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536-56

PACIFIC WESTERLY (STA. 0+00 TO  
STA. 35+00) Prop. IMPROV.

3015-23

W.O.

W.P.

LOCATION

GEOCRES NO.

## ● DATA ON FILE IN SOIL MECHANICS SECTION

REFER TO: S.P. PLAN

REMARKS

Project Cancelled

GEOCRES

INDEXING CARD FOR REPORTS NOT MICROFILMED

GI-20 AUG. 74

Oversized Drawings  
program status report.

## MEMORANDUM

To: Mr. R. G. Burnfield,  
Regional Functional  
Planning Engineer,  
Central Region (Toronto),

FROM: Foundation Section,  
Materials & Testing Office,  
Room 107, Lab. Bldg.

ATTENTION: Central Bldg.

DATE: April 1, 1971

OUR FILE REF.

IN REPLY TO

APR 14 1971

SUBJECT:

30M5-23

GEOCRES No.

FOUNDATION INVESTIGATION REPORT

For

Proposed Improvement of Hwy. #3

Along the Niagara Escarpment

West of Dundas, Ontario

Station 0+00 to Station 35+00

District No. 4 (Hamilton)

W.O. 71-11001 -- W.P. 536-56

Attached, we are forwarding to you the results of a foundation investigation carried out for the above mentioned project. The investigation was originally requested in a memo dated November 12, 1971 from Mr. R. G. Burnfield to Mr. T. J. Kovich.

We believe the information contained in our report will be sufficient for your present purposes, though we would like to point out that additional investigation will be necessary when the project reaches the design stage.

Should further information be required, please contact this Office.

AGS/MdeF

Attach.

cc: Messrs. R. G. Burnfield (2)

F. G. Allen

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A. G. Sternac

PRINCIPAL FOUNDATION ENGINEER

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FOUNDATION INVESTIGATION REPORT  
For  
Proposed Improvement of Hwy. #8  
Along the Niagara Escarpment  
West of Dundas, Ontario  
Station 0+00 to Station 35+00  
District No. 4 (Hamilton)  
W.O. 71-11001 -- W.P. 536-56

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1. INTRODUCTION:

A foundation investigation was requested by Mr. E. J. McCabe, Senior Project Planning Engineer, Central Region, at the site of the proposed improvement of Hwy. #8 along the Niagara Escarpment near the West limit of Dundas.

Two alternative alignments are being considered at the present time by Functional Planning, to replace this section of the highway. One alignment would cross the C.N.R. tracks with a subway, just east of the existing structure. West of the crossing the road would run partially along the existing highway, but would also cut into the escarpment for the additional lanes. This alignment is referred to as "Subway Line". The other alternative calls for a very high overhead bridge, to cross the C.N.R. tracks some 1,300 ft. west of the existing structure. This alignment would utilize embankments running south of the railway. In order to reach the top of the escarpment, embankments as high as 100 ft. from toe to top would have to be built - (henceforth referred to as "Overhead Line").

The purpose of the foundation investigation has been to obtain adequate information for the solution of geotechnical problems, so that Functional Planning can prepare a reasonably accurate cost estimate of their proposals.

Presented in this report are the results of the soils investigation, together with some discussion and comments pertaining to structure foundations, embankment and cut stabilities, retaining walls, etc., along the proposed lines.

## 2. DESCRIPTION OF THE SITE AND GEOLOGICAL BACKGROUND OF THE ESCARPMENT:

Highway #8 along the investigated area is approx. 3,000 ft. long, and it rises with an average gradient of 8% from el. 390 ft. up to around el. 650 ft. The easterly 1,000 ft. or so of the road lies within the Town of Dundas, where near the bottom of the escarpment, the area is occupied by industrial buildings. Farther to the west the top of the escarpment is mainly residential development, and south of the railway tracks there is a golf and country club.

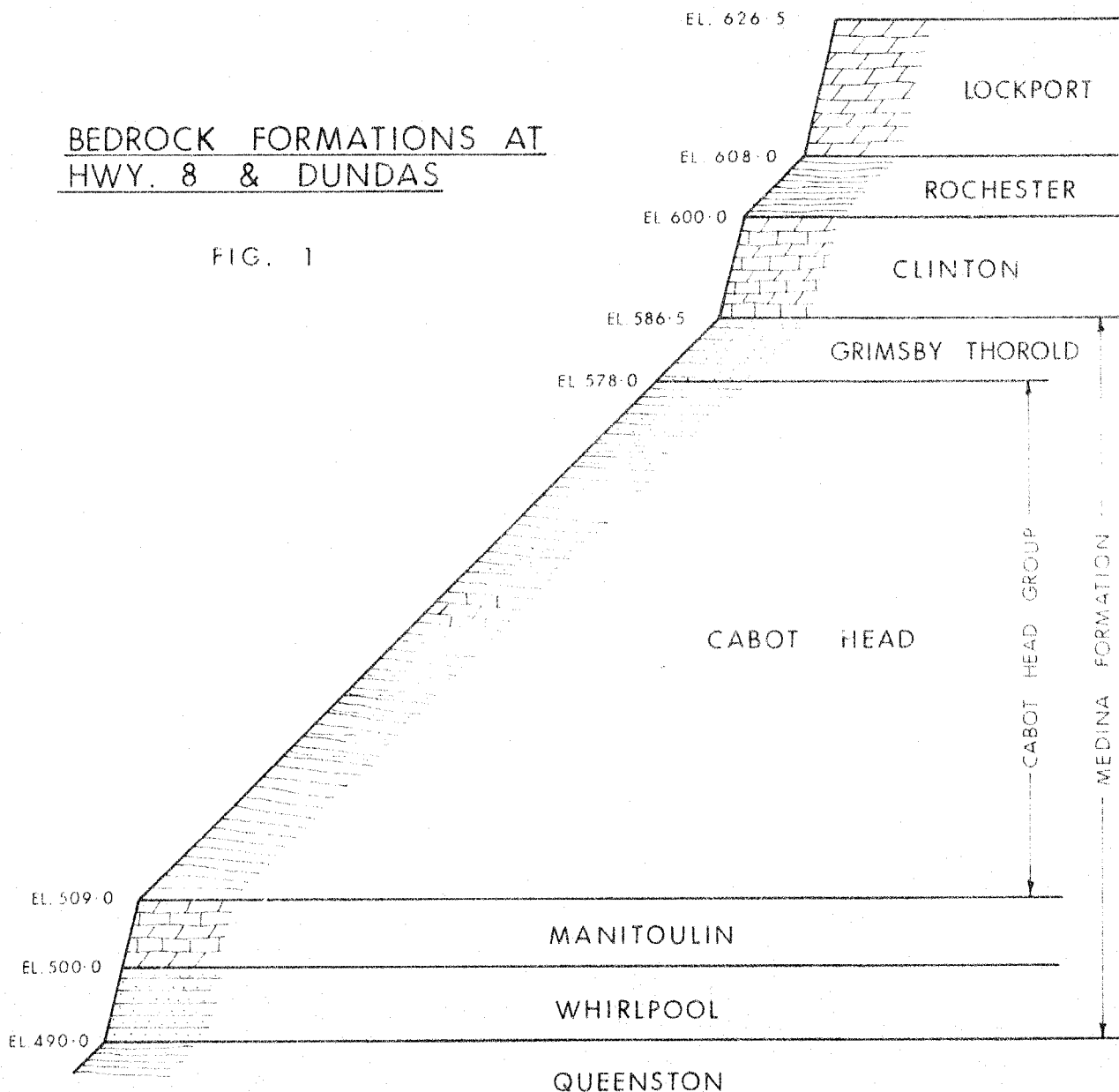
The Niagara Escarpment is by far the greatest topographic break produced by differential erosion of harder and softer rock in Ontario. The Dundas Valley is the only deep preglacial landscape in the southern part of the escarpment. The vertical cliffs along the brow mark the edge of the Silurian dolomite. The geological formations, which constitute the bedrock of the escarpment at Dundas are a series of almost horizontal strata. Figure #1 illustrates the full sequence of various rock formations and thicknesses as stated by the Geological Survey of Canada. Exposures on the escarpment within our area, is limited mainly to the upper formations, the remainder being concealed by the talus material, covering the larger portion of the rocks.

From an engineering standpoint, the geological succession may be regarded as consisting of two limestone members (Lockport and Clinton), separated by a shaly member (Rochester) and underlain by a thick sequence of shales. The Manitoulin limestone and Whirlpool sandstone are relatively hard members, but are too deeply buried to have any direct effect on the proposed cuts.

The Lockport dolomite and the Clinton limestone are both hard members, and they erode usually along near vertical cliffs. Both formations may be regarded as fairly permeable units. The Rochester shale which separates the two limestones is not a true shale, but is composed of 2 - 3 inch beds of limestone, separated by thin shaly horizons. The Thorold and

# BEDROCK FORMATIONS AT HWY. 8 & DUNDAS

FIG. 1



DOLOMITE - Grey, massive, porous, crinoidal.

SHALE - Dark grey, thin-bedded dolomite, interbedded with shale. Dark grey thin-bedded soft shale with sandy limestone.

DOLOMITIC LIMESTONE - Grey and dark grey, massive, coarse, dense.

SANDSTONE & SHALE - Light grey, quartzose, grey to greenish grey with interbedded bluish shale.

SHALE - Red, interbedded with sandstones and limestones. Grey shale with 2 to 4 inch interbeds of grey sandstone and sandy limestone.

DOLOMITIC LIMESTONE - Thin calcareous beds with numerous grey shale partings.

SANDSTONE - Massive, white to light grey, fine grained, cross bedded quartzose.

SHALE - 3 feet of greenish grey shale, then red shale with green mottling and streaks.

2. DESCRIPTION OF THE SITE AND GEOLOGICAL BACKGROUND  
OF THE ESCARPMENT: (cont'd.) ...

Grimsby sandstones in our particular area are represented mainly by shales, and as such, it is very difficult to discern from the underlying Cabot Head shales. Groundwater is only partially able to percolate through the Rochester shale, while the Medina formation, consisting essentially of red and greenish-grey shales are practically impermeable units. The simplified geological processes which are at work on the escarpment face are outlined briefly as follows:

Agents of erosion, such as water, expansion and contraction, freezing and thawing, etc., all result in the gradual retreat of the escarpment face. The softer shale units are removed more easily and rapidly than the limestone, so that the latter are undercut, until blocks of limestones fall down the slope forming a large portion of the talus material. This accumulated talus serves as a protective covering to the shales and slows down the erosion. Roots of trees and other vegetation act as further protection so that the talus slopes eventually assume a state of quasi-equilibrium. The angle of repose of such slopes remains roughly constant, but a steady downward creep may occur, when the surface materials are loosened each spring, or washed by heavy rains, unless proper drainage is provided for. Disturbance of the equilibrium slopes by excavations, therefore, is extremely dangerous and bound to result in an attempt to re-establish the natural angle, by slides.

An appreciation of the mechanism suggests that any solution of the problem must be based on the methods of keeping the talus as dry as possible, and excavating the new slopes with the natural angle of repose of the material (or even flatter). Past experience indicates that, right after such slopes are built, they must be protected by sod, vegetation, or similar effective erosion control.

### 3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

Some 29 boreholes were carried out during the field work, borings having been placed along the proposed lines and at the locations of the bridges, retaining walls, embankment and cut slopes. Boreholes were achieved by using a continuous hollow stem auger and two conventional diamond drill rigs, adapted for soil sampling purposes. Split-spoon and, where possible, Shelby tube samples were taken in frequent intervals within the overburden, while the rocks were proved by BXL size diamond drilling.

All the soil samples were taken to the laboratory, where they were visually examined and classified. Representative samples were further tested in order to define moisture contents, Atterberg limits, grain-size distributions, and bulk densities. Undisturbed samples were subjected to unconfined and quick triaxial tests to obtain undrained shear strength characteristics of the cohesive strata. A limited number of consolidation tests were performed on samples taken from below the proposed high embankment. Field and laboratory test results are plotted on the borelog sheets, accompanying this report. The locations and elevations of the borings are marked on Drawing #71-11001A in the Appendix. Estimated soil stratifications shown on the profiles and cross sections are based upon the borelogs.

### 4. DISCUSSION AND RECOMMENDATIONS:

#### 4.1) General:

In the forthcoming sections the proposed lines are discussed separately, giving a brief outline of the subsoil conditions at the particular location and foundation recommendations for the proposed structures. Embankment and cut stabilities are also dealt with.

It is pointed out that the comments are of a general nature only, and do not go into great detail. It is believed, however, that the information and geotechnical data presented

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

here will be sufficient for preliminary design and cost estimating purposes. When the final alignment and grade is decided upon, more field and laboratory investigation will be necessary, in order to provide the designer with detailed final recommendations for each individual structure.

4.2) SUBWAY LINE:

Along the subway line investigations were carried out (1) at the location of the proposed bridge over Spencer Creek; (2) along the proposed retaining wall, south of the highway between Station 5+40 and Station 11+00; (3) at the wall, retaining the railway fill, east of the future subway bridge; (4) at the proposed subway; (5) along the cut section of the realigned Station Road, and (6) along the widened highway west of the railway crossing. The estimated stratigraphical profile along the proposed subway line is shown on Drawing #71-11001A.

4.2.1) Bridge over Spencer Creek:

a) Soil Conditions -

Two boreholes, numbered 1 and 2 were drilled at the site of the proposed bridge. The overburden in both holes was found to consist of clayey silts with some gravel and traces of sand. Numerous fragments of shale and limestone were observed within the overburden, indicating that the soils were derived from the escarpment. Due to the large amount of broken rock, the consistency of the layers varied from stiff to hard, corresponding to penetration 'N' values between 15 blows per ft. up to much above 100 blows per ft. Shale bedrock of the Queenston formation was found at el. 369.1 ft. below the east bank of the creek and at el. 383.1 ft. below the west bank (see Drawing #71-11001A). The rock cores were noted to be fairly sound, of red colour with random greyish-green layers.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.1) Bridge over Spencer Creek: (cont'd.) ...

b) Recommendations:

From the soil stratigraphy, it appears that the proposed bridge can economically be supported on spread footings in shallow depths. Footings may be placed below the depth of frost penetration - i.e., a minimum depth of four ft. below finished ground. The depth of footings should, of course, comply with the hydrological requirements as well. Safe loads of four TSF may be used for design purposes on the base of the spread footings.

On account of the presence of fractured limestone and boulders within the overburden, pile driving in this site does not seem to be practical. As an alternative to spread footings, the structure can be founded, however, on drilled caissons. In adopting such foundations, the caissons should be socketed at least four ft. into the sound bedrock. For estimating purposes, the caissons may be designed with an end-bearing value of 50 TSF and adhesion along the shaft of 6.5 TSF within the sound shale. No adhesion should be assumed to act along the perimeter of the caissons within the overburden. The caissons should have a minimum diameter of 30 inches.

No stability problems are anticipated for the approach fills, provided they are constructed with 2 horizontal to 1 vertical slopes.

4.2.2) Retaining Wall South of the Proposed Highway -  
Between Station 5+40 and Station 11+00 -  
(Wall #1):

a) Soil Conditions:

Boreholes #3, 4 and 5 were placed along the proposed wall and B.H. #2 was also used to estimate the bedrock surface. Heterogeneous clayey silts and sandy silts with gravel and some

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SURWAY LINE: (cont'd.) ...

4.2.2) Retaining Wall South of the Proposed Highway -  
Between Station 5+40. and Station 11+00 -  
(Wall #1): (cont'd.) ...

a) Soil Conditions: (cont'd.) ...

boulders constitute the overburden, having very stiff to hard consistency and generally compact relative density. Zones of fine sands were noted in B.H. #3, with fairly high natural moisture contents. These layers exhibit quick dilatancy, hence they are susceptible to unbalanced hydrostatic head. The bedrock surface was established between el. 383 ft. and 414 ft. sloping easterly. The shale bedrock belongs to the Queenston formation. B.H. #5, placed on the high ground in front of the existing houses, revealed that this portion was built up by mixed fill material, underlain by bouldery clayey silts and silts.

b) Recommendations:

The retaining wall will be necessary in order to support laterally the new fill for this portion of the widened highway and the new entrance road to the golf club. Two cross sections - (A-A and B-B) are presented on Drawing #71-11001B. On the sections the approx. proposed walls and the estimated soil stratigraphy are also shown. A rough profile along the proposed wall is also shown on the drawing (Retaining Wall #1).

The wall should be supported on sound bedrock. It is believed that along some length of the wall it would be feasible to excavate down to the top of the rock surface. Excavations would need to be properly sheeted and braced. Along this length spread footings may be constructed on sound bedrock, using design loads of 10 TSP. Along those sections of the wall where the overburden is too deep for the economical design of spread footings, the structure should be founded on drilled caissons, socketed at least 8 ft. into sound rock. For design loads on the caissons, the

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.2) Retaining wall South of the Proposed Highway -  
Between Station 5+40 and Station 11+00 -  
(Wall #1): (cont'd.) ...

b) Recommendations: (cont'd.) ...

comments given under Subsection 4.2.1 a) will apply.

Consideration should be given to constructing the fill section with 2 horizontal to 1 vertical slopes instead of with retaining walls. If the entire slope cannot be constructed with 2:1 slopes due to space limitations, it might be still possible to build the slope partially and support it with a much lower wall at or near the future right-of-way fence. Further field investigations will be necessary when the final scheme is decided upon to determine the feasibility of this latter suggestion.

4.2.3) Retaining Wall North of the Proposed Highway -  
Between Approx. Station 10+00 and Station 12+30 -  
(Marked as Wall #2):

a) Soil Conditions:

Soil stratigraphy was evaluated along the proposed wall, based on three borings, numbered 13, 24 and 25. B.H.'s #24 and 25 were drilled through the existing railway fill, which was found to be composed of clayey silts and silts with numerous irregular seams and layers of sand and traces of gravel. The consistency of this generally cohesive material ranges from very stiff to hard, with penetration resistances up to about 50 - 60 blows per ft. Shale bedrock of the Queenston formation was established around el. 451 ft. The sound shale is overlain by layers of hard glacial till and decomposed, weathered shale. B.H. #13, placed at the toe of the existing fill revealed that the upper portion of the bedrock was completely eroded at this location down to el. 426 ft., at which depth the sound portion of the shale was encountered. The overburden in B.H. #13 was noted to be mainly sands and silts with gravel and boulders (glacial till) of a very dense nature.

The subsoil profile along the proposed wall is presented on Drawing #71-11001C.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.3) Retaining Wall North of the Proposed Highway -  
Between Approx. Station 10+00 and Station 12+30 -  
(Marked as Wall #2): (cont'd.) ...

b) Recommendations:

The grade of the subway line will be around el. 455 ft. at the east end of the proposed retaining wall, and around el. 475 ft. at the west end. The height of the wall near the future railway crossing will be over 40 ft. above the finished grade. Since the depth of the overburden under the proposed grade varies between 15 and 30 ft., spread footings for the wall appear to be uneconomical. As a consequence, the wall again should be placed on caissons drilled at least 8 ft. below sound rock surface. The caissons should be designed to resist the lateral earth pressures behind the full height of the wall, plus the lateral pressures between the bottom of the wall and the top of the sound rock. For estimating purposes, it may be assumed that the sound shale bedrock will support safe loads of 50 TSF by end-bearing and some 6.5 TSF by adhesion, mobilized along the shaft.

The provision of proper drainage behind the wall will be essential, since seepage along sandy seams within the railway fill was noted in the boreholes.

4.2.4) Subway Bridge under the C.N.R. Tracks:

a) Soil Conditions:

B.H.'s #7 and 24 were drilled near the east abutment of the proposed bridge, while Hole #6 was located in the vicinity of the west abutment. Due to the heavy traffic along the existing road and the adverse weather conditions, no borings could be placed closer to the future abutment. The overburden in the above boreholes was found to consist of a surficial mixed gravel and cinder fill, underlain by layers of clayey silt to silt with seams of sand

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.4) Subway Bridge under the C.N.R. Tracks: (cont'd.)...

a) Soil Conditions: (cont'd.) ...

and traces of gravel. In B.H.'s #24 and 6 overlying the sound bedrock a 13-ft. thick, hard glacial till, mixed with fractured and decomposed shale was encountered. The surface of the sound Queenston red shale dips steeply from el. 481.7 ft. in B.H. #7 down to el. 441.1 ft. in B.H. #6. The estimated cross section of the subsoils is shown on Drawing #71-11001C, Section D-D.

b) Recommendations:

The finished grade of the proposed subway line at the railway crossing will be around el. 430 ft. Due to the sloping bedrock surface, it is postulated that the northerly portion of the abutments of the proposed bridge could be supported on spread footings, placed on sound bedrock, and the southerly portion on drilled caissons, socketed at least 8 ft. into the bedrock. Remarks given under Subsection 4.2.3 b) as to lateral earth pressures and design loads on caissons are applicable for the foundations of the subway bridge as well. Spread footings on sound bedrock may be assumed to support loads of 10 TSF.

4.2.5) Cut Section Along the Realigned Station Road:

a) Soil Conditions:

B.H.'s #8, 27, 28 and 29 were drilled along the talus slope of the escarpment above the realigned Station Road in order to establish the depth of the talus and the degree of erosion of the various rock formations. Since it was felt that, at this early stage of planning, a more detailed soil and rock survey was not justified, the information obtained by the above borings was assumed to be representative along this approx. 300-ft. long portion of the slope. Soil and rock configuration established in the holes were projected, therefore, to the three cross sections, presented in Drawings #71-11001C and D, as Sections CC-DD and EE.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.5) Cut Section Along the Realigned Station Road:  
(cont'd.) ...

a) Soil Conditions: (cont'd.) ...

The talus is an irregular mixture of materials, derived from the various rocks, and from the glacial till on the top of the escarpment. The samples taken from the talus usually contained a fair amount of clay and silt size particles originating from weathered shales. The Grimsby-Thorold formations consist of layers of sandstone, which when weathered, disintegrate to sands. Numerous blocks of limestone, ranging from gravel sizes up to boulders of several feet thick, were hit in the boreholes. At certain depths very high penetration 'N' values were obtained within the overburden, albeit that portion of the talus having large rock fragments is the most recent deposit, and as such, has not yet had time to become consolidated.

b) Recommendations:

As is shown on the referred cross sections, the proposed Station Rd. will cut quite deeply into the escarpment slope. The geometry of the existing slope is indicative of previous slip failures or slow creeping downward movements. Experience with talus slopes indicates that such slopes are inherently unstable, in the long run, especially when disturbed by excavations unless the geometry is improved. Within the talus material it is suggested that the slopes above the new Station Rd. be built with 2-1/2 horizontal to 1 vertical within the overburden up to the intersection of the slope, with bedrock. On reaching the bedrock the slope may be excavated with 2 horizontal to 1 vertical within the shales and sandstones (Rochester, Grimsby-Thorold and Cabot Head groups). At the upper contact of the Grimsby-Thorold and of the Rochester members, 10-ft. wide benches should be built with intercepting drainage trenches for surface water and for water seeping through the permeable limestone layers. The slope

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.5) Cut Section Along the Realigned Station Road:  
(cont'd.) ...

b) Recommendations: (cont'd.) ...

within the Clinton limestone and Lockport dolomite may be constructed with 1/4 horizontal to 1 vertical. The geometry of these recommended slopes is shown on the cross sections on Drawing #71-11001C.

It is to be pointed out that the excavations within the overburden should start at the top, and proceed downward, so that at no time during the construction will the slopes be steeper than the approx. natural slopes within the talus. The above recommendations are conditional, based on the limited scale field work and must be further substantiated by a detailed talus and bedrock investigation during the pre-engineering stage. Further soil surveys might prove that even the 2-1/2 horizontal to 1 vertical slopes within the talus are not stable, in which case, the construction of a retaining wall, supported on bedrock will be necessary somewhere above the road, to augment slope stability. After the excavations are completed, the exposed shale and sandstone surfaces and the newly formed talus slopes should be protected by vegetation against surface erosion as soon as possible. An effective drainage system will have to be provided in order to eliminate surface water from entering the talus slopes.

4.2.6) Cut Section Along Proposed Hwy. #8 between Station 15+00 and 30+00:

a) Soil Conditions:

The subsoil and rock stratigraphy along this cut section was based on B.H.'s #9, 10, 11 and 12. The upper surface of the Lockport dolomite, at the top of the escarpment, was estimated by means of shallow hand-augered holes, numbered 14, 15 and 16.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.6) Cut Section Along Proposed Hwy. #8 between Station 15+00 and 30+00: (cont'd.) ...

a) Soil Conditions: (cont'd.) ...

The overburden in B.H.'s #9 and 10 was found to be mixed talus, the physical properties of which were similar to the ones described previously. In B.H. #12 the Lockport dolomite, Rochester shale, Clinton limestone, Grimsby-Thorold sandstones and the Cabot Head shale were proved by diamond drilling, some 60 ft. below rock surface. Cross sections, marked PF, GG, and HH, with the estimated soil and rock stratigraphy, are given on Drawings #71-11001E and 71-11001F.

b) Recommendations:

Immediately west of the proposed subway bridge the new line will cut into the escarpment, generally running along or near the existing highway. In order to provide room for the additional lanes, the escarpment has to be excavated some 40 - 60 ft. farther back towards the north. At this section of the escarpment the talus covering the rock was noted to be gradually diminishing westerly, and as the road ascends, around proposed Station 27+00 - 28+00, the covering talus entirely disappears. From this point on the escarpment above the road, consists of a cliff of exposed rocks.

It is anticipated that the first approx. 200 ft. length of the new line immediately west of the subway bridge will have to be excavated with the same procedures as were recommended for Station Rd., since the lower portion of the cut will stay within the talus. From around Station 18+00 westerly the full depth of the talus cover will likely be stripped by the excavations, and the final slopes be formed in the rock. No major stability problems are foreseen for these excavations, provided they are constructed with 2 horizontal to 1 vertical slopes within the

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.2) SUBWAY LINE: (cont'd.) ...

4.2.6) Cut Section Along Proposed Hwy. #8 between Station 15+00 and 30+00: (cont'd.) ...

b) Recommendations: (cont'd.) ...

shales and sandstones, and with 1/4 horizontal to 1 vertical within the limestone and dolomite formations. The 10-ft. wide benches with drainage ditches on top of the Grimsby-Thorold and Rochester shales should also be incorporated, as discussed earlier. On cross sections FF, GG and HH the approximate cut slopes are marked, with the intention to be used as guidelines for estimating purposes.

Recommendations given for the Station Rd. cuts for the actual method of excavating, drainage, and erosion control, should be followed along this section as well.

4.3) OVERHEAD LINE:

The easterly approx. 300-ft. length of the overhead line follows the same alignment as the subway scheme, consequently the proposed bridge over Spencer Creek and the retaining wall south of the highway, between Station 5+40 and Station 9+00 will be similar for both lines. Recommendations for these two structures, therefore, will not be repeated here. Further recommendations are given below for (1) the proposed high embankment between Station 15+00 and Station 26+00, (2) for the retaining wall north of the fill, and (3) for the overhead structure.

The estimated stratigraphical profile along the overhead line is shown on Drawing #71-11001A.

4.3.1) Proposed Embankment between Station 15+00 and Station 26+00:

a) Soil Conditions:

Boreholes #17, 18 and 19 were placed along the proposed high fill, while B.H.'s #21 and 23 were carried out at the estimated toe of the fills. A fairly deep deposit of fluvial soils, underlain by glacial tills were found to form the overburden beneath the

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.3) OVERHEAD LINE: (cont'd.) ...

4.3.1) Proposed Embankment between Station 15+00 and Station 26+00: (cont'd.) ...

a) Soil Conditions: (cont'd.) ...

proposed fill. The depth of overburden was observed to be around 25 ft. under the centre-line, increasing southerly, so that at the toe of the future fill it was measured to be some 46 - 50 ft. thick. The overburden was generally identified to be silt, sandy silt and clayey silt, with very slight plasticity. The average plastic limit was estimated to be around 15%, the liquid limit being 20 - 24%. The natural moisture contents are near the plastic limits or slightly above them, indicating a fairly stable structure. An appreciable amount of sand and some gravel size particles were noted within the strata. The uppermost 7 - 19 ft. thick portion of the overburden is brown in colour, with penetration 'N' values ranging from 10 blows per ft. up to 90 blows per ft. Below this depth the consistency of the grey-coloured material decreases somewhat, so that laboratory undrained shear strengths of approx. 600 PSF were measured around 20 ft. depth. Below this depth the shear strength increases again up to and over 2,000 PSF. Boreholes were terminated in reaching the Queenston shale bedrock between el. 452 ft. and 412 ft. The bedrock surface was found to dip in a southerly direction.

On cross sections FF and GG in the Appendix the estimated soil stratigraphy, together with the proposed fills, are plotted - (Drawing #71-11001E).

b) Recommendations:

The height of the proposed embankment between Station 15+00 and 17+30 will range from 5 ft. to 22 ft. No stability problems are anticipated within this section of the fill, since the subsoils have adequate strength to support fills up to 25 - 30 ft. height without detrimental deformations. Standard 2 horizontal to 1 vertical slopes should be constructed.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.3) OVERHEAD LINE: (cont'd.) ...

4.3.1) Proposed Embankment between Station 15+00 and  
Station 26+00: (cont'd.) ...

b) Recommendations: (cont'd.) ...

Between Station 17+50 and the overhead structure the height of the embankment will vary between 50 and 60 ft. at the centre-line. Due to the sloping topography, however, the fills between the top and the south toe of the slope will be as high as 100 ft. The economical design of an embankment of such height is considered to be a major engineering endeavour. The problem becomes even more involved by the sloping ground and the underlying subsoils, a portion of which, is the actual lower slope of the escarpment.

In considering the embankment alone, it is our experience that the performance of a fill much in excess of 30 ft. is often troublesome, when constructed of cohesive soils. Clays and silts, even when properly compacted, will not develop sufficient shear strength to remain stable with 2 to 1 slopes with the high fills. As a consequence, it is suggested that those portions of the fill less than 30 ft. height be constructed of cohesive material; for fills in excess of 30 ft., however, granular type materials should be used. It is further recommended that a 4 - 5 ft. thick layer of rock fill be placed first upon the ground, along the entire length and width of the fill to expedite drainage. Depressions in the ground beneath the embankment should be carefully eliminated prior to placing the rock fill so that no water could accumulate under the fill.

The stability of the subsoils under the high fill was analyzed by an electronic computer, using strength parameters in terms of total stresses. Calculations indicated that the fill, built with 2 horizontal to 1 vertical slopes, will require berms

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.3) OVERHEAD LINE: (cont'd.) ...

4.3.1) Proposed Embankment between Station 15+00 and Station 26+00: (cont'd.) ...

b) Recommendations: (cont'd.) ...

to maintain stability, between Station 17+50 and the overhead bridge. Since the north side of the fill will be supported by a retaining wall, berms of 100 ft. length at half height of the fill should be designed at the south slope. Surface drainage should be provided along the berm by a slope of 50 horizontal to 1 vertical. The width of the area necessary for the right-of-way will naturally increase by the construction of the berm. Since berms also ought to be built in the forward direction, a considerably longer structure will have to be designed for the overhead crossing.

4.3.2) Retaining Wall Along the North Side of the Fill - (Stations 21+00 and 26+00) - and

4.3.3) The Overhead Structure:

a) Soil Conditions:

Boreholes #20, 22 and 26 were carried out along the proposed retaining wall and near the overhead bridge. The thickness of the overburden ranges from 36 ft. to 47 ft., increasing westerly. The materials are mainly clayey silts with seams and layers of silty and gravelly sands. The subsoils in B.H. #20 were noted to be predominantly gravelly sands with irregular layers of clayey silts. The constituent gravels and boulders were identified to have originated from the various eroded rocks of the escarpment. The generally high penetration resistances indicated hard consistencies and very high relative densities. Shale bedrock was established around el. 484 ft. - 490 ft. and was proved by diamond drilling. In Hole #26 the upper approx. 3 ft. of the rock was badly weathered.

4. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

4.3) OVERHEAD LINE: (cont'd.) ...

4.3.2) Retaining Wall Along the North Side of the Fill -  
(Stations 21+00 and 26+00) - and

4.3.3) The Overhead Structure:

a) Soil Conditions: (cont'd.) ...

The estimated soil profile along the proposed wall is shown on Drawing #71-11001F (Wall #3), together with a cross section (R-H) through the proposed overhead bridge.

b) Recommendations:

The retaining wall is proposed to sustain the approach embankment at the north side, where, due to the C.N.R. tracks, no space is available for the slopes. The height of the fill so retained at the location of the wall will be around 32 - 35 ft. A very high bridge will be required for the overhead structure, the proposed grade of the bridge being some 60 - 62 ft. higher than the C.N.R. tracks. Regardless of the high strength of the overburden, spread footings cannot be recommended for these structures on account of the unstable structure of the escarpment. Pile driving through the very bouldery material would also be difficult, if not impossible. It is suggested that both structures be supported on drilled caissons, the minimum diameter of which should be 30 inches. Caissons will have to be socketed at least 8 ft. into the bedrock. It is again estimated, that the bedrock will sustain 50 TSF design loads by end-bearing and will mobilize adhesions of 6.5 TSF along the shaft, embedded in sound rock.

5. CONCLUDING REMARKS:

Soils and foundation investigations carried out along the two alignments of the proposed Hwy. #3 at the Niagara Escarpment, west of Dundas, have been reported. On account of the inherently unstable nature of the talus slopes, numerous problems are anticipated regarding structure foundations, embankment and cut stabilities.

5. CONCLUDING REMARKS: (cont'd.) ...

In considering the type of foundations for structures, it was realized that large lateral earth pressures will develop behind retaining walls and bridge abutments, pressures being further augmented by possible creep of the talus slopes. For these reasons, bridges and retaining walls along both lines are recommended to be supported on drilled caissons of a minimum diameter of 30 inches, socketed some 4 - 8 ft. into the bedrock. It has been estimated that the Queenston shale bedrock under the caissons will develop safe strengths of 50 TSF by end-bearing and will mobilize 6.5 TSF adhesion between the caisson shaft and the sound rock.

The subway line and the realigned Station Rd. will cut deeply into the talus slope and into the various rock formations of the escarpment. Special recommendations are given in the report for slopes within the talus, and for slopes intersecting the limestone and shaley layers. A detailed soil and rock survey will be required for the actual design of the slopes along these sections.

The foundation and stability problems relative to the construction of the high embankment along the overhead line were discussed at some length in Sub-section 4.3.1). Considering all the engineering difficulties and the probable exorbitant cost of such an enormous granular fill, the economical feasibility of the entire overhead line becomes indeed questionable.

In conclusion, it may be stated that the proposed subway line appears to be more attractive from the foundation and geotechnical point of view, than the overhead line.

6. MISCELLANEOUS:

The field investigation was carried out during the period January 5 - February 9, 1971, by Messrs. H. Szymanski and H. Stankaitus, Engineering Technicians, under the supervision of Mr. A. K. Bersvary, Senior Foundation Engineer, who also prepared this report.

6. MISCELLANEOUS: (cont'd.) ...

Equipment used was owned and operated by P.V.K. Drilling Company, Burford, Ontario.

The report was reviewed by Mr. K. C. Selby, Supervising Foundation Engineer.

April, 1971

APPENDIX I

FOUNDATION SECTION

ORIGINATED BY HS  
COMPILED BY AKB  
CHECKED BY

[illegible]

CHECKED BY

[illegible]

FOUNDATION SECTION

CHECKED BY

[illegible]

FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

CHECKED BY

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FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

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FOUNDATION SECTION

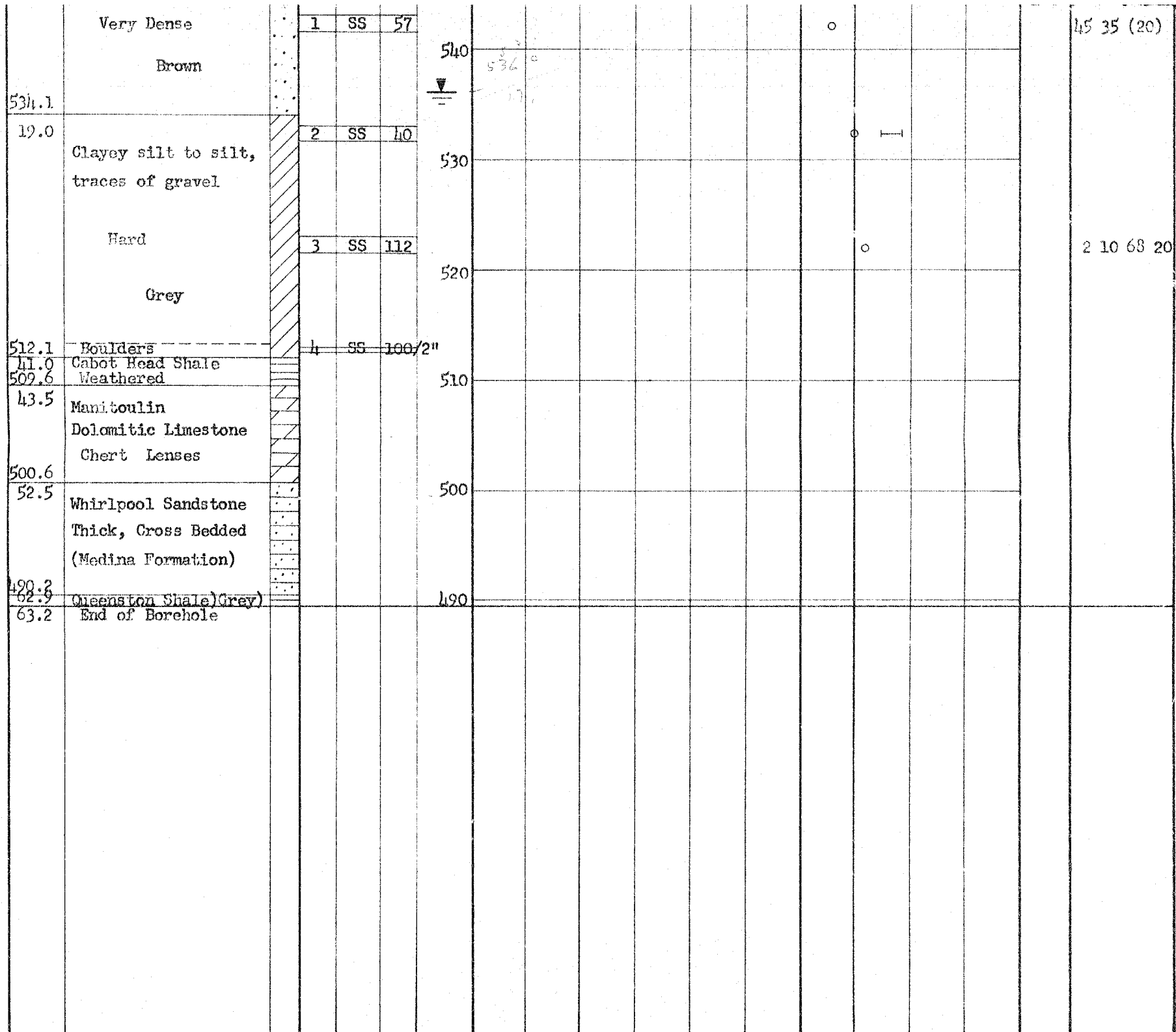
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COMPILED BY AKB

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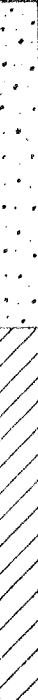

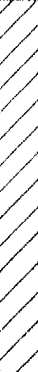
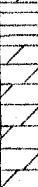
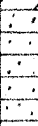


FOUNDATION SECTION

ORIGINATED BY HHS

COMPILED BY AKB

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— W <sub>L</sub> PLASTIC LIMIT ——— W <sub>P</sub> WATER CONTENT ——— W			BULK DENSITY Y	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		WATER CONTENT %					
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE	W <sub>P</sub>	W	W <sub>L</sub>			
553.1	Ground Level											P.C.F.	GR. SA. SI. CL.	
0.0	Sandy gravel with some silt.					550								
	Very Dense		1	SS	57									45 35 (20)
	Brown					540								
534.1														
19.0	Clayey silt to silt, traces of gravel		2	SS	110	530								
	Hard		3	SS	112									2 10 68 20
	Grey					520								
512.1	Boulders		4	SS	100/2"									
41.0	Cabot Head Shale					510								
509.6	Weathered													
43.5	Manitoulin Dolomitic Limestone Chert Lenses													
500.6														
52.5	Whirlpool Sandstone Thick, Cross Bedded (Middle Formation)					500								

FOUNDATION SECTION

ORIGINATED BY JIS

COMPILED BY AKB

CHECKED BY

[illegible]

FOUNDATION SECTION

JOB	71-11001	LOCATION	Exist. Hwy. 8 Sta. 16 +47 114' Rt.	ORIGINATED BY	HS
W.P.	536-56	BORING DATE	Jan. 29 - Feb. 3, 1971	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Washboring, NK Casing	CHECKED BY	

[illegible]

FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

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[illegible]

Dolomite

608.4

2 BXL 92%

610

19.6

Rochester Shale

3 BXL 98%

600

600.2

27.8

Clinton Limestone

4 BXL 100%

590

586.5

41.5

Grimsby-Thorold  
Shale & Siltstone

580

578.0

50.0

Cabot Head Shale

5 BXL 97%

570

567.2

60.8

End of Borehole

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 12

FOUNDATION SECTION

JOB 71-11001 LOCATION Exist. Hwy. 8 Sta. 26 + 60 69' Rt. ORIGINATED BY HS  
 W.P. 536-56 BORING DATE Feb. 16 - 19, 1971 COMPILED BY AKB  
 DATUM Geodetic BOREHOLE TYPE Washboring, BXL Core Drilling CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$		BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT % $w_p$ — $w$ — $w_L$			
628.0	Ground Level											
626.7 1.3	Topsoil											
	Lockport Dolomite		1	BXL	96%	620						
			2	BXL	92%	610						
608.4 19.6	Rochester Shale		3	BXL	98%	600						
600.2 27.8	Clinton Limestone					590						
586.5 41.5	Grimsby-Thorold Shale & Siltstone		4	BXL	100%	580						
578.0 50.0	Cabot Head Shale		5	BXL	97%	570						
567.2 60.8	End of Borehole											

FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

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FOUNDATION SECTION

JOB	1-11001	LOCATION	Exist. Hwy. 3 Sta. 12 + 82 300' Rt.	ORIGINATED BY	HS
W.P.	536-56	BORING DATE	Jan. 21, 1971	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Hand auger	CHECKED BY	

[illegible]

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MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 15

FOUNDATION SECTION

JOB 71-11001 LOCATION Exist Hwy. 8 Sta. 15 + 00 260' Rt. ORIGINATED BY HS  
 W.P. 536-56 BORING DATE Jan. 21, 1971 COMPILED BY AKB  
 DATUM Geodetic BOREHOLE TYPE Hand auger CHECKED BY 20

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— $W_L$ PLASTIC LIMIT ——— $W_p$ WATER CONTENT ——— $W$				BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				$W_p$ ——— $W$ ——— $W_L$ WATER CONTENT %					
630.2	Ground Level															
628.4	Probable Bedrock															
1.8	End of Borehole															

## FOUNDATION SECTION

JOB	<u>71-11001</u>	LOCATION	<u>Exist. Hwy. 8 Sta. 20+00 159' Rt.</u>	ORIGINATED BY	<u>KS</u>
W.P.	<u>536-56</u>	BORING DATE	<u>Jan. 21, 1971</u>	COMPILED BY	<u>AKB</u>
DATUM	<u>Geodetic</u>	BOREHOLE TYPE	<u>Hand Auger</u>	CHECKED BY	<u></u>

[illegible]

FOUNDATION SECTION

JOB	71-11001	LOCATION	Exist. Hwy. 3 Sta. 10 + 92 100' Lt.	ORIGINATED BY	HS
W.P.	536-56	BORING DATE	Jan. 22, 1971	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Auger	CHECKED BY	

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 18

FOUNDATION SECTION

JOB	71-11001	LOCATION	Exist. Hwy. 8 Sta. 15 + 16 163' Lt.	ORIGINATED BY	HS
W.P.	536-56	BORING DATE	Jan. 15, 1971	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Auger	CHECKED BY	

[illegible]



FOUNDATION SECTION

JOB	71-11001	LOCATION	Exist. Hwy. 8 Sta. 20 + 00 122' Lt.	ORIGINATED BY	HS
W.P.	536-56	BORING DATE	Mar. 4-8, 1971	COMPILED BY	AKB
DATUM	Geodetic	BOREHOLE TYPE	Washboring, BX Casing	CHECKED BY	

[illegible]

Oversized Drawings

Record of Borehole No. 21.  
22

FOUNDATION SECTION

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OVERSIZED DRAWINGS

record of borehole no. 24

25

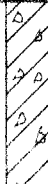

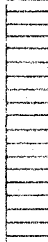
26

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 27

FOUNDATION SECTION

JOB 71-11001 LOCATION Exist. Hwy. 8 Sta. 11 + 37 240' Rt. ORIGINATED BY HS  
 W.P. 536-56 BORING DATE Feb. 11, 1971 COMPILED BY AKB  
 DATUM Geodetic BOREHOLE TYPE Washboring, BX & NX Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT ——— $w_L$ PLASTIC LIMIT ——— $w_p$ WATER CONTENT ——— $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT.	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE			$w_p$ ——— $w$ ——— $w_L$ WATER CONTENT % 10 20 30				
558.3	Ground Level													
0.0	Clayey silt with gravel, traces of sand.		1	SS	70/7"	550								
	Decomposed shale & limestone talus.		2	SS	58									
540.3	Hard		3	SS	100/6"	540								
18.0	Shale Bedrock		4	RC	55%									
	Grey		5	RC	65%	530								
	Cabot Head Formation		6	RC	90%									
525.3														
33.0	End of Borehole													

FOUNDATION SECTION

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COMPILED BY AKB

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FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

CHECKED BY *[Signature]*

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## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE "N" - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>"N" BLOWS/FT.</u>	<u>c LB / SQ FT</u>	<u>DENSENESS</u>	<u>"N" BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W	THINWALL OPEN
W.S	WASHED SAMPLE	T.P	THINWALL PISTON
S.B	SCRAPER BUCKET SAMPLE	O.S	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE
S.T	SLOTTED TUBE SAMPLE		
	P.H		SAMPLE ADVANCED HYDRAULICALLY
	P.M		SAMPLE ADVANCED MANUALLY

### SOIL TESTS

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY

# ABBREVIATIONS USED IN THIS REPORT

## SOIL PROPERTIES

## GENERAL

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_c$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF $\sigma$
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF $\sigma$ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

## STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

## EARTH PRESSURE

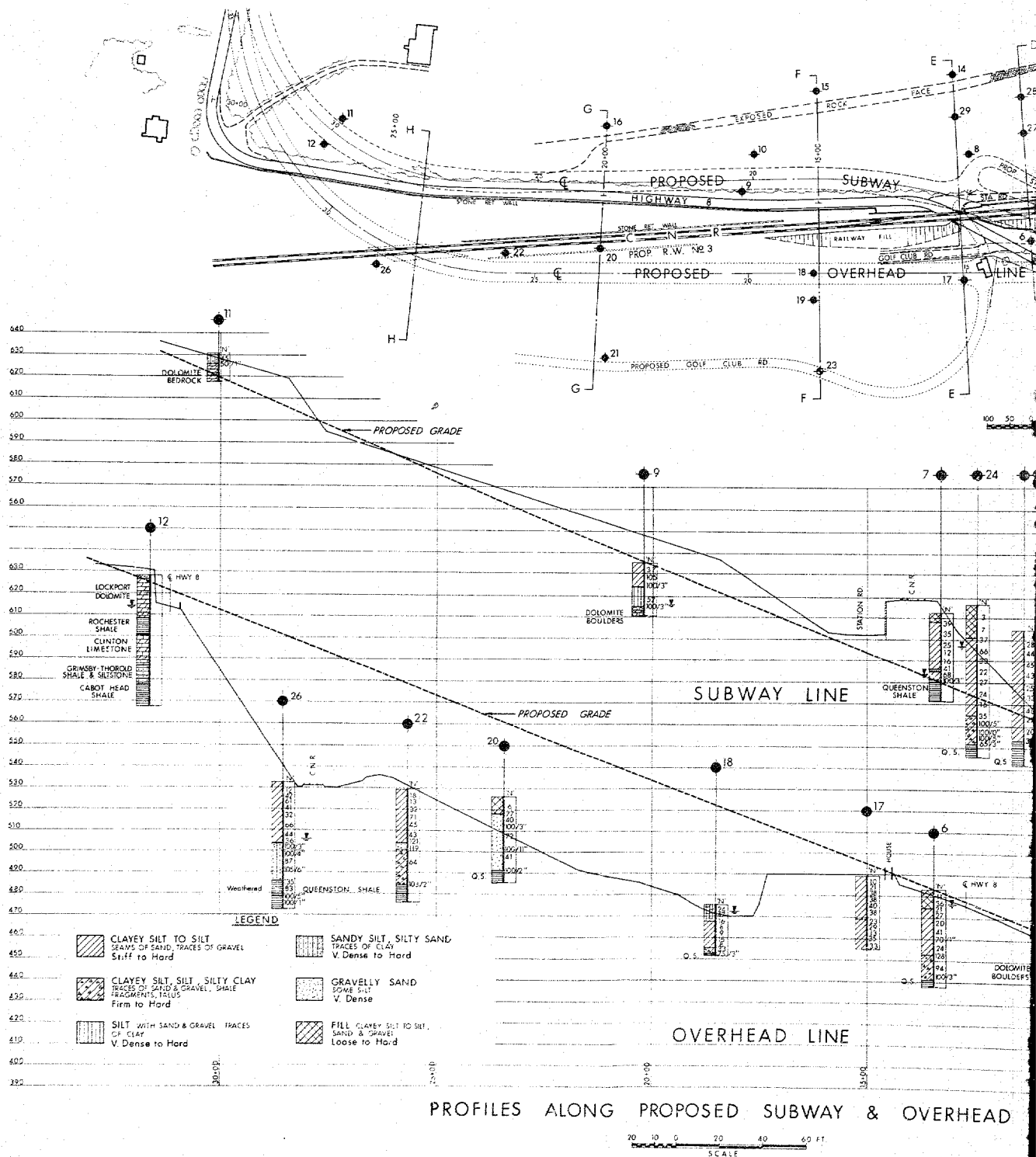
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

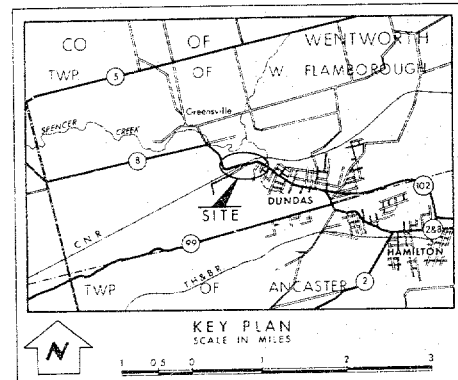
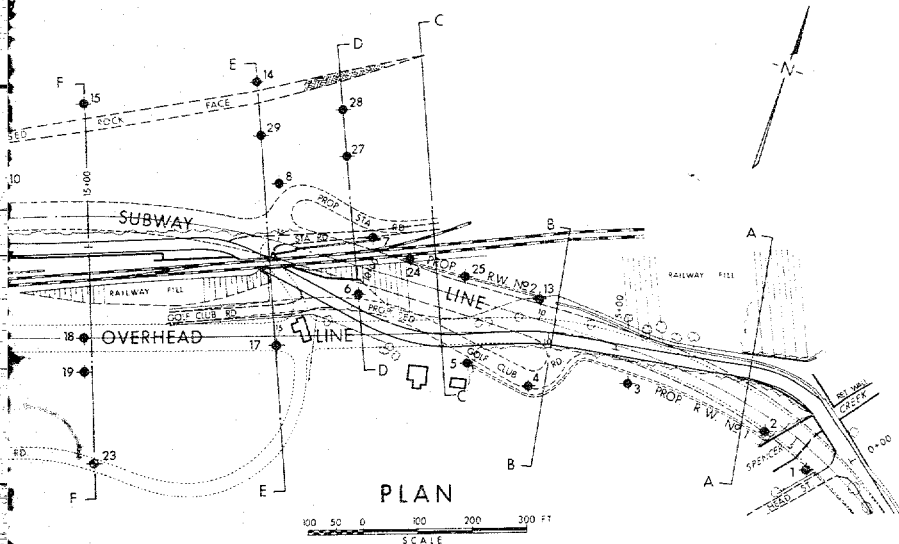
## FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

## SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL





**LEGEND**

- Bore Hole
- ⊕ Cone Penetration Hole
- ⊕ Bore & Cone Penetration Hole
- ↓ Water Levels established at time of field investigation JAN & FEB 1971

NOTE - Water Level in Bore Holes 5, 11, 17, 20 & 22 not established at time of investigation.

NO.	ELEVATION	EXIST. HWY 8 STATION	EXIST. HWY 8 OFFSET
1	400.8	0 + 30	75.11
2	398.8	0 + 30	100.11
3	401.1	0 + 30	35.11
4	402.2	0 + 30	35.11
5	404.4	0 + 30	40.11
6	402.2	0 + 30	10.11
7	401.1	0 + 30	133.11
8	401.1	0 + 30	133.11
9	401.1	0 + 30	133.11
10	401.1	0 + 30	133.11
11	401.1	0 + 30	133.11
12	401.1	0 + 30	133.11
13	401.1	0 + 30	133.11
14	401.1	0 + 30	133.11
15	401.1	0 + 30	133.11
16	401.1	0 + 30	133.11
17	401.1	0 + 30	133.11
18	401.1	0 + 30	133.11
19	401.1	0 + 30	133.11
20	401.1	0 + 30	133.11
21	401.1	0 + 30	133.11
22	401.1	0 + 30	133.11
23	401.1	0 + 30	133.11
24	401.1	0 + 30	133.11
25	401.1	0 + 30	133.11
26	401.1	0 + 30	133.11
27	401.1	0 + 30	133.11
28	401.1	0 + 30	133.11
29	401.1	0 + 30	133.11

**-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

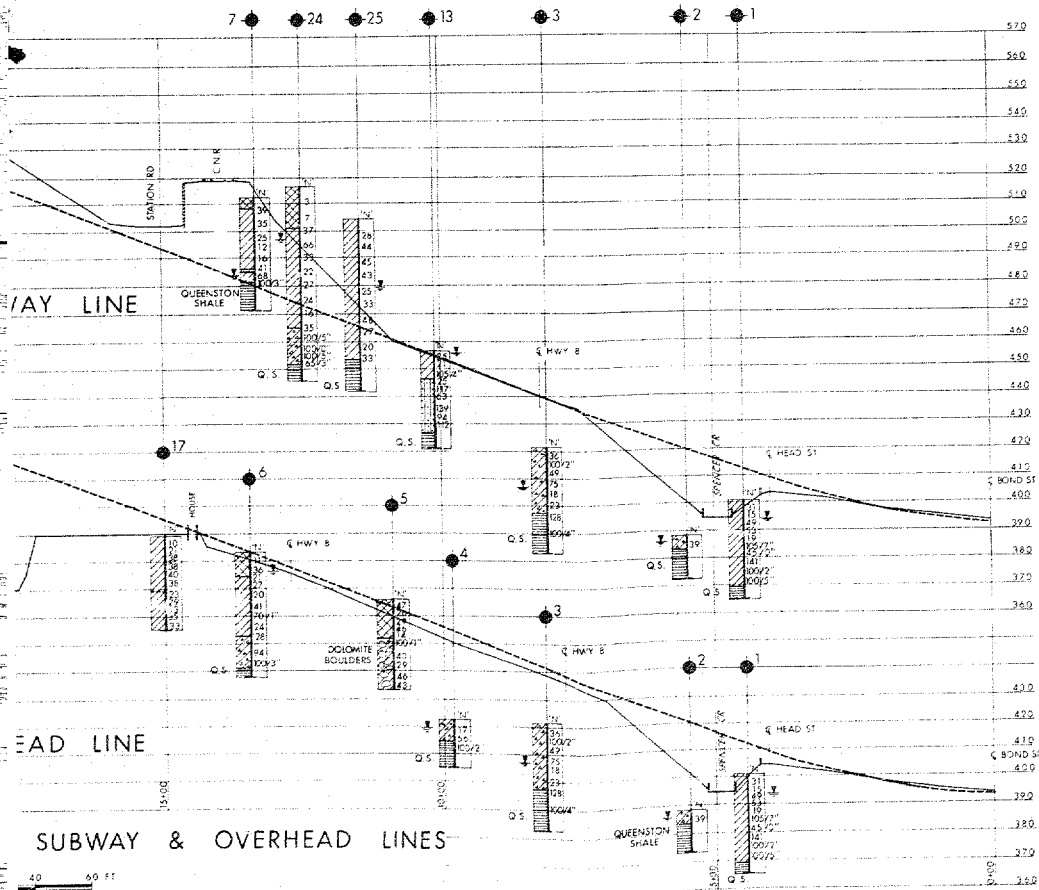
DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

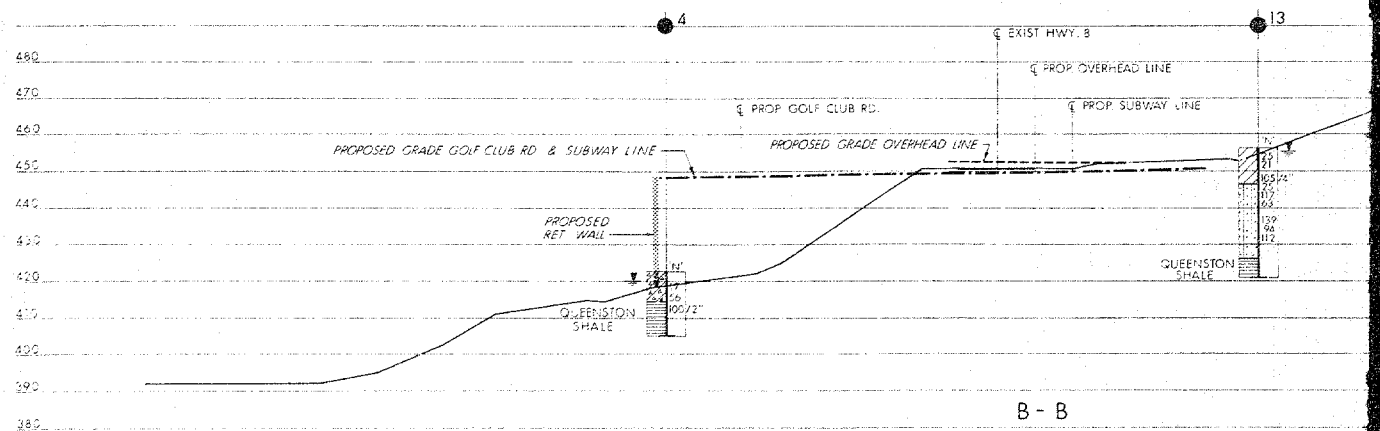
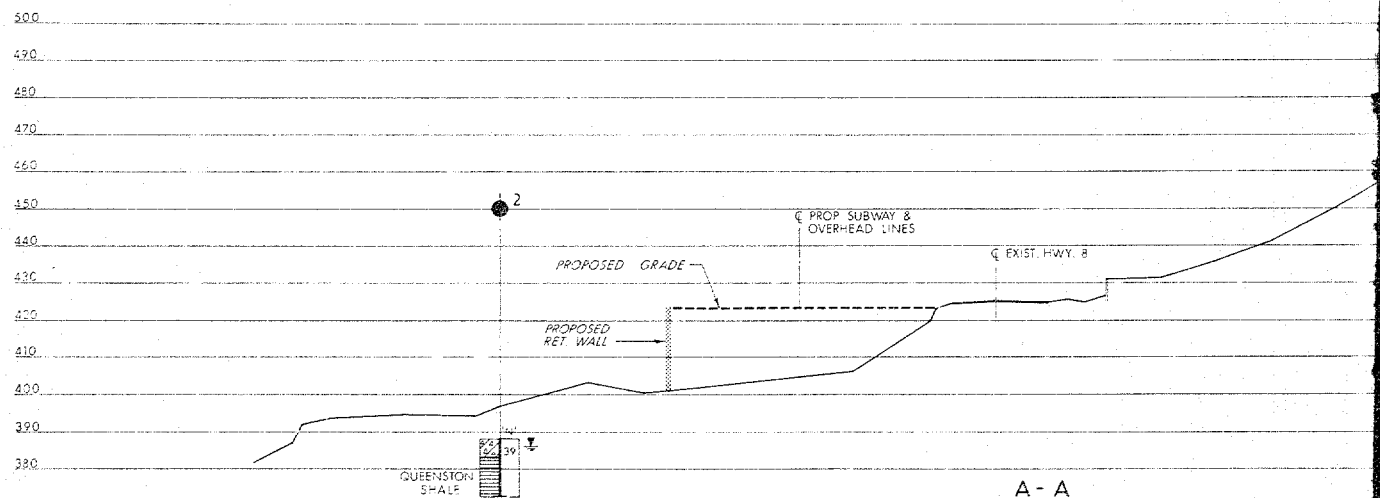
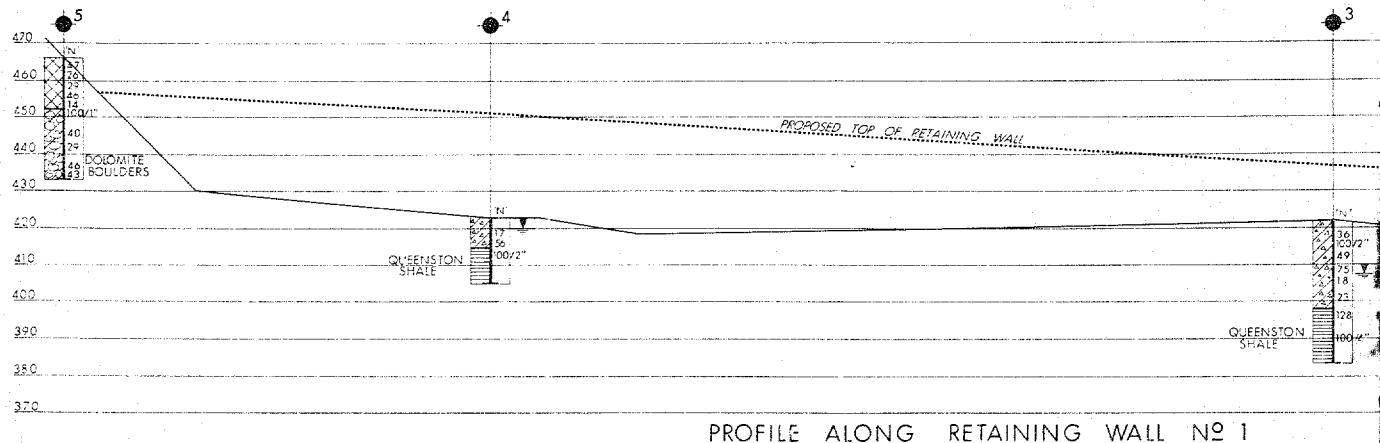
**PROPOSED HWY. 8 IMPROVEMENT  
(WEST OF DUNDAS)**

HIGHWAY NO. 8 RE-ALIGNMENT DIST NO. 4  
CO. WENTWORTH  
TWP. E. FLAMBOROUGH LOT   CON.  

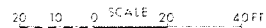
**BORE HOLE LOCATIONS & SOIL STRATA**

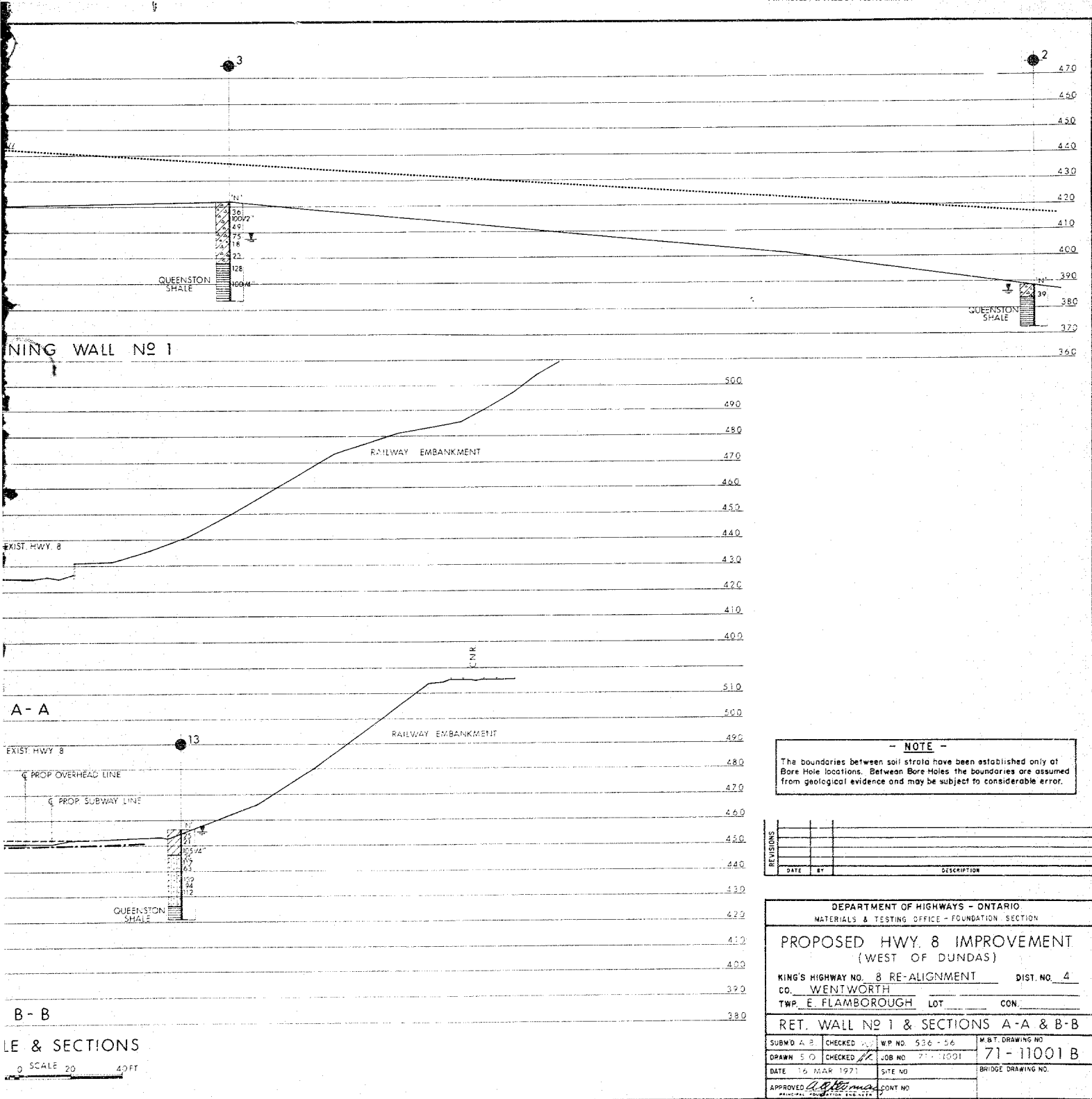
SUBM'D A/B	CHECKED <u> </u>	WP NO. <u>536-55</u>	M & T DRAWING NO. <u>71-11001 A</u>
DRAWN: S.O.	CHECKED <u> </u>	JOB NO. <u>71-11001</u>	BRIDGE DRAWING NO. <u> </u>
DATE <u>15 MAR. 1971</u>	SITE NO. <u> </u>	CONT NO. <u> </u>	
APPROVED <u> </u>	PRINCIPAL FOUNDATION ENGINEER		



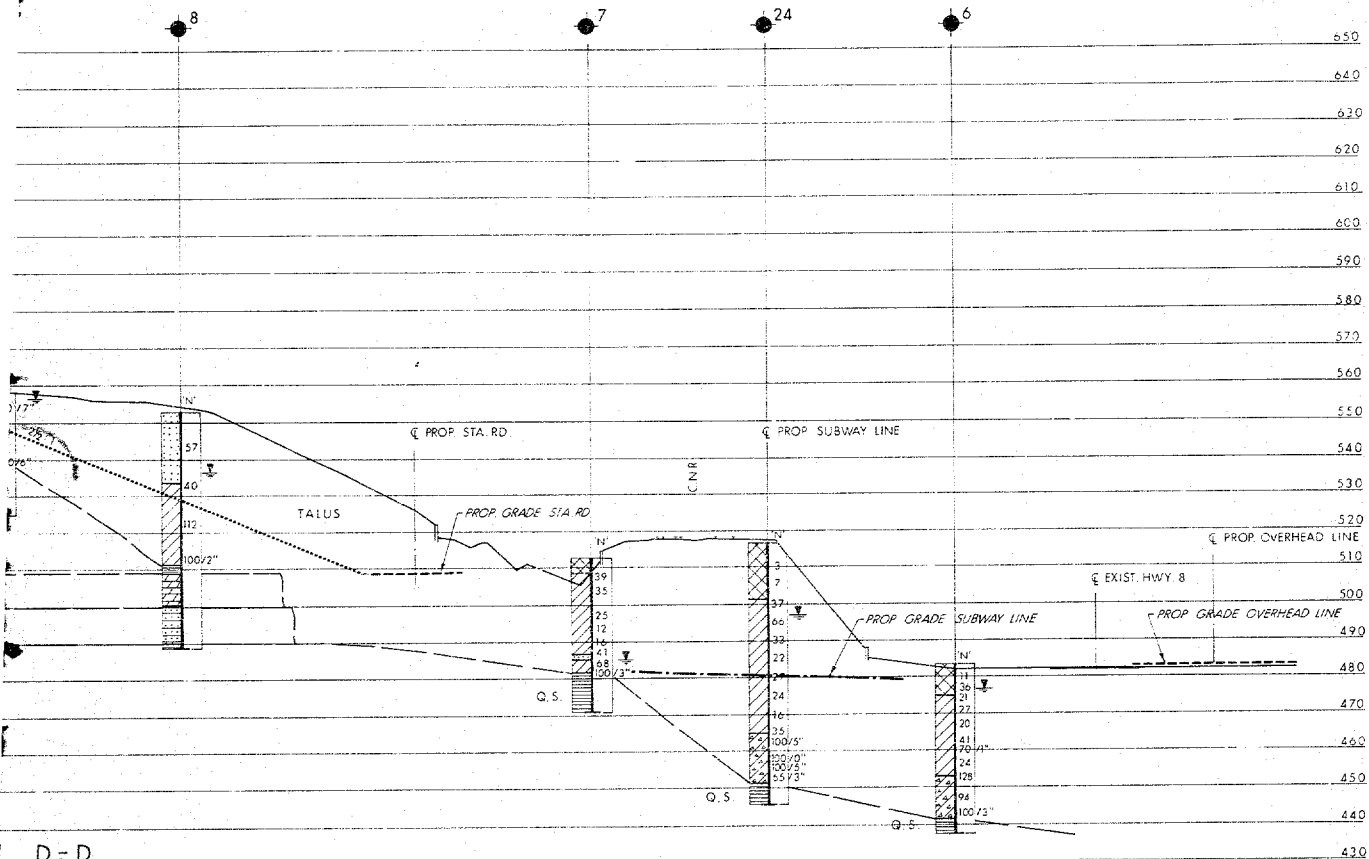


## PROFILE & SECTIONS

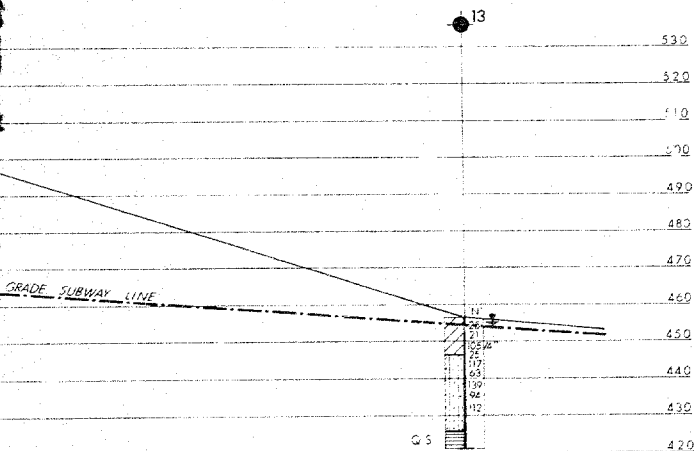








D-D



**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

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

**PROPOSED HWY 8 IMPROVEMENT  
(WEST OF DUNDAS)**

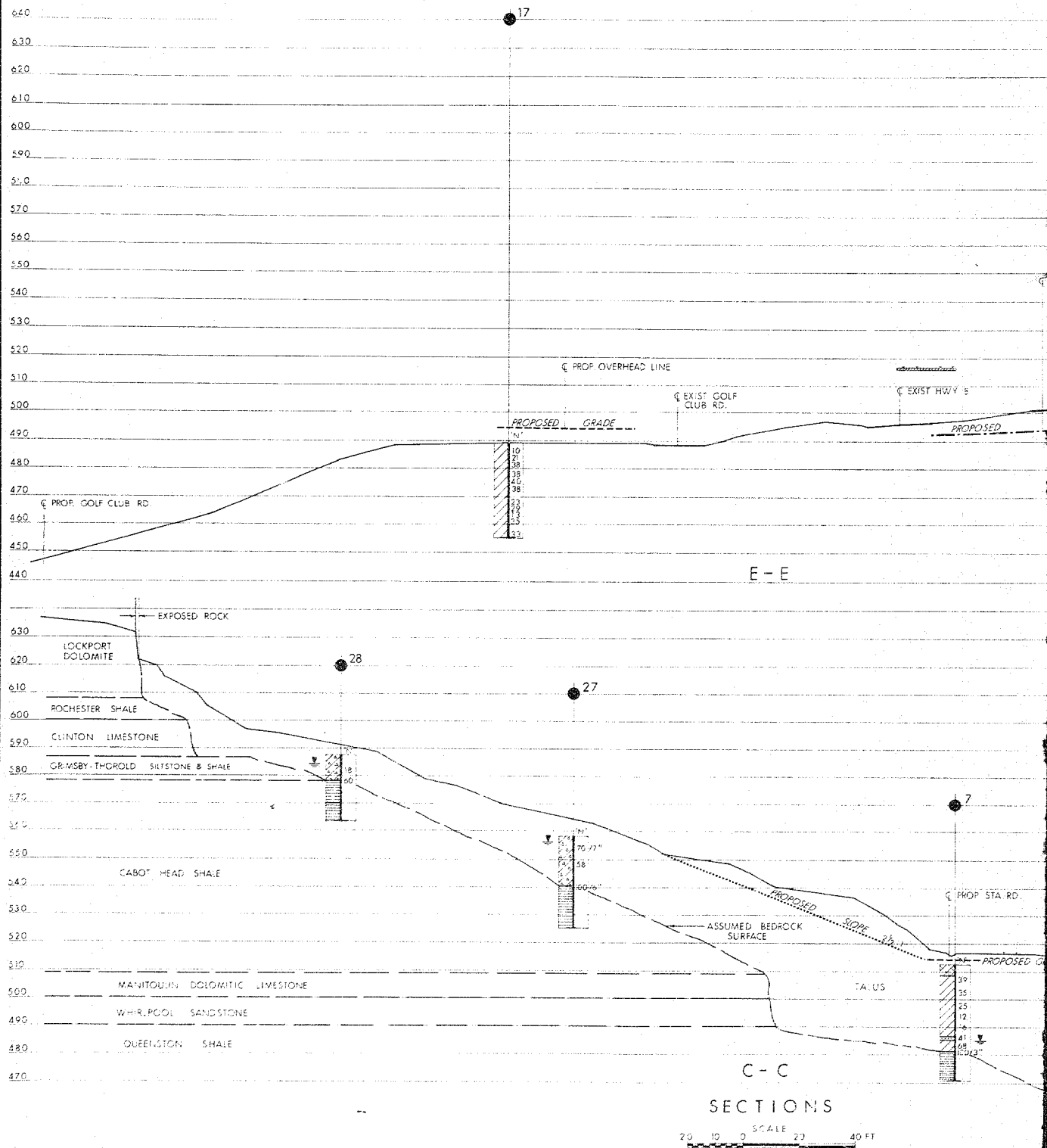
KING'S HIGHWAY NO. 8 RE-ALIGNMENT DIST. NO. 4  
CO. WENTWORTH  
TWP. E. FLAMBOROUGH LOT. CON.

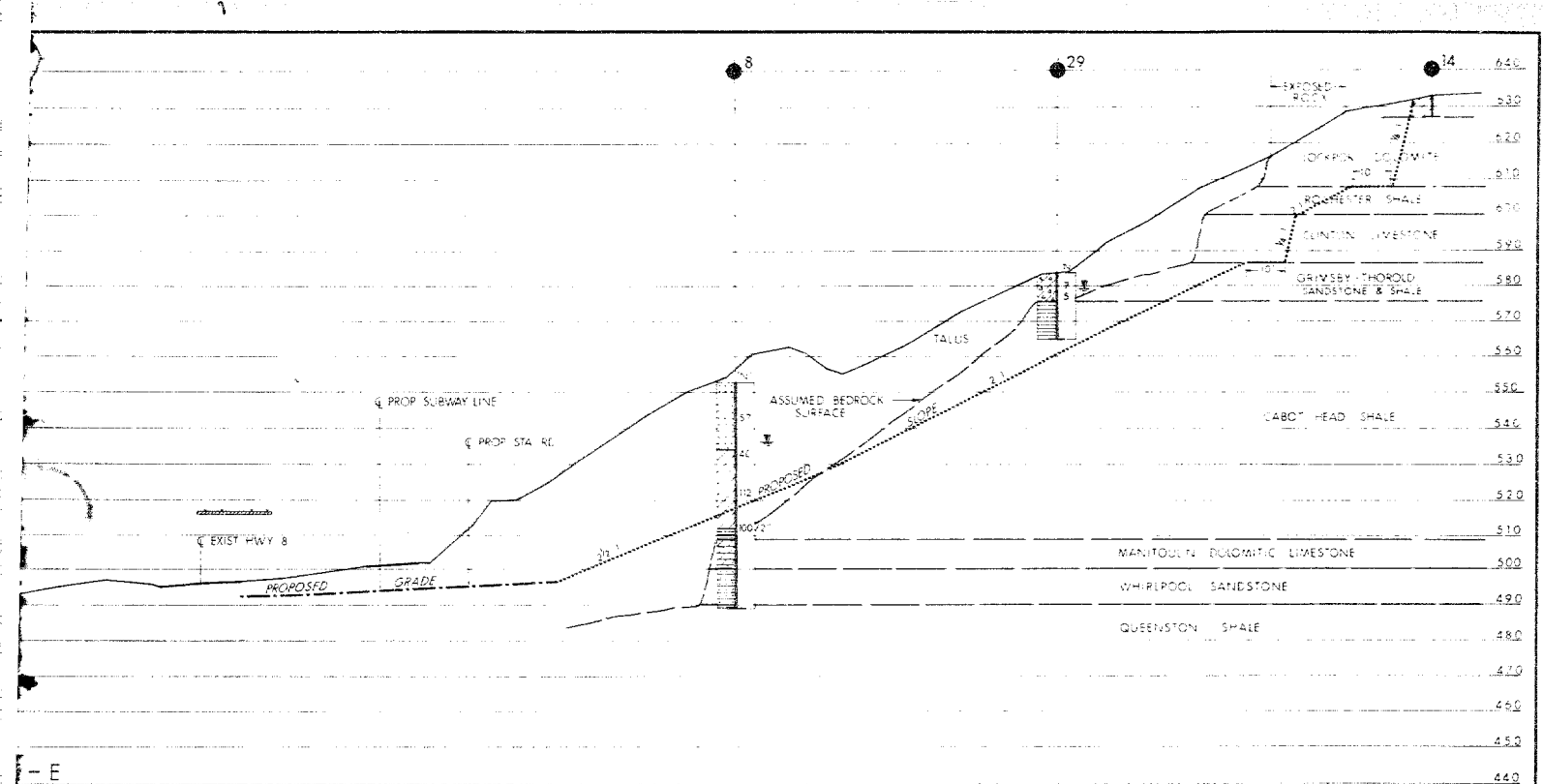
**RETAINING WALL NO 2 & SECTION D-D**

SUBA. A B	CHECKED <input checked="" type="checkbox"/>	W.P. NO. 536-56	M.B.T. DRAWING NO.
DRAWN S O	CHECKED <input checked="" type="checkbox"/>	JOB NO. 71-11001	71-11001 C
DATE 18 MAR 1971	SITE NO.	BRIDGE DRAWING NO.	
APPROVED <i>A. J. Thomas</i>	CONT. NO.		

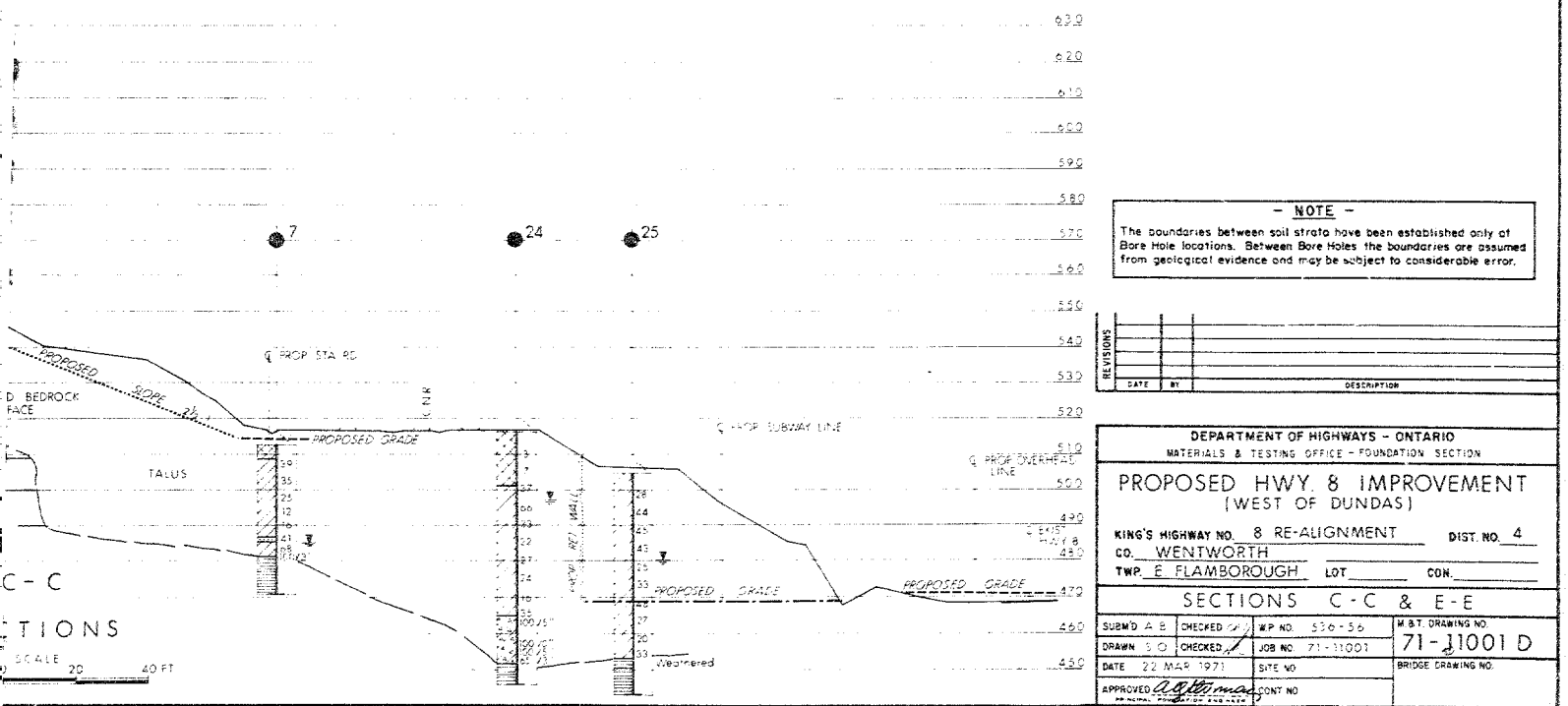
RETAINING WALL NO 2

SCALE 20 40 FT





E-E



**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

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

**PROPOSED HWY. 8 IMPROVEMENT  
(WEST OF DUNDAS)**

KING'S HIGHWAY NO. 8 RE-ALIGNMENT DIST. NO. 4  
CO. WENTWORTH  
TWP. E FLAMBOROUGH LOT CON.

**SECTIONS C-C & E-E**

SUBMD A-B	CHECKED	WP NO. 530-56	M.B.T. DRAWING NO.
DRAWN 50	CHECKED	JOB NO. 71-11001	71-11001 D
DATE 22 MAR 1971	SITE NO.	BRIDGE DRAWING NO.	
APPROVED <i>Algerman</i>	CONT NO.		

630

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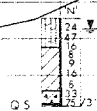
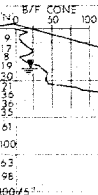
210

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18



F - F

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200

21

C PROP GOLF CLUB RD

PROPOSED BERM

2:1

C EXIST GOLF CLUB RD.

PROPOSED GRADE

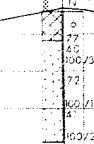
2:1

C PROP OVERHEAD LINE

PROPOSED RET WALL

20

CNR



G - G

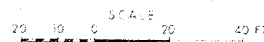
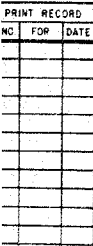
SECTIONS

20 10 0 SCALE 20 40 FT

PRINT RECORD

NO. FOR DATE







MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. A. G. Stermac,  
Principal Foundation Engineer,  
West Building.

FROM: G. C. E. Burkhardt,  
Structural Planning Office,  
3501 Dufferin Street.

ATTENTION: K. Selby

DATE: January 17, 1973.

DUP FILE REF.

IN REPLY TO

SUBJECT: Proposed Improvement of Highway #8  
Along the Niagara Escarpment,  
West of Dundas, Ontario,  
W.P. 536-56, District 4.

71-11-001

Attached are copies of the plan, profile and cross-sections for the proposed improvements.

As per our conversation, would you please arrange for a review of Foundation Investigation Report W.O. 71-11001 in relation to the high retaining walls as shown on the attached plans. Your comments and recommendations will be appreciated.

WMK:lc  
Attach.

*W. M. Killin*  
W. M. Killin,  
for:  
G. C. E. Burkhardt,  
REG. STRUCTURAL PLANNING ENG.

c.c. J. Cullen  
R. Fitzgibbon



Ontario

Ministry of  
Transportation  
and  
Communications

Box 5020, Burlington L7R 3Z9  
May 2, 1973

MINUTES OF PLANNING REVIEW MEETING HELD APRIL 27, 1973 IN BOARDROOM #2-HAMILTON DIST. OFFICE

SUBJECT: TUNNEL CULVERT COLLAPSE  
TOWN OF DUNDAS  
HIGHWAY NO. 8, OSLER DRIVE

In attendance:-

Philips Planning & Engineering Ltd.  
D. Tefft  
G. Sardesai

Town of Dundas  
P. Morris

Golder Associates  
D. Townsend

M.T.C.  
V. R. Astrop.....Structural Office, Downsview  
✓ K. G. Selby.....Foundation Section, Downsview  
H. Donnelly.....Asst. to Municipal Engineer  
A. L. Laidman.....Asst. Eng. Office Supervisor

Soils Conditions

Bore Hole Tests were taken for proof of seepage and actual void possibilities.

Basically, material is sandy to clayey silt material by classification with in situ material at 80% silt.

Ground water level is approximate elevation 258 with bottom of tunnel culvert at 252± elevation which indicates artesian pressures. Previous bore holes to rock level showed piezometric water level up to 268 elevation. Ground water is approximately 8 feet above required culvert footings.

Liquid content of soils, in the strata in which the culvert is situated, range from 20% to 30% with optimum moisture assumed as less than 18%. The upper 20 feet of material contains water content within the optimum range.

A total of 4 alternate schemes for reconstruction were discussed along with estimated costs, advantages and disadvantages of each scheme.

continued/2

MINUTES OF PLANNING REVIEW MEETING  
TUNNEL CULVERT COLLAPSE  
TOWN OF DUNDAS

-2-

May 2, 1973

Messrs. Astrop and Selby indicated that they prefer the placing of a concrete box culvert with sheet piling and H pile lagging to be used as outside forms of said culvert and this piling to remain in the work. The well points should be brought up through the floor of the culvert to provide a permanent bleed off of artesian pressures.

The box culvert connection to C.S.P. culvert would have to be designed for a proper transfer of pressure.

The meeting came to the conclusion that scheme #4 should be developed by the consultants.

A tentative target date for the awarding of a contract was discussed and a date in early August, 1973 was indicated as being possible.

Meeting adjourned at 11:00 A.M.

*A. L. Laidman*

A. L. Laidman  
Asst. Eng. Office Supervisor

ALL:cdk

c.c. All Attending  
C. R. Robertson  
J. P. Marcolin  
L. Fiander





**Golder Associates**  
CONSULTING GEOTECHNICAL ENGINEERS

73-11027  
X. 3151 WHARTON WAY, MISSISSAUGA (TORONTO), ONTARIO, CANADA.

• 1796 COURTWOOD CRESCENT, OTTAWA, ONTARIO. K2C 2B5

• 747 HYDE PARK ROAD, LONDON, ONTARIO. N6H 3S5

• 2479 HOWARD AVENUE, WINDSOR, ONTARIO. N8X 3V7

TRANSMITTAL FORM

CONSIGNEE: Ministry of Transportation and  
Communications  
Designs Services Branch,  
Downsview 464, Ontario

DATE: April 30, 1973

ATTENTION: Mr. K. Selby, P. Eng

PROJECT No.: 73047

RE: Culvert Collapse, Highway & Dundas, Ontario

Sent by:-

☐ MESSENGER

☐ UNDER SEPARATE COVER

☒ ENCLOSED

No.  
Copies

Item

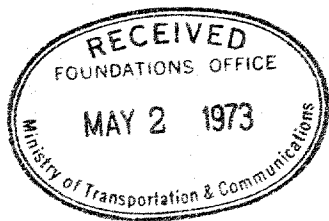
Description

1

BOREHOLE  
LOGS AND FIGS.

Remarks:

Per \_\_\_\_\_





ONTARIO

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

Box 5020, Burlington L7R 3Z9  
March 29, 1973

MINUTES OF A SITE MEETING HELD MARCH 28, 1973 IN THE TOWN OF DUNDAS

Project: Town of Dundas - Highway No. 8 - Connecting Link  
Binkley's Hollow Culvert (15.0Ø Steel Multi-Plate)

Present:-

H. Law.....	Chairman of the Public Works Committee-Dundas	
P. Morris.....	Town Engineer	-Dundas
J. Wilson.....	Manager-Public Utilities Commission	-Dundas
J. Langridge.....	" " "	-Dundas
J. Marcolin.....	Municipal Engineer-M.T.C. - Hamilton District	
H. Donnelly.....	Asst. to Municipal Engineer	" "

An on-site meeting was held at 10:30 A.M. at which time the failure of the tunnelled section of the above subject culvert was viewed and the associated damage to the existing watermains and roadway was discussed.

The tunnelled section of the culvert showed severe signs of rupture. Timber struts were being installed in an attempt to avoid or delay its apparent eminent collapse. The two westbound lanes of the road (Hwy. 8) had settled considerably and were closed to traffic. There are two watermains crossing the culvert area situated at a depth of approximately 12.0 feet in the fill embankment over the culvert. These watermains are a 16" Ø and a 12" Ø located on opposite sides of the road. The 12" Ø main on the north side of the road (westbound) had fractured apparently due to the road settlement and had been shut off. The 16" Ø main was still operative and providing service to the Town; however, the P.U.C. were concerned in restoring service in the 12" main in case the 16" main should also fracture. The P.U.C. representative indicated they would prefer to replace the 12" main in its final location rather than get involved in a major relocation. In the event of an emergency it was indicated that the 12" main could be temporarily restored to service within 24 hours. It was agreed that the latter arrangement was preferred provided an early decision could be reached with respect to the remedial action to be taken to correct the culvert and road failure. The Ministry's representatives advised that they would contact their Foundations Office and Structural Section and arrange for members of these offices to inspect the site as quickly as possible. This meeting was then adjourned pending comment from the above-mentioned two Ministerial offices.

A further site meeting took place on the same day at 2:00 P.M. with the following in attendance:-

continued/2

MINUTES OF SITE MEETING  
BINKLEY'S HOLLOW CULVERT

-2-

March 29, 1973

K. Selby.....Foundations Office - Downsview  
R. Astrop.....Municipal Structural Section - Downsview  
G. Sardesai.....Consultant - Philips Planning & Engineering  
P. Morris.....Town Engineer - Town of Dundas  
J. Marcolin.....Municipal Engineer - M. T. C. - Hamilton  
H. Donnelly.....Asst. to Municipal Eng. " "

It was generally agreed to, that the existing tunnel section of the subject culvert had failed to a point of non-repair. It was suggested, however, that the Town approach Armco Metal Products, the supplier of the culvert material, to inspect the damage to ascertain if they felt the existing facility could be reinstated. Failing a solution to making good the existing ruptured section, the Town was advised to direct their consultant to prepare a report on various schemes for replacement of the deformed tunnel section. With regard to replacement the following possibilities were discussed:-

- (1) Close the road to traffic, complete excavation of the material over the tunnel section, make necessary repairs and backfill with acceptable material.
- (2) Maintain two lane traffic by means of sheet piling and make necessary repairs in two stage construction.
- (3) Maintain two lane traffic by means of bailey bridging, excavate, complete culvert repairs and reinstate the road in a two phase operation.
- (4) Possibly extend the undamaged portion of the culvert to the north and realign the road to maintain two lane traffic during repairs.

It is pointed out that the above four alternatives are not listed in any order of precedence nor limited to them alone.

The Town's consultant felt that such a report could be made available within three to four weeks.

The cost sharing arrangement for the work necessary to reinstate the culvert, road embankment, along with utility alterations, will be in accordance with the Connecting Link Agreement and current Ministry policies.

  
H. Donnelly  
Asst. to Municipal Engineer

HD:cdk

c.c. C. R. Robertson  
L. O. Fiander  
H. Orlando

CORPORATION OF THE TOWN OF DUNDASHWY. # 8 - (OSLER DRIVE)15'-0" DIA. TUNNEL REPAIRSESTIMATED COSTS

Alternative # 1 - Open Cut Excavation (Road closed to traffic)

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
1.	Unwatering	L.S.			8,000.00
2.	Well-point system	L.S.			3,000.00
3.	Excavation and backfill	C.Y.	15,500	5.00	77,500.00
4.	Remove existing culvert	L.S.			600.00
5.	Granular bedding	Ton	400	4.00	1,600.00
6.	Multi-plate culvert	L.F.	120	190.00	22,800.00
7.	Granular B Backfill	Ton	5,600	3.00	16,800.00
8.	Granular A Road Base	Ton	1,900	3.75	7,125.00
9.	Water for compaction	M.Gal.	98	8.00	784.00
10.	Calcium Chloride	Ton	2	100.00	200.00
11.	Double Catch Basin	Ea.	1	350.00	350.00
12.	18" Dia. C.S.P.	L.F.	75	8.00	600.00
13.	Curb and Gutter	L.F.	330	4.00	1,320.00
14.	Sidewalk	S.Y.	92	10.00	920.00
15.	Asphalt Paving	Ton	220	11.00	2,420.00
16.	Guide Rail	L.F.	320	8.00	2,560.00
17.	Topsoil and Sodding	S.Y.	1,600	1.80	2,880.00
18.	Temporary Watermain	L.S.			8,000.00
19.	Permanent Watermain Relocation	L.S.			<u>15,000.00</u>
Sub Total					172,459.00

Continued . . . . .

TABLE 1 CONTINUED

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
	Sub Total				172,459.00
	Detour Signs and Sundry Construction (+ 10%)				17,246.00
	Contingencies and Engineering (+ 15%)				<u>28,495.00</u>
	TOTAL				\$ <u>218,200.00</u>

/sg

CORPORATION OF THE TOWN OF DUNDASHWY. # 8 - (OSLER DRIVE)15'-0" DIA. TUNNEL REPAIRSESTIMATED COSTS

Alternative # 2 - Sheet Piling and Excavation in Two Stages.

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
1.	Unwatering	L.S.			20,000.00
2.	Well-point System	L.S.			3,000.00
3.	Sheeting or H-piles plus Lagging	S.F.	12,000	8.00	96,000.00
4.	Excavation and backfill	C.Y.	4,500	6.50	29,250.00
5.	Remove existing culvert	L.S.			600.00
6.	Granular bedding	Ton	300	4.00	1,200.00
7.	Multi-plate Culvert	L.F.	120	220.00	26,400.00
8.	Granular B Backfill	Ton	2,100	3.00	6,300.00
9.	Granular A Road Base	Ton	280	3.75	1,050.00
10.	Water for Compaction	M.Gal.	24	8.00	192.00
11.	Calcium Chloride	Ton	0.5	100.00	50.00
12.	Double C.B.	Ea.	1	350.00	350.00
13.	18" Dia. C.S.P.	L.F.	20	8.00	160.00
14.	Curb and Gutter	L.F.	60	5.00	300.00
15.	Sidewalk	S.Y.	34	11.00	374.00
16.	Asphalt Paving	Ton	50	12.00	600.00
17.	Guide Rail	L.F.	60	8.00	480.00
18.	Topsoil and Sodding	S.Y.	500	2.00	1,000.00
19.	Support 16" Watermain and Relocate 12" Watermain	L.S.			9,000.00
Sub Total					196,306.00

Continued . . . .

TABLE II CONTINUED

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
	Sub Total				196,306.00
	Sundry Construction (+ 10%)				19,674.00
	Contingencies and Engineering (+ 15%)				<u>32,420.00</u>
	TOTAL				<u>\$ 248,400.00</u>

/sg

## CORPORATION OF THE TOWN OF DUNDAS

## HWY. # 8 - (OSLER DRIVE)

## 15'-0" DIA. TUNNEL REPAIRS

ESTIMATED COSTS

## Alternative # 3 - Sheet Piling and Excavation with Temporary Bridge

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
1.	Unwatering	L.S.			18,000.00
2.	Well-point System	L.S.			3,000.00
3.	Sheeting or H-piles plus Lagging	S.F.	11,500	7.50	86,250.00
4.	Excavation and Backfill	C.Y.	4,500	6.00	27,000.00
5.	Remove Existing Culvert	L.S.			600.00
6.	Granular Bedding	Ton	300	4.00	1,200.00
7.	Multi-plate Culvert	L.F.	120	210.00	25,200.00
8.	Granular B Backfill	Ton	2,100	3.00	6,300.00
9.	Granular A Road Base	Ton	280	3.75	1,050.00
10.	Water for Compaction	M.Gal.	24	8.00	192.00
11.	Calcium Chloride	Ton	0.5	100.00	50.00
12.	Double C.B.	Ea.	1	350.00	350.00
13.	18" Dia. C.S.P.	L.F.	20	8.00	160.00
14.	Curb and Gutter	L.F.	60	5.00	300.00
15.	Sidewalk	S.Y.	34	11.00	374.00
16.	Asphalt Paving	Ton	50	12.00	600.00
17.	Guide Rail	L.F.	60	8.00	480.00
18.	Topsoil and Sodding	S.Y.	500	2.00	1,000.00
19.	Support 16" Watermain and Relocate 12" Watermain	L.S.			9,000.00

Continued . . . .

TABLE III CONTINUED

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
20.	Temporary Bridge	L.S.			2,500.00
	Sub Total				183,606.00
	Sundry Construction (+ 10%)				18,361.00
	Contingencies and Engineering (+ 15%)				30,333.00
	TOTAL				\$ 232,300.00

/sg

CORPORATION OF THE TOWN OF DUNDASHWY. # 8 - (OSLER DRIVE)15'-0" DIA. TUNNEL REPAIRSESTIMATED COSTS

Alternative # 4 - Sheet Piling and Excavation with Concrete Culvert

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
1.	Unwatering	L.S.			18,000.00
2.	Well-point System	L.S.			3,000.00
3.	Sheeting or H-piles plus Lagging	S.F.	11,500	7.50	86,250.00
4.	Excavation and Backfill	C.Y.	3,500	6.00	21,000.00
5.	Remove Existing Culvert	L.S.			600.00
6.	Concrete in Working Slab	C.Y.	40	50.00	2,000.00
7.	Concrete in Culvert	C.Y.	480	80.00	38,400.00
8.	Reinforcement	Ton	45	300.00	13,500.00
9.	Granular B Backfill	Ton	1,500	2.50	3,750.00
10.	Granular A Road Base	Ton	280	3.75	1,050.00
11.	Water for Compaction	M.Gal.	24	8.00	192.00
12.	Calcium Chloride	Ton	0.5	100.00	50.00
13.	Double C.B.	Ea.	1	350.00	350.00
14.	18" Dia. C.S.P.	L.F.	20	8.00	160.00
15.	Curb and Gutter	L.F.	60	5.00	300.00
16.	Sidewalk	S.Y.	34	11.00	374.00
17.	Asphalt Paving	Ton	50	12.00	600.00
18.	Guide Rail	L.F.	60	8.00	480.00
19.	Topsoil and Sodding	S.Y.	500	2.00	1,000.00

Continued . . . .

TABLE IV CONTINUED

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>	<u>Estimated Quantity</u>	<u>Unit Price</u>	<u>Amount</u>
20.	Support 16" Watermain and Relocate 12" Watermain	L.S.			9,000.00
21.	Temporary Bridge	L.S.			2,000.00
	Sub Total				202,056.00
	Sundry Construction (+ 10%)				20,204.00
	Contingencies and Engineering (+ 15%)				33,340.00
	TOTAL				\$ 255,600.00

/sg

CORPORATION OF THE TOWN OF DUNDAS

HWY. #8 (OSLER DRIVE)

15'-0" dia Tunnel Repairs

Estimated Cost of Pumping for Unwatering Foundation

Flow: Estimated D.W.F. : 12 c.f.s.  
Estimated Capacity of 1-10" pump @ 15' head : 10 c.f.s.  
Estimated Capacity of 1-8" pump @ 15' head : 6 c.f.s.

Use 1-10" pump and 1-8" pump run by one ± 175 kw. generator  
Use 1-10" pump and 1-80 kw. generator standby.

Estimated Cost of Rental for One Month:

1-10" pump.....	\$ 975.00
1-8" pump.....	750.00
1-175 kw. generator.....	1,800.00
1-10" pump standby.....	975.00
1-80 kw. generator standby.....	1,025.00
700'-10" hose.....	2,420.00
350'- 8" hose.....	<u>805.00</u>
	\$8,750.00
Fuel & Maintenance.....	2,500.00
Installation & Removal.....	2,250.00
General Contractor's mark-up.....	<u>2,500.00</u>
	\$16,000.00
Miscellaneous work & small pumps.....	<u>2,000.00</u>
TOTAL.....	\$18,000.00

## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPES

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

### II. PENETRATION RESISTANCES

**Dynamic Penetration Resistance:** The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

**Standard Penetration Resistance, *N*:** The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

*WH* sampler advanced by static weight—weight, hammer

*PLH* sampler advanced by pressure—pressure, hydraulic

*PM* sampler advanced by pressure—pressure, manual

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

<i>Relative Density</i>	<i>N, blows/ft.</i>
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils

<i>Consistency</i>	<i>c<sub>u</sub>, lb./sq. ft.</i>
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

### IV. SOIL TESTS

*C* consolidation test

*H* hydrometer analysis

*M* sieve analysis

*MH* combined analysis, sieve and hydrometer<sup>1</sup>

*Q* undrained triaxial<sup>2</sup>

*R* consolidated undrained triaxial<sup>2</sup>

*S* drained triaxial

*U* unconfined compression

*V* field vane test

### NOTES:

<sup>1</sup>Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

<sup>2</sup>Undrained triaxial tests in which pore pressures are measured are shown as  $\bar{Q}$  or  $\bar{R}$ .

## LIST OF SYMBOLS

### I. GENERAL

$\pi$	= 3.1416
$e$	= base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of $a$
$\log_{10} a$ or $\log a$	logarithm of $a$ to base 10
$t$	time
$g$	acceleration due to gravity
$V$	volume
$W$	weight
$M$	moment
$F$	factor of safety

### II. STRESS AND STRAIN

$u$	pore pressure
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\bar{\sigma}$ is also used)
$\tau$	shear stress
$\epsilon$	linear strain
$\epsilon_{xy}$	shear strain
$\nu$	Poisson's ratio ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

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

#### (b) Consistency

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

#### (c) Permeability

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

#### (d) Consolidation (one-dimensional)

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

#### (e) Shear strength

$\tau_f$	shear strength
$c'$	effective cohesion
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_r$	sensitivity

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

OVERSIZED DRAWINGS

record of borehole 101  
102  
103  
104  
105  
106  
107  
108

EXISTING ROAD LOCATION (1964)  
PRIOR TO RECENT CONSTRUCTION

LOCATION OF PAVEMENT COLLAPSE

FLDN

EXISTING ROAD

TO  
DUNDAS

SCA

TO  
HAMILTON

BH.1

BH.107

BH.106

BH.A

BH.105

P.T.108

BH.102

BH.C

BH.101

BH.B

BH.104

BH.2A

BH.103

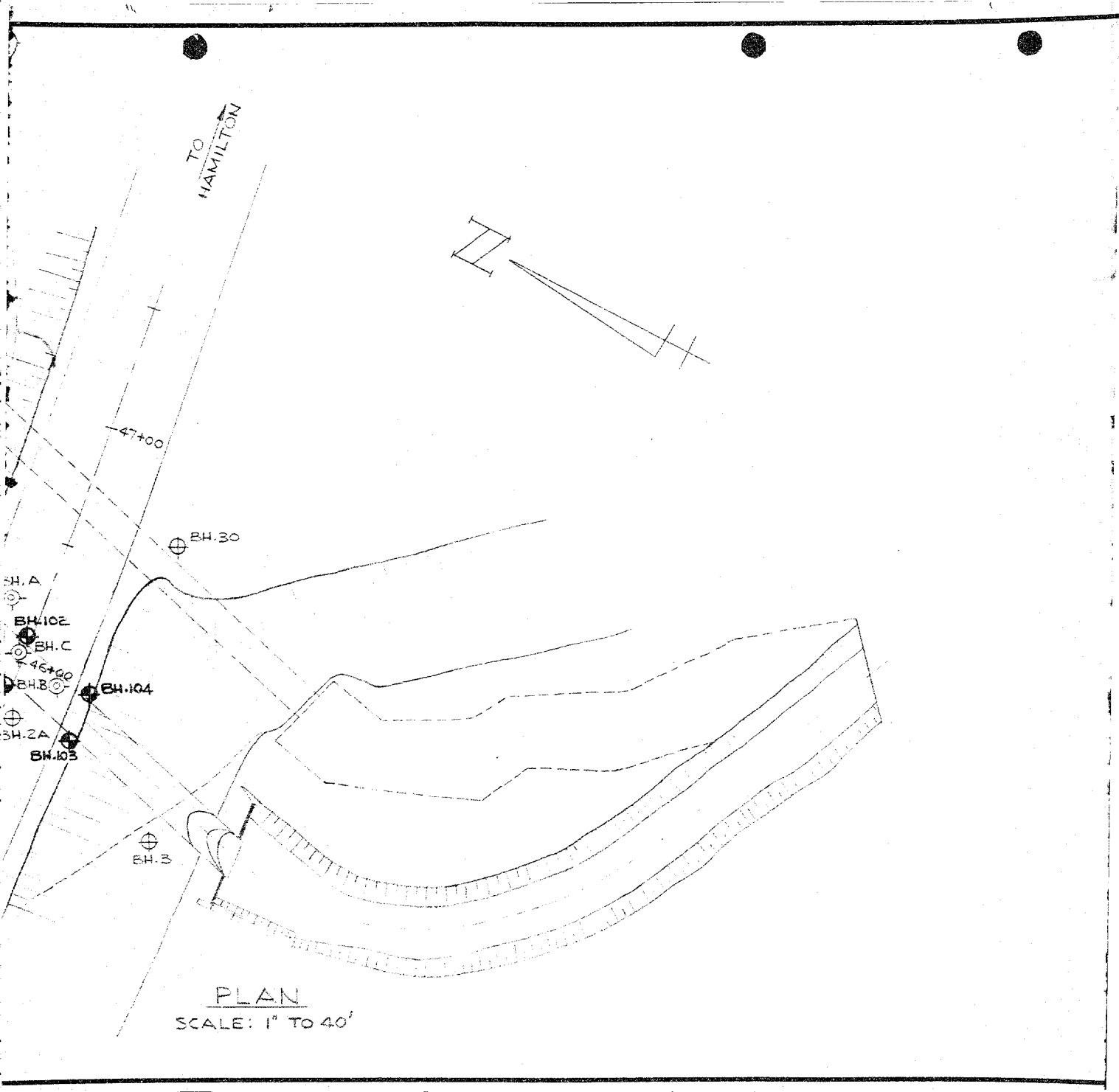
BH.3

BH.3

-47+00

-45+00





-46+00



PLAN  
SCALE: 1" TO 40'

PRELIMINARY

LEGEND

	BOREHOLE LOCATION IN PLAN	} PRESENT INVESTIGATION
	PEN. TEST LOCATION IN PLAN	
	BOREHOLE LOCATION IN PLAN	} PREVIOUS INVESTIGATION BY ASSOCIATED GEOTECHNICAL SERVICES LTD. JANUARY AND JULY 1964.
	BOREHOLE LOCATION IN PLAN	

REFERENCE

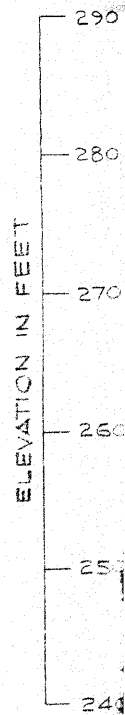
PHILIPS & ROBERTS LTD., CONSULTING ENGINEERS  
 DRAWING "TOWN OF DUNDAS HIGHWAY No 8, BINKLEY'S  
 HOLLOW - PROPOSED CULVERT", DRAWING No. 611-404F  
 DATED APRIL, 1964. REVISED SEPT. 1966 AS CONSTRUCTED.

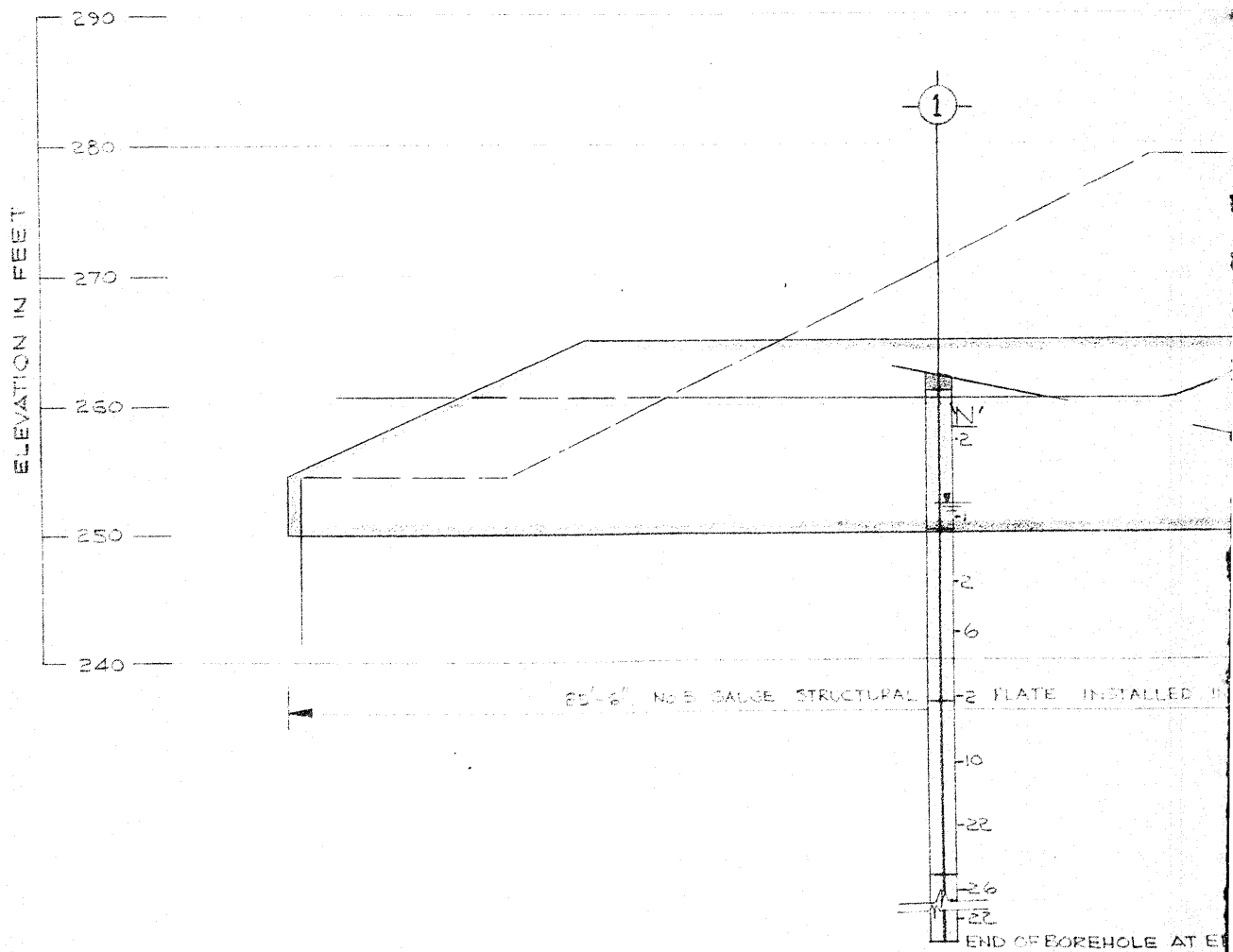
Date APRIL 9, 1973

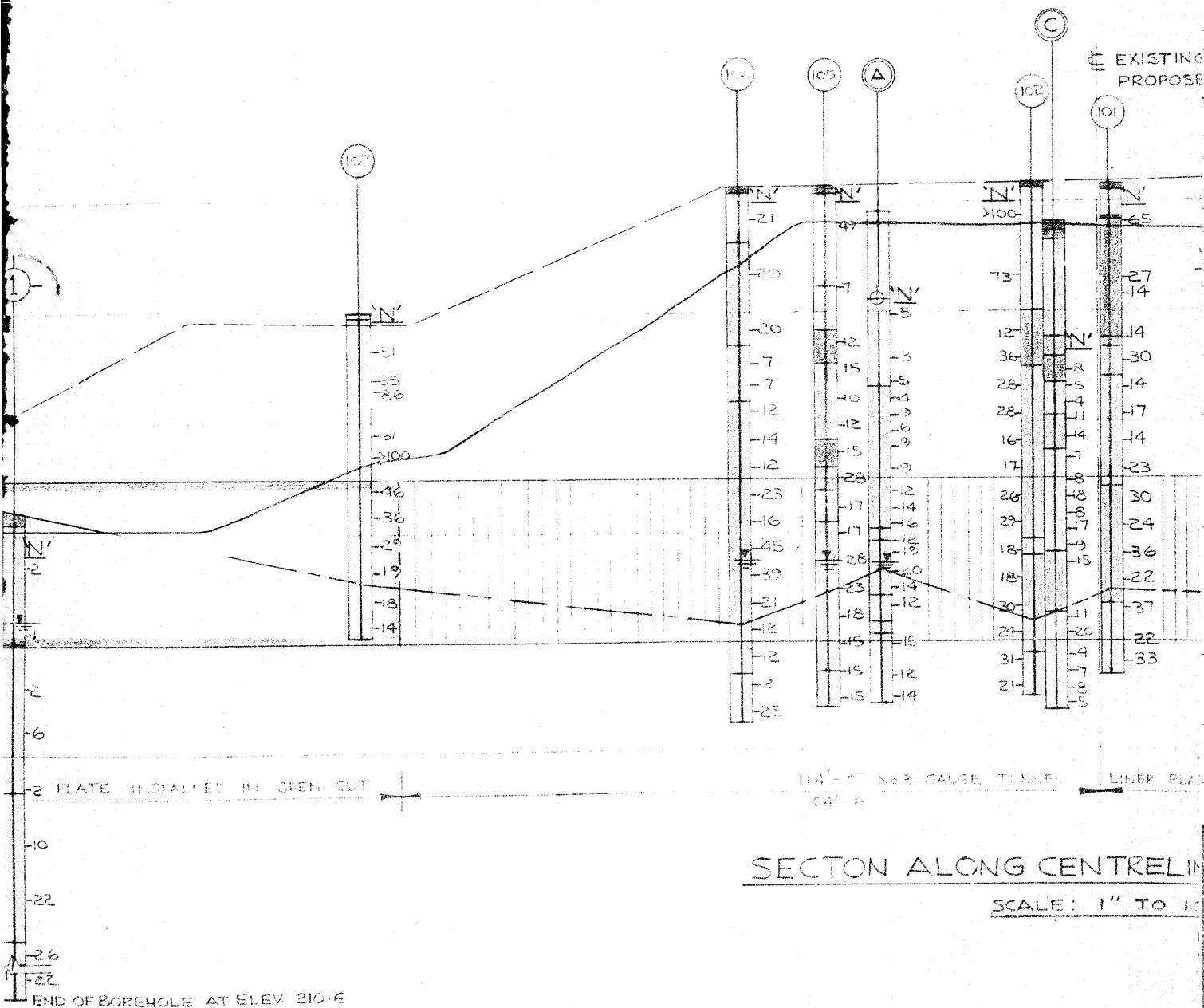
Golder Associates

Drawn M. J. P.  
 Chkd. ....  
 Appd. ....

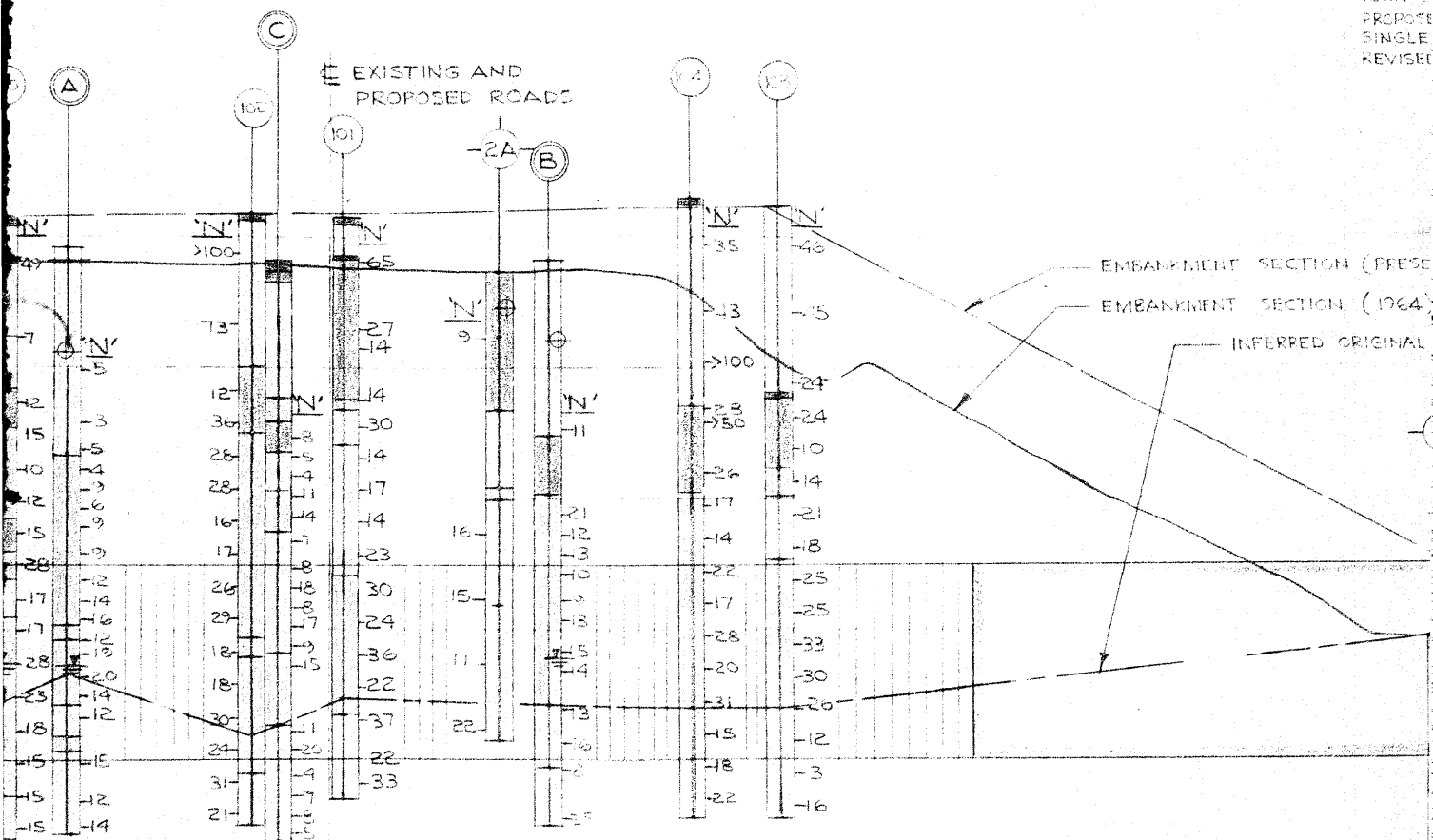
73047







REFER  
PHILIPS  
TOWN C  
PROPOSE  
SINGLE  
REVISED



NO. 3 GALV. TUNNEL LINER PLATE, INSTALLED

NO. 3 & NO. 5 GALV. STANDARD PLATE

TION ALONG CENTRELINE OF EXISTING CULVERT

SCALE: 1" TO 10'

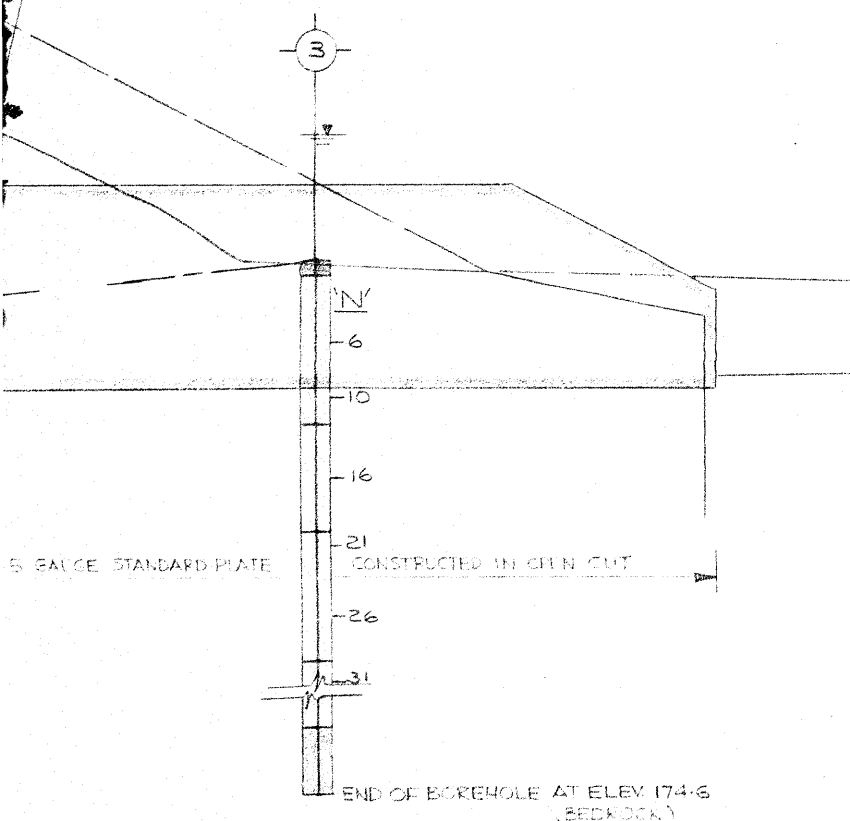
## REFERENCE

PHILIPS & ROBERTS LTD. DRAWING NO. 211-404F  
TOWN OF LUNenburg HIGHWAY N.E. BINKLEY'S HOLLOW  
PROPOSED CULVERT ALTERNATIVE B LAYOUT  
SINGLE 15' Ø TUNNEL, DATED APRIL 1964  
REVISED SEPT. 1964 AS CONSTRUCTED

ANKMENT SECTION (PRESENT)

ANKMENT SECTION (1964)

INFERRED ORIGINAL GROUND SURFACE



(101)

BOREHOLE PRESENT

(A)

BOREHOLE GEOTECHNICAL REPORT

(I)

BOREHOLE GEOTECHNICAL REPORT

WATER

S

FILL



ASHPH



DENSE AND



GENE SAND



GENE



VERY TRAC



COME

IN SITU SOILS



TOP



GENE TO S



COME



VERY



BED

Date APRIL 10, 1973

### LEGEND

### PRELIMINARY



BOREHOLE IN ELEVATION,  
PRESENT INVESTIGATION



BOREHOLE IN ELEVATION, ASSOCIATED  
GEOTECHNICAL SERVICES LIMITED,  
REPORT DATED JULY, 1964

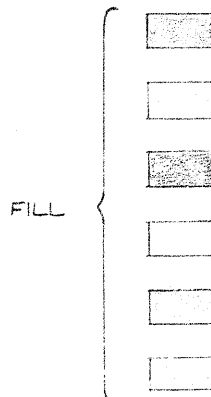
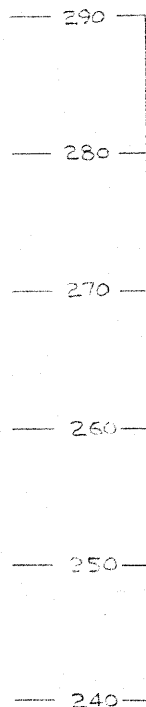


BOREHOLE IN ELEVATION, ASSOCIATED  
GEOTECHNICAL SERVICES LIMITED,  
REPORT DATED APRIL 9, 1964



WATER LEVEL IN BOREHOLE

### STRATIGRAPHY



ASHPHALT

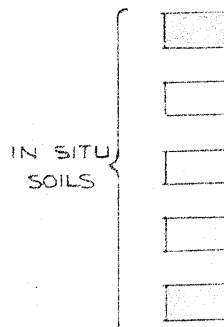
DENSE TO VERY DENSE BROWN SILTY SAND  
AND GRAVEL (RECENT FILL)

GENERALLY COMPACT BROWN SILTY SAND TO  
SANDY SILT, TRACE TO SOME GRAVEL (FILL)

GENERALLY COMPACT BROWN SILTS AND  
SANDS (FILL)

VERY STIFF TO HARD CLAYEY SILT,  
TRACE TO SOME SAND, (FILL)

COMPACT TO DENSE SILT, SAND AND  
GRAVEL (FILL)



TOPSOIL

GENERALLY COMPACT GREY SILTY SAND  
TO SANDY SILT WITH OCCASIONAL LAYERS  
OF ORGANIC MATTER

COMPACT GREY SILT, TRACE TO SOME SAND

VERY STIFF GREY CLAYEY SILT, TRACE SAND  
TRACE GRAVEL

BEDROCK

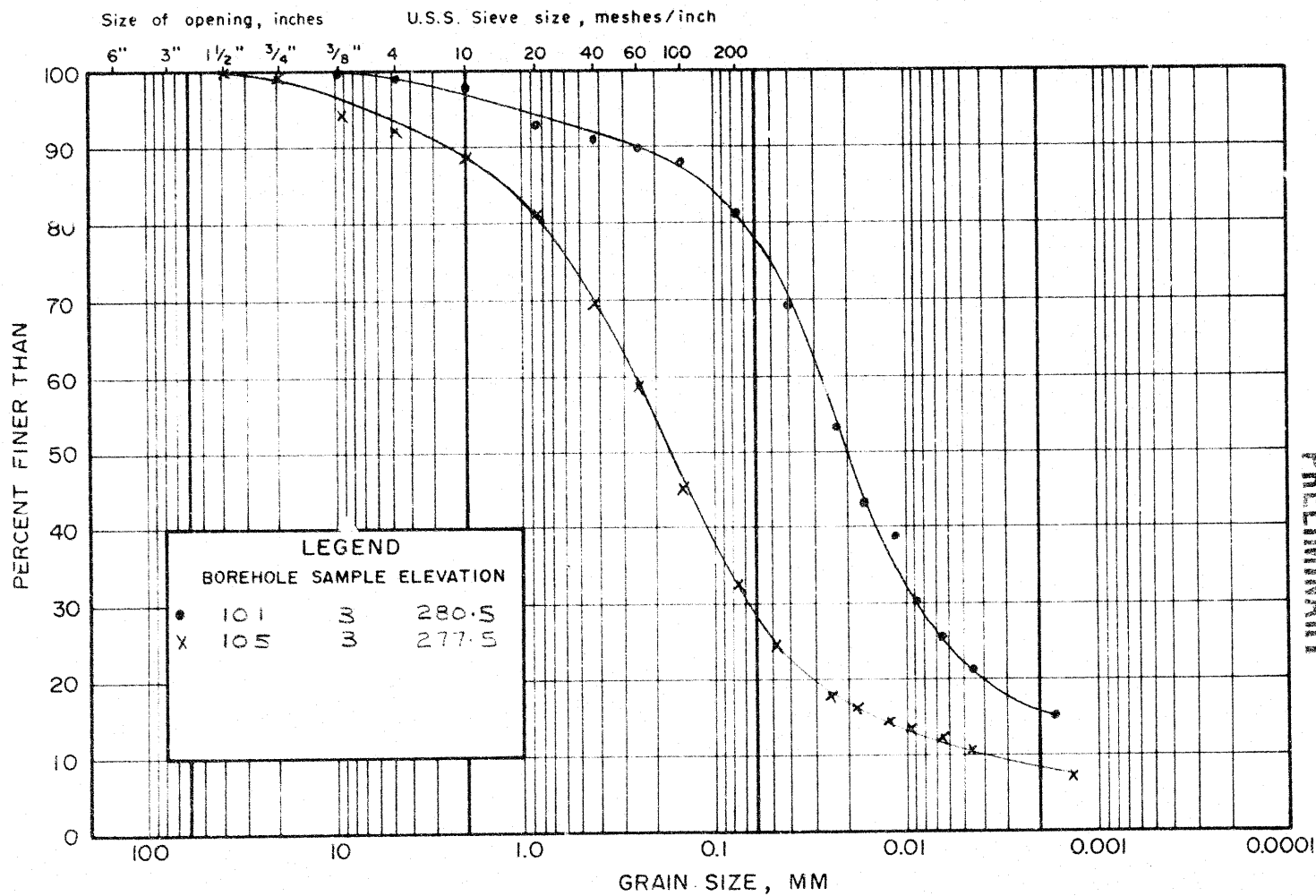
Date APRIL 10, 1973

Golder Associates

Drawn *Mif L.*  
Chkd.....  
Appd.....

Golder Associates

## M.I.T. GRAIN SIZE SCALE



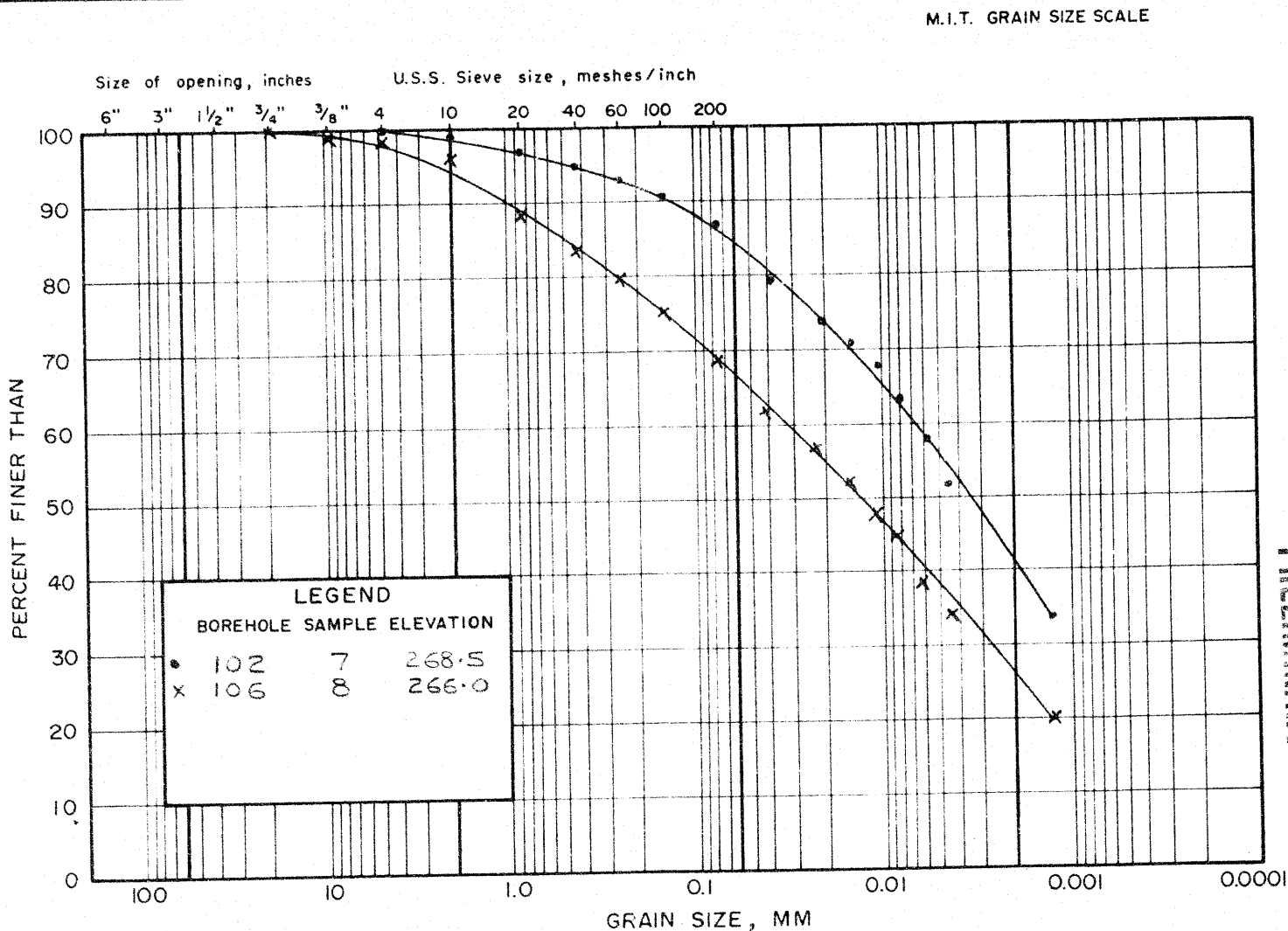
PRELIMINARY

GRAIN SIZE DISTRIBUTION  
SILT AND SAND (FILL)

FIGURE 3

Golder Associates

PRELIMINARY

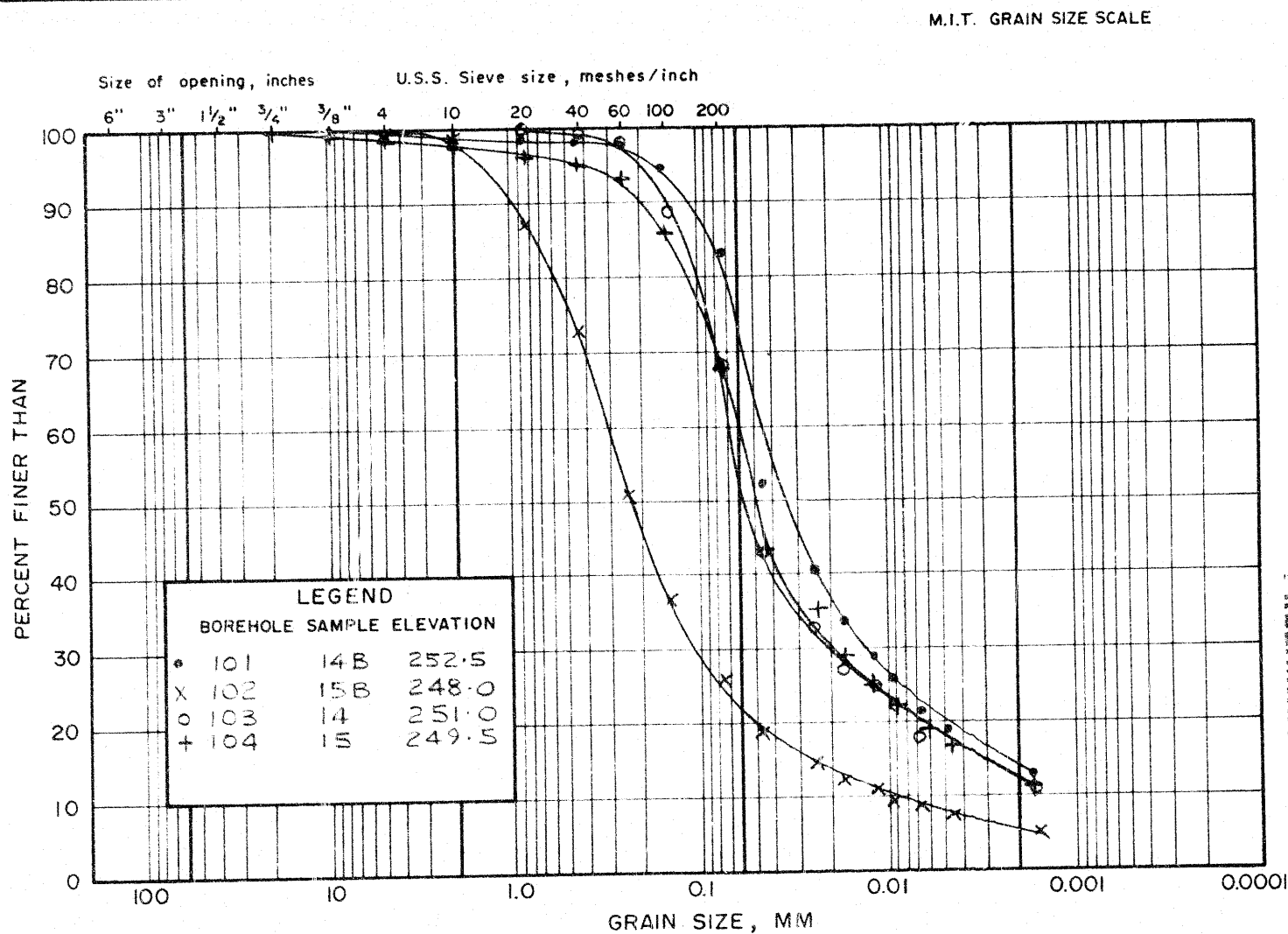


COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED		

GRAIN SIZE DISTRIBUTION  
CLAYEY SILT (FILL)

FIGURE 4

Golder Associates



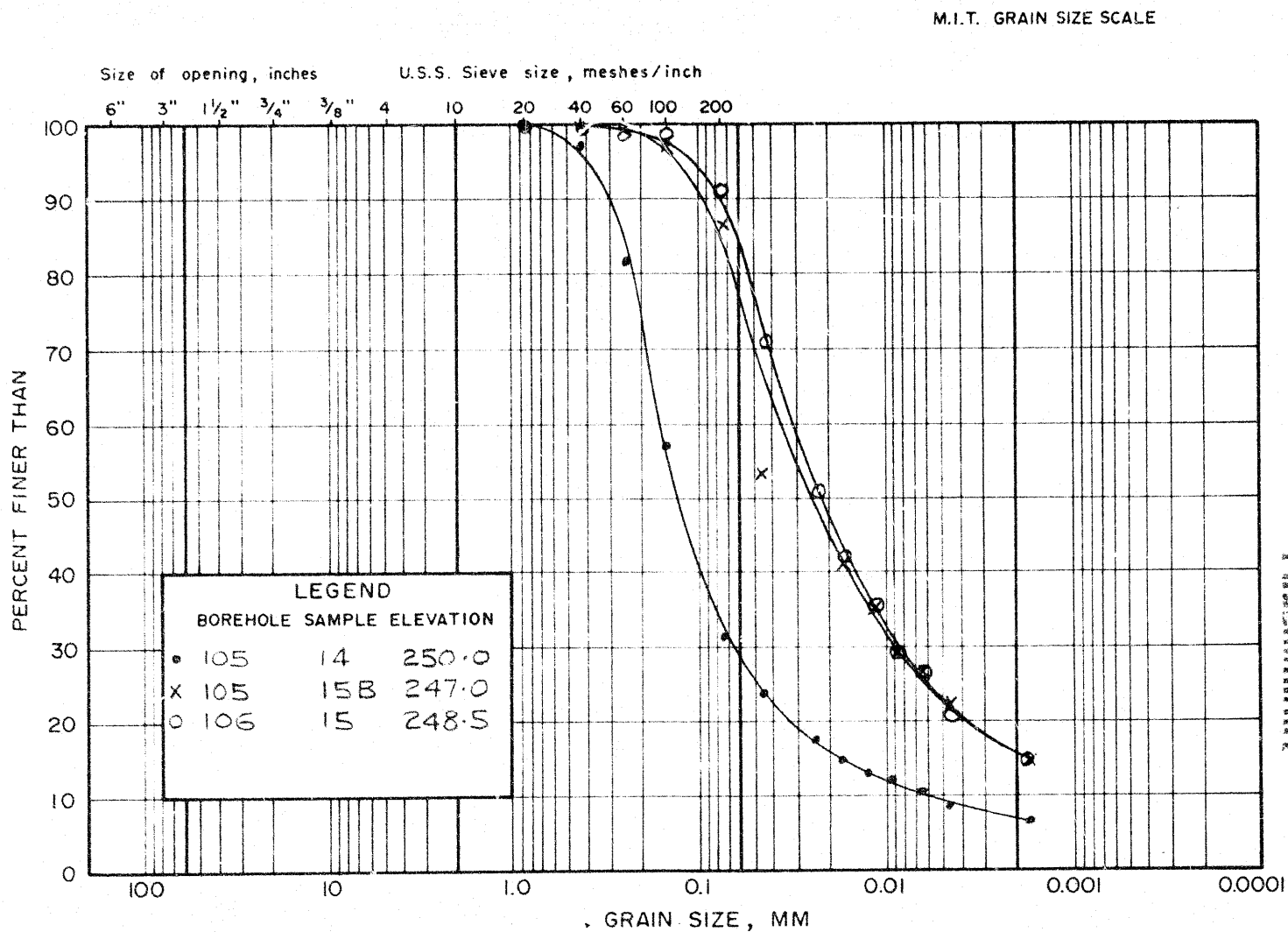
COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED		

GRAIN SIZE DISTRIBUTION  
SANDY SILT TO SILTY SAND

PRELIMINARY

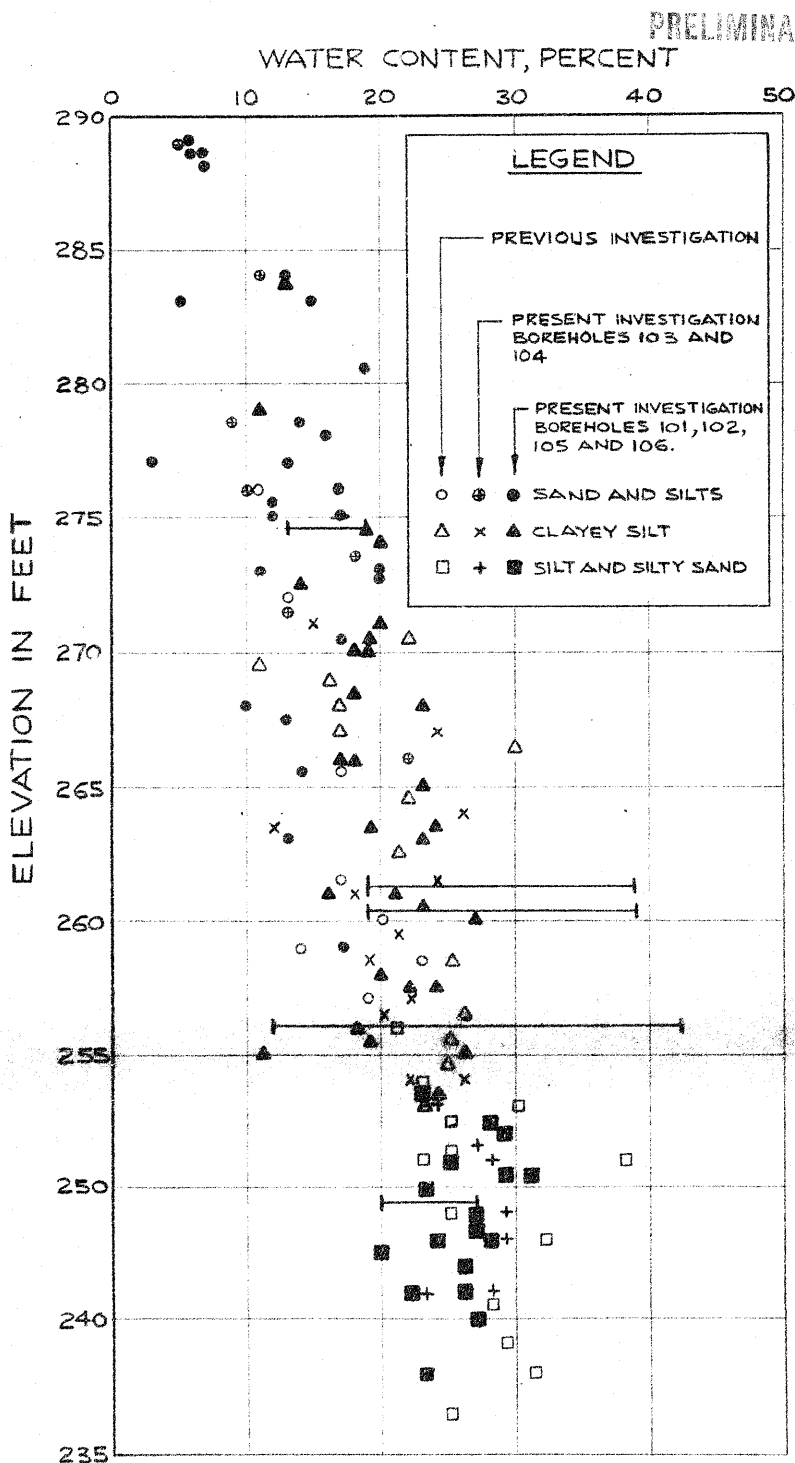
FIGURE 5

Golder Associates

GRAIN SIZE DISTRIBUTION  
SANDY SILT TO SILTY SAND

PRELIMINARY

FIGURE 6



73-11027  
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. A. G. Stermac,  
Principal Foundation Engineer,  
West Building.

FROM: G. C. E. Burkhardt,  
Structural Planning Office,  
3501 Dufferin Street.

ATTENTION: Mr. K. Selby

DATE: July 9, 1973.

OUR FILE REF.

IN REPLY TO

SUBJECT: Proposed Improvement of Highway 8  
along the Niagara Escarpment,  
West of Dundas, Ontario,  
W.P. 536-56, District 4.

This will confirm our recent conversation regarding the above project and that Systems Design expect to make their presentation in mid-September. You indicated that Mr. W. Lin and yourself should have no difficulty in completing the review, of the foundation report in relation to the high retaining wall requirements, by late August.

WMK:lc



W. M. Killin,  
for:  
G. C. E. Burkhardt,  
REG. STRUCTURAL PLANNING ENG.

c.c. W. Lin  
J. Cullen  
R. Fitzgibbon

*Jan 5/74*

R. G. Burnfield  
Regional Highway Design Engineer  
Central Region

Foundations Office  
Design Services Branch  
Design Division

August 24, 1973

Highway 8 - Dundas to Petes's Corners  
W.P. 536-56-00, District 4 - Hamilton  
Systems Design Report - Project Appraisal  
Central Region

On page 46 of the above-mentioned report it is stated that further information will be required for foundations of the subway, the bridge and the retaining walls, and that this information is to be provided by the Materials and Testing Office.

However, this information, if and when required, will be provided by the Foundation Office which is now part of the Design Services Branch, Design Division.

We would appreciate if in the future, when dealing with foundations, proper reference to the Foundation Office be made.

*AGS*

AGS:mt

A. G. Stermac  
Principal Foundation Engineer

G. C. E. Burkhardt,  
Regional Structural Plan. Eng.,  
Central Region,  
3801 Dufferin Street,  
Downsview, Ontario.

Foundations Office,  
Design Services Branch,  
West Building, Downsview.

W. Killen

November 12, 1973

Hwy. 8 Improvement along the  
Niagara Escarpment west of Dundas  
Sta. 0 + 00 to Sta. 35 + 00  
W.O. 71-11001 W.P. 536-56  
District #4 (Hamilton)

As requested by you we have reviewed Plan No. B-151-20 showing the proposed alignment for the above mentioned project, also various cross sections showing proposed slope treatment and/or retaining walls. A joint review of the proposals was also carried out by the writer and Mr. W. Lin of the Structural Office. Following is a summary of the main conclusions reached:

1. In general the cross sections showing final slopes comply with recommendations given in the Foundations Report.
2. Where possible, it would be preferable to slope the escarpment face rather than provide retaining walls to maintain stability. Experience indicates that many areas of the Niagara Escarpment are inherently unstable. The best approach is to ensure that any changes due to construction result in a more favourable geometry for the entire slope from bottom to top. Retaining walls may stabilize a portion of the slope yet create more unfavourable geometry for the overall slope. In any event the construction of the very high retaining walls (shown as an alternative to constructing slopes) would require large amounts of excavation and back fill. For stability reasons excavated material could not be stockpiled in large quantities on the escarpment face. The temporary slopes required during construction of the walls would pose a stability problem which would have to be considered during the design stages and would add considerably to the cost.

*K. G. Selby*

KGS/ji  
c.c. W. Lin  
Foundation File  
Documents

K. G. Selby,  
SUPERVISING FOUNDATIONS ENGINEER.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. A.G. Stermac  
Principal Foundations Engineer  
WEST Building

FROM: R.G. Burnfield  
Regional Systems Design Office

ATTENTION:

DATE: November 19, 1973

OUR FILE REF.

IN REPLY TO

SUBJECT:

Project Appraisal Report  
W.P. 536-56-00  
Peter's Corners at Dundas  
Highway 8

71-11-001

Thank you for your comments of August 24, 1973  
on the above report.

We regret we inadvertently noted that the  
Foundations Office was a sub-section of Materials  
and Testing. It should, of course, have been the  
Design Services Branch of the Design Division.  
Apologies for our over-sight.



J.P. Cullen  
Sr. Project  
Design Engineer

JPC:mck

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M5-23  
DIST. 4 REGION CENTRAL  
W.P. No. 536-56

CONT. No. N.A. PROJECT CANCELLED

W. O. No. 71-F-1

STR. SITE No.

HWY. No. 8

LOCATION DUNDAS WESTERLY (STA. 0+00  
TO STA. 35+00) PROP. IMPROV.

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. 8/1

REMARKS: DOCUMENTS TO BE UNFOLDED  
BEFORE MICROFILMED



DEPARTMENT OF HIGHWAYS, CHIEF ENGINEER'S OFFICE		RECORD OF BOREHOLE No. 21		FOUNDATION RECORD	
MATERIALS & TESTING OFFICE		LOCATION: Bldg. 8 Sta. 19 + 75 371' E.		ORIGINATED BY: ES	
JOB: 71-11001		BORING DATE: Jan. 1962, 1971		CHECKED BY: ASD	
W.P.: 536-58		BORING TYPE: Auger		CHECKED BY:	
CUTLOG: Sandstone					
DEPTH	DESCRIPTION	TEMPERATURE	WATER CONTENT	SHRINKAGE	REMARKS
0.0	Ground Level				
0.5	Brown Silty				
1.0	Traces of sand				
1.5	Hard				
2.0	Clayey silt to silt				
2.5	Very stiff to firm				
3.0	Grey				
3.5	Sandy silt to silty				
4.0	sandy with traces of clay				
4.5	Very Dense				
5.0	Red-brown & Grey				
5.5	Shale & Sandstone				
6.0	End of Borehole				

FORM 66-101 (2-1-57) (REV. 1965)

OFFICE REPORT ON SOIL EXPLORATION

30 MV-33  
01-52212

RECORD OF BOREHOLE No. 27				FOUNDATION SECTION	
MATERIALS & TESTING OFFICE				ORIGINATED BY	
SOIL TYPE				COMPILED BY	
DATE				CHECKED BY	
LOCATION				BOREHOLE TYPE	
Geologic				Vashon, AZ & BK Chasing	
DEPTH	DESCRIPTION	STRATIGRAPHIC UNIT	TYPE	REL. STATE	REMARKS
0.0	Ground Level				
0.0	Clay silt to silt, traces of gravel.	SS	13		
0.0	Blacks of decomposed shale.	SS	13		
0.0	Grey & Red	SS	13		
0.0	Silt to Hard	SS	13		
0.0	Very Dense	SS	13		
0.0	Clay silt with traces of sand and gravel. Fragments of shale.	SS	13		
0.0	Hard	SS	13		
0.0	Quartzite Shale	SS	13		
0.0	Gravel	SS	13		
0.0	End of borehole				

10  
100% % STRAIN AT FAILURE

SHEET No.

FEDERAL HIGHWAY DISTRICT		RECORD OF BOREHOLE No. 26		FOUNDATION SECTION	
MATERIALS & TESTING OFFICE		LOCATION		ORGANIZED BY	
JOB		BORING DATE		COMPLETED BY	
W.P.		BORING TYPE		CHECKED BY	
DATE		BORING TYPE		CHECKED BY	
206.0	Ground Level	1	20	3	10
206.1	Sand, gravel & black cinder	1	20	3	10
206.2	Fill	1	20	3	10
206.3	Loose	1	20	3	10
206.4	Clayey silt to silt, seams of sand and traces of gravel	1	20	3	10
206.5	Very Stiff to Hard	1	20	3	10
206.6	Brown & Grey	1	20	3	10
206.7	Clayey silt to silt, fragments of shale & blocks of limestone (Special Fill, weathered shale)	1	20	3	10
206.8	Hard	1	20	3	10
206.9	Quartzite Shale	1	20	3	10
207.0	End of Borehole	1	20	3	10

10  
10-5 % STRAIN AT FAILURE

FORM 08-102 (REV. 1949)

OFFICE REPORT ON SOIL EXPLORATION

307-533  
RECEIVED

DEPARTMENT OF HIGHWAYS, CHICAGO		RECORD OF BOREHOLE No. 25		FOUNDATION SECTION			
MATERIALS & TESTING OFFICE		LOCATION: State, Reg. 8 Sta. 7 + 78. 112' 21."		ORIGINATED BY: JEC			
NO. 75-11501		BORING DATE: Feb. 19 - 23, 1951		COMPILED BY: JEC			
W.P. 238-50		BORING TYPE: Hammering, SC & MC Casing		CHECKED BY: JEC			
UNION: Goodell							
SOIL PROFILE	DEPTH (FEET)	DIAMETER (INCHES)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	REMARKS
Ground Level	0.0						
Clayey silt to silt	1.00	3.68	20				
with irregular veins	2.00	3.36	14				
of sand, trace of gravel	3.00	3.36	14				
Very Stiff to Hard	4.00	3.36	25				
Brown & Grey	5.00	3.36	27				
	6.00	3.36	27				
	7.00	3.36	27				
	8.00	3.36	27				
	9.00	3.36	27				
	10.00	3.36	27				
	11.00	3.36	27				
	12.00	3.36	27				
	13.00	3.36	27				
	14.00	3.36	27				
	15.00	3.36	27				
	16.00	3.36	27				
	17.00	3.36	27				
	18.00	3.36	27				
	19.00	3.36	27				
	20.00	3.36	27				
	21.00	3.36	27				
	22.00	3.36	27				
	23.00	3.36	27				
	24.00	3.36	27				
	25.00	3.36	27				
	26.00	3.36	27				
	27.00	3.36	27				
	28.00	3.36	27				
	29.00	3.36	27				
	30.00	3.36	27				
	31.00	3.36	27				
	32.00	3.36	27				
	33.00	3.36	27				
	34.00	3.36	27				
	35.00	3.36	27				
	36.00	3.36	27				
	37.00	3.36	27				
	38.00	3.36	27				
	39.00	3.36	27				
	40.00	3.36	27				
	41.00	3.36	27				
	42.00	3.36	27				
	43.00	3.36	27				
	44.00	3.36	27				
	45.00	3.36	27				
	46.00	3.36	27				
	47.00	3.36	27				
	48.00	3.36	27				
	49.00	3.36	27				
	50.00	3.36	27				
	51.00	3.36	27				
	52.00	3.36	27				
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	63.00	3.36	27				
	64.00	3.36	27				
	65.00	3.36	27				
	66.00	3.36	27				
	67.00	3.36	27				
	68.00	3.36	27				
	69.00	3.36	27				
	70.00	3.36	27				
	71.00	3.36	27				
	72.00	3.36	27				
	73.00	3.36	27				
	74.00	3.36	27				
	75.00	3.36	27				
	76.00	3.36	27				
	77.00	3.36	27				
	78.00	3.36	27				
	79.00	3.36	27				
	80.00	3.36	27				
	81.00	3.36	27				
	82.00	3.36	27				
	83.00	3.36	27				
	84.00	3.36	27				
	85.00	3.36	27				
	86.00	3.36	27				
	87.00	3.36	27				
	88.00	3.36	27				
	89.00	3.36	27				
	90.00	3.36	27				
	91.00	3.36	27				
	92.00	3.36	27				
	93.00	3.36	27				
	94.00	3.36	27				
	95.00	3.36	27				
	96.00	3.36	27				
	97.00	3.36	27				
	98.00	3.36	27				
	99.00	3.36	27				
	100.00	3.36	27				

11-W 3 % STRAIN AT FAILURE

FORM CE-107 (24 MAY 1963)

OFFICE REPORT ON SOIL EXPLORATION

301E-21  
10/1/63

DEPARTMENT OF HIGHWAYS, OHIO MATERIALS & TESTING OFFICE				RECORD OF BOREHOLE No. 26				FOUNDATION SECTION			
JOB 71-11003		LOCATION: East, W. 8. 250. 35. 00. 100. 15.		BORING DATE: Feb. 25, March 1, 1971		COMPILED BY: JJB		CHECKED BY:			
W.P. 520-50		BORING TYPE: Weathering, WE & DE Casing									
DATUM: Gunderside											
ELEV (DEPTH)	DESCRIPTION	SPT NO.	SAMPLES		DYNAMIC PENETRATION BLows/FOOT	RESISTANCE PSI	WATER CONTENT %	LIQUID LIMIT %	PLASTICITY INDEX %	REMARKS	
			THINNESS INCHES	REMARKS							
520.6	Ground Level										
0.0	Clayey silt to silt, some sand and gravel		1. 88 14		500		0				
			2. 88 14				0				
			3. 88 14				0				
	Fractured Limestone		4. 88 14		520		0				
			5. 88 14				0				
			6. 88 14				0				
	Hard		7. 88 14		510		0				
			8. 88 14				0				
50.3			9. 88 14				0				
25.5	Silty sand with some gravel		10. 88 14		500		0			1.75 (25)	
			11. 88 14				0				
	Very Dense		12. 88 14		400		0				
100.8			13. 88 14				0			0.65 (50)	
100.0	Grey & Red Weathered & decomposed Shale		14. 88 14		130		0				
107.5			15. 88 14				0				
115.0	Bedrock		16. 88 14				0				
117.5			17. 88 14				0				
119.0	End of Borehole										

IN  
1-W-5 % STRAIN AT FAILURE

Form C.A. - 2-1

2017-12-12  
0000000000

Project No. 18057

RECORD OF BOREHOLE 101										PRELIMINARY	
LOCATION: 5th FIGHT		BORING DATE: MARCH 30, 1978		DATUM: MEAN SEA LEVEL							
SAMPLER: HANMER WEIGHT 140 LB., DROP 30 IN.		PENETRATION TEST: HANMER WEIGHT 140 LB., DROP 30 IN.									
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLES TYPE	DISTANCE FEET	DYNAMIC PENETRATION RESISTANCE, BLASTS/FT		COEFFICIENT OF PERMEABILITY, % (10/100)				PERMEABILITY OF INSTALLATION	
				140	140	140	140	140	140		
				SHEAR STRENGTH K/BLAST		WATER CONTENT, PERCENT					
				REL. V. - 0.8		REL. V. - 0.8					
				REL. V. - 0.8		REL. V. - 0.8					
0.0	GROUND SURFACE										
0.5	GRAVELLY SAND (FILL)		2.00								
1.0	GRAVELLY SAND (FILL)		2.00								
1.5	GRAVELLY SAND (FILL)		2.00								
2.0	GRAVELLY SAND (FILL)		2.00								
2.5	GRAVELLY SAND (FILL)		2.00								
3.0	GRAVELLY SAND (FILL)		2.00								
3.5	GRAVELLY SAND (FILL)		2.00								
4.0	GRAVELLY SAND (FILL)		2.00								
4.5	GRAVELLY SAND (FILL)		2.00								
5.0	GRAVELLY SAND (FILL)		2.00								
5.5	GRAVELLY SAND (FILL)		2.00								
6.0	GRAVELLY SAND (FILL)		2.00								
6.5	GRAVELLY SAND (FILL)		2.00								
7.0	GRAVELLY SAND (FILL)		2.00								
7.5	GRAVELLY SAND (FILL)		2.00								
8.0	GRAVELLY SAND (FILL)		2.00								
8.5	GRAVELLY SAND (FILL)		2.00								
9.0	GRAVELLY SAND (FILL)		2.00								
9.5	GRAVELLY SAND (FILL)		2.00								
10.0	GRAVELLY SAND (FILL)		2.00								
10.5	GRAVELLY SAND (FILL)		2.00								
11.0	GRAVELLY SAND (FILL)		2.00								
11.5	GRAVELLY SAND (FILL)		2.00								
12.0	GRAVELLY SAND (FILL)		2.00								
12.5	GRAVELLY SAND (FILL)		2.00								
13.0	GRAVELLY SAND (FILL)		2.00								
13.5	GRAVELLY SAND (FILL)		2.00								
14.0	GRAVELLY SAND (FILL)		2.00								
14.5	GRAVELLY SAND (FILL)		2.00								
15.0	GRAVELLY SAND (FILL)		2.00								
15.5	GRAVELLY SAND (FILL)		2.00								
16.0	GRAVELLY SAND (FILL)		2.00								
16.5	GRAVELLY SAND (FILL)		2.00								
17.0	GRAVELLY SAND (FILL)		2.00								
17.5	GRAVELLY SAND (FILL)		2.00								
18.0	GRAVELLY SAND (FILL)		2.00								
18.5	GRAVELLY SAND (FILL)		2.00								
19.0	GRAVELLY SAND (FILL)		2.00								
19.5	GRAVELLY SAND (FILL)		2.00								
20.0	GRAVELLY SAND (FILL)		2.00								
20.5	GRAVELLY SAND (FILL)		2.00								
21.0	GRAVELLY SAND (FILL)		2.00								
21.5	GRAVELLY SAND (FILL)		2.00								
22.0	GRAVELLY SAND (FILL)		2.00								
22.5	GRAVELLY SAND (FILL)		2.00								
23.0	GRAVELLY SAND (FILL)		2.00								
23.5	GRAVELLY SAND (FILL)		2.00								
24.0	GRAVELLY SAND (FILL)		2.00								
24.5	GRAVELLY SAND (FILL)		2.00								
25.0	GRAVELLY SAND (FILL)		2.00								
25.5	GRAVELLY SAND (FILL)		2.00								
26.0	GRAVELLY SAND (FILL)		2.00								
26.5	GRAVELLY SAND (FILL)		2.00								
27.0	GRAVELLY SAND (FILL)		2.00								
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28.0	GRAVELLY SAND (FILL)		2.00								
28.5	GRAVELLY SAND (FILL)		2.00								
29.0	GRAVELLY SAND (FILL)		2.00								
29.5	GRAVELLY SAND (FILL)		2.00								
30.0	GRAVELLY SAND (FILL)		2.00								
30.5	GRAVELLY SAND (FILL)		2.00								
31.0	GRAVELLY SAND (FILL)		2.00								
31.5	GRAVELLY SAND (FILL)		2.00								
32.0	GRAVELLY SAND (FILL)		2.00								
32.5	GRAVELLY SAND (FILL)		2.00								
33.0	GRAVELLY SAND (FILL)		2.00								
33.5	GRAVELLY SAND (FILL)		2.00								
34.0	GRAVELLY SAND (FILL)		2.00								
34.5	GRAVELLY SAND (FILL)		2.00								
35.0	GRAVELLY SAND (FILL)		2.00								
35.5	GRAVELLY SAND (FILL)		2.00								
36.0	GRAVELLY SAND (FILL)		2.00								
36.5	GRAVELLY SAND (FILL)		2.00								
37.0	GRAVELLY SAND (FILL)		2.00								
37.5	GRAVELLY SAND (FILL)		2.00								
38.0	GRAVELLY SAND (FILL)		2.00								
38.5	GRAVELLY SAND (FILL)		2.00								
39.0	GRAVELLY SAND (FILL)		2.00								
39.5	GRAVELLY SAND (FILL)		2.00								
40.0	GRAVELLY SAND (FILL)		2.00								
40.5	GRAVELLY SAND (FILL)		2.00								
41.0	GRAVELLY SAND (FILL)		2.00								
41.5	GRAVELLY SAND (FILL)		2.00								
42.0	GRAVELLY SAND (FILL)		2.00								
42.5	GRAVELLY SAND (FILL)		2.00								
43.0	GRAVELLY SAND (FILL)		2.00								
43.5	GRAVELLY SAND (FILL)		2.00								
44.0	GRAVELLY SAND (FILL)		2.00								
44.5	GRAVELLY SAND (FILL)		2.00								
45.0	GRAVELLY SAND (FILL)		2.00								
45.5	GRAVELLY SAND (FILL)		2.00								
46.0	GRAVELLY SAND (FILL)		2.00								
46.5	GRAVELLY SAND (FILL)		2.00								
47.0	GRAVELLY SAND (FILL)		2.00								
47.5	GRAVELLY SAND (FILL)		2.00								
48.0	GRAVELLY SAND (FILL)		2.00								
48.5	GRAVELLY SAND (FILL)		2.00								
49.0	GRAVELLY SAND (FILL)		2.00								
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52.0	GRAVELLY SAND (FILL)		2.00								
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55.5	GRAVELLY SAND (FILL)		2.00								
56.0	GRAVELLY SAND (FILL)		2.00								
56.5	GRAVELLY SAND (FILL)		2.00								
57.0	GRAVELLY SAND (FILL)		2.00								
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58.0	GRAVELLY SAND (FILL)		2.00								
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60.5	GRAVELLY SAND (FILL)		2.00								
61.0	GRAVELLY SAND (FILL)		2.00								
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67.0	GRAVELLY SAND (FILL)		2.00								
67.5	GRAVELLY SAND (FILL)		2.00								
68.0	GRAVELLY SAND (FILL)		2.00								
68.5	GRAVELLY SAND (FILL)		2.00								
69.0	GRAVELLY SAND (FILL)		2.00								
69.5	GRAVELLY SAND (FILL)		2.00								
70.0	GRAVELLY SAND (FILL)		2.00								
70.5	GRAVELLY SAND (FILL)		2.00								
71.0	GRAVELLY SAND (FILL)		2.00								
71.5	GRAVELLY SAND (FILL)		2.00								
72.0	GRAVELLY SAND (FILL)		2.00								
72.5	GRAVELLY SAND (FILL)		2.00								

Form G.A.-5-1

30 MAY 1973

Project No. 730-51

RECORD OF BOREHOLE LOG										PRELIMINARY					
LOCATION: SEA FIGHT										BORING DATE: MARCH 27, 1973					
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.										PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.					
SOIL PROFILE										DYNAMIC PENETRATION		COEFFICIENT OF PERMEABILITY, $k$		PIEZOMETER	
DESCRIPTON										RESISTANCE, BLows/F.T.		1/10 1/10 1/10 1/10		ON HEAD OF	
										SHEAR STRENGTH, $c$ LB./SQ. FT.		WATER CONTENT, PERCENT		INSTALLATION	
										1/10 1/10 1/10 1/10		15 25 35 45			
00.0 GROUND SURFACE															
01.0															
VERY LOOSE TO COMPACT BROWN SILTY SAND															
TRACE TO SOME GRAVEL															
(NEGATIVE) FILL															
02.0															
03.0															
04.0															
05.0															
06.0															
07.0															
08.0															
09.0															
10.0															
11.0															
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94.0															
95.0															
96.0															
97.0															
98.0															
99.0															
100.0															

VERTICAL SCALE 1 IN. TO 2 FT.

Golder Associates

DESIGN: D.M.

CHECKED: \_\_\_\_\_

RECORD OF BOREHOLE 103											
LOCATION: 1st Floor		BORING DATE: 11-MARCH-29-1973		DATE: 3-29-73		SECTION: 103		PENETRATION TEST HAMMER WEIGHT 140 LB, DROP 30 IN.			
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	DYNAMIC PENETRATION RESISTANCE (LBS/IN) 20 40 60 80 100	COEFFICIENT OF PENETRATION 1/2 IN. 1/4 IN. 1/8 IN. 1/16 IN.	WATER CONTENT, PERCENT	PIEZOMETER OR STANDARD INSTALLATION	DYNAMIC PENETRATION TEST RESULTS			
								20	40	60	80
0.0	GROUND SURFACE										
0.1	ASPHALT	1	1	1							
0.2	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL, TRAIL CLAY TRACE ORGANIC MATERIAL (RECENT FILL)	2	2	2							
0.3	ASPHALT	3	3	3							
0.4	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	4	4	4							
0.5	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	5	5	5							
0.6	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	6	6	6							
0.7	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	7	7	7							
0.8	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	8	8	8							
0.9	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	9	9	9							
1.0	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	10	10	10							
1.1	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	11	11	11							
1.2	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	12	12	12							
1.3	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	13	13	13							
1.4	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	14	14	14							
1.5	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	15	15	15							
1.6	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	16	16	16							
1.7	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	17	17	17							
1.8	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	18	18	18							
1.9	CONCRETE TO GRADE BELOW CLAY SAND & GRAVEL (FILL)	19	19	19							
2.0	END OF HOLE	20	20	20							

VERTICAL SCALE  
1 IN. TO 2 FT.

Golden Associates

DATE: 3-29-73  
CHECKED: \_\_\_\_\_

RECORD OF BOREHOLE 104 PRELIMINARY										
LOCATION: Sea Floor		BORING DATE: March 28, 1953		DATUM: Geodetic						
SAMPLER: HANMER WEIGHT 140 LB., DROP 30 IN.		PENETRATION TEST: HANMER WEIGHT 140 LB., DROP 30 IN.								
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	ELEVATION FEET	DYNAMIC PENETRATION RESISTANCE, BLUNTS/FT. 20 40 60 80 100			COEFFICIENT OF PERMEABILITY, K, CM/SEC. 10 100 1000 10000			PIEZOMETER OR STADIOMETER INSTALLATION
				SHEAR STRENGTH BLUNTS/FT.	WATER CONTENT, PERCENT	WATER CONTENT, PERCENT	WATER CONTENT, PERCENT	WATER CONTENT, PERCENT		
0.0	20 FT. BEHIND BLUNTS		10.0							
1.0			9.0							
2.0			8.0							
3.0			7.0							
4.0	CONTACT TO VERY		6.0							
5.0	COARSE, BROWN		5.0							
6.0	SILTY SAND &		4.0							
7.0	SAND, LAMINAR		3.0							
8.0	COARSE, (FILL)		2.0							
9.0			1.0							
10.0			0.0							
11.0			-1.0							
12.0			-2.0							
13.0			-3.0							
14.0			-4.0							
15.0			-5.0							
16.0			-6.0							
17.0			-7.0							
18.0			-8.0							
19.0			-9.0							
20.0			-10.0							
21.0			-11.0							
22.0			-12.0							
23.0			-13.0							
24.0			-14.0							
25.0			-15.0							
26.0			-16.0							
27.0			-17.0							
28.0			-18.0							
29.0			-19.0							
30.0			-20.0							
31.0			-21.0							
32.0			-22.0							
33.0			-23.0							
34.0			-24.0							
35.0			-25.0							
36.0			-26.0							
37.0			-27.0							
38.0			-28.0							
39.0			-29.0							
40.0			-30.0							
41.0			-31.0							
42.0			-32.0							
43.0			-33.0							
44.0			-34.0							
45.0			-35.0							
46.0			-36.0							
47.0			-37.0							
48.0			-38.0							
49.0			-39.0							
50.0			-40.0							
51.0			-41.0							
52.0			-42.0							
53.0			-43.0							
54.0			-44.0							
55.0			-45.0							
56.0			-46.0							
57.0			-47.0							
58.0			-48.0							
59.0			-49.0							
60.0			-50.0							
61.0			-51.0							
62.0			-52.0							
63.0			-53.0							
64.0			-54.0							
65.0			-55.0							
66.0			-56.0							
67.0			-57.0							
68.0			-58.0							
69.0			-59.0							
70.0			-60.0							
71.0			-61.0							
72.0			-62.0							
73.0			-63.0							
74.0			-64.0							
75.0			-65.0							
76.0			-66.0							
77.0			-67.0							
78.0			-68.0							
79.0			-69.0							
80.0			-70.0							
81.0			-71.0							
82.0			-72.0							
83.0			-73.0							
84.0			-74.0							
85.0			-75.0							
86.0			-76.0							
87.0			-77.0							
88.0			-78.0							
89.0			-79.0							
90.0			-80.0							
91.0			-81.0							
92.0			-82.0							
93.0			-83.0							
94.0			-84.0							
95.0			-85.0							
96.0			-86.0							
97.0			-87.0							
98.0			-88.0							
99.0			-89.0							
100.0			-90.0							

VERTICAL SCALE: 1 IN. TO 2 FT.

Golden Associates

DRAWN: J.M.

CHECKED:

Sheet 31  
GROSS No.

Project No. 72047

RECORD OF BOREHOLE 105												PRELIMINARY			
LOCATION 5th Flgms 1												BORING DATE MARCH 28, 1973		DATUM SE-1000	
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.												PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.			
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	STAGE CUT	SOIL TYPE	REMARKS	DYNAMIC PENETRATION RESISTANCE (LBS./FT.)			COEFFICIENT OF PENETRATION K <sub>1</sub> (IN./IN.)			WATER CONTENT, PERCENT	RESISTANCE OR STANDARD INSTALLATION		
						20	40	60	100	120	140			160	
0.0	GROUND SURFACE														
0.5	COMPACT TO SANDY SILT (FILL)	1													
1.0	COMPACT TO SANDY SILT (FILL)	2													
1.5	COMPACT TO SANDY SILT (FILL)	3													
2.0	COMPACT TO SANDY SILT (FILL)	4													
2.5	COMPACT TO SANDY SILT (FILL)	5													
3.0	COMPACT TO SANDY SILT (FILL)	6													
3.5	COMPACT TO SANDY SILT (FILL)	7													
4.0	COMPACT TO SANDY SILT (FILL)	8													
4.5	COMPACT TO SANDY SILT (FILL)	9													
5.0	COMPACT TO SANDY SILT (FILL)	10													
5.5	COMPACT TO SANDY SILT (FILL)	11													
6.0	COMPACT TO SANDY SILT (FILL)	12													
6.5	COMPACT TO SANDY SILT (FILL)	13													
7.0	COMPACT TO SANDY SILT (FILL)	14													
7.5	COMPACT TO SANDY SILT (FILL)	15													
8.0	COMPACT TO SANDY SILT (FILL)	16													
8.5	COMPACT TO SANDY SILT (FILL)	17													
9.0	COMPACT TO SANDY SILT (FILL)	18													
9.5	COMPACT TO SANDY SILT (FILL)	19													
10.0	COMPACT TO SANDY SILT (FILL)	20													
10.5	COMPACT TO SANDY SILT (FILL)	21													
11.0	COMPACT TO SANDY SILT (FILL)	22													
11.5	COMPACT TO SANDY SILT (FILL)	23													
12.0	COMPACT TO SANDY SILT (FILL)	24													
12.5	COMPACT TO SANDY SILT (FILL)	25													
13.0	COMPACT TO SANDY SILT (FILL)	26													
13.5	COMPACT TO SANDY SILT (FILL)	27													
14.0	COMPACT TO SANDY SILT (FILL)	28													
14.5	COMPACT TO SANDY SILT (FILL)	29													
15.0	COMPACT TO SANDY SILT (FILL)	30													
15.5	COMPACT TO SANDY SILT (FILL)	31													
16.0	COMPACT TO SANDY SILT (FILL)	32													
16.5	COMPACT TO SANDY SILT (FILL)	33													
17.0	COMPACT TO SANDY SILT (FILL)	34													
17.5	COMPACT TO SANDY SILT (FILL)	35													
18.0	COMPACT TO SANDY SILT (FILL)	36													
18.5	COMPACT TO SANDY SILT (FILL)	37													
19.0	COMPACT TO SANDY SILT (FILL)	38													
19.5	COMPACT TO SANDY SILT (FILL)	39													
20.0	COMPACT TO SANDY SILT (FILL)	40													
20.5	COMPACT TO SANDY SILT (FILL)	41													
21.0	COMPACT TO SANDY SILT (FILL)	42													
21.5	COMPACT TO SANDY SILT (FILL)	43													
22.0	COMPACT TO SANDY SILT (FILL)	44													
22.5	COMPACT TO SANDY SILT (FILL)	45													
23.0	COMPACT TO SANDY SILT (FILL)	46													
23.5	COMPACT TO SANDY SILT (FILL)	47													
24.0	COMPACT TO SANDY SILT (FILL)	48													
24.5	COMPACT TO SANDY SILT (FILL)	49													
25.0	COMPACT TO SANDY SILT (FILL)	50													
25.5	COMPACT TO SANDY SILT (FILL)	51													
26.0	COMPACT TO SANDY SILT (FILL)	52													
26.5	COMPACT TO SANDY SILT (FILL)	53													
27.0	COMPACT TO SANDY SILT (FILL)	54													
27.5	COMPACT TO SANDY SILT (FILL)	55													
28.0	COMPACT TO SANDY SILT (FILL)	56													
28.5	COMPACT TO SANDY SILT (FILL)	57													
29.0	COMPACT TO SANDY SILT (FILL)	58													
29.5	COMPACT TO SANDY SILT (FILL)	59													
30.0	COMPACT TO SANDY SILT (FILL)	60													
30.5	COMPACT TO SANDY SILT (FILL)	61													
31.0	COMPACT TO SANDY SILT (FILL)	62													
31.5	COMPACT TO SANDY SILT (FILL)	63													
32.0	COMPACT TO SANDY SILT (FILL)	64													
32.5	COMPACT TO SANDY SILT (FILL)	65													
33.0	COMPACT TO SANDY SILT (FILL)	66													
33.5	COMPACT TO SANDY SILT (FILL)	67													
34.0	COMPACT TO SANDY SILT (FILL)	68													
34.5	COMPACT TO SANDY SILT (FILL)	69													
35.0	COMPACT TO SANDY SILT (FILL)	70													
35.5	COMPACT TO SANDY SILT (FILL)	71													
36.0	COMPACT TO SANDY SILT (FILL)	72													
36.5	COMPACT TO SANDY SILT (FILL)	73													
37.0	COMPACT TO SANDY SILT (FILL)	74													
37.5	COMPACT TO SANDY SILT (FILL)	75													
38.0	COMPACT TO SANDY SILT (FILL)	76													
38.5	COMPACT TO SANDY SILT (FILL)	77													
39.0	COMPACT TO SANDY SILT (FILL)	78													
39.5	COMPACT TO SANDY SILT (FILL)	79													
40.0	COMPACT TO SANDY SILT (FILL)	80													
40.5	COMPACT TO SANDY SILT (FILL)	81													
41.0	COMPACT TO SANDY SILT (FILL)	82													
41.5	COMPACT TO SANDY SILT (FILL)	83													
42.0	COMPACT TO SANDY SILT (FILL)	84													
42.5	COMPACT TO SANDY SILT (FILL)	85													
43.0	COMPACT TO SANDY SILT (FILL)	86													
43.5	COMPACT TO SANDY SILT (FILL)	87													
44.0	COMPACT TO SANDY SILT (FILL)	88													
44.5	COMPACT TO SANDY SILT (FILL)	89													
45.0	COMPACT TO SANDY SILT (FILL)	90													
45.5	COMPACT TO SANDY SILT (FILL)	91													
46.0	COMPACT TO SANDY SILT (FILL)	92													
46.5	COMPACT TO SANDY SILT (FILL)	93													
47.0	COMPACT TO SANDY SILT (FILL)	94													
47.5	COMPACT TO SANDY SILT (FILL)	95													
48.0	COMPACT TO SANDY SILT (FILL)	96													
48.5	COMPACT TO SANDY SILT (FILL)	97													
49.0	COMPACT TO SANDY SILT (FILL)	98													
49.5	COMPACT TO SANDY SILT (FILL)	99													
50.0	COMPACT TO SANDY SILT (FILL)	100													

VERTICAL SCALE  
1 IN. = 5 FT.

Golder Associates

DATE 3-31-73  
CHECKED

RECORD OF BOREHOLE LOG - PUELLICHAWAY											
LOCATION: 8th Fwy		BORE DATE: MARCH 27, 1973		DATUM: GEODETIC							
SAMPLED HAMMER WEIGHT: 140 LB., DROP 30 IN.		PENETRATION TEST HAMMER WEIGHT: 140 LB., DROP 30 IN.									
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	ELEVATION FEET	DYNAMIC PENETRATION RESISTANCE, PLW/FT.		COEFFICIENT OF PERMEABILITY, K, CM/SEC.		WATER CONTENT, PERCENT		PIEZOMETER OR STANDARD INSTALLATION	
				20	40	100	200	100	200		100
				SHEAR STRENGTH, KLB/RSQ		NEUT. P. & C.B. RES. - 0					
257.5	LOOSE SAND	1	257.5								
258.0	COMPACT SANDY SILT SAND & GRAVEL (FILL)	2	258.0								
258.5	STIFF TO VERY STIFF BROWN CLAYEY SILT & GRAVEL (FILL)	3	258.5								
259.0	LOOSE BROWN SILT SAND (FILL)	4	259.0								
259.5		5	259.5								
260.0		6	260.0								
260.5		7	260.5								
261.0		8	261.0								
261.5		9	261.5								
262.0	VERY STIFF TO HARD GREY CLAYEY SILT & GRAVEL, SILT SAND, SILT (FILL)	10	262.0								
262.5		11	262.5								
263.0		12	263.0								
263.5		13	263.5								
264.0		14	264.0								
264.5		15	264.5								
265.0	COMPACT GRAY SILT SAND	16	265.0								
265.5	LOOSE TO COMPACT GRAY SILT SAND WITH CHALK MATERIAL	17	265.5								
266.0	END OF HOLE	18	266.0								

VERTICAL SCALE: 1 IN. TO 5 FEET

Golder Associates

Checked: [Signature]

RECORD OF BOREHOLE 107										PRELIMINARY	
LOCATION: 3rd Floor		BORING DATE: MARCH 10, 1978		DATUM: GUYANA							
SAMPLER: HAMMER WEIGHT 140 LB, DROP 30 IN.		PENETRATION TEST: HAMMER WEIGHT 140 LB, DROP 30 IN.									
DEPTH FEET	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	ELEVATION FEET	DYNAMIC PENETRATION RESISTANCE, KLB/FT.		COEFFICIENT OF PERMEABILITY, K, CM/SEC.		WATER CONTENT, PERCENT	PIESOMETER OR FLUORIMETER INSTALLATION		
				20 40 60	80 100 120	140 160 180	200 220 240				
				SHEAR STRENGTH, KLB/FT.		WATER CONTENT, PERCENT					
				N/A		N/A					
26.5											
26.0											
25.5											
25.0											
24.5											
24.0											
23.5											
23.0											
22.5											
22.0											
21.5											
21.0											
20.5											
20.0											
19.5											
19.0											
18.5											
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10.5											
10.0											
9.5											
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8.5											
8.0											
7.5											
7.0											
6.5											
6.0											
5.5											
5.0											
4.5											
4.0											
3.5											
3.0											
2.5											
2.0											
1.5											
1.0											
0.5											
0.0											

VERTICAL SCALE: 1 IN. TO 10 FT.

Golden Associates

DATE: 3-11-78

CHECKED: \_\_\_\_\_

[illegible]