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CONT. No.

W. O. No. 82-26020

STR. SITE No. N/A

HWY. No. Q.E.W.

LOCATION Q.E.W. FROM HUMBER RIVER
WESTERLY TO PARK LAWN RD.

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry of
Transportation and
Communications

FILE No. _____ DATE _____

Bob Jaffarides

REMARKS

* Require W.P. no
✓ site plans
- approach slabs?

N.O.

Dave Aspinwall 224-7463

✓ Tom Walsh

Mimico Patrol Yard - Kipling Ave
Jim Holiday 251-5293



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT TO

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

GEOTECHNICAL INVESTIGATION
SETTLEMENT OF PAVEMENTS ON
FILL EMBANKMENTS
Q.E.W. AND LAKESHORE BLVD.
WEST OF HUMBER RIVER
ETOBICOKE, ONTARIO
WO-82-26020

Distribution:

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ABSTRACT

A subsurface investigation was carried out by Golder Associates for the Ministry of Transportation and Communications at the site of several existing fill embankments along the Q.E.W., west of the Humber River in Etobicoke, Ontario. The existing fill is up to 11.5 metres high and has been in place for over 10 years. The pavements on top of the embankments have settled up to 457 mm since construction.

The major causes of settlement is the use of poor quality fill materials placed immediately behind structures and inadequate compaction during construction. Significant further settlement of these fill materials is not likely at most locations because they are located below 4 to 5 metres of well compacted fill. However, in the area behind Retaining Wall No. 6, Borehole 304 found poorly compacted fill immediately beneath the pavement for a depth of about 4 metres. In this area the fill must be sub-excavated and recompacted to prevent future settlement, otherwise increased maintenance can be anticipated.

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1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications to carry out a subsurface investigation at the site of several existing fill approach embankments along the Q.E.W. just west of the Humber River in Etobicoke, Ontario. The embankments were constructed between 1970 and 1972 and since that time the pavements resting on the embankments have settled considerably. Authorization for the investigation was received in a letter dated July 26, 1982 from the Hon. James Snow, Minister of Transportation and Communications.

The purpose of the investigation was to determine the subsurface conditions at each embankment, to assess the causes of the apparent settlement, to estimate the future settlement, and to provide engineering recommendations for the geotechnical aspects of pavement resurfacing at each location.

The field investigation was carried out and this report was prepared in accordance with the terms of reference outlined in Golder Associates proposal letter dated August 12, 1982 to Mr. M. S. Devata, P. Eng., Supervisory Engineer in the Soil Mechanics Section, Ministry of Transportation and Communications, Downsview, Ontario.

2.0 SITE AND PROJECT DESCRIPTION

The details and requirements of the project were provided during a meeting between Mr. T. Kazmierowski of the Ministry and Mr. J. Busbridge of Golder Associates on August 3, 1982. Additional details were provided on copies of predesign foundation investigations carried out by the Ministry for the bridge and retaining wall structures adjacent to the fill embankments. As well, a copy of an overall survey of the constructed pavement elevations along the Q.E.W. was provided.

The project site is located on the Q.E.W. just west of the Humber River (refer to Figure 1) where the ramps for access to Lakeshore Blvd. are situated. The pavement surface of the Q.E.W. at this location is about 10 metres above the level of the surrounding ground. C.N.R. railway tracks cross beneath the Q.E.W. as do the access ramps to Lakeshore Blvd. The fill embankments under investigation, form the approaches to the bridge structures which allow the railway tracks and access ramps to pass under the Q.E.W. pavement. The pavement surface over the fill embankments has numerous shallow depressions which present a hazard to traffic travelling at high speeds. In addition, there is significant overall settlement of the entire pavement surface where it is supported on the fill embankments. Prior to carrying out pavement resurfacing at these locations, M.T.C. decided that the settlements be investigated and that estimates of future settlement be provided.

It is understood that the Q.E.W. at this location was reconstructed from 1970 to 1972 and that this reconstruction involved the realignment of the Q.E.W. as well as the

construction of bridges and fill embankments. Some of the embankments were new embankments while others were existing embankments that were increased in height and/or partially widened.

3.0 SUBSURFACE CONDITIONS

The detailed soil stratigraphy encountered in each of the boreholes put down during this investigation is given on the attached Record of Borehole sheets. The locations of the boreholes and stratigraphic sections showing the inferred subsurface conditions are given on the attached Figures 2 and 3. Results of laboratory testing carried out on representative samples are shown on the Record of Borehole sheets and on Figures 6 to 13 inclusive. The details of the field investigation procedures are given in Appendix I.

3.1 Borehole 301

Borehole 301 is situated on the pavement shoulder immediately beside the travelled lanes of the pavement about 13.4 metres behind the bridge abutment, west of the CNR tracks (see Figure 2). The ground surface consists of asphaltic concrete which was found to extend to a depth of 0.12 metres. The asphaltic concrete is underlain by embankment fill to a depth of 11.81 metres below pavement surface. The fill consists of layers of different materials as follows:

<u>Depth Below Ground Surface (metres)</u>	<u>Fill Composition</u>	<u>'N' Values</u>	<u>Estimated Compaction</u>
0.12 to 2.13	sand and gravel	18 to 28	well compacted
2.13 to 5.18	gravelly sand, some silt	20 to 41 (2.13 to 4.5 m)	well compacted
		8 (4.5 to 5.18 m)	poorly compacted
5.18 to 6.71	gravelly sand and silt	3 to 4	poorly compacted
6.71 to 10.52	organic silty clay, with zones of gravel, sand and clayey silt	1 to 6	poorly compacted
10.52 to 11.81	silty clay with trace organics	9	well compacted

The measured water contents of the fill were generally less than 11 per cent down to a depth of about 8 metres below ground surface. From a depth of 8 to 10 metres, the water content was between 14 and 22 per cent and below 10 metres the water content of the fill was from 28 to 32 per cent.

The measured liquid limit of the organic silty clay fill varied from 47 to 50 per cent and the plastic limit was 24 per cent giving a plasticity index of 23 to 26 (refer to Figure 10). By comparison, the underlying silty clay fill had a measured liquid limit of 29 per cent and a plastic limit of 21 per cent giving a plasticity index of 8. Using the unified soil classification system, the materials are therefore clays of intermediate and low plasticity, respectively (refer to Figure 10).

Available information on the highway alignments and profiles prior to 1970 indicate that the boundary between the two types of fill is consistent with the older highway elevation. The lower fill is probably material placed before 1970.

Beneath the 11.81 metres of embankment fill, the natural soil consists of silty clay with some sand and trace organics. The consistency of the clay is firm to very stiff to a depth of 14.5 metres and hard to a depth of 15.7 metres below pavement surface. The water content of the silty clay decreased from about 28 per cent to a depth of 12 metres to about 17 per cent at a depth of 15 metres below ground surface. The measured liquid limit of the silty clay was 36 per cent and the plastic limit 20 per cent for a plasticity index of 16. This indicates a clay of intermediate plasticity (refer to Figure 10). At a depth of 15.7 metres below ground surface, refusal was met on a very hard, rock-like object which could be bedrock or a boulder. The stabilized water level in the Borehole 301 piezometer was at a depth of 9.14 metres below pavement surface (elevation 89.30 m) about one week after drilling.

3.2 Borehole 302

Borehole 302 is located on the pavement shoulder about 10.36 metres behind the bridge abutment west of the Lakeshore Blvd. entrance ramp (see Figure 3). The asphaltic concrete at ground surface is 0.23 metres thick. It is underlain by embankment fill to a depth of 9.75 metres below pavement surface. The composition of the fill is described below:

<u>Depth Below Ground Surface (metres)</u>	<u>Fill Composition</u>	<u>'N' Values</u>	<u>Estimated Compaction</u>
0.23 to 3.66	sand and gravel	13 to 37	well compacted
3.66 to 9.75	silt with zones of gravel, sand, and clay	5 to 46	poorly to moderately compacted

The measured water contents were generally between 6 and 9 per cent for the sand and gravel fill, increasing to between 11 and 18 per cent for the silty fill.

Beneath the 9.75 metres of embankment fill, the natural soil consists of a silty clay with some sand and trace organics. The consistency of the silty clay is stiff to very stiff to a depth of 12.04 metres and is hard to a depth of 12.95 metres below pavement surface. The measured water content of the silty clay ranged from 11 to 31 per cent.

Below a depth of 12.95 metres, Borehole 302 encountered highly weathered red shale and refusal to augering was met at a depth of 13.5 metres below ground surface.

The stabilized water level in the Borehole 302 piezometers was found at a depth of 12.95 metres below ground surface (elevation 79.98) about one week after drilling. The water level corresponds to the level of the shale.

3.3 Borehole 303

Borehole 303 was put down through the travelled pavement about 4.5 metres behind (north of) Retaining Wall No. 10 on the Lakeshore Blvd. exit ramp (see Figure 3). Retaining Wall No. 10 is located immediately west of the TTC bridge which carries the Q.E.W. ramp over the TTC streetcar tracks. The pavement at this location consist of 0.10 metres of asphaltic concrete surfacing on top of 0.30 metres of unreinforced concrete slab. The concrete slab is supported by a crushed limestone base which extends to a depth of 1.06 metres below pavement surface. The crushed limestone base is in turn underlain by fill to a depth of 8.84 metres below pavement surface which also corresponds to the base of the adjacent retaining wall. The fill can be described as follows:

<u>Depth Below Ground Surface (metres)</u>	<u>Fill Composition</u>	<u>'N' Values</u>	<u>Estimated Compaction</u>
1.06 to 7.47	silt with some sand, gravel	10 to 54 (1.06 to 5.5 m) 5 to 7 (5.5 to 7.4 m)	well compacted poorly compacted
7.47 to 8.84	silty sand, fine	2 to 16	poorly compacted

The measured water contents of the fill varied from 8 to 15 per cent down to a depth of 5 metres and from 15 to 21 per cent at depths greater than 5 metres below pavement surface. Figure 11 presents the results of a laboratory Standard Proctor compaction test carried out on a composite sample of the silt with some sand (fill).

The native soil underlying the fill was found to consist of stiff to very stiff, silty clay with occasional fine sand lenses, to a depth of 12.95 metres below pavement surface. The measured water content of the silty clay ranged from 16 to 23 per cent. The liquid and plastic limits were found to range from 28 to 33 and from 15 to 19 per cent, respectively (see Figure 10). Adopting the Unified Soil Classification System, the material is therefore a clay of low plasticity. At a depth of 12.95 metres, the borehole encountered refusal to augering on top of a rock-like surface; likely a boulder or shale bedrock. The water level in the Borehole 303 piezometer stabilized at a depth of 6.86 metres (elevation 97.49 m) about one week after drilling.

3.4 Borehole 304

Borehole 304 was drilled on the pavement shoulder some 76 metres east of the east abutment of the C.N.R. bridge and about 3 metres from the parapet wall atop the embankment (see Figure 2). The pavement surface consists of asphaltic concrete to a depth of 0.15 metres. The asphaltic concrete is underlain by embankment fill to a depth of 6.71 metres below pavement surface. The details of the fill are as follows:

<u>Depth Below Ground Surface (metres)</u>	<u>Fill Composition</u>	<u>'N' Values</u>	<u>Estimated Compaction</u>
0.15 to 1.07	sand and gravel	9	poorly compacted
1.07 to 6.71	silt and sand, some clay	6 to 9 (1.07 to 4.0 m) 13 to 19 (4.0 to 6.71 m)	poorly compacted well compacted

The measured water contents for the fill were generally between 8 and 12 per cent. Figure 12 presents the results of a laboratory Standard Proctor compaction test carried out on a sample of the silt and sand fill.

Below the fill, a very stiff to hard silty clay with trace sand was encountered to a depth of at least 11.13 metres below pavement surface. The measured water contents of the silty clay varied from 11 to 14 per cent.

The piezometer installed in Borehole 304 was found to be dry about one week after the field drilling.

3.5 Borehole 305

Borehole 305 is located on the pavement shoulder about 12.71 metres behind the bridge abutment west of the CNR railway tracks (see Figure 2). At this location, a retaining wall located about 3.4 metres to the north, extends down about 10 metres to level ground. The asphaltic concrete at the borehole ground surface is 0.20 metres deep. The pavement is underlain by retaining wall backfill down to a depth of 11.58 metres where the borehole encountered refusal to augering on the rock-like surface. Inspection of the auger teeth on the end of the augers revealed concrete cuttings which together with construction drawings (showing the location of the pile cap foundations) suggests that the borehole was terminated on top of the pile cap. To a depth of 9.75 metres, the retaining wall backfill was found to consist of sand and gravel with some silt. The gravel included coarse sized limestone pieces which fragmented when sampled by the driven split-spoon. The measured water contents of laboratory samples of the sand and gravel fill was between 3 and 9 per cent. The fill is generally well compacted although there are zones of poorly compacted material as reflected by 'N' values of 8 and 11 which were found at depths of 3 and 5 metres respectively.

Beneath the sand and gravel fill, firm silty clay fill was found to the end of the borehole. The silty clay fill also contained sand and organics. The measured water content of the silty clay fill was from 16 to 18 per cent. The liquid and plastic limits were 26 and 16 per cent respectively, indicating a clay of low plasticity (see Figure 10).

The water level in the piezometer in Borehole 305, stabilized at a depth of 9.30 metres (elevation 88.95 m) below pavement surface, about one week after the field drilling.

4.0 DETAILS OF SETTLEMENT

Settlement of the road surface atop the fills at each borehole location is clearly shown on Figures 15 to 18 which are photographs of the road at the borehole locations. In most cases, the settlement is evident from the obvious deformation of the concrete curbs. The curbs have settled differentially and this has caused severe cracking. The original design had the top of the curb at the same level as the base of the parapet walls. The photographs clearly show locations where the top of the curb has settled while the parapet walls which are generally founded on piles* show negligible settlement. The photographs also show pavement areas where the asphalt surface has cracked to accommodate severe differential settlement. A large area around Borehole 304 appears to have been repaired recently.

At each abutment location where a borehole was put down to examine the nature of the materials, a levelling survey along the road alignment was made. The measured profiles are presented in Figures 4 and 5. Also shown on the figures are the pavement surface profiles measured by the Foundation of Canada Engineering Corporation Limited after original construction in 1972. The profiles provide a measure of the total pavement settlement which has taken place since 1972. Table 1 gives a summary of the underlying fill and the settlements at each borehole location.

* Drawing D-6766-1 shows that the east abutment of Bridge Number 9 is founded on spread footings. All other abutments are indicated to be on piles in the respective drawings.

5.0 DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations are addressed to the apparent settlement of the road surface at each borehole location, including:

- a) cause(s) of past settlement,
- b) estimate of future settlement,
- c) considerations for pavement resurfacing.

Specific comments are also made in regard to the state of compaction of the fill and types of backfill behind retaining walls and abutments.

5.1 Causes of Settlement

Excessive settlement of a pavement surface can result from the effect of combinations of three factors:

- 1) Settlement due to the presence of compressible native subsoils.
- 2) Settlement due to the use of poor quality embankment fill.
- 3) Inadequate compaction of the fill materials.

The first of these factors depends on the particular sites where the embankments are constructed. The use of well graded granular material is commonly specified for fills immediately behind bridge abutments¹ and when such a material is compacted to greater than 90 per cent of it's Proctor Density, it is about 3 to 4 times less compressible than a silt or clay compacted to the same proportion of it's maximum density².

1 Ontario Highway Bridge Design Code, 1979.

2 NAVFACS DM-7, March 1971, pg. 7-9-2.

The degree of compaction also has a significant effect on the compressibility of a fill. For example, a sand at a relative density of 60 per cent is about 6 times more compressible than the same material at 80 per cent relative density³.

At the approaches to structures which are founded on rigid piled foundations, the settlement will be severely differential and sharp undulations will be evident in the highway alignment. Deep-seated settlements are usually reflected at the surface by ground subsidence over large areas while shallow-seated settlements are usually reflected by differential ground subsidence over short distances.

5.1.1 Compressibility of Native Subsoil

The consolidation characteristics of the native silty clay underlying the fill were established by an oedometer test carried out on representative samples of the soil. The e-log p curve for the native stiff silty clay displays a discernable p'_c which has not been exceeded by the stresses induced by the existing fill (p_o') (Refer to Figure 13). The geotechnical reports by M.T.C. during pre-design* (1969-70) estimated a recompression settlement within the silty clay of the order of 50 to 100 mm (2 to 4 in.) due to the increased fill loads of the new approach embankments. Further, these reports estimated a differential settlement in the native subsoils of the order of 25 to 63 mm (1 to 2.5 in.) between the old fill and the new fill where existing embankments were to be widened as well as increased in height. The reports stated that the majority of the settlement would occur during or immediately after construction of the fill. Thus, it was expected that the pavement would not be affected by excessive settlement of the parent subsoil after construction. Table 1 presents a summary of the measured settlement from all

3 Earth Manual, U.S. Bureau of Reclamation 1974, pg. 53

* D.H.O. Foundation Investigation Report No's. W.P. 314-65-6, W.P. 314-65-7 and 11, and W.P. 314-65-8, 9 and 10 all dated January, 1970.

borehole location. According to Table 1, the actual settlement to date at the locations of Boreholes 301 to 305 is on average about 210 mm (8.3 in.) ranging from 64 to 427 mm (2.5 to 16.8 in.). Thus, on average the observed settlement exceeds the predicted settlement by about 135 mm (5.3 in.) or 180 per cent.

The compressibility data presented on Figure 13 indicate that the estimates made prior to construction were reasonable. If the secondary compression of the underlying silty clay stratum since 1972 is considered using the data presented on Figure 14, then a further 25 mm (1 in.) of settlement can be accounted for. The remaining average settlement of 110 mm (4.3 in.) has likely occurred within the embankment fill materials. The nature of these materials and their state of compaction are discussed in the following sections for each of the bridges in turn.

5.1.2 Bridge No. 5 (Borehole 301 and 305)

Boreholes 301 and 305 were put down through the approach embankment on the west side of Bridge No. 5 which allows the C.N.R. tracks to pass beneath the Q.E.W. Both boreholes were located about 13 metres behind the west abutment, which, based on M.T.C. records, is founded on driven piles. At Borehole 301 an embankment slopes to the south while at Borehole 305 a retaining wall about 3 metres to the north extends about 10 metres down to the level of the C.N.R. tracks. Records show a concrete apron slab extending from the abutment for a distance of about 6 metres.

Figure 4 shows that the ground surface at the abutment near the boreholes has not changed from that surveyed after construction. The apron slab at Borehole 301 settled up to 130 mm (5 in.) while at Borehole 305 the slab settled less than 25 mm (1 in.). Settlement of the pavement surface

around Borehole 301 varied from 60 mm (2.4 in.) to 140 mm (5.5 in.) and was quite irregular while around Borehole 305 the settlement was from 50 to 100 mm (2 to 4 in.).

