FORM NO. 81-C

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-7

SITE Port Colborne SHEET No. 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
72.50 to 89.80	Shale	Dark grey, fine grained, dolomitic in parts, dense, distinctly bedded, weak along the bedding plane.		
89.80 to 100.30	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum in nodular and fibrous form, fractured locally.		
100.30		End of Borehole		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-7

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
25.65	Open joint	30°	x		x				C	Gy				.5	
26.50	Void*	90°												25	
29.85	Joint*	55°	x		x				C	Gy				1	
30.20	Fracture*	70°					x		S	Gy				3	
35.25	Fracture, sub-horizontal	90°					x		S	Gy				12	
35.50	Fracture*	90°					x							3	
38.25	B shale parting*												x	.5	
39.90	B shale parting*												x		
41.00	Fracture*	Var					x								
43.30	B joint*	90°			x	x			S	Gy				12	
44.10	3 fractures sub-parallel to horizontal bedding plane*						x							2	
45.1	B shale parting*	90°												3	
46.6	3 fractures, sub-horizontal, rock pieces in the middle*	Var					x							25	max
48.10	Fracture, sub-horizontal*	90°												3	
50.65	B joint*	90°			x	x								6	
51.40	Fracture						x							3	
55.80	B joint	90°			x	x								.5	
55.95	B shale parting												x	.5	

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO. BH-7

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
56.20	B shale parting											x		.5	
65.85	B shale parting											x		.5	
77.90	B shale parting									S	Gy		x	.5	
79.10	B shale parting	90°								S	Gy			.5	
85.20 to 85.25	Rock fractured	90°					x	x		C	Gy			.5	
89.90 to 94.10	Rock fractured						x	x		C	Gy				
96.50 to 98.00	Rock fractured						x	x		C	Gy				
99.00 to 99.50	Rock fractured						x	x							
99.70 to 100.30	Rock fractured						x	x		C	Gy				
100.30	End of Borehole														

S = Shale
B joint = Bedding joint
B shale parting = Shale parting along the bedding
* = T.V. camera study
Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-8

SITE Port Colborne, Ontario SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 17, 1971

FINISHED .M. December 22, 1971

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used

ROCK CORE DIAM.

LOCATION: LATITUDE 15582483.91N DEPARTURE 1067152.52E BEARING – INITIAL DIP 90° OTHER DIPS –

ELEVATIONS: DATUM CGD; DRILL PLATFORM –; GROUND SURFACE 579.50 ft; ROCK SURFACE 564.30 ft; BOTTOM OF HOLE 477.80 ft; WATER TABLE 572.60 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.5	Organic Clayey Sandy silt	Dark grey organic clayey sandy silt with roots	1	AQ		0.0 1.0 1.5		
2.5 to 5.0	Silty clay	Hard dark brown silty clay, with some fine gravel, slight evidence of layering and weathering	2	AQ		2.5		
5.0 to 7.0	Peat	Hard dark brown to black peat, also soft to firm medium grey clayey silt, organic roots	3	AQ		5.0		
7.0 to 12.5	Varved Silty clay	Stiff silty clay varves of varying browns and occasional grey silt lenses	4 TW-5 6	AQ BO AQ		7.0 10.0 12.5		

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR B. Clarke

LOGGED BY M. Walia

APPROVED A F Berger

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario)
JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge
HOLE No. BH-8

SITE Port Colborne, Ontario
SHEET No. 2 OF 2

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RET'D	
12.5 to 15.2	Silty Clay	Hard brown silty clay, appears layered	7	AQ		15.0		
15.2		Bedrock						

FORM NO 91-B

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P.2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-8

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED M. Dec. 17, 1971

FINISHED M. Dec. 22, 1972

METHOD OF DRILLING: SOIL Auger CASING DIAM.

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582483.91 N DEPARTURE 1067152.52 E BEARING -- INITIAL DIP 90° OTHER DIPS --

ELEVATIONS: DATUM CGD DRILL PLATFORM - GROUND SURFACE 579.50 ft ROCK SURFACE 564.30 ft BOTTOM OF HOLE 477.80 ft WATER TABLE 572.60 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 15.20		Overburden	
15.20 to 19.30	Limestone	Dark grey, fine grained, shaly, silty, distinctly bedded, well-consolidated, two silt seams at 15.48 ft and 15.81 ft resp.	
19.30 to 24.15	Fossiliferous Cherty Limestone	Dark grey, fine grained rock with chert nodules, silty, abundant fossils, occasional shale partings.	
24.15 to 28.22	Cherty Dolomitic Limestone	Dark grey, fine grained, nodules of chert occasionally brecciated, fractured locally.	
28.22 to 29.05	Shaly, cherty Sandstone	Brownish grey, fine grained, shaly, cherty, glauconitic, distinctly bedded.	
29.05 to 42.45	Mottled Dolomite	Brownish grey, fine grained, wavy indistinct bedding, shale partings, well consolidated.	
42.45 to 51.70	Shaly Dolomite	Brownish grey, fine grained, finely laminated, distinctly bedded, weak along the bedding plane	

INSPECTOR B. Clarke

LOGGED BY M. Walia

APPROVED A P Benson

DATE January, 1972

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-8

SITE Port Colborne SHEET No. 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
51.70 to 66.40	Brown, Porous, Dolomite	Light brown, fine grained, porous chemically weathered, fractured locally, shale partings		
66.40 to 82.80	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, minor amount of hydrogen sulphide, fractured locally.		
82.80 to 101.70	Gypsum, Rich, Shale	Dark grey, fine grained, gypsum rich, (gypsum in nodular and fibrous form), porous locally, badly fractured occasionally.		
101.7		End of borehole.		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO. BH-8

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
18.60	B joint	78°		x	x				CGy				5		
18.97	Fracture	Var		x		x	x		CGy				1		
25.55	B joint	70°		x	x				CGy				.5		
26.10	Fracture, partly filled with Calcareous material	0°					x								
30.80	B shale parting						x					x			
34.80	B shale parting						x					x			
36.05	B shale parting						x					x			
37.40	B shale parting						x					x			
38.20	B shale parting						x					x			
38.40	B shale parting						x					x			
39.25 to 39.45	Rock fractured				x		x	x							
39.95	B shale parting				x										
42.30	B joint	80°	x		x										
51.30	B joint	85°	x		x				C	Gy			.2		
51.40	B joint	85°	x		x				C	Gy			.2		
51.65	B joint	85°	x		x				C	Gy			.2		
56.80	Fracture	90°	x												

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO. BH-8

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
66.20 to 66.40	Rock fractured				x		x								
77.60	Fracture						x								
81.60	Fracture						x								
82.00 to 82.10	Rock fractured				x		x								
83.30	Joint, partly filled with gypsum	50°		x		x			G	W				5	
83.70	B joint				x		x		G	W				1	
87.90	Fracture						x								
95.80 to 96.00	Rock fractured				x		x								
97.10 to 98.00	Rock fractured				x		x								
101.00															

G = Gypsum W = White
B joint = Bedding joint
B shale parting = Shale parting along the bedding
Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-9

SITE Port Colborne, Ontario SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. December 17, 19 71

FINISHED .M. December 22, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. none used

ROCK CORE DIAM.

LOCATION: LATITUDE 15582478.29N DEPARTURE 1067521.35E BEARING – INITIAL DIP 90° OTHER DIPS –

ELEVATIONS: DATUM CGD
DRILL PLATFORM –
GROUND SURFACE 584.48 ft
ROCK SURFACE 573.58 ft
BOTTOM OF HOLE 483.68 ft
WATER TABLE 573.08 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 4.0	Silt sand and gravel	Grey silt, fine sand and fine gravel and occasional grey coarse gravel	2	AQ		2.5 3.0 3.5 4.0		
4.0 to 6.5	Silt, sand and gravel	Olive-brown silt, fine sand and fine gravel with coarse gravel sized concrete chunks	3	AQ		5.0 5.5 6.0 6.5		
6.5 to 10.9	Silty clay	Soft to firm brown silty clay - one piece of coarse gravel	5	AQ		10.0 10.5 10.9		
10.9		Bedrock						

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR R. H. Tilk

LOGGED BY M. Walia

APPROVED R P Benson

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-9

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. Dec. 17, 19 71

FINISHED .M. Dec. 22 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. --

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582478.29 N
DEPARTURE 1067521.35 E
BEARING --
INITIAL DIP 90°
OTHER DIPS --

ELEVATIONS: DATUM CGD
DRILL PLATFORM -
GROUND SURFACE 584.48 ft
ROCK SURFACE 573.58 ft
BOTTOM OF HOLE 483.68 ft
WATER TABLE 573.08 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 10.90		Overburden	
10.90 to 20.00	Coralline, Cherty, Limestone	Medium brownish grey, fine to medium grained, crystalline, distinctly bedded, shaly in parts, cherty, shale partings occasionally.	
20.00 to 23.40	Limestone	Brownish grey, fine grained, indistinct bedding, shaly, silty, medium dark grey weathering.	
23.40 to 35.00	Fossiliferous Cherty, Limestone	Light grey, fine grained, silty, abundant fossils, grey and brown chert nodules.	
35.00 to 37.10	Siltstone	Medium grey, locally brown in color, fine grained, wavy bedding, conglomerate at the base of this bed has undergone strain flow and has been elongated along the bedding plane.	

INSPECTOR A. H. Tilk

LOGGED BY M. Walia

APPROVED

DATE January, 1972

FORM NO. 91-C

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) — **JOB No.** P-2955

PROJECT Highway No. 3, Tunnel/Bridge — **HOLE No.** BH-9

SITE Port Colborne — **SHEET No.** 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
37.10 to 49.20	Mottled, Dolomite	Light brown, fine grained, buff to brown weathering, wavy indistinct bedding, shale partings, fractured locally.		
49.20 to 58.70	Shaly, Dolomite	Light brown, fine grained, distinctly bedded, finely laminated, dense, weak along bedding plane.		
58.70 to 71.90	Brown Porous Dolomite	Light brown, fine grained, porous, finely laminated, fractured locally, chemically weathered.		
71.90 to 90.60	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, dense, weak along bedding plane.		
90.60 to 100.80	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum rich (gypsum occurs in nodular and fibrous form), porous locally, fractured occasionally. Silt seam from 91.6 ft to 92.0 ft.		
100.80		End of borehole.		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-9

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION												MUTUAL ANGLE
			SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	
11.90	Fracture*	90°			x			x						12	
15.65	B shale parting*	90°										x		6	
17.00	B shale parting*											x		1	
17.60	B joint*	90°			x	x								25	
18.30	B shale parting*											x		1	
20.15 to 20.30	Rock fractured*				x			x						2	
21.50	Fracture*							x						.5	
22.15	Void*							x						25	
22.15 to 22.60	Irregular Fracture	0°						x						1	
26.5	B shale parting*												x	1	
37.1 to 37.2	Rock fractured*							x						5	
42.1	B shale parting*												x	1	
45.85	Fracture*							x						1	
46.55	Fracture*					x		x						3	
51.00	Joint	53°		x		x				C	Gy			.5	
51.10	Joint	50°		x		x				C	Gy			.5	

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-9

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
51.30	Joint	55°	x		x					C	Gy			.5	
57.10	Fracture*			x			x								
57.80	Fracture*	90°		x										1	
63.00	Fracture*						x							.5	
64.15	Fracture*					x	x							15	
67.65	B shale parting*	90°												.5	
72.90	Fracture, sub-horizontal*	90°		x			x							1	
80.90	B shale parting*												x	3	
81.10	B shale parting*												x	3	
83.15	B shale parting*												x	1.5	
90.65	Fracture, partly filled with gypsum*						x		G	W					
92.85	Fracture*	0°												1	
98.95 to 99.45	Rock fractured	90°													

G = Gypsum W = White

* = T.V. camera study

C = CARBONATE H = HEMATITE K = CHLORITE ++Br = BROWN +Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-10

SITE Port Colborne, Ontario SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. December 16, 19 71
FINISHED .M. December 21, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15582465.46N
DEPARTURE 1067945.80E
BEARING -
INITIAL DIP 90°
OTHER DIPS -

ELEVATIONS: DATUM CGD
DRILL PLATFORM -
GROUND SURFACE 582.50 ft
ROCK SURFACE 568.20 ft
BOTTOM OF HOLE 472.40 ft
WATER TABLE 573.00 ft

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE #	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.0	Fine sand to Medium gravel	Charcoal-grey, fine sand to med-gravel, bits of coal and clay	1	AQ		0.5 1.0 1.5 2.0		
2.0 to 6.5	Peat with silt and sand	Dark brown black peat with some organic brownish-grey silt with sand to gravel	2	AQ		3.0 3.5 4.0		
			3A	AQ		5.0 5.5 6.0 6.5		
6.5 to 12.5	Varved silty clay	Stiff varves of silty clay of varying browns with some grey silt lenses, occasional sand and fine gravel	3B	AQ		6.6 7.0		
			4	AQ		8.0 8.5 9.0 9.5 10.0		

SAMPLING METHOD
* A — SPLIT TUBE
B — THIN WALL TUBE
C — PISTON SAMPLER
D — CORE BARREL
E — AUGER
F — WASH

SHIPPING CONTAINER
N — INSERT
O — TUBE
P — WATER CONTENT TIN
Q — GLASS JAR
R — CLOTH BAG
S — PLIOFILM BAG
Z — DISCARDED

INSPECTOR V. Katic

LOGGED BY M. Walia

APPROVED A Berezan

DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario)

JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge

HOLE No. BH-10

SITE Port Colborne, Ontario

SHEET No. 2 OF 2

DEPTH feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RET'D	
			5	AQ		11.0 11.5 12.0 12.5		
12.5 to 14.3	Silty sand and gravel	Light brown silty fine sand and gravel	6	AQ		13.8 14.1		
14.3		Bedrock						

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-10

SITE Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED .M. Dec. 16, 1971
FINISHED .M. Dec. 21 1971

METHOD OF DRILLING: SOIL Auger CASING DIAM. ...
ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582465.46N DEPARTURE 1067945.80E BEARING ... INITIAL DIP 90° OTHER DIPS ...

ELEVATIONS: DATUM CGD DRILL PLATFORM - GROUND SURFACE 582.50 ft ROCK SURFACE 568.20 ft BOTTOM OF HOLE 472.40 ft WATER TABLE 573.00 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 14.30		Overburden	
14.30 to 17.40	Coralline, Cherty, Limestone	Medium brownish grey, fine to medium grained, crystalline, shaly, thick bedded, coralline in parts, cohesive.	
17.40 to 21.30	Limestone	Brownish grey, fine grained, shaly, silty, medium dark grey weathering, wavy distinct bedding, fractured locally.	
21.30 to 31.90	Fossiliferous Cherty Limestone	Light grey, fine grained, shaly, cherty, fossiliferous, shale partings.	
31.90 to 32.45	Siltstone	Medium grey, fine grained, glauconitic, green, chert, indistinctly bedded, fractured locally.	
32.45 to 44.10	Mottled Dolomite	Light brown, brown weathering, fine grained wavy indistinct bedding, cohesive.	
44.10 to 55.50	Shaly Dolomite	Medium light brown, fine grained, finely laminated, well consolidated rock, weak along the bedding.	

INSPECTOR V. Katic
LOGGED BY M. Walia
APPROVED R F Berger
DATE January, 1972

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-10

SITE Port Colborne SHEET No. 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
55.50 to 69.90	Brown Porous Dolomite	Light brown, fine grained, porous, gypsum deposited in the cavities locally, chemically weathered, fractured ocasionally		
69.90 to 86.30	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, dense, shale partings.		
86.30 to 100.10	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum rich shale, gypsum occurs in nodular and fibrous form occasionally filling the fractures.		
100.10		End of Borehole.		

FORM NO. 81-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-10

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
18.10	B shale parting*				x				S	Gy		x		1	
18.70	Fracture				x		x	x							
20.35 to 21.30	B shale parting								S	Gy		x		.5	
22.95	B shale parting*								S	Gy		x		.2	
24.00	B shale parting*								S	Gy		x		.2	
28.50	B shale parting*								S	Gy		x		.2	
31.20	B shale parting*								S	Gy		x		.2	
32.25	Fracture*							x						3	
36.10	B shale parting*								S	Gy		x		.2	
36.95	B shale parting*								S	Gy		x		.2	
37.95	Fracture*							x						1	
42.55	Fracture*	90°												3	
44.30	B shale parting											x		1	
44.55	Void*							x						12	
46.65	B shale parting*											x		1	
50.90	Fracture*	90°												2	
55.00	Fracture*	90°				x								1.5	

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3 Tunnel/Bridge HOLE NO BH-10

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
60.70 to 60.90	Rock fracture				x		x	x							
62.30	B shale parting											x		1	
65.00	B joint, minor chemical weathering along joint face	85°			x	x								5	
68.20	B shale parting	80°			x	x				G	W				
70.10	Fracture*	90°			x									6	
76.85	B shale parting*	90°										x		1	
86.85	Fracture							x						1.5	
87.10	Fracture							x						1.5	
99.50 to 100.10	Rock fracture				x		x	x							
100.10	End of borehole														

S = Shale G = Gypsum
W = White
B joint = Bedding joint
B shale parting = Shale parting along the bedding
* = T.V. camera study

C = CARBONATE H = HEMATITE K = CHLORITE ++Br = BROWN +Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-11

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED .M. December 28, 19 71
FINISHED .M. December 29, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15582544.29N
DEPARTURE 1069022.86E
BEARING –
INITIAL DIP 90°
OTHER DIPS –

ELEVATIONS: DATUM CGD
DRILL PLATFORM –
GROUND SURFACE 584.88 ft
ROCK SURFACE 581.78 ft
BOTTOM OF HOLE 544.88 ft
WATER TABLE 576.08 ft

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.0	Contaminated Clayey Silt	Soft dark brown clayey silt with slag, coal also charcoal -grey silt & sand with some fine gravel.	1	AQ		0.5 1.0 1.5 2.0		
2.0 to 3.1	Silty Clay	Brown silty clay with broken shale fragments.	2	AQ		3.0		
3.1		Bedrock						

SAMPLING METHOD
*A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR V. Katic
LOGGED BY M. Walia
APPROVED
DATE January, 1972

FORM NO. 91-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Department of Transportation and Communications (Ontario) JOB No. P-2955
PROJECT: Highway No. 3, Tunnel/Bridge HOLE No. BH-11
SITE: Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear
STARTED .M. December 28, 19 71
FINISHED .M. December 29, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. --
ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582544.29 N
DEPARTURE 1069022.86 E
BEARING --
INITIAL DIP 90°
OTHER DIPS --

ELEVATIONS: DATUM CGD
DRILL PLATFORM --
GROUND SURFACE 584.88 ft
ROCK SURFACE 581.78 ft
BOTTOM OF HOLE 544.88 ft
WATER TABLE 576.08 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 3.10		Overburden	
3.10 to 21.10	Coralline Cherty Limestone	Brown, fine grained, shaly, cherty, abundant corals, numerous shale partings.	
21.10 to 21.30		Silt seam, rich in carbonatic material.	
21.30 to 22.80	Limestone	Brownish grey, fine grained, distinctly bedded, silty, shaly, medium grey weathering, shale partings, well-consolidated rock.	
22.80 to 32.70	Fossiliferous Cherty Limestone	Light grey, fine grained, cherty, silty, abundant fossils, shale partings	
32.70 to 34.10	Siltstone	Medium brown, fine grained, shaly, cherty, glauconitic sand, fractured locally	

INSPECTOR V. Katic
LOGGED BY M. Walia
APPROVED A.T. Boyer
DATE January, 1972

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-11

SITE Port Colborne SHEET No. 2 OF 2

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
34.10 to 40.00	Mottled Dolomite	Brownish grey, brown weathering locally fine grained, wavy indistinct bedding, numerous shale partings, cohesive rock.		
40.00		End of Borehole		

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Port Colborne Highway 3, Tunnel/Bridge HOLE NO BH-11

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
33.60	Joint; minor chemical weathering along Joint face	60°		x		x				C	Gy			1	
33.80	Joint; minor chemical weathering	40°		x		x				C	Gy			1	
36.10	B Shale Parting									S	Gy		x		
38.55	Joint	70°		x		x								.5	
39.05	Fracture	Var					x	x						1	
39.25	Shale Parting												x	.1	
40.0	End of hole														

S = Shale

B Shale Parting = Shale parting along bedding

Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-10

SITE Port Colborne SHEET No. 2 OF 2

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
55.50 to 69.90	Brown Porous Dolomite	Light brown, fine grained, porous, gypsum deposited in the cavities locally, chemically weathered, fractured ocasionally		
69.90 to 86.30	Shale	Dark grey, fine grained, dolomitic in parts, distinctly bedded, dense, shale partings.		
86.30 to 100.10	Gypsum Rich Shale	Dark grey, fine grained, dolomitic in parts, gypsum rich shale, gypsum occurs in nodular and fibrous form occasionally filling the fractures.		
100.10		End of Borehole.		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE NO BH-10

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
18.10	B shale parting*				x				S	Gy		x	1		
18.70	Fracture				x		x	x							
20.35 to 21.30	B shale parting								S	Gy		x	.5		
22.95	B shale parting*								S	Gy		x	.2		
24.00	B shale parting*								S	Gy		x	.2		
28.50	B shale parting*								S	Gy		x	.2		
31.20	B shale parting*								S	Gy		x	.2		
32.25	Fracture*							x					3		
36.10	B shale parting*								S	Gy		x	.2		
36.95	B shale parting*								S	Gy		x	.2		
37.95	Fracture*							x					1		
42.55	Fracture*	90°											3		
44.30	B shale parting											x	1		
44.55	Void*							x					12		
46.65	B shale parting*											x	1		
50.90	Fracture*	90°											2		
55.00	Fracture*	90°				x							1.5		

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario) JOB NO P-2955

PROJECT Highway No. 3 Tunnel/Bridge HOLE NO BH-10

SITE Port Colborne SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
60.70 to 60.90	Rock fracture				x		x	x							
62.30	B shale parting											x	1		
65.00	B joint, minor chemical weathering along joint face	85°			x	x							5		
68.20	B shale parting	80°			x	x				G	W				
70.10	Fracture*	90°			x								6		
76.85	B shale parting*	90°										x	1		
86.85	Fracture							x					1.5		
87.10	Fracture							x					1.5		
99.50 to 100.10	Rock fracture				x		x	x							
100.10	End of borehole														

S = Shale G = Gypsum
W = White
B joint = Bedding joint
B shale parting = Shale parting along the bedding
* = T.V. camera study

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT Highway No. 3, Tunnel/Bridge HOLE No. BH-11

SITE Port Colborne SHEET No. 1 OF 1

CONTRACTOR: Longyear STARTED M. December 28, 19 71
FINISHED M. December 29, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. None used
ROCK CORE DIAM.

LOCATION: LATITUDE 15582544.29N
DEPARTURE 1069022.86E
BEARING –
INITIAL DIP 90°
OTHER DIPS –

ELEVATIONS: DATUM CGD
DRILL PLATFORM –
GROUND SURFACE 584.88 ft
ROCK SURFACE 581.78 ft
BOTTOM OF HOLE 544.88 ft
WATER TABLE 576.08 ft

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST
0.0 to 2.0	Contaminated Clayey Silt	Soft dark brown clayey silt with slag, coal also charcoal -grey silt & sand with some fine gravel.	1	AQ		0.5 1.0 1.5 2.0		
2.0 to 3.1	Silty Clay	Brown silty clay with broken shale fragments.	2	AQ		3.0		
3.1		Bedrock						

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR V. Katic
LOGGED BY M. Walia
APPROVED
DATE January, 1972

FORM NO. 81-A

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Department of Transportation and Communications (Ontario) JOB No. P-2955

PROJECT: Highway No. 3, Tunnel/Bridge HOLE No. BH-11

SITE: Port Colborne SHEET No. 1 OF 2

CONTRACTOR: Longyear STARTED M. December 28, 19 71

FINISHED M. December 29, 19 71

METHOD OF DRILLING: SOIL Auger CASING DIAM. --

ROCK Diamond Drill CORE DIAM. NXL

LOCATION: LATITUDE 15582544.29 N ELEVATIONS: DATUM CGD

DEPARTURE 1069022.86 E DRILL PLATFORM --

BEARING -- GROUND SURFACE 584.88 ft

INITIAL DIP 90° ROCK SURFACE 581.78 ft

OTHER DIPS -- BOTTOM OF HOLE 544.88 ft

WATER TABLE 576.08 ft

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
0.00 to 3.10		Overburden	
3.10 to 21.10	Coralline Cherty Limestone	Brown, fine grained, shaly, cherty, abundant corals, numerous shale partings.	
21.10 to 21.30		Silt seam, rich in carbonatic material.	
21.30 to 22.80	Limestone	Brownish grey, fine grained, distinctly bedded, silty, shaly, medium grey weathering, shale partings, well-consolidated rock.	
22.80 to 32.70	Fossiliferous Cherty Limestone	Light grey, fine grained, cherty, silty, abundant fossils, shale partings	
32.70 to 34.10	Siltstone	Medium brown, fine grained, shaly, cherty, glauconitic sand, fractured locally	

INSPECTOR V. Katic

LOGGED BY M. Walia

APPROVED A. Bruce

DATE January, 1972

H. G. ACRES LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Department of Transportation and Communications (Ontario)
JOB No.: P-2955
PROJECT: Highway No. 3, Tunnel/Bridge
HOLE No.: BH-11
SITE: Port Colborne
SHEET No.: 2 OF 2

DEPTH feet	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	LENGTH OF RUN	% CORE
34.10 to 40.00	Mottled Dolomite	Brownish grey, brown weathering locally fine grained, wavy indistinct bedding, numerous shale partings, cohesive rock.		
40.00		End of Borehole		

FORM NO. 91-D

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications (Ontario JOB NO P-2955

PROJECT Port Colborne Highway 3, Tunnel/Bridge HOLE NO BH-11

SITE Port Colborne SHEET NO. 1 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	Wavy	OPENING mm	MUTUAL ANGLE
4.2	Fracture	0°		x										.5	
5.00	B Shale Parting								S	Gy				.5	
5.95	B Shale Parting								S	Gy		x			
7.95	B Shale Parting								S	Gy		x			
9.80	B Shale Parting								S	Gy		x			
12.10	B Shale Parting								S	Gy		x			
12.15	B Shale Parting								S	Gy		x			
12.50	B Shale Parting								S	Gy		x			
13.90	B Shale Parting								S	Gy		x			
14.30	B Shale Parting								S	Gy		x			
17.20	B Shale Parting								S	Gy		x			
22.80	B Shale Parting								S	Gy		x			
25.90	B Shale Parting											x			
28.05	B Shale Parting	80°		x		x			S	Gy				.5	
29.50	Joint	70°		x		x			S	Gy				.5	
30.20	Joint	50°		x		x			X	Gy				1	
32.30	Fracture			x			x	x	C	Gy				1	
33.15 to 33.30	Rock Fractured							x							

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY

H. G. ACRES LIMITED - NIAGARA FALLS

DRILLING REPORT
(CORE DETAILS)

CLIENT Department of Transportation and Communications JOB NO P-2955

PROJECT Port Colborne Highway 3, Tunnel/Bridge (Ontario)

HOLE NO BH-11

SITE Port Colborne

SHEET NO. 2 OF 2

DEPTH (FT.)	DISCONTINUITY (JOINT, FAULT, BEDDING PLANES, CLEAVAGE, LINEATION)	ANGLE WITH CORE AXIS	DESCRIPTION: SLICK	SMOOTH	ROUGH	PLANE	CURVED	IRREGULAR	SLICKENSIDED	FILLING +	STAINING ++	BLEACHING	WAVY	OPENING mm	MUTUAL ANGLE
33.60	Joint; minor chemical weathering along Joint face	60°		x		x				C	Gy			1	
33.80	Joint; minor chemical weathering	40°		x		x				C	Gy			1	
36.10	B Shale Parting									S	Gy		x		
38.55	Joint	70°		x		x								.5	
39.05	Fracture	Var					x	x						1	
39.25	Shale Parting												x	.1	
40.0	End of hole														

S = Shale

B Shale Parting = Shale parting along bedding

Var = Variable

C = CARBONATE H = HEMATITE K = CHLORITE ++ Br = BROWN + Gy = GRAY