At Borehole 301, the older fill (pre 1972) at a depth of 10.52 to 11.81 metres below ground surface is in a well compacted state (refer to Figure 2). The new fill (post 1972) to a depth of about 5 metres is well compacted granular material. It is not possible to determine whether this fill was compacted during construction or after construction by vehicular traffic. This granular fill extended to a depth of 6.71 metres. From a depth of 5 to 10 metres, the new fill is poorly compacted and contains significant organic material which would classify it as being unsuitable for use in a settlement-sensitive embankment. The use of this poor quality fill material is considered to be the primary causes of the observed settlement. It is estimated that the organic fill and the native silty clay will experience further secondary compression of the order of 50 mm (2 in.) during the next 100 years.

At Borehole 305, the pavement is supported by 11.38 metres of fill placed in 1972 (refer to Figure 2). The fill rests on the concrete pile cap foundation of the bridge abutment and retaining wall. Therefore, pavement settlement at this location has resulted from compression of the backfill only. To a depth of 9.75 metres below pavement surface, the fill consists of well compacted sand and gravel with occasional zones of poorly compacted material. Beneath the granular fill, 1.83 metres of silty clay fill was found in a well compacted condition. The probable causes of settlement in this area are:

- a) consolidation of the loose zones in the sand and gravel fill, by traffic, and
- b) consolidation of the silty clay fill under the weight of the overlying granular fill.

Secondary compression of the silty clay fill over the next 100 years is estimated to be about 7 mm.

5.1.3 Bridge No. 9 (Borehole 302)

Borehole 302 was put down through the approach embankment on the east side of Bridge No. 9. Bridge No. 9 carries the east bound Q.E.W. traffic exiting to Lakeshore Blvd. over the exit and entrance ramps for Lakeshore Blvd. (refer to Figures 1 and 3). M.T.C. records indicate that the west abutment is founded on driven piles but that the east abutment near Borehole 302 is founded on a spread footing at about elevation 83.5 m (Geodetic). At Borehole 302 the approach embankment extends to a height of about 9 metres. Records show a concrete apron slab extending from the abutment for a distance of about 6 metres.

Figure 5 shows the existing pavement profile and the profile in 1972 immediately after construction. It is apparent from Figure 5 that during this time, the east abutment (which is on a footing) has settled about 238 mm (9 in.). Also, the apron slab appears to have settled up to 310 mm (12.3 in.). The pavement surface near Borehole 302 appears to have settled quite uniformly by about 300 mm (12 in.).

At Borehole 302, all of the fill was placed in 1972 (refer to Figure 1). The fill to a depth of about 1.7 metres consists of good granular material in a well compacted state. Again, it is not possible to determine whether the granular fill was compacted during construction or after construction by traffic. From a depth of 3.7 to 5.1 metres below pavement surface the fill consists of silt in a poorly compacted state. The probable cause of excessive settlement at this location is the 6.1 metres thick zone of poorly compacted silt fill. The future settlement due to secondary compression of the underlying native silty clay is estimated to be about 15 mm over the next 100 years.

5.1.4 Retaining Wall No. 10 (Borehole 303)

Borehole 303 was put down about 4.5 metres behind Retaining Wall No. 10 which is about 8 metres high at that location (refer to Figures 1 and 3). According to M.T.C. records, the retaining wall is supported on piles driven to bedrock. Figure 5 indicates that the pavement surface near Borehole 303 has settled uniformly about 430 mm (17 in.). The photograph of Borehole 303 on Figure 16 shows the curb and catchbasin beside the borehole location. It can be seen that excessive settlement has occurred and that the catchbasin did not settle as much as the adjacent pavement surface. Catchbasins are normally about 1.5 metres deep. This implies that the soil between the bottom of the catchbasin and the pavement surface is responsible for the difference in amount of settlement.

At Borehole 303, the pavement is supported by about 0.75 metres of well compacted crushed limestone. Beneath the crushed stone base, the fill placed in 1972 consists of well compacted silt to a depth of 5.2 metres and poorly compacted silt from that level to a depth of about 8 metres below pavement surface (refer to Figure 3). The poor compaction of the silt fill is the probable cause of excessive settlement, however, differential movement with respect to the catchbasin implies some settlement of the upper material. Future settlement due to secondary compression of the underlying native silty clay is estimated to be about 20 mm over the next 100 years.

5.1.5 Retaining Wall No. 6 (Borehole 304)

At Borehole 304, an embankment slopes down to the north of the top of Retaining Wall No. 6 which is about 3 metres high at that point. The difference in elevation between the ground in front of the wall and the pavement at Borehole 304 is about 7 metres.

Figure 4 shows that the east abutment of Bridge No. 5, some 75 metres west of Borehole 304, has not settled. M.T.C. records show that this abutment is founded on driven piles. The survey data presented on Figure 4 indicates that the abutment has not settled and that the pavement surface near Borehole 304 has settled from 60 to 200 mm (2.5 to 8.0 in.) since construction. However, it should be noted that this may not be an accurate indication of the total settlement since the pavement around Borehole 304 shows some recent pavement repair.

At Borehole 304, the old fill (pre-1972) from a depth of about 4 to 6.7 metres below pavement surface is in a well compacted condition (refer to Figure 2). The new fill (placed in 1972) consists of silt and sand and it is poorly compacted from beneath the pavement down to its full depth of about 4 metres. The poor compaction of this new fill is the probable cause of excessive settlement. It is estimated that a further 35 mm of settlement will take place over the next 100 years as a result of secondary compression within the underlying native silty clay.

5.1.6 Summary

In summary, the following conclusions are made about the probable causes of excessive settlement:

- a) Based on the subsurface conditions encountered in this investigation the predictions of settlement due to consolidation of the silty clay reported by the 1969 D.H.O. foundation investigations are reasonably accurate.
- b) The excessive pavement settlement conditions which are apparent 10 years after construction are due to the use of poor quality fill material immediately behind rigid retaining walls and abutments, and inadequate compaction of fill during construction.

- c) if granular fill had been placed and good construction practice followed during fill placement, as specified in O.H.B.D.C. (1979), then settlement of the pavement surface would have been significantly less.
- d) future settlement of the pavement surface is estimated at 7 mm to 50 mm due to secondary compression of the silty clay fill and underlying native silty clay.

5.2 Remedial Measures

At the locations of Boreholes 301, 302, 303 and 305, a depth of 4 to 5 metres of well compacted granular fill underlies the pavement surface which significantly distributes and dampens traffic loads and vibrations to the zones of poorly compacted fill located below. Noticeable future settlements of the poorly compacted fill at depth due to traffic are not anticipated unless the traffic loads are increased. In view of the 10 years of service under heavy traffic volumes, it is considered that most of the settlement has already occurred. Accordingly, after the proposed pavement resurfacing in these areas, there should be little further differential settlements in the pavement surface. Alternatively, the slight risk of additional settlement can be eliminated by improving the compaction of the loose fill at depth. This would require a major disruption of traffic on the Q.E.W. which is probably not tolerable. Further, the cost of such work would be significantly higher than resurfacing and possible minor maintenance.

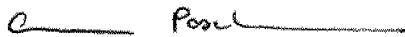
The area of Borehole 304 appears to have been repaired recently and the zones of poorly compacted fill materials are near the pavement surface. These shallow zones have not likely been stabilized by 10 years of service under heavy traffic, and future differential settlement is probable.

To prevent future differential settlement, the poorly compacted fill should be subexcavated to a depth of 3 metres and properly compacted before resurfacing. Alternatively, the pavement can be resurfaced without subexcavation and additional settlement with increased maintenance can be anticipated.

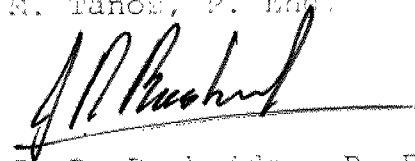
The concrete approach slabs have been fairly successful in eliminating sudden depressions under the road pavement which are evident on the embankment shoulders. However, it is likely that voids now exist under these slabs and consideration should be given to concrete grouting the area immediately under the slab.

It must be realized that a limited number of boreholes were put down and not every approach embankment showing signs of settlement was investigated. If only an overlay is proposed to regrade the existing pavement, further boreholes should be put down to a depth of 3 metres at the sites not yet investigated. These will determine if the upper materials need to be replaced as at Borehole 304. If the total pavement is to be replaced, the areas not covered in this investigation can be inspected at the time of construction and an allowance made for excavation and recompaction.

GOLDER ASSOCIATES


For

M. Tanom, P. Eng.



J. R. Busbridge, P. Eng.

MT/JRB/cg

APPENDIX 'A'

FIELD WORK

October, 1982

821-1239

FIELD WORK

The present boring program consisted of five boreholes (numbered 301 to 305) which were put down between August 10 and 16, 1982 at the locations shown on Figure 1. A bombardier-mounted CME-75 power auger (supplied by Master Soil Investigations Ltd.) was used with 175 mm diam. hollow stem augers for all boreholes. A total of 65 metres of sampled borings were put down to depths of between 11 and 16 metres.

Soil samples were taken at 0.75 metre intervals of depth, using a standard 50 mm O.D. split-barrel sampler advanced by 63.5 kg weight falling freely through 0.75 metre to determine 'N' values (blows per 0.3 metre penetration). In soft firm soils, 76 mm O.D. Shelby tubes were used to obtain relatively undisturbed samples. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets.

Piezometers were sealed into all boreholes to allow monitoring of groundwater levels across the site. A protective pipe sleeve and cap were cemented at the surface of each backfilled borehole.

The field work was supervised throughout by a member of our engineering staff who located the borings in the field, cleared the site for buried services, directed the drilling and sampling operations, and logged the boreholes.

The borehole locations, ground elevations and pavement profiles at the boreholes were surveyed by Golder Associates. The elevations were referred to Geodetic datum using BM E-1116 (Elev. 88.903 m) located at the north end of the east abutment of the bridge structure on the Q.E.W. over Parkson Lake.

All soil samples were shipped to our laboratory for detailed examination. Selected representative samples were tested for

grain size distribution, liquid and plastic limits, Proctor compaction, consolidation, specific gravity, and unit weight, while all samples were subjected to a water content determination. The test results are summarized on the Record of Borehole sheets and on Figures 6 to 13.

TABLE 1

SUMMARY OF SETTLEMENT AND FILL MATERIAL

	BOREHOLE NO.				
	301	302	303	304	305
Settlement at Borehole (mm)	137	274	427	152	65
Range of Settlement Near Borehole (mm)	61 to 137	229 to 290	401 to 457	46 to 183	56 to 107
Depth of Fill beneath Pavement (m)	11.69	9.52	8.54	6.56	11.38
Description of Fill	5.06 m sand & gravel	3.43 m sand & gravel	0.76 m crushed stone	0.92 m sand & gravel	9.55 m sand & gravel
	1.53 m sand and silt	6.09 m silt	6.41 m silt	5.64 m silt and sand	1.83 m clayey silt
	3.81 m organic sand, silt, clay		1.37 m silty sand		
	1.29 m clayey silt				
Approximate Thickness of Poorly Compacted Fill (m)	6.1	4.5	6.1	4.5	4.5
Approximate Thickness of Native Clayey Silt Beneath Fill (m)	6.0	2.5	4.0	8.0	---

RECORD OF BOREHOLE No 301

W P _____ LOCATION Co-ords N 4,831,641 E 306,090 ORIGINATED BY MT
DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem auger COMPILED BY GP
DATUM Geodetic DATE August 10 and 11, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ Mg/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										SHEAR STRENGTH			WATER CONTENT (%)		
																		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
98.44	Ground Level																						
0.00	Asphaltic Concrete						SEAL																
0.12	Fill, sand and gravel.						98																
	Well compacted Brown		1	SS	18																		
			2	SS	28		97																
96.31																							
2.13	Fill, gravelly sand with some silt.		3	SS	41		96																
			4	SS	37		95																
			5	SS	20		94																
	Well compacted Brown		6	SS	8												27 58 12 3						
93.26																							
5.18	Fill, gravelly sand and silt.		7	SS	3		93																
	Poorly compacted		8	SS	4		92										30 37 25 8						
	Grey-brown																						
91.73			9	SS	6		91																
6.71	Fill, organic silt with zones of coarse and fine sand, silty clay and gravel.		10	SS	4																		
			11	SS	1		90																
	Poorly compacted						SEAL																
	Grey and black		12	TW	PH												2 12 56 30						
			13	SS	1												20 60 15 5						
87.92			14	SS	9		88																
10.52	Fill, silty clay, with sand and trace organics						Piezometer																
	Firm to Stiff Grey-green		15	TW	PH		87									1.86	1 28 57 14						
86.63																							
11.81	Continued						86																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 301 (cont d)

W P _____ LOCATION Co-ords N 4,831,641 E 306,090 ORIGINATED BY MT
DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem auger COMPILED BY GP
DATUM Geodetic DATE August 10 and 11, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
86.63	Continued													
11.81	Silty clay some sand and trace organics		16	SS	4									
	Firm to Hard		17	SS	-									8 18 40 14
	Grey-black		18	SS	-									
82.74														
15.70	Refusal End of Borehole													

RECORD OF BOREHOLE No 302

W P _____ LOCATION Co-ords N 4,831,778 E 306,406 ORIGINATED BY MT
 DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem auger COMPILED BY GP
 DATUM Geodetic DATE August 11 and 12, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							SHEAR STRENGTH
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		10 20 30					
92.93	Ground Level														
0.00	Asphaltic Concrete														
0.23	Fill, sand and gravel.						SEAL								
			1	SS	37		92			○					
	Well compacted		2	SS	20		91			○					
	Brown		3	SS	13		90			○					
			4	SS	19					○					
39.27															
3.66	Fill, silt with zones of varying amounts of gravel, sand, and clay.		5	SS	9		89			○					
			6	SS	12		88			○					
	Poorly to moderately compacted		7	SS	5		Seal			○					
			8	SS	7		Pea Gravel 87					○		1 4 81 14	
	Grey-brown		9	SS	24		Piezometer #2 Dry on August 17, 1982 86			○					
			10	SS	16*		Seal					○			
			11	SS	46		85			○					
			12	SS	9		84					○		14 19 60 7	
83.18															
9.75	Silty clay, with some sand and trace organics		13	SS	35		83			○					
	Stiff to very stiff		14	SS	11		82					○			
	Brown		15	SS	16		81					○			
80.89							Seal					○			
12.04	Silty clay, with trace sand and occa- sional shale fragments		16	SS	42										
79.98	Hard Brown														
12.95	Shale, highly weathered.		17	SS	10/450 mm					○					
79.43							Water Level at Elev. 79.98 on August 17/1982 Piezometer #1								
13.50	Refusal to augering End of Borehole														
	* 'N' value affected by stones.														

RECORD OF BOREHOLE No 303

W P _____ LOCATION Co-ords N 4,831,896 E 306,501 ORIGINATED BY MT
DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem auger COMPILED BY GP
DATUM Geodetic DATE August 13, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ Mg/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.87	Ground Level																
0.00	Asphaltic Concrete																
0.10	Concrete																
0.30	Fill, crushed limestone																
86.81	Well compacted Grey																
1.06	Fill, silt with some sand and gravel.		1	SS	13												
			2	SS	18												
	Moderately compacted		3	SS	10												
			4	SS	12												
			5	SS	54*												
			6	SS	21												
			7	SS	7												
	Poorly compacted		8	SS	5												
			9	SS	6												
80.40	Brown																
7.47	Fill, silty fine sand.		10	SS	2												
	Poorly compacted Grey		11	SS	16												
79.03																	
8.84	Silty clay, with some occasional fine sand lenses.		12	SS	29												
			13	SS	18												
			14	SS	7												
	Stiff to very stiff		15	TW	PH												
	Grey		16	TW	PH												
74.92																	
12.95	Refused to augering End of Borehole																
	* 'N' value affected by stones.																

RECORD OF BOREHOLE No 304

W P _____ LOCATION Co-ords N 4,831,809 E 306,340 ORIGINATED BY MT
DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem auger COMPILED BY GP
DATUM Geodetic DATE August 16, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
							20 40 60 80 100								
							● QUICK TRIAXIAL × LAB VANE								
94.35	Ground Level													GR SA SI CL	
0.00	Asphaltic Concrete														
0.15	Fill, sand and gravel						94								
93.28	Poorly compacted		1	SS	9										
1.07	Fill, silt and sand with some clay, and shale fragments.		2	SS	6		93								
			3	SS	8		92								
	Poorly compacted		4	SS	9		91							25 29 35 11	
	Grey		5	SS	19*		90								
			6	SS	17*		89								
			7	SS	17		88								
87.64			8	SS	13		87								
6.71	Silty clay with trace sand, and gravel (TILL)		9	SS	30		86							0 5 78 17	
			10	SS	24		85								
	Very stiff Grey		11	SS	29		84								
			12	SS	35		83								
83.22	Hard		13	SS	95										
11.13	End of Borehole														
* 'N' value affected by stones.															

*3, *5: Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 305

W P _____ LOCATION: Co-ords N 4,831,710 E 306,158 ORIGINATED BY MT
DIST 6 HWY Q.E.W. BOREHOLE TYPE Hollow-stem augers COMPILED BY GP
DATUM Geodetic DATE August 16, 1982 CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
98.25	Ground Level																
0.00	Asphaltic Concrete																
0.20	Fill, sand and gravel with some silt.		1	SS	35		98						○				
			2	SS	43		97						○				
	Well compacted with loose zones.		3	SS	29		96						○				
	Brown		4	SS	8		95						○				27 54 15 4
			5	SS	44*		94						○				
			6	SS	56*		93						○				
			7	SS	11		92						○				
			8	SS	22*		91						○				
			9	SS	32*		90						○				
			10	SS	22		89						○				
			11	SS	29		88						○				
			12	SS	13		87						○				
88.50							86										
9.75	Fill, silty clay with sand and organics.		13	SS	10		85										
	Firm to stiff		14	SS	6		84										5 22 58 15
	Grey						83										
86.67							82										
11.58	Refusal to augering End of Borehole.						81										
	* 'N' value affected by stones.						80										

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

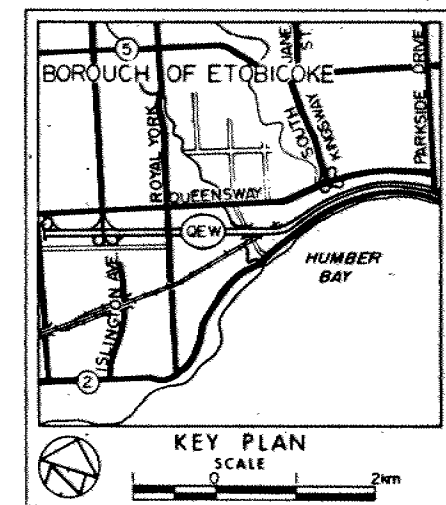
CONT No
WP No



SHEET
FIGURE 1

BORE HOLE LOCATIONS & SOIL STRATA

GOLDER ASSOCIATES



LEGEND

- Bore Hole (This Investigation)
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation

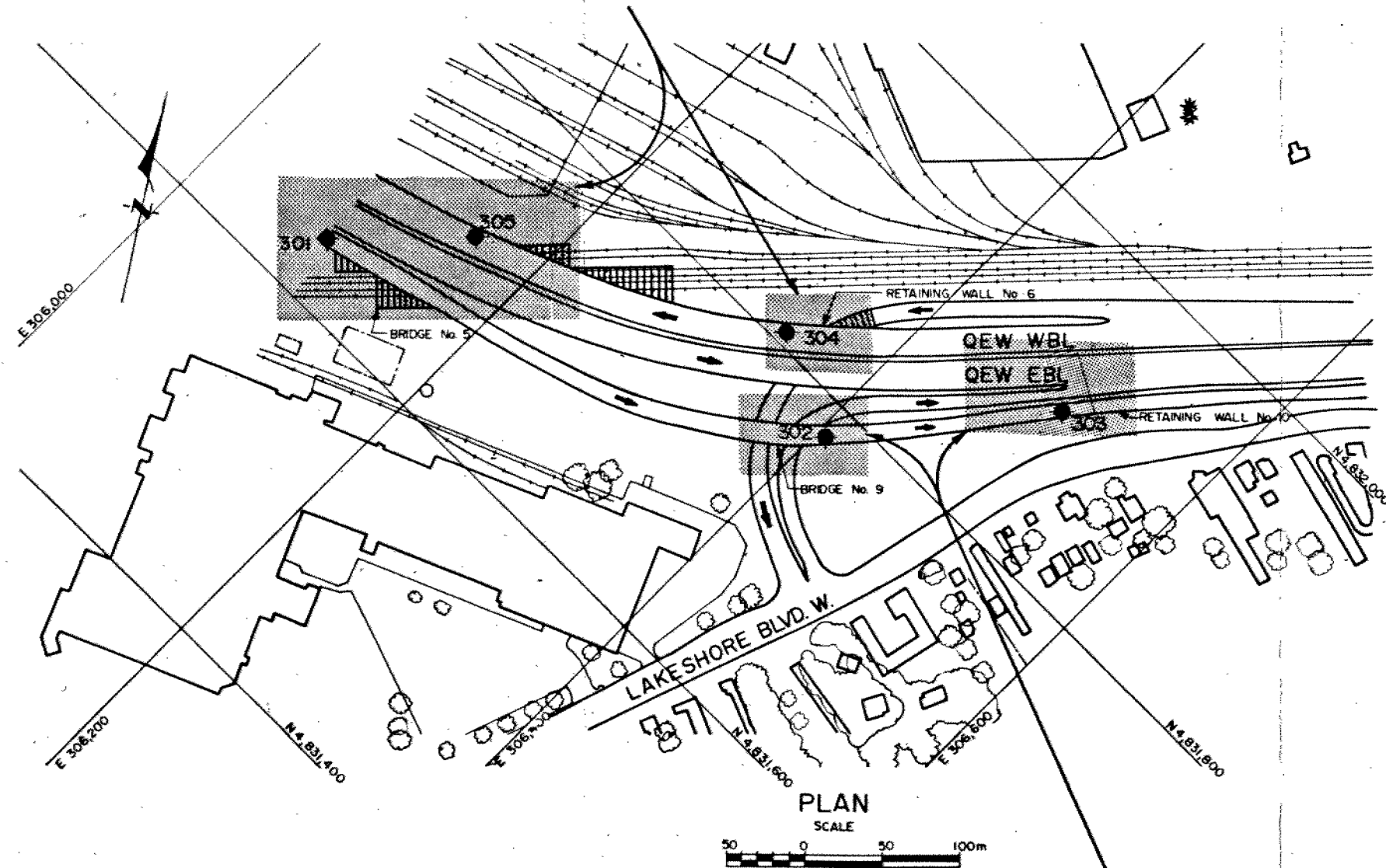
No	ELEVATION	NORTH	EAST
301	98.44	4,831,641	306,090
302	92.93	4,831,778	306,406
303	87.87	4,831,896	306,501
304	94.35	4,831,809	306,340
305	98.25	4,831,710	306,158

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

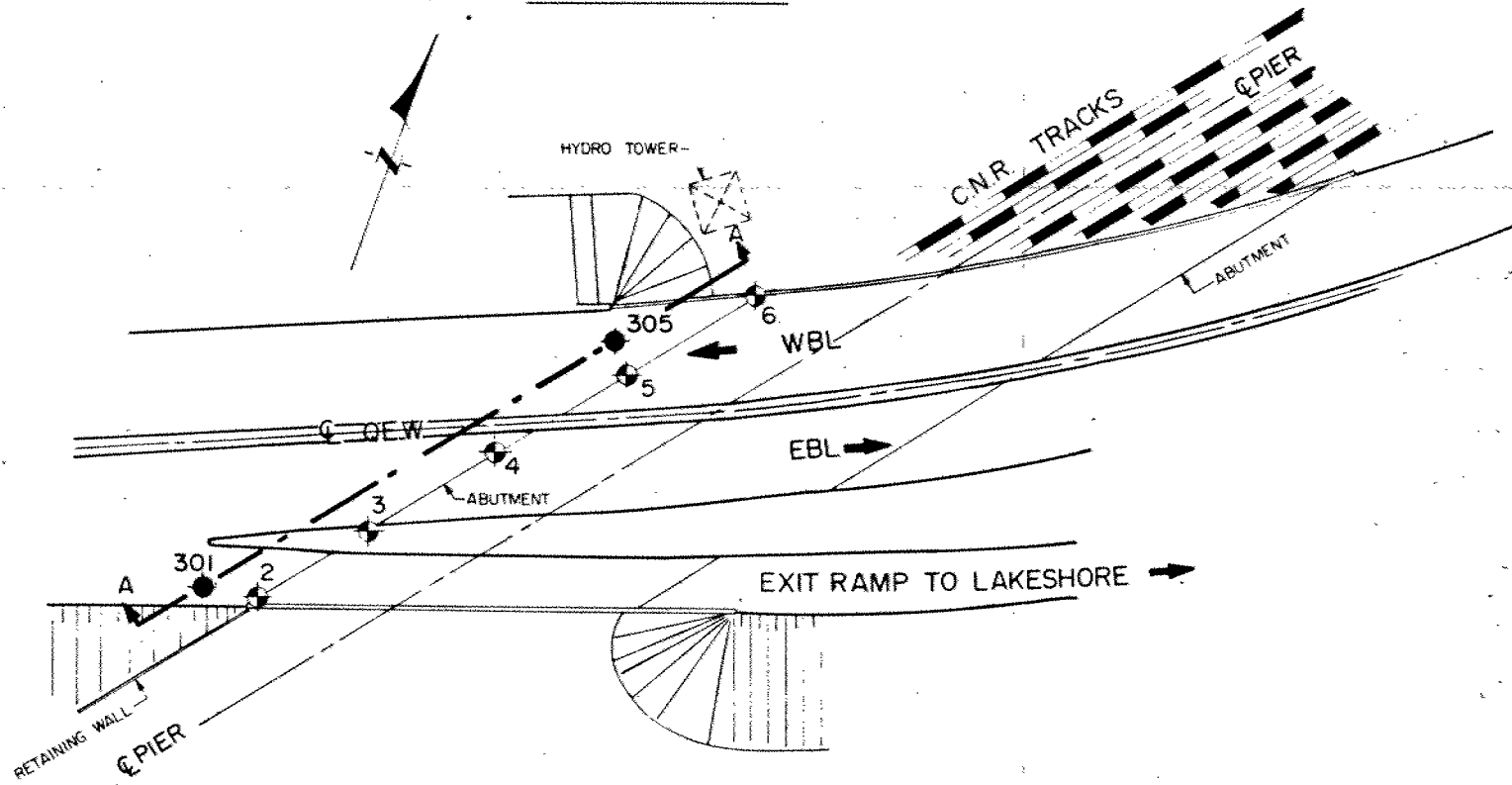
REVISIONS			
DATE	BY	DESCRIPTION	
Geocres No			
HWY No	Q.E.W.	DIST	6
SUBMD	CHECKED	DATE 02, 09, 23	SITE
DRAWN/RW	CHECKED M.T.	APPROVED	FIGURE 1

FOR DETAILED PLAN
AND SECTIONS REFER
TO FIGURE No. 2



FOR DETAILED PLAN
AND SECTIONS REFER
TO FIGURE No. 3

BRIDGE No 5



RETAINING WALL
No 6

METRIC

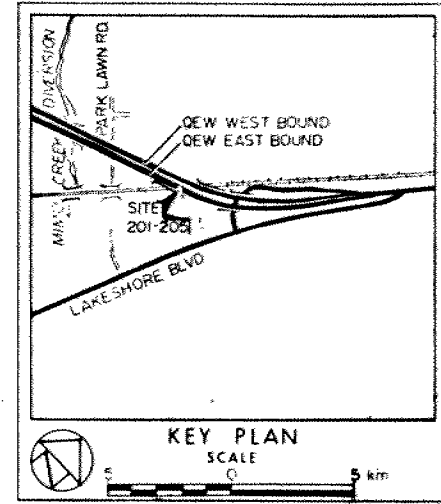
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

CONT No
WP No

BRIDGE No 5 AND
RETAINING WALL No 6
BORE HOLE LOCATIONS & SOIL STRATA

SHEET
FIGURE 2

GOLDER ASSOCIATES



LEGEND

- Bore Hole (This Investigation)
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone (Previous Investigation)
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation (1982,08)
- ⊕ Piezometer

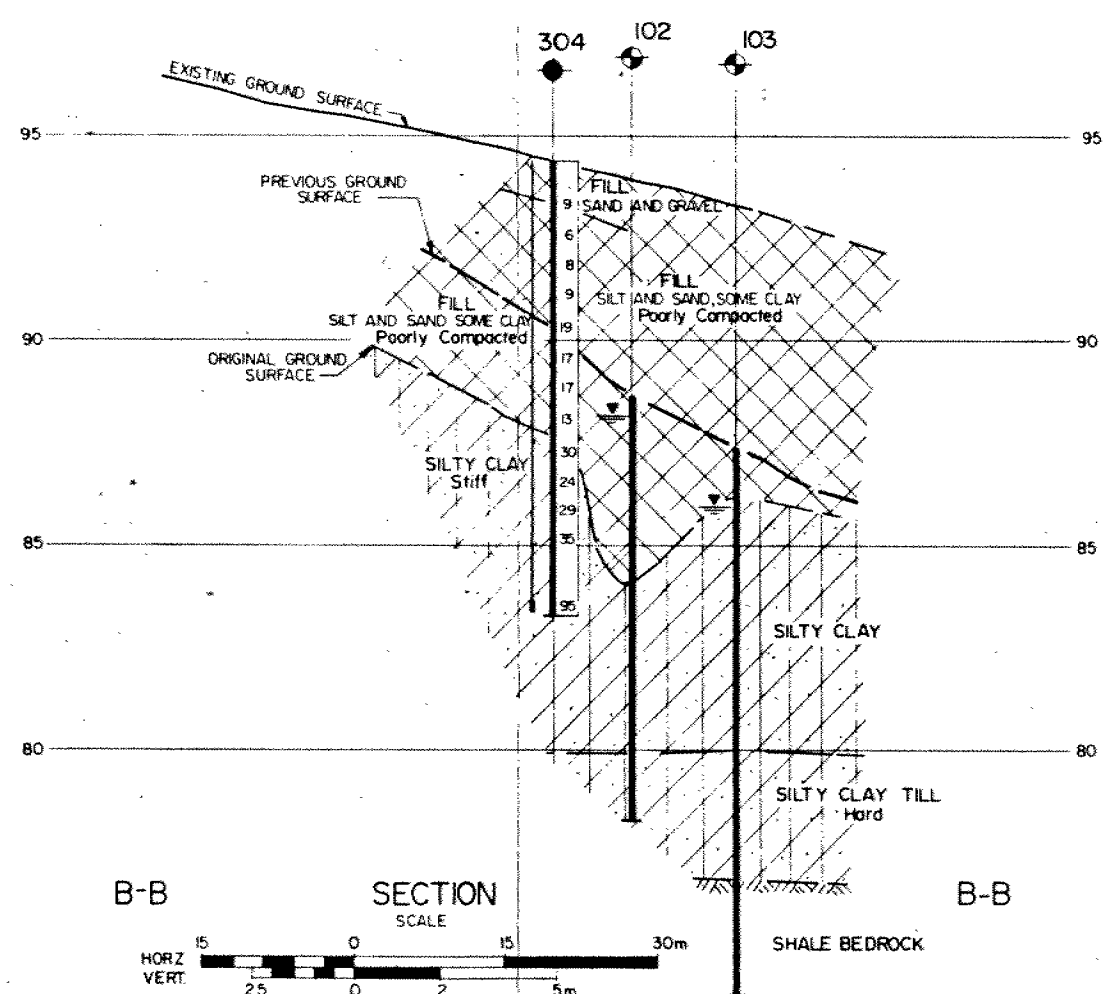
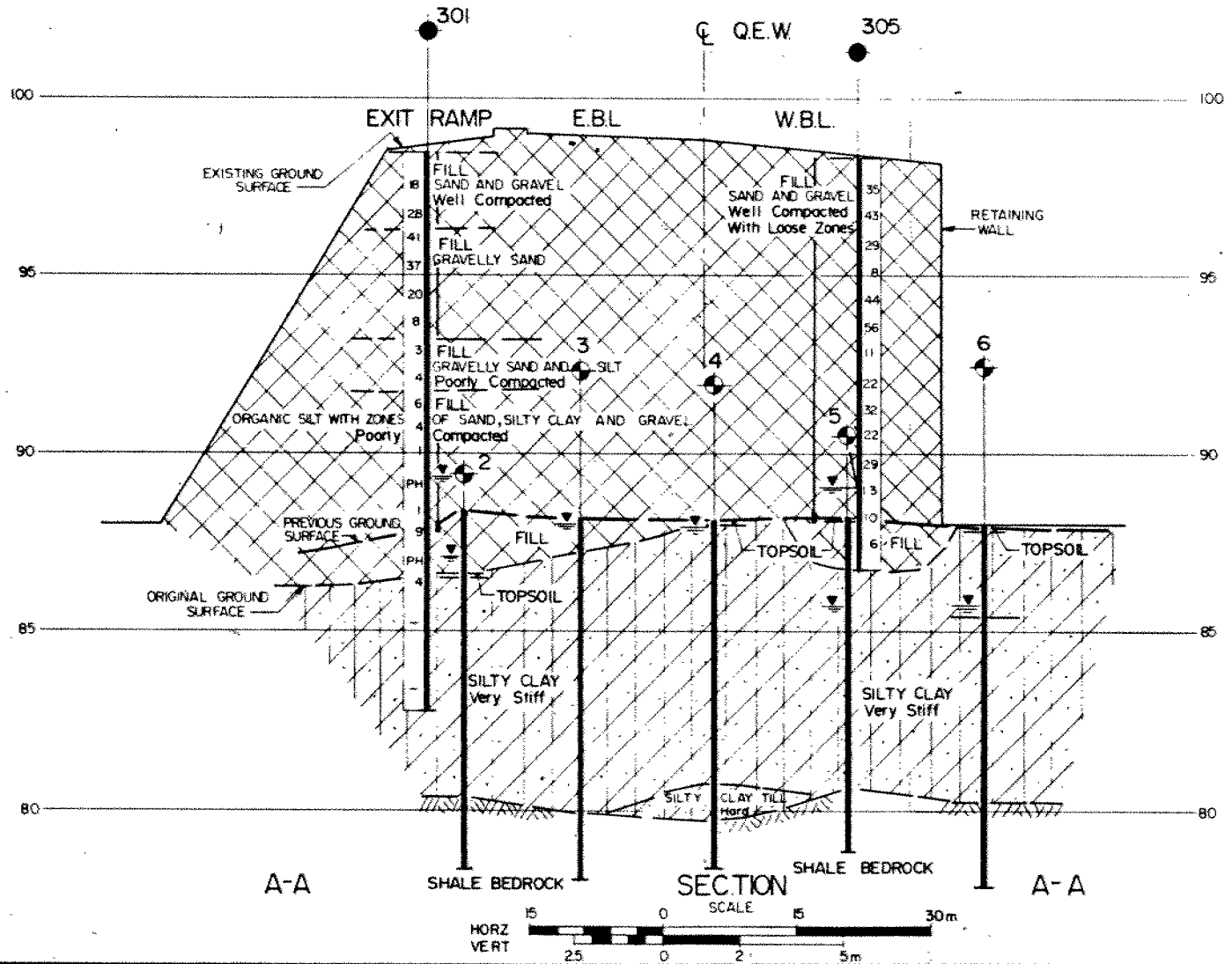
No	ELEVATION		
301	98.44		
302	92.93		
303	87.87		
304	94.35		
305	98.25		

NOTES

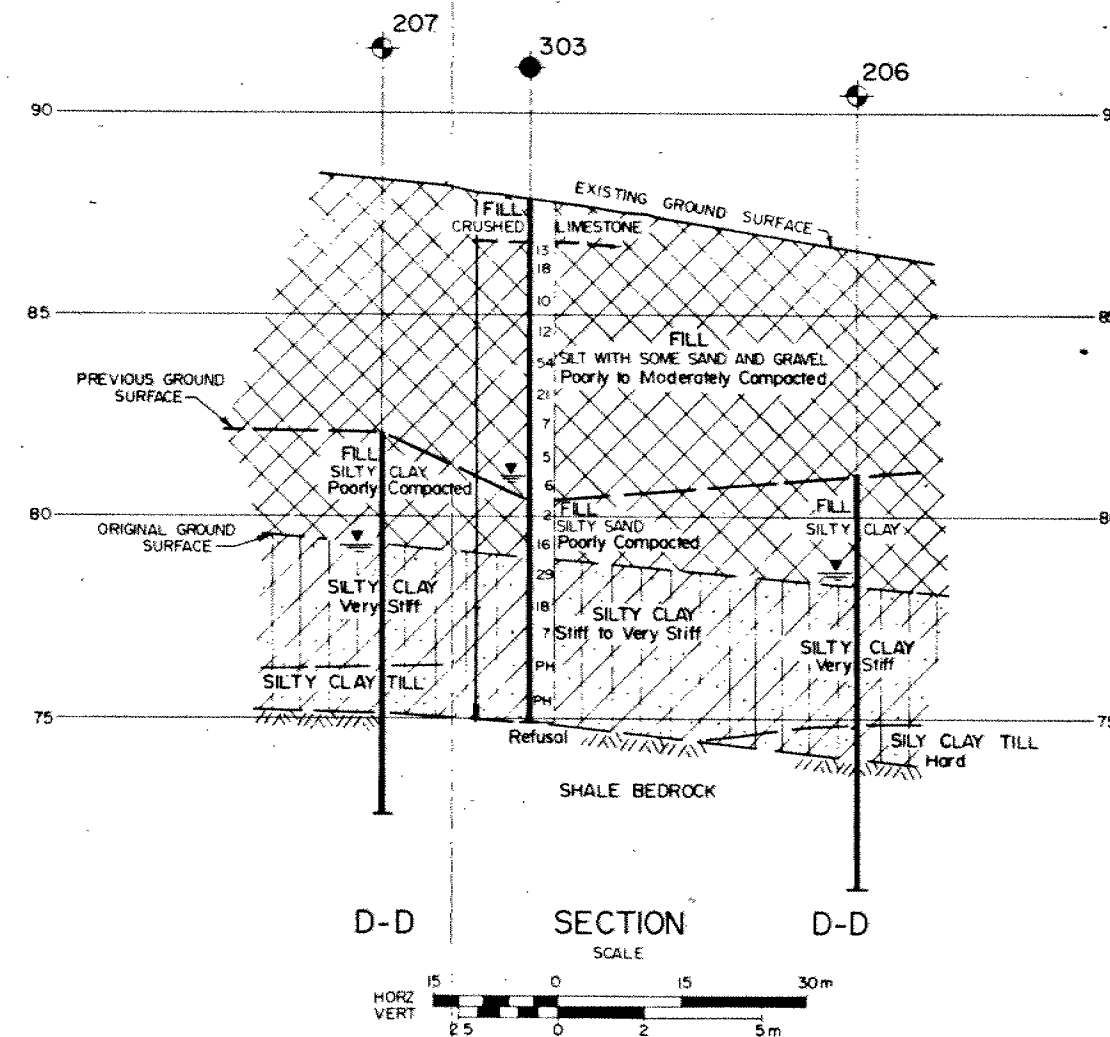
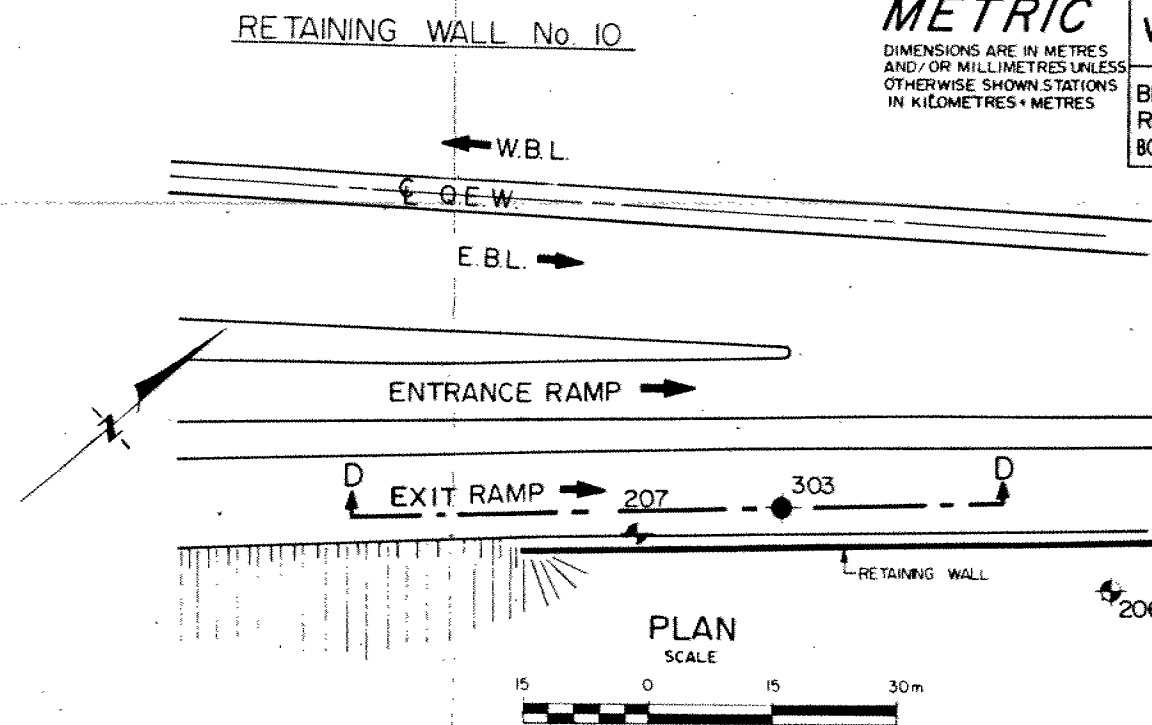
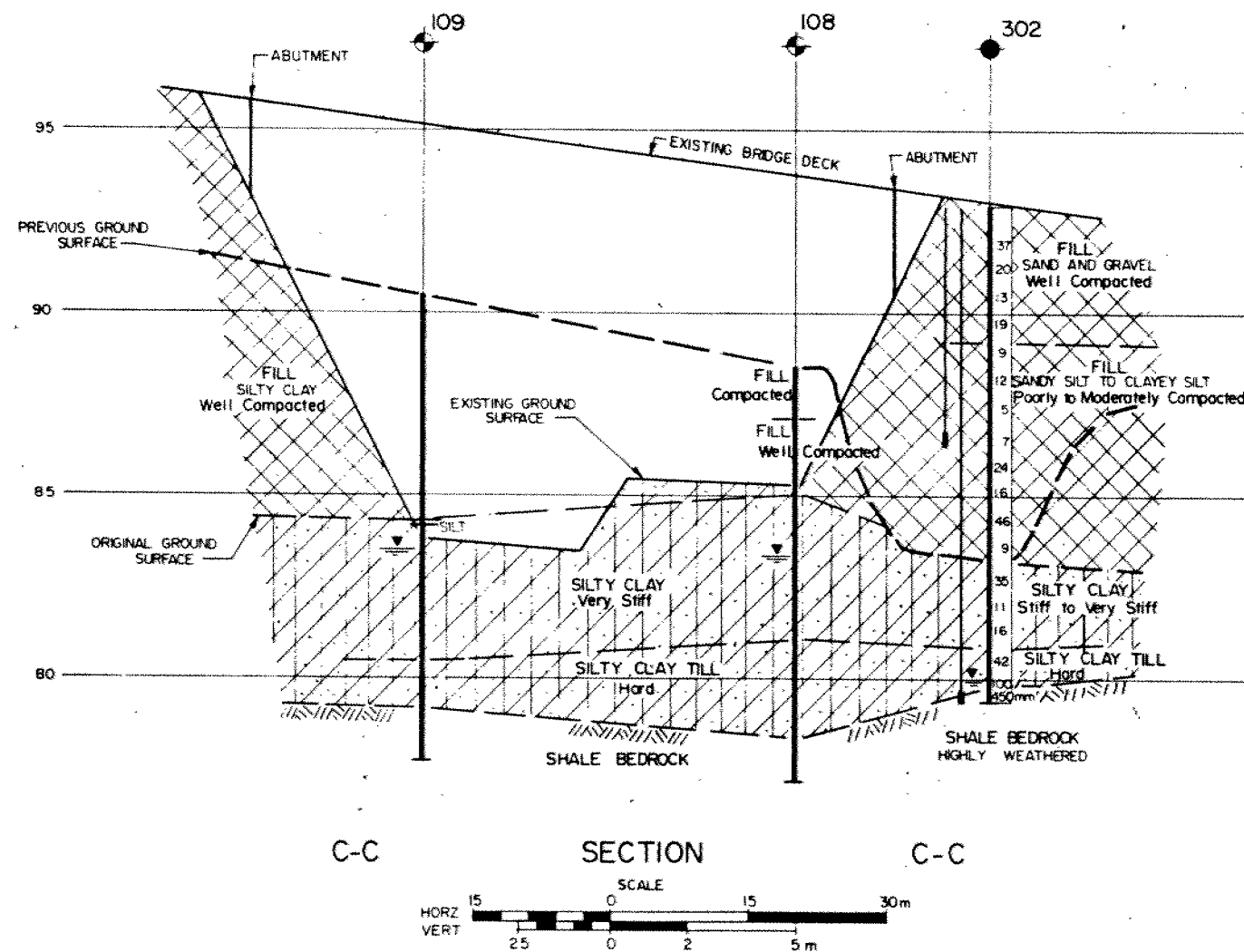
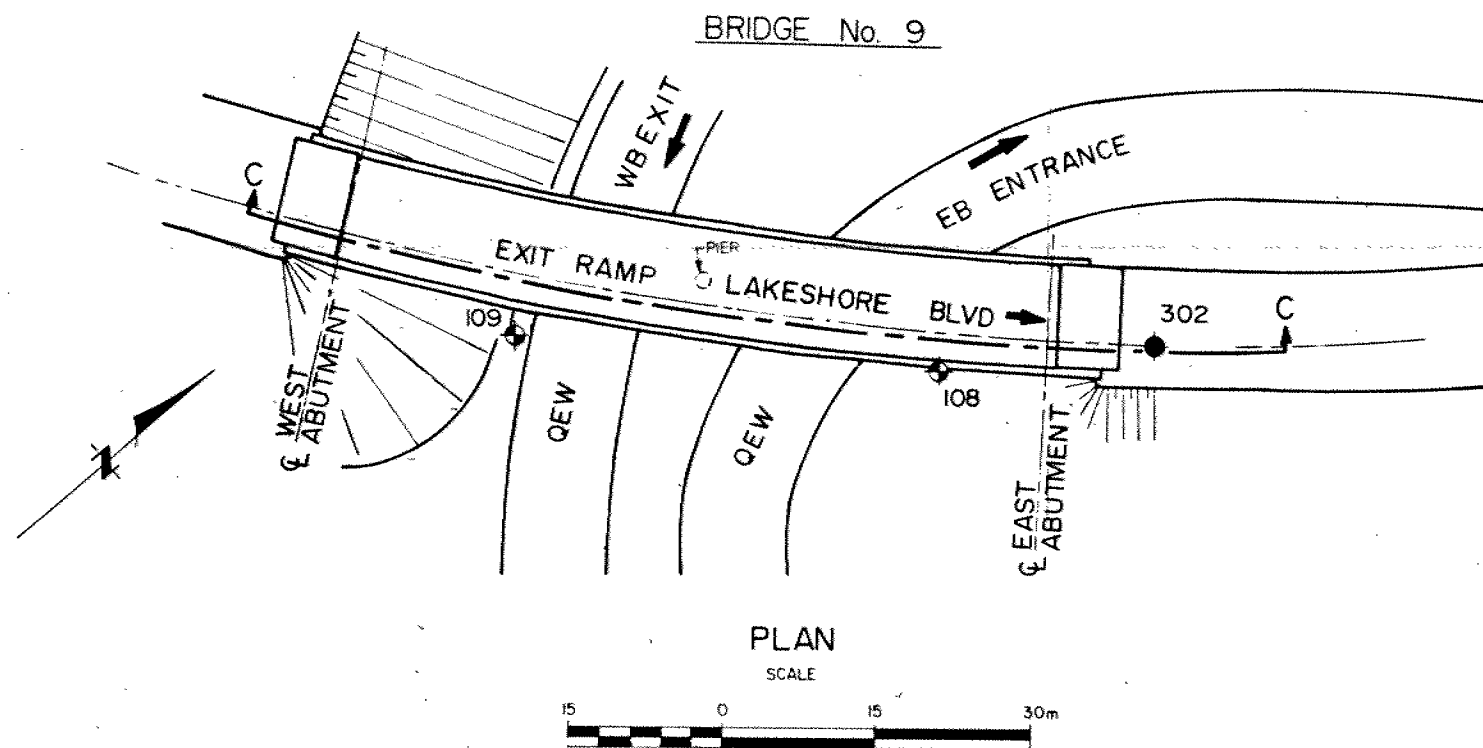
1. The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
2. This drawing should be read in conjunction with Report No. 821-1239.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No			
HWY No	G.E.W.		DIST 6
SUBM'D	CHECKED	DATE 82, 09, 23	SITE
DRAWN G.P.	CHECKED M.T.	APPROVED	FIGURE 2



MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PR-D-207 (Formerly OB-MT-308M 78-04)



METRIC

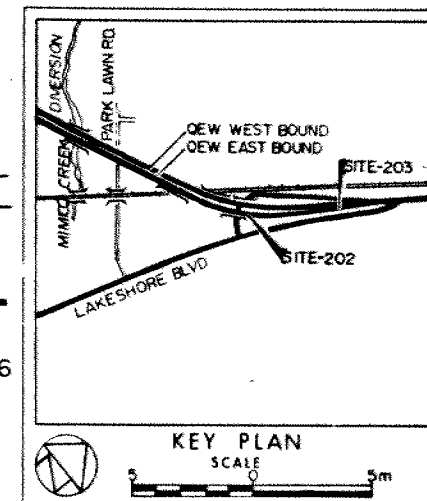
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

CONT No
WP No

BRIDGE No. 9 AND
RETAINING WALL No. 10
BORE HOLE LOCATIONS & SOIL STRATA

SHEET
FIGURE 3

GOLDER ASSOCIATES



LEGEND

- Bore Hole (This Investigation)
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone (Previous Investigation)
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation (1982, 08)
- ↓ Piezometer

No	ELEVATION		
301	98.44		
302	92.93		
303	87.87		
304	94.35		
305	98.25		

NOTES

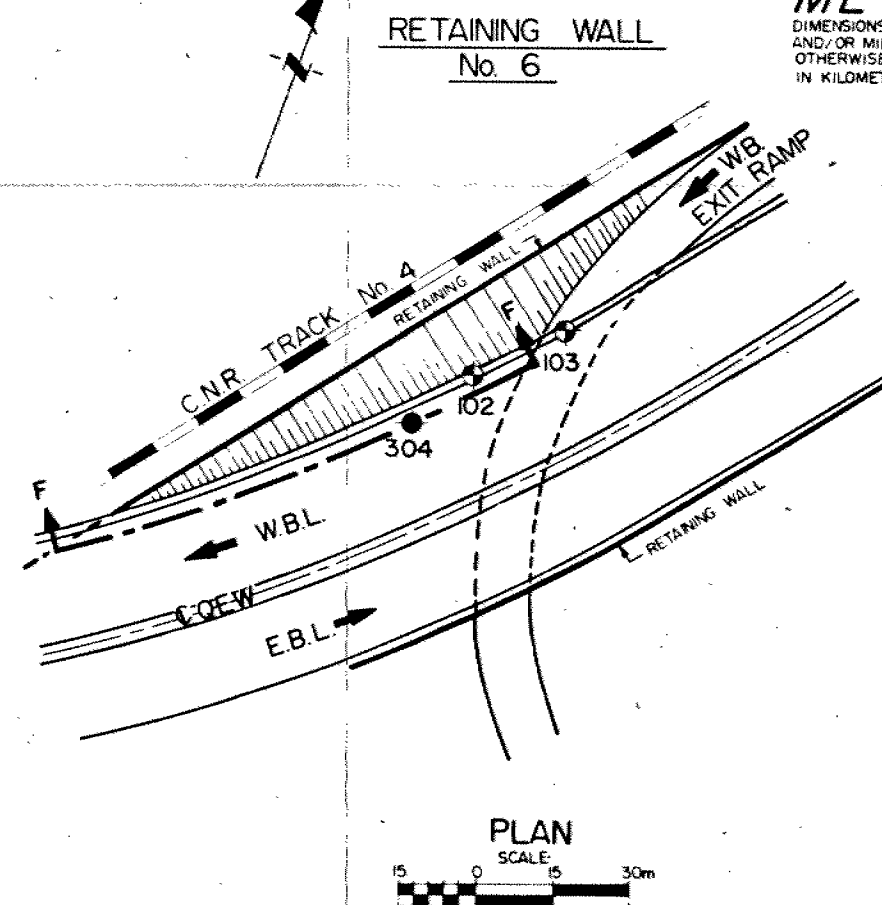
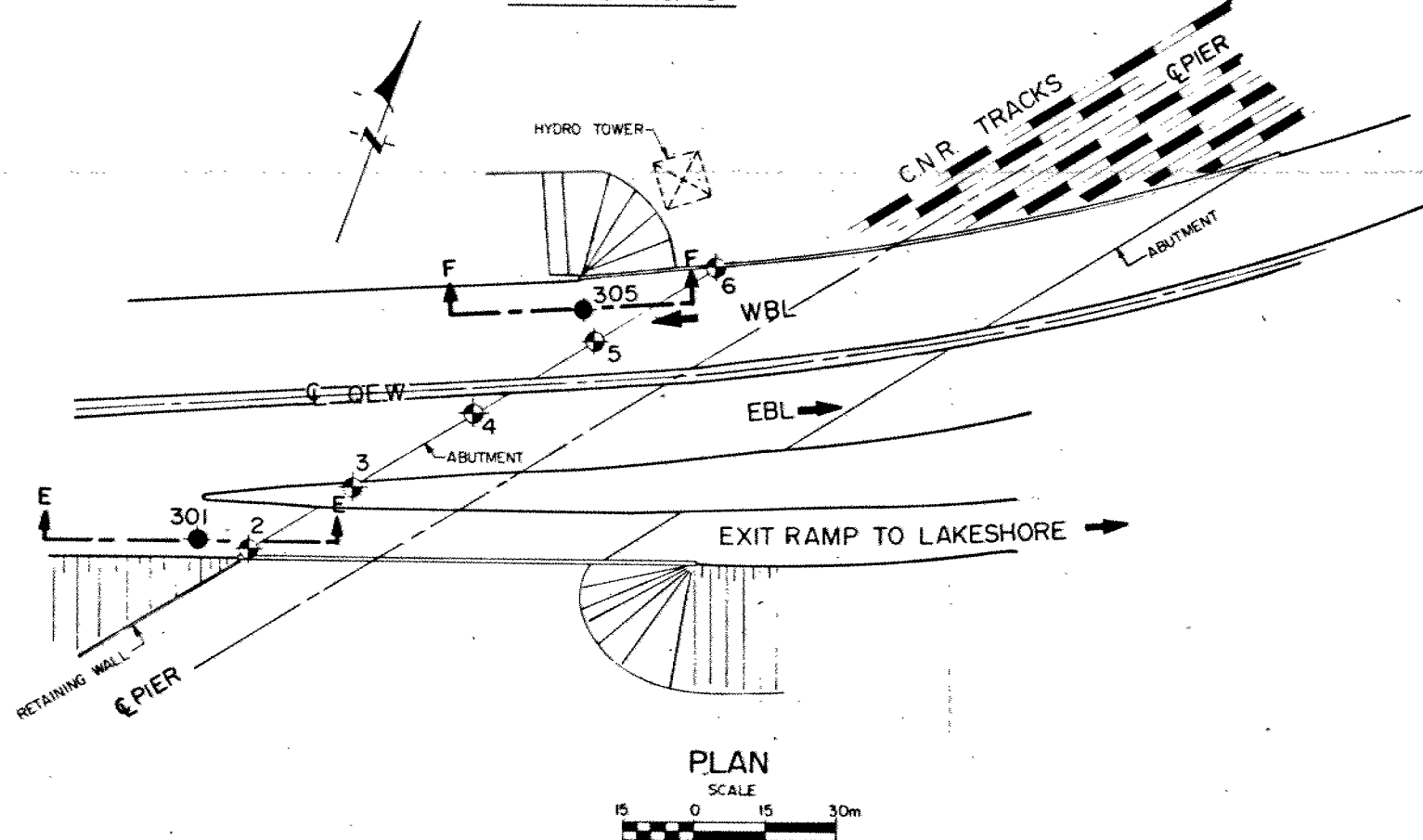
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
2 This drawing should be read in conjunction with REPORT No. B21-1239

REVISIONS	DATE	BY	DESCRIPTION

Geacres No

HWY No	QEW	DIST	6
SUBMIT	CHECKED	DATE	82, 09, 23
DRAWN/RWR	CHECKED	APPROVED	FIGURE 3

BRIDGE No. 5



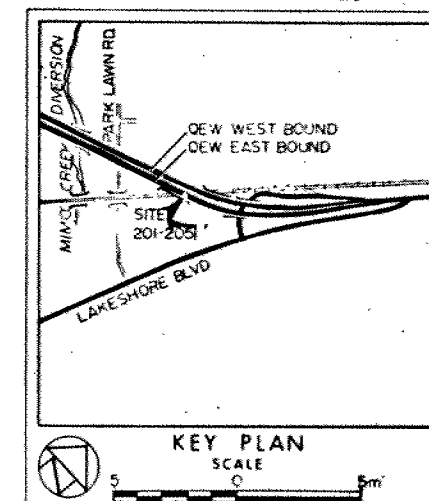
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES

CONT	No
WP	No





BRIDGE No. 5 AND
RETAINING WALL No. 6
BORE HOLE LOCATIONS

SHEET
FIGURE 4

GOLDER ASSOCIATES



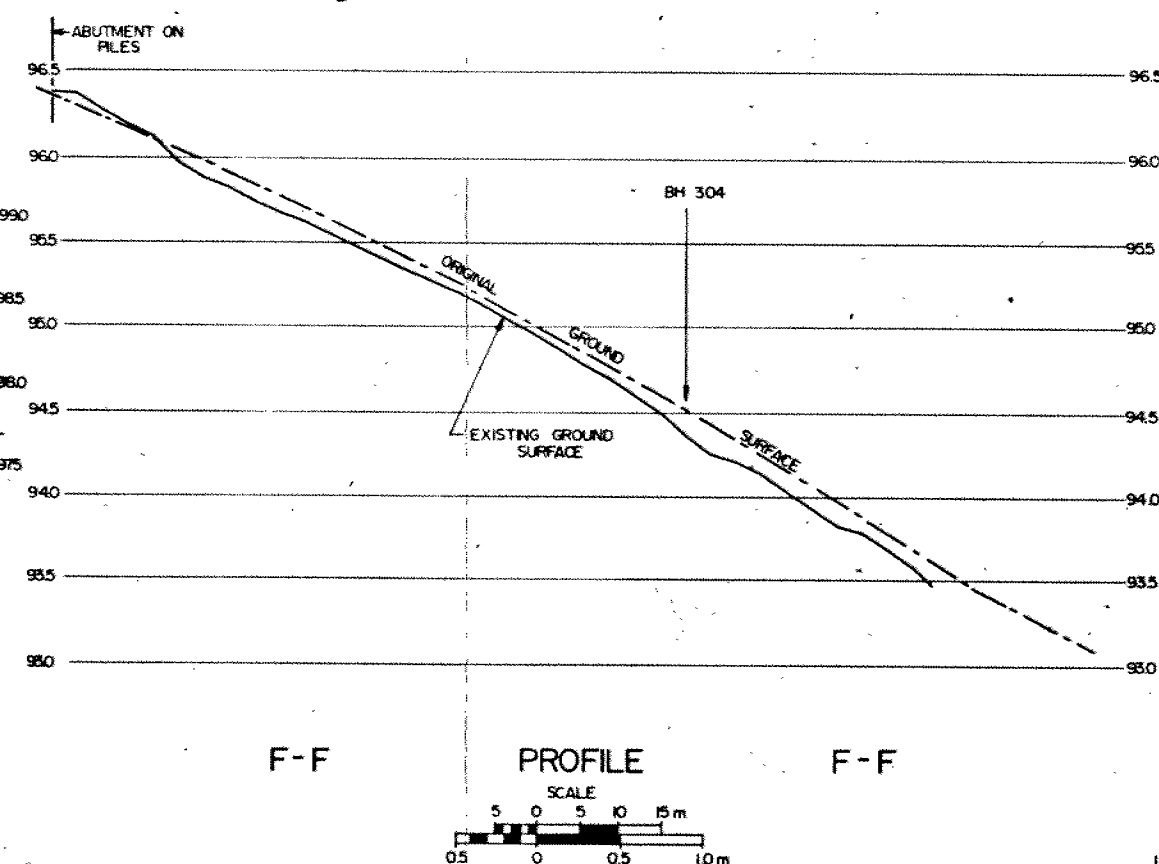
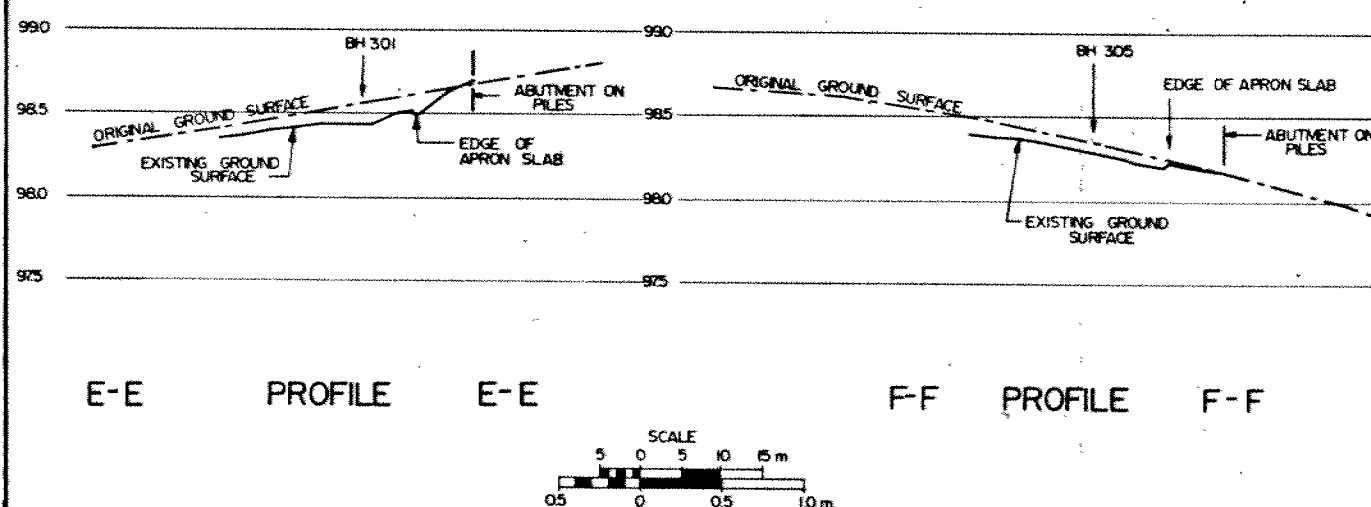
LEGEND

- | | |
|---|---|
|  | Bore Hole (This Investigation) |
|  | Dynamic Cone Penetration Test (Cone) |
|  | Bore Hole & Cone (Previous Investigation) |
| N | Blows/0.3m (Std Pen Test, 475 J/blow) |
| CONE | Blows/0.3m (60° Cone, 475 J/blow) |
|  | WL at time of investigation |

No	ELEVATION		
301	96.44		
302	92.93		
303	87.87		
304	94.35		
305	98.25		

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

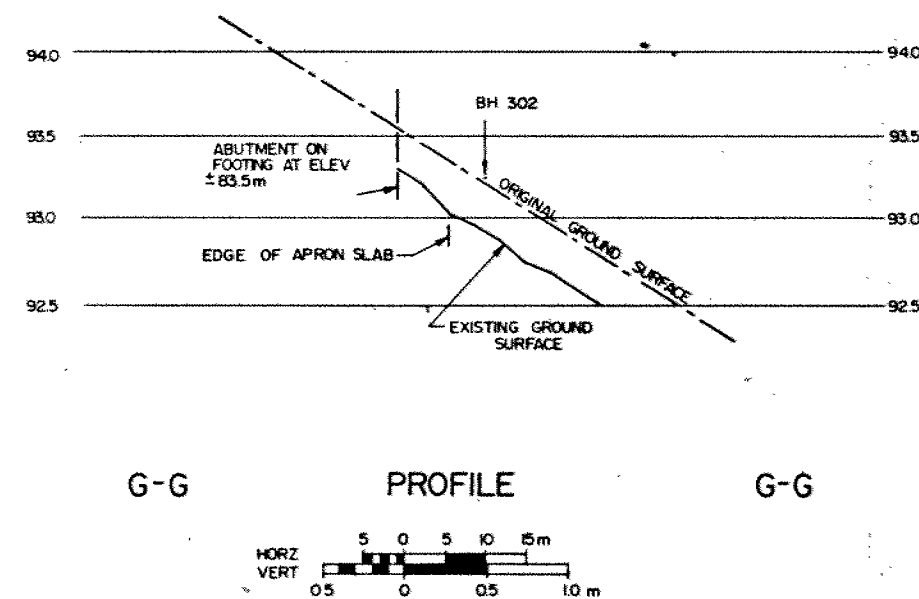
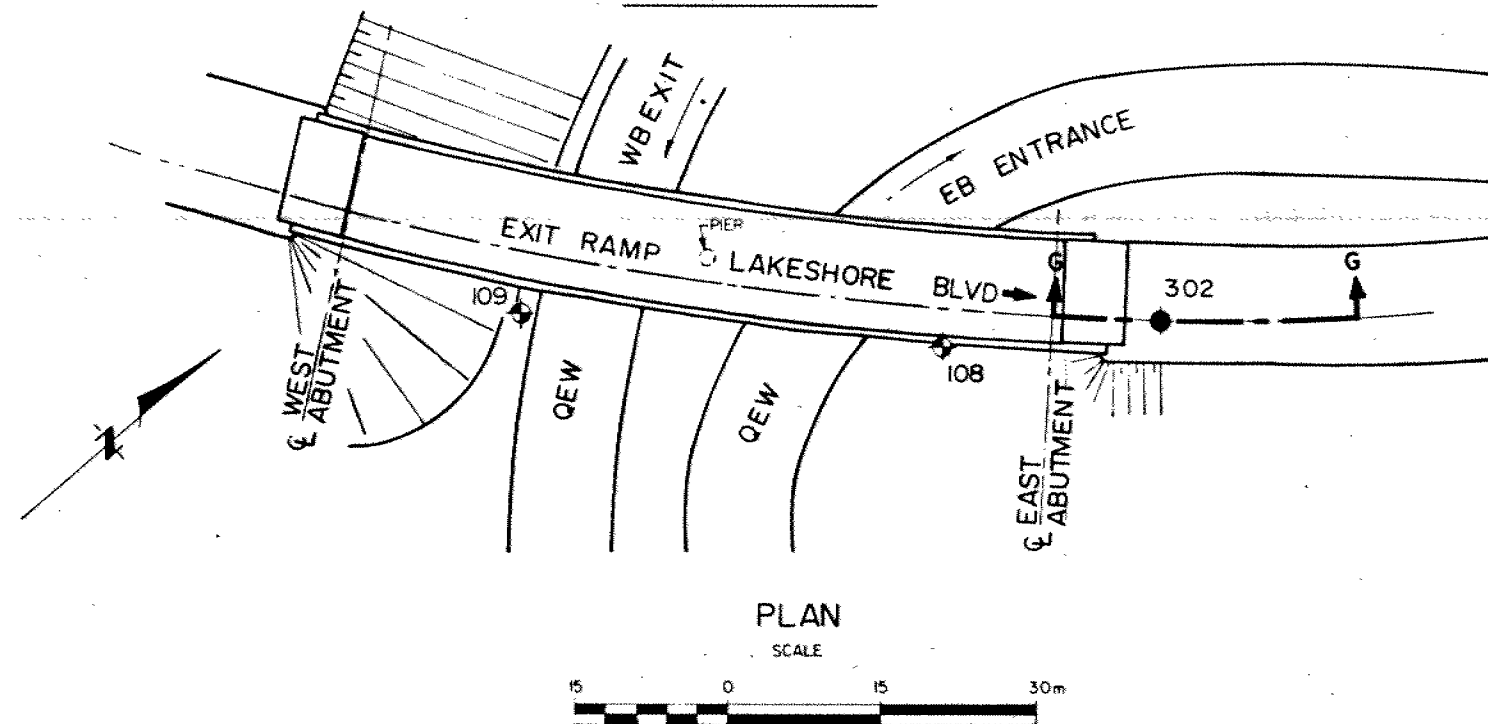


REV				
	DATE	BY	DESCRIPTION	

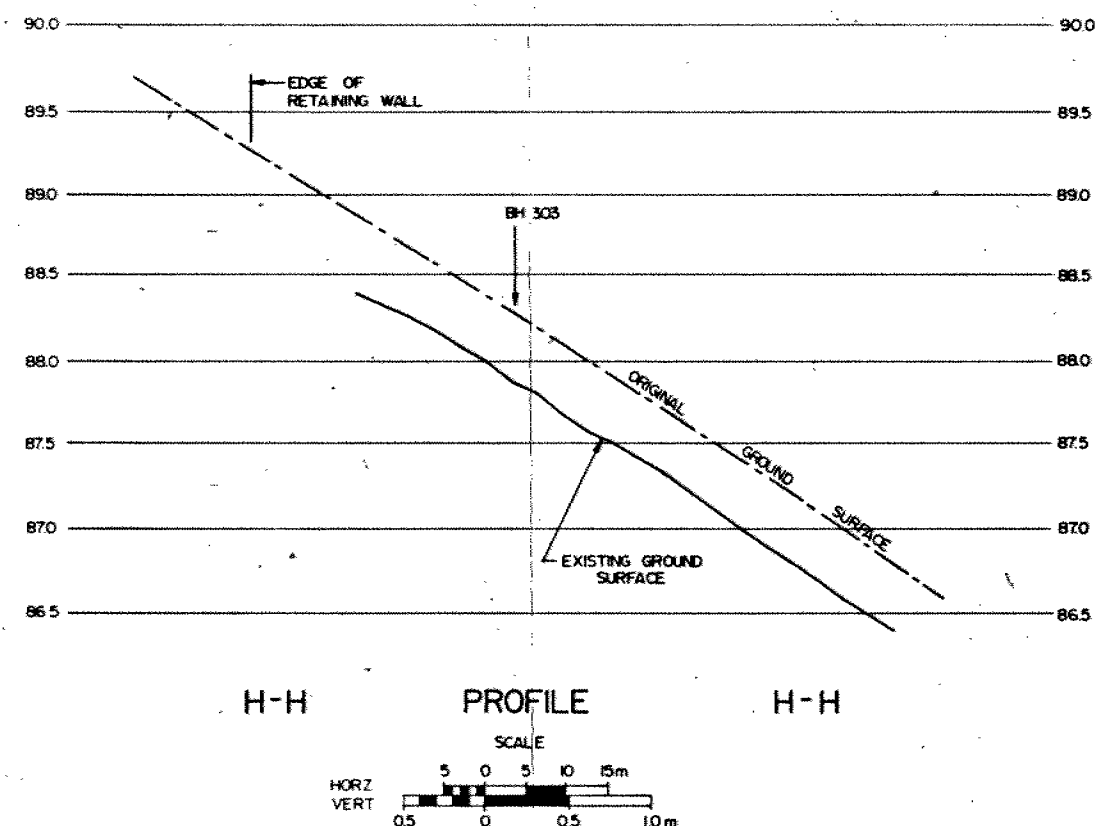
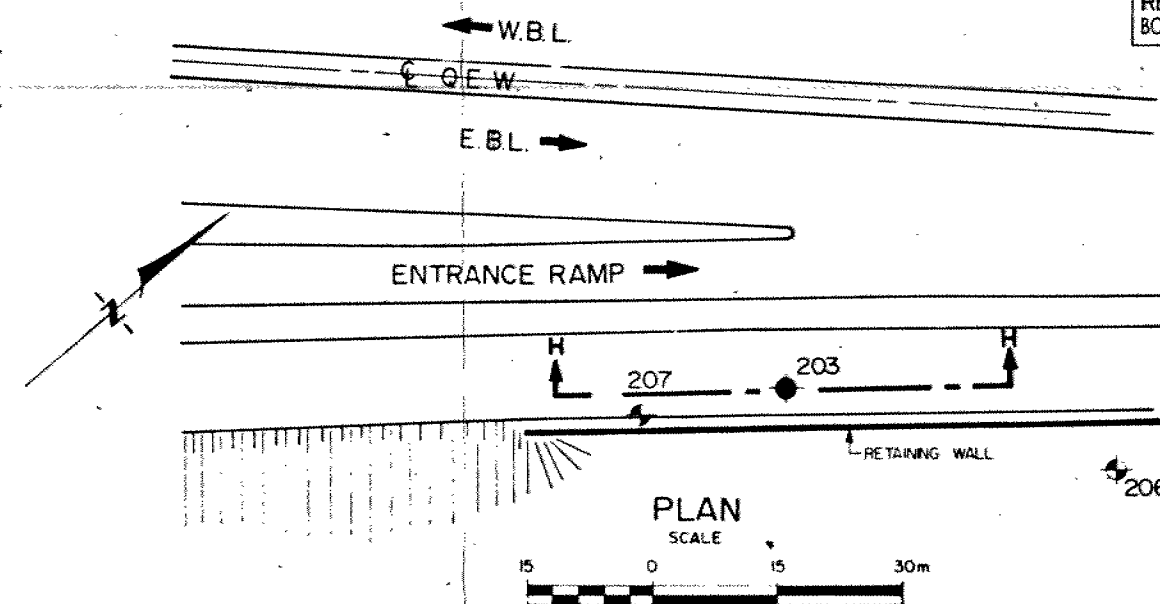
Geocres No

HWT No	QEW	DIST	6
SUBA'D	CHECKED	DATE	82, 09, 23
DRAWN	G.P.	CHECKED	MT
		APPROVED	
			FIGURE 4

BRIDGE No. 9



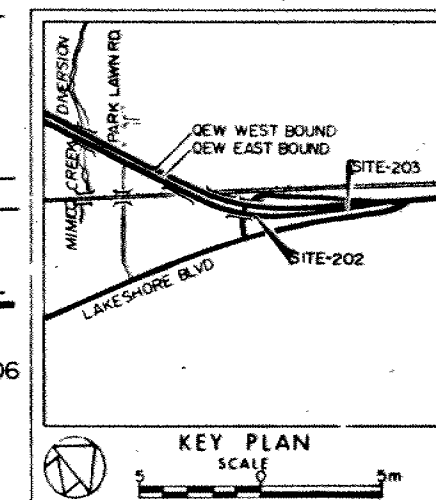
RETAINING WALL No. 10



METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRESCONT No
WP NoBRIDGE No. 9 AND
RETAINING WALL No. 10
BORE HOLE LOCATIONSSHEET
FIGURE 5

GOLDER ASSOCIATES



LEGEND

- ◆ Bore Hole (This Investigation)
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone (Previous Investigation)
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ↓ W.L. at time of investigation

No	ELEVATION		
301	98.44		
302	92.93		
303	87.87		
304	94.35		
305	98.25		

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

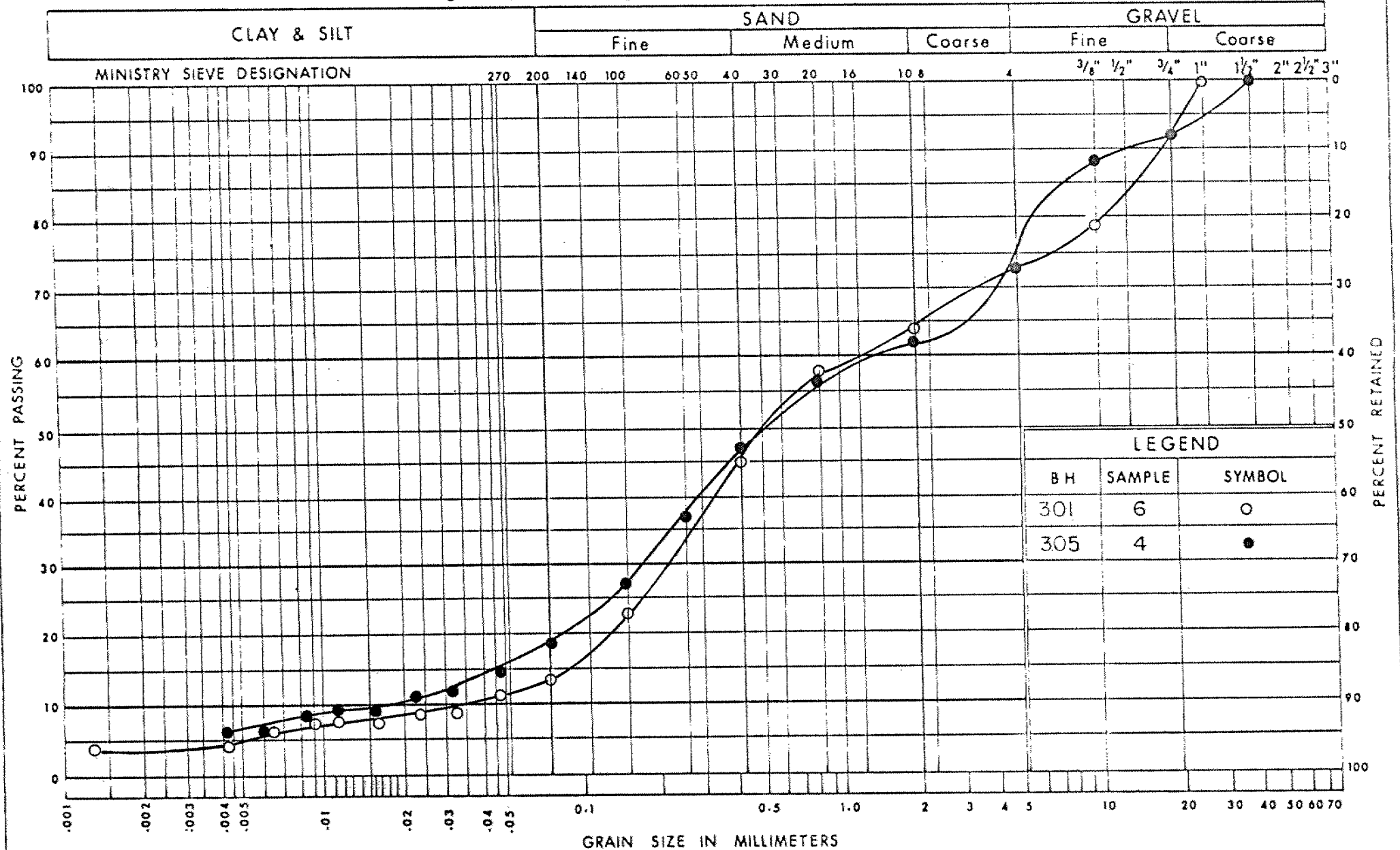
REV	DATE	BY	DESCRIPTION

Geocres No

HWY No	Q.E.W.	DIST	6
SUBMD	CHECKED	DATE	82, 09, 23
DRAWN	GP	CHECKED	MT
APPROVED			

FIGURE 5

UNIFIED SOIL CLASSIFICATION SYSTEM



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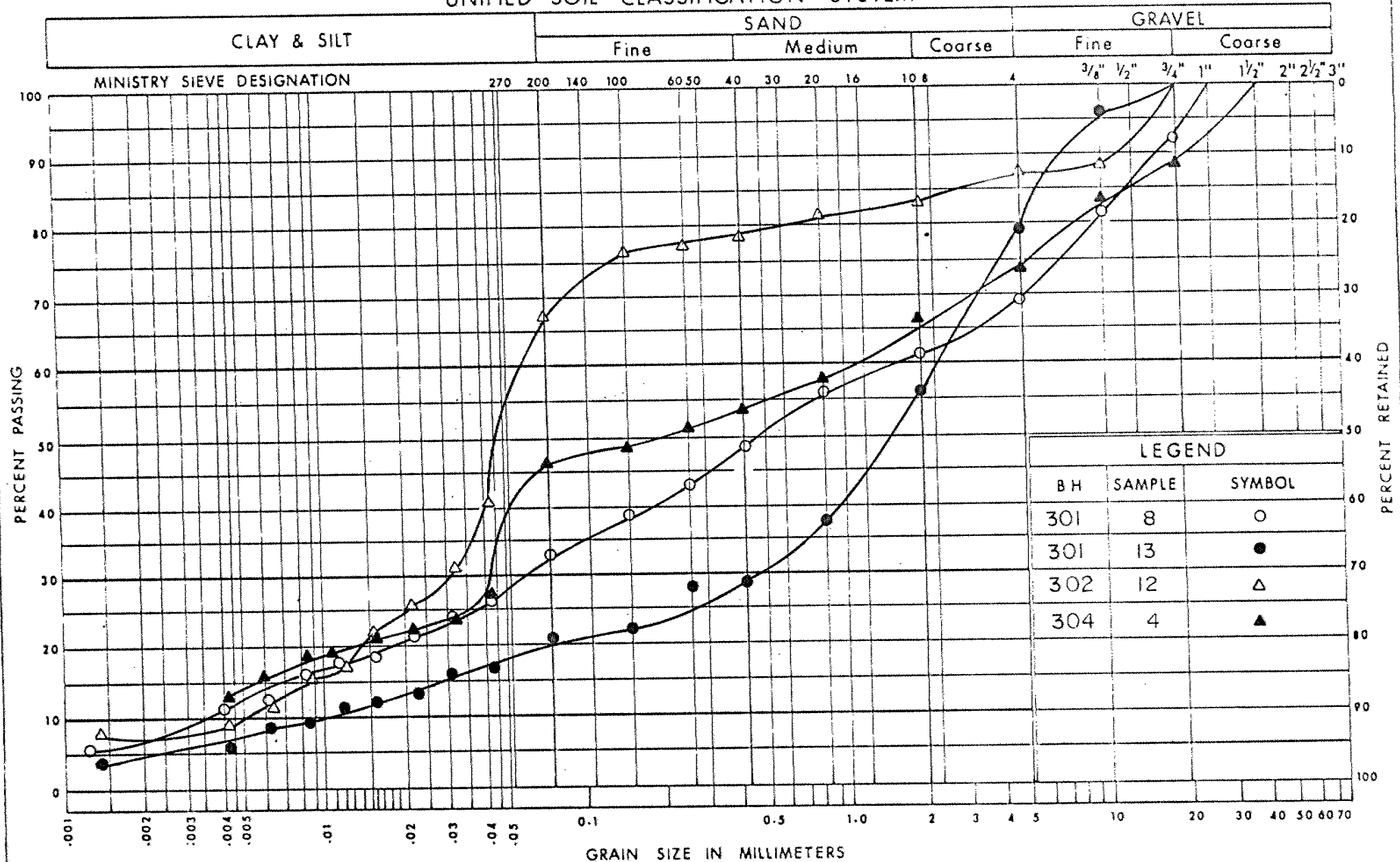
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION FILL GRAVELLY SAND

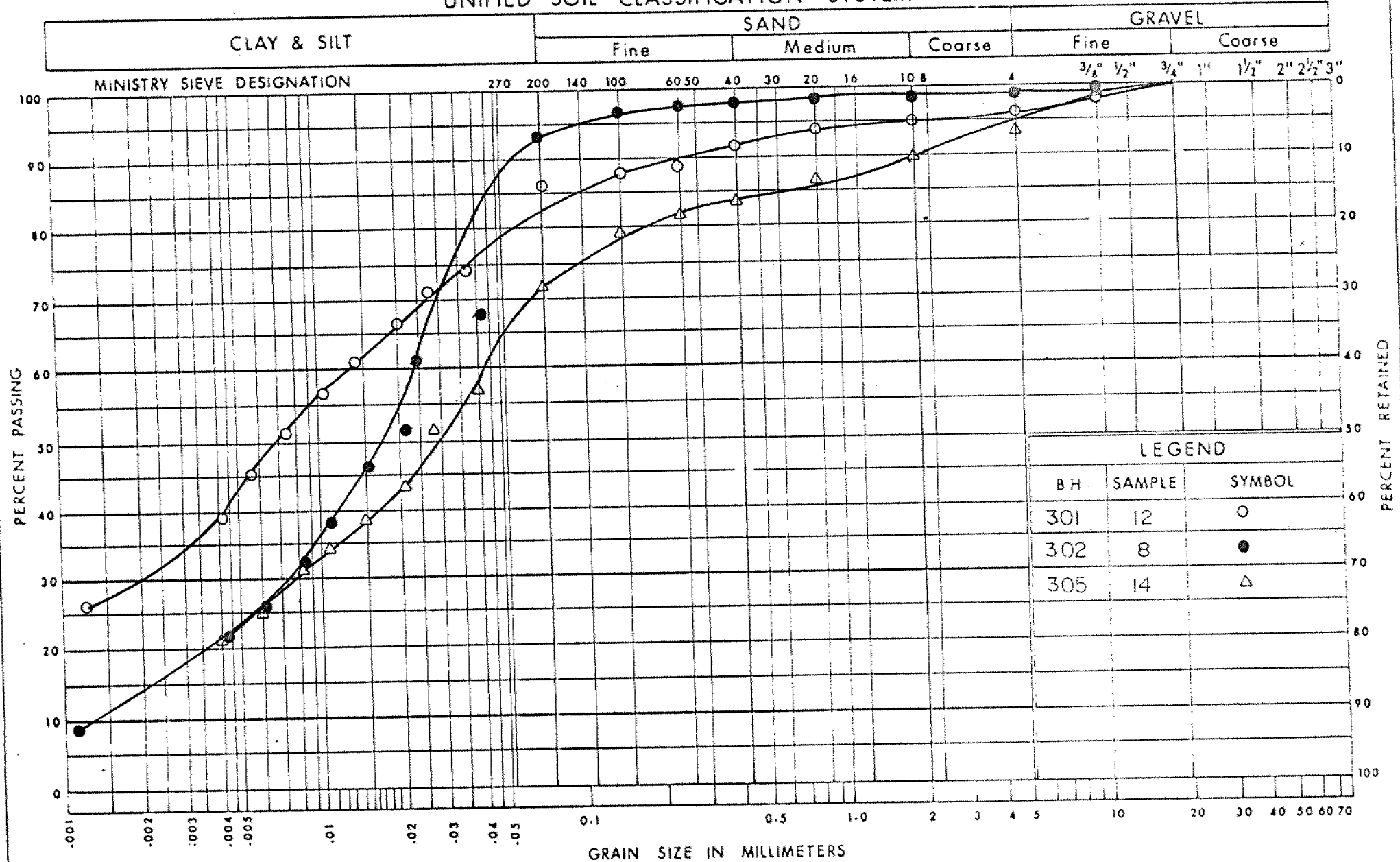
FIG No 6

W P

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario
ENGINEERING SERVICES BRANCH

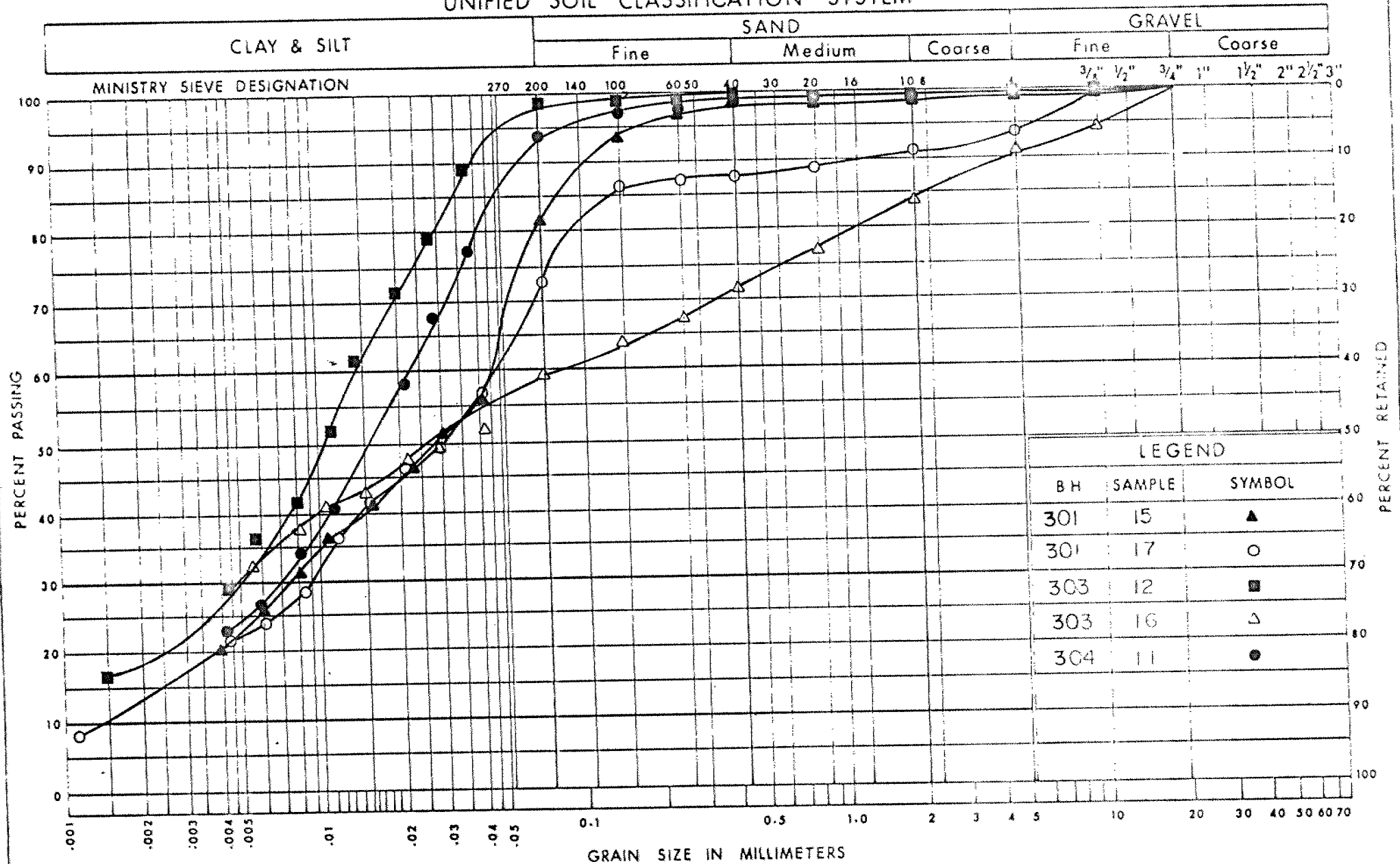
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GRAIN SIZE DISTRIBUTION
FILL-SILTY CLAY
SOME SAND, TRACE OF GRAVEL

FIG No 8

W P

UNIFIED SOIL CLASSIFICATION SYSTEM



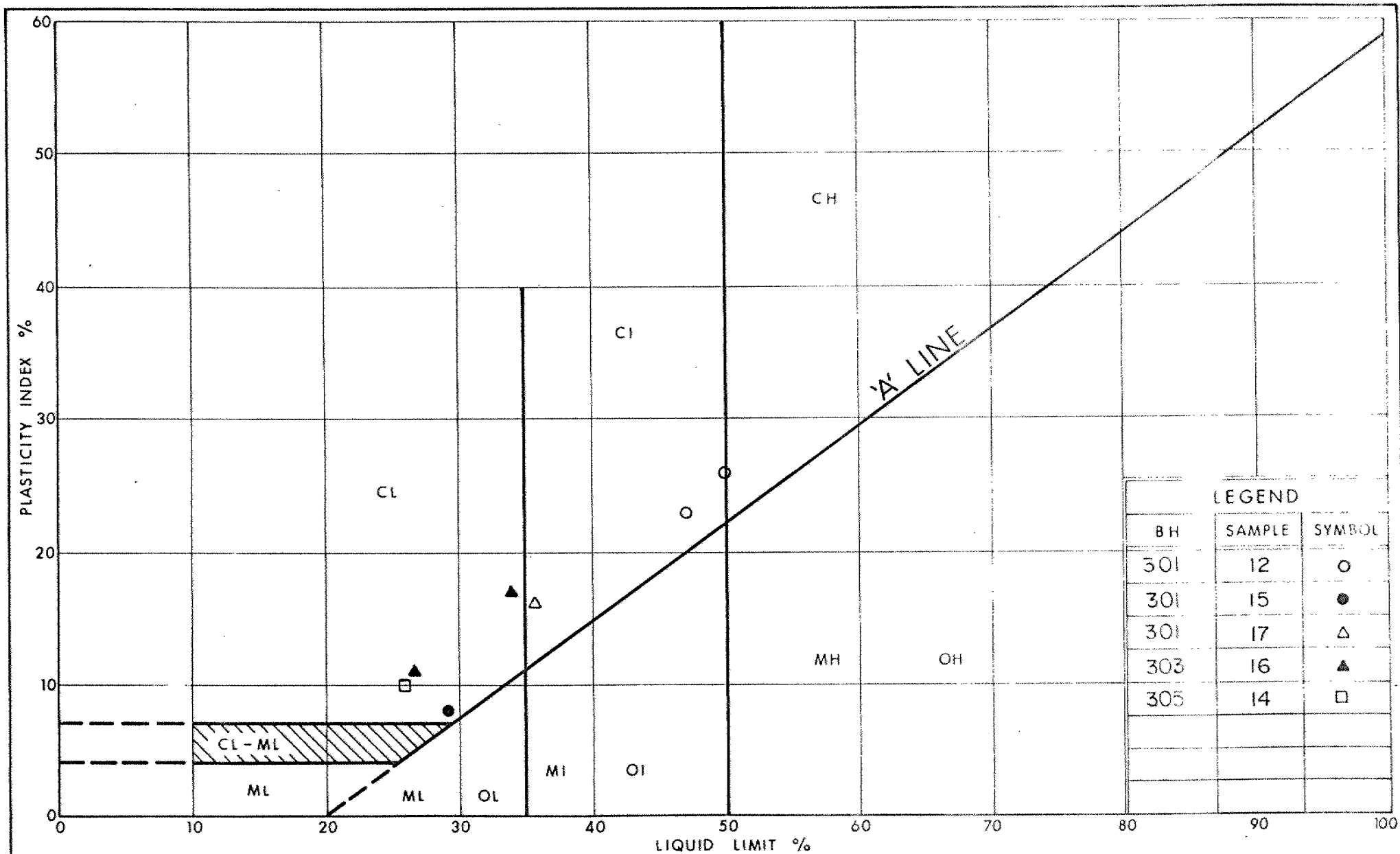
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ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
SILTY CLAY
SOME SAND, TRACE OF GRAVEL

FIG No 9

W P

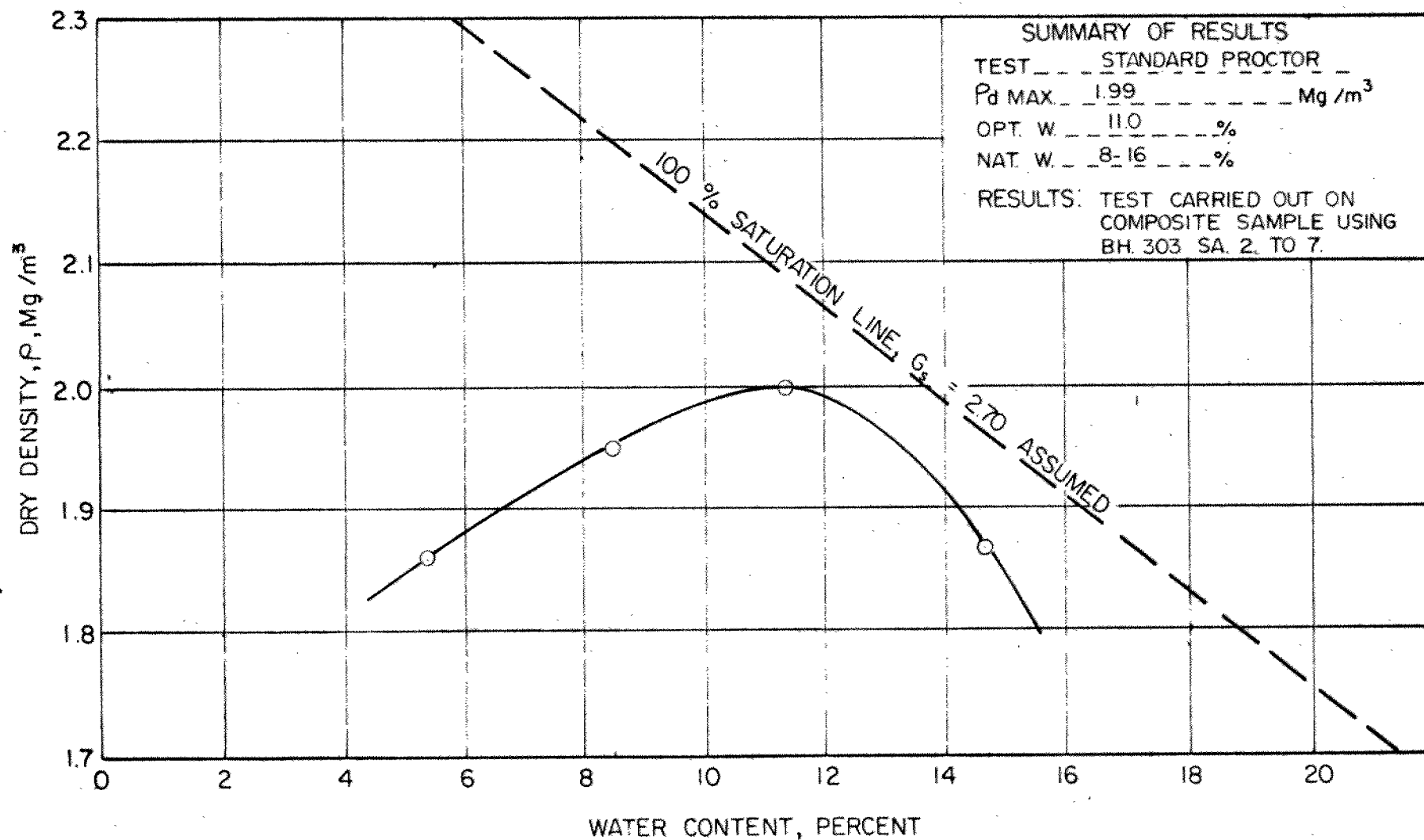


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PLASTICITY CHART SILTY CLAY LOW TO INTERMEDIATE PLASTICITY

FIG No 10

W P



Ontario

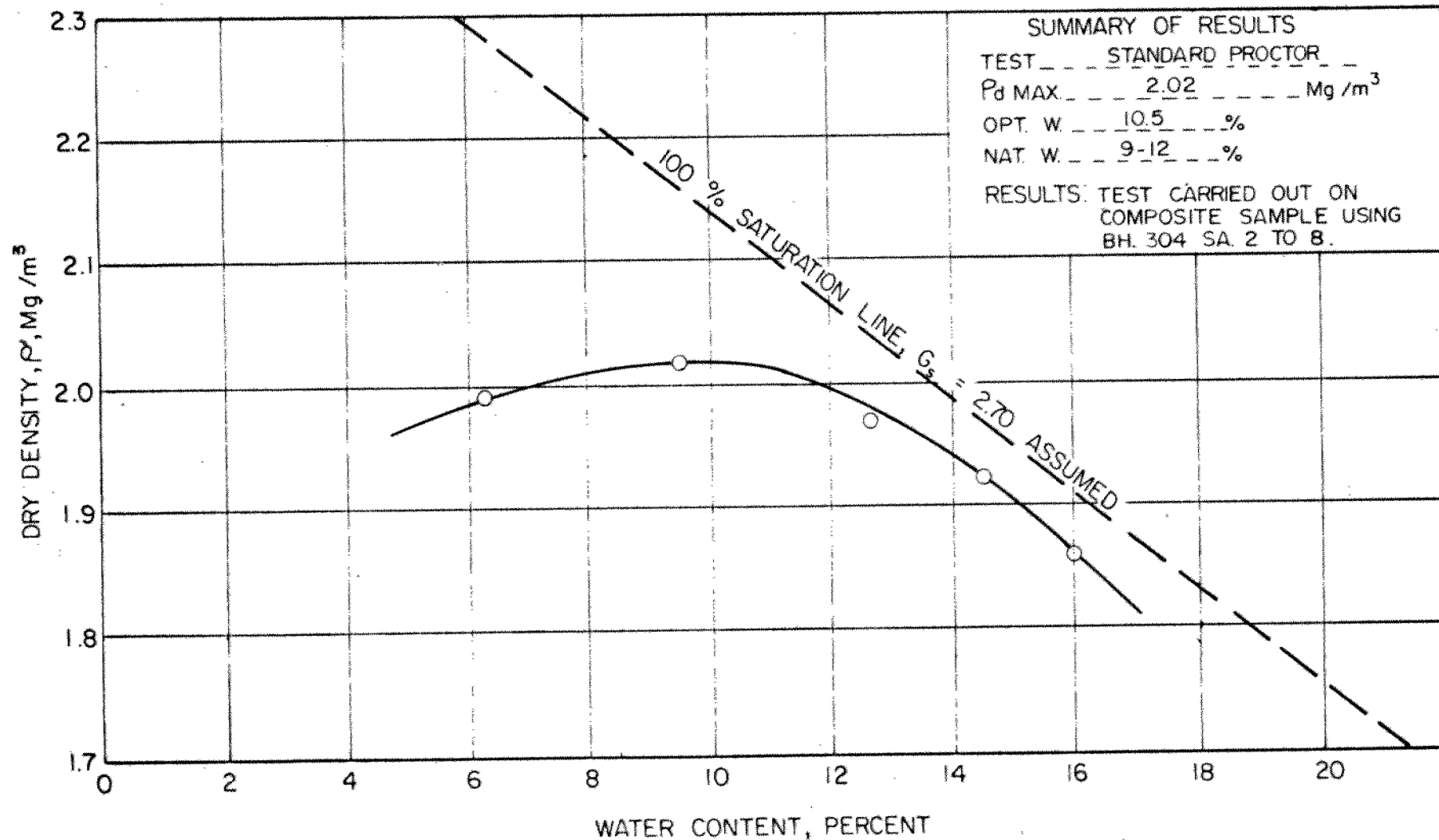
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LABORATORY COMPACTION TEST RESULTS

FILL, SILT WITH SOME SAND

FIG No 11

W P



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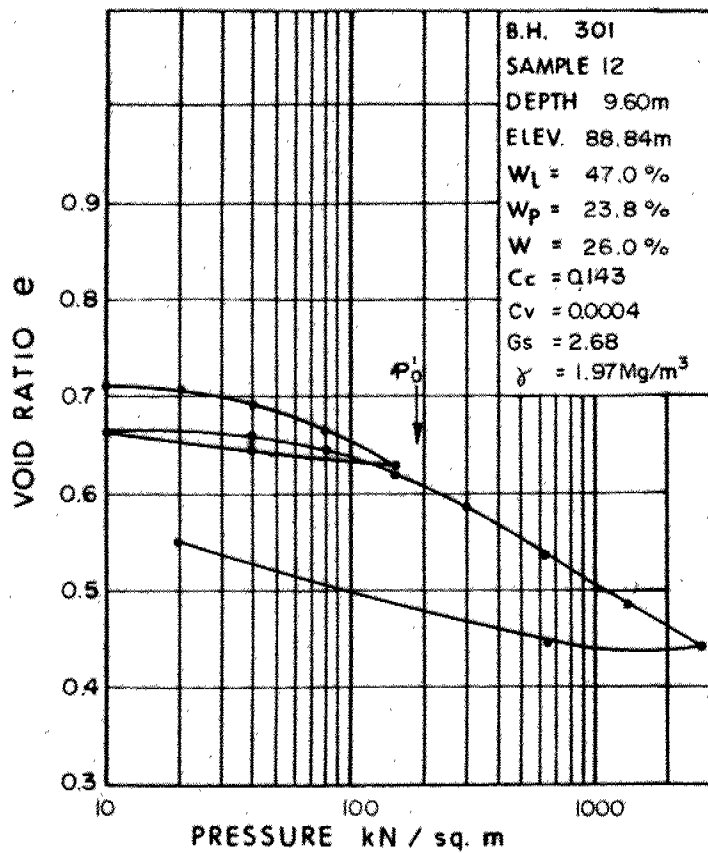
LABORATORY COMPACTION TEST RESULTS
FILL, SILT AND SAND WITH SOME CLAY

FIG No 12

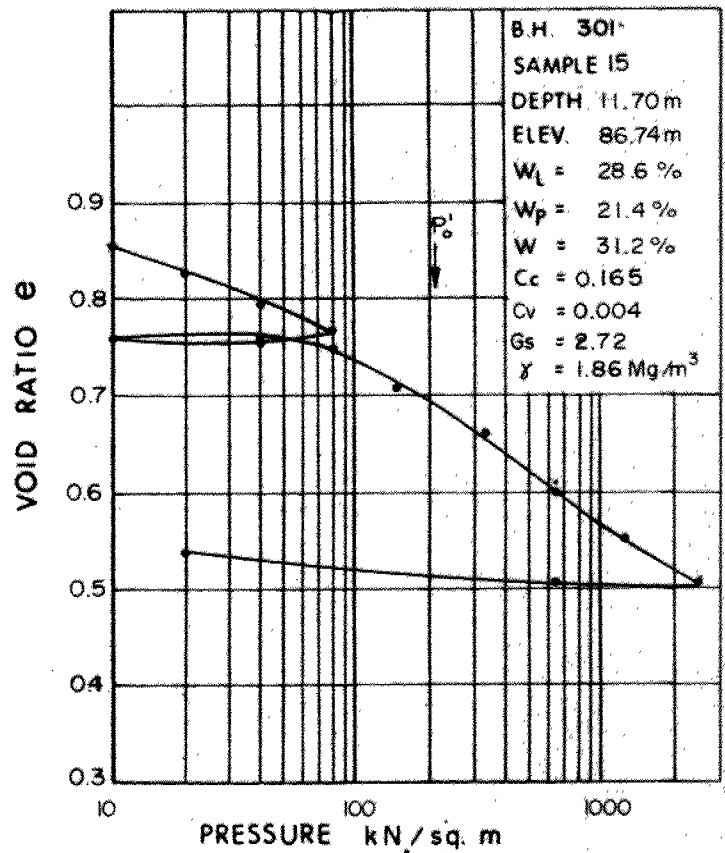
W P

VOID RATIO-PRESSURE CURVES

FILL, SILTY CLAY.



FILL, SILTY CLAY WITH ORGANICS



SILTY CLAY

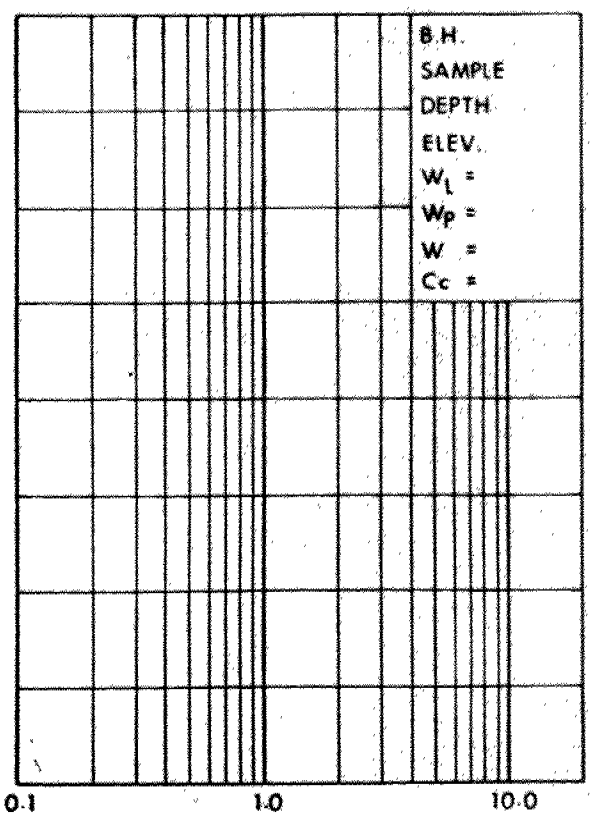
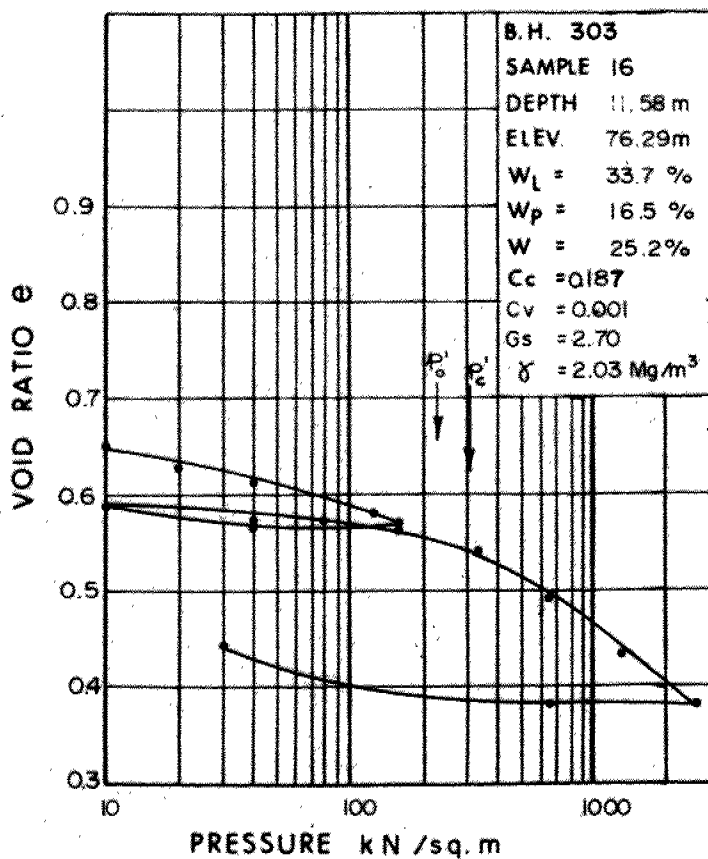
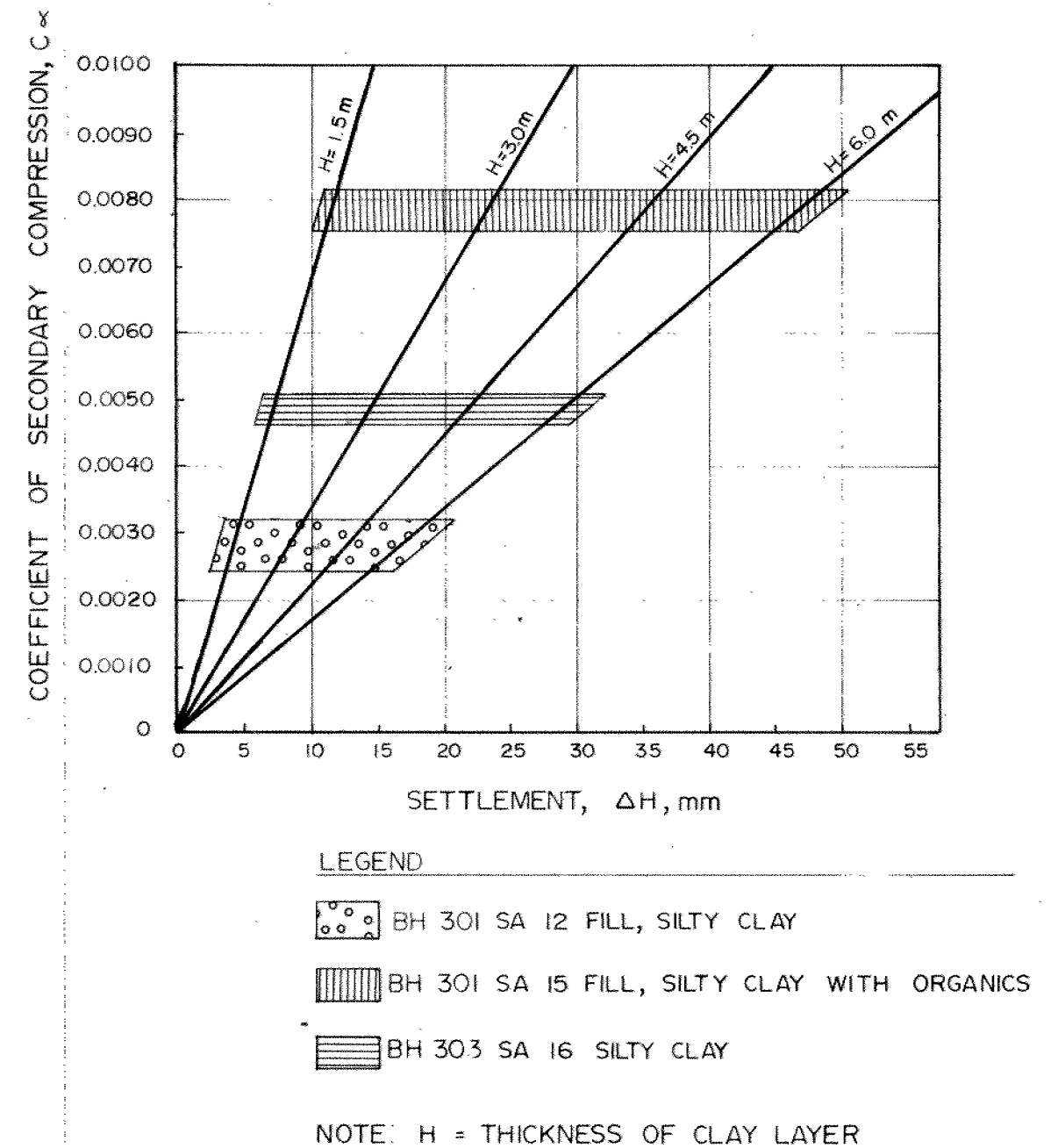
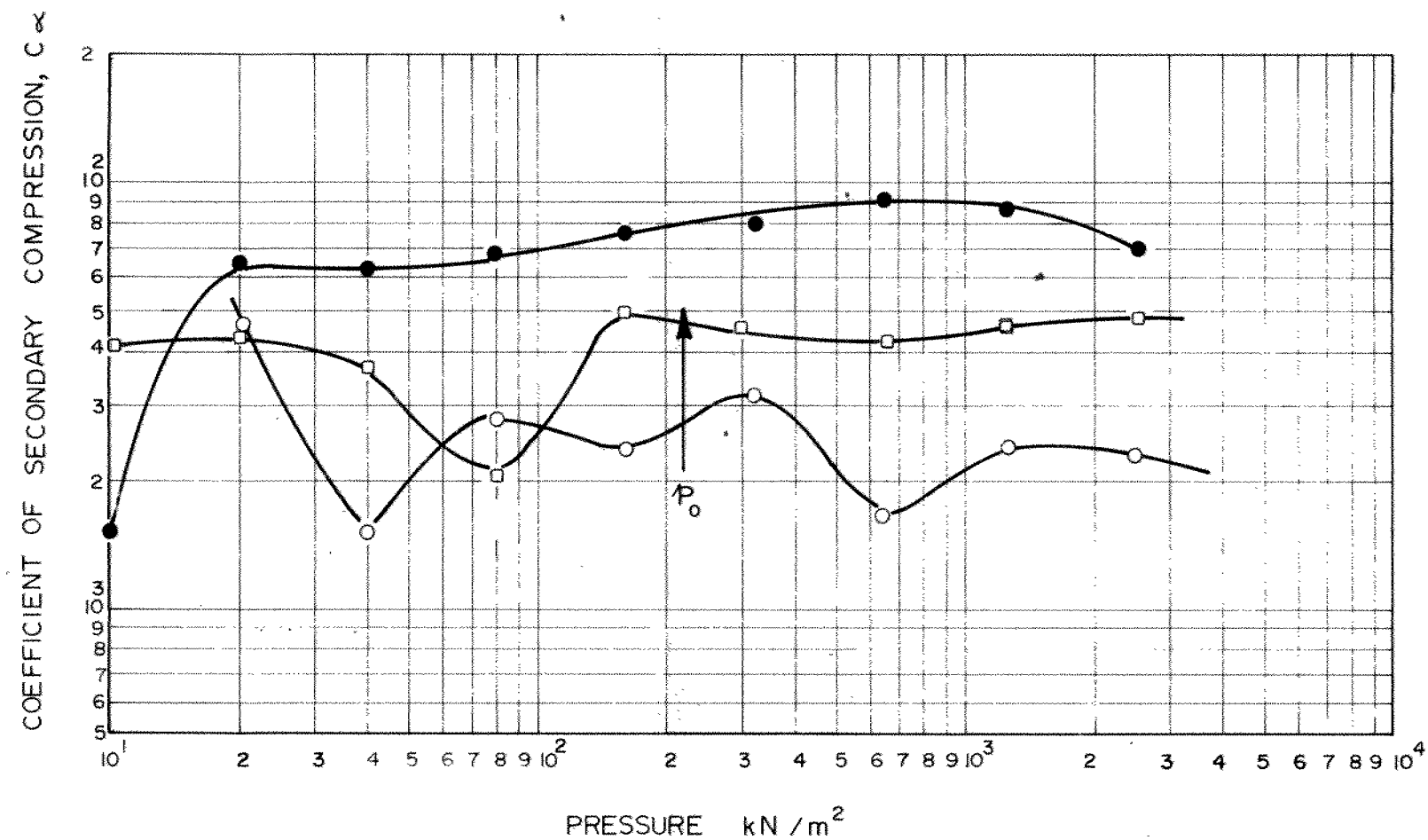


FIG. 13



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SETTLEMENT DUE TO SECONDARY COMPRESSION

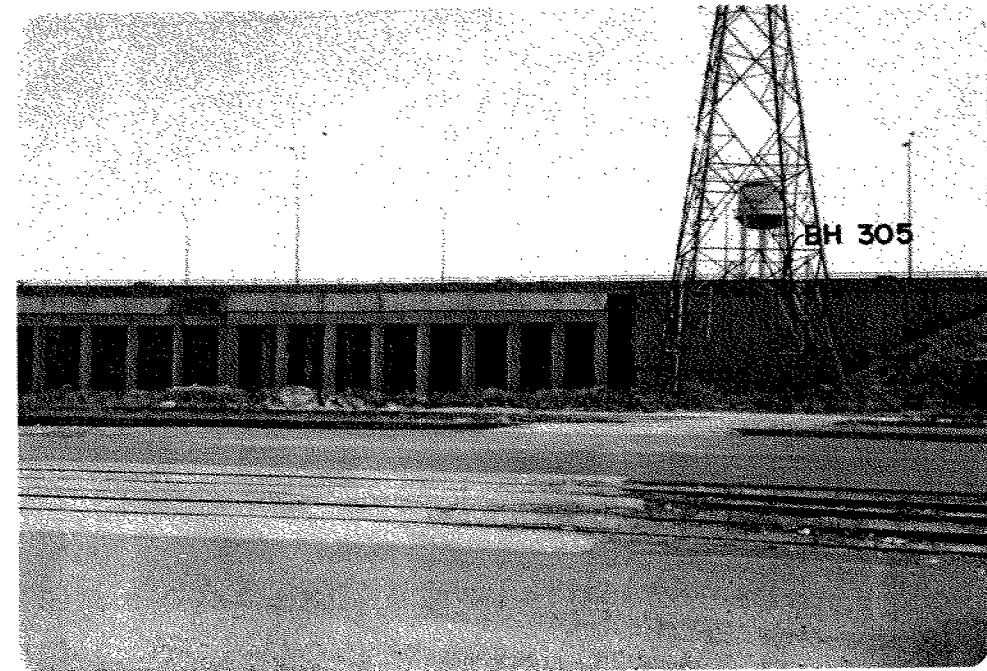
FIG No 14

WP

BRIDGE No. 5



SETTLEMENT OF EMBANKMENT SHOULDER - NOTE SETTLEMENT
OF CURB RELATIVE TO PAVEMENT.



WEST ABUTMENT

BOREHOLE 305



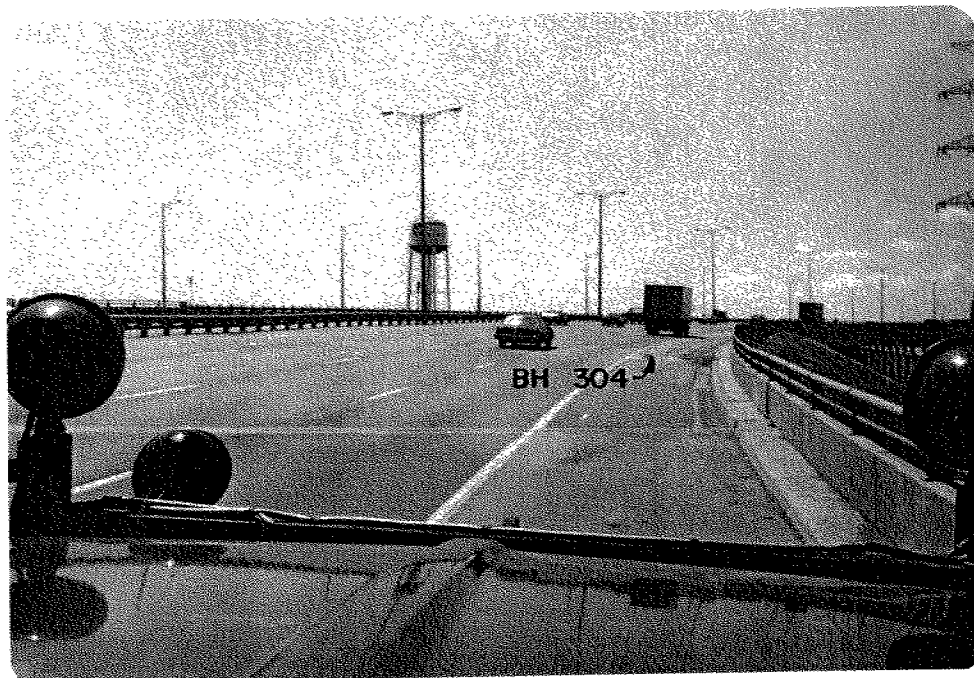
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PHOTOGRAPHS

FIG No 15

W P

RETAINING WALL No. 6



VIEW LOOKING WEST SHOWING UNDULATIONS IN PAVEMENT



RETAINING WALL FROM THE NORTH

BOREHOLE 304



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PHOTOGRAPHS

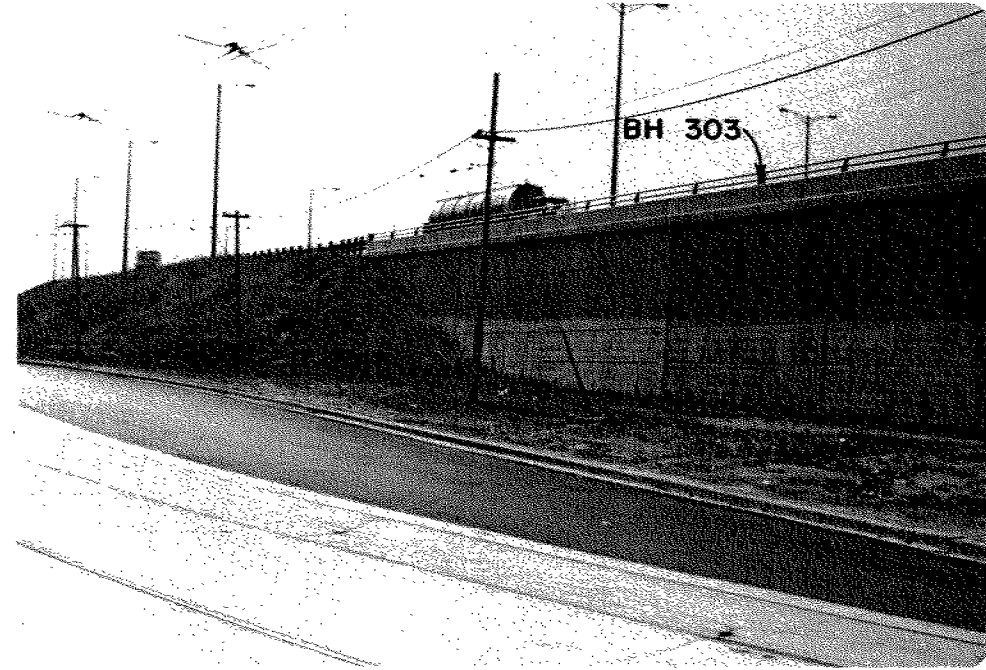
FIG No 16

W P

RETAINING WALL No. 10



SETTLEMENT OF PAVEMENT SURFACE AND DIFFERENTIAL
MOVEMENT WITH RESPECT TO CATCH BASIN.



RETAINING WALL FROM THE SOUTH

BOREHOLE 303



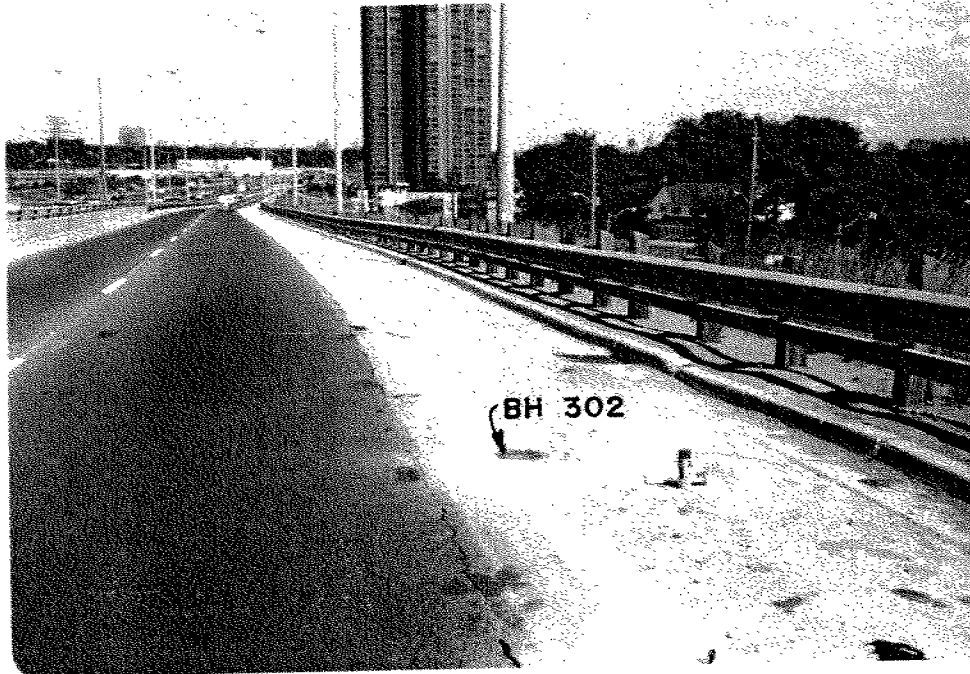
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PHOTOGRAPHS

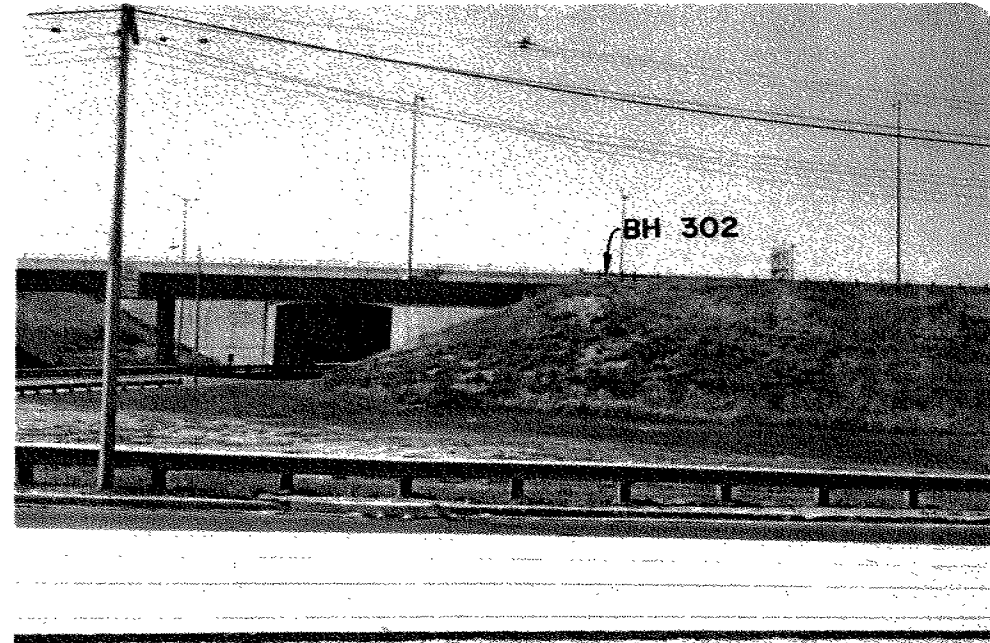
FIG No 17

W P

BRIDGE No. 9



LOCATION OF BOREHOLE SHOWING DIFFERENTIAL
MOVEMENT OF CURB.



BRIDGE No 9 FROM THE SOUTH

BOREHOLE 302



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PHOTOGRAPHS

FIG No 18

W P

memorandum



To: Mr. R.D. Gunter
Head, Geotechnical Office
Central (5000 Yonge St.) Region

Date: 82 12 01

From: Pavement & Foundation Design Section
Room 315, Central Building
Downsview

Re: Geotechnical Investigation
Settlements of Fill Embankments
Q.E.W. From the Humber River
Westerly to Park Lawn Rd.
District #6 (Toronto) Central Region
W.O. 82-26020

Golder Associates have been retained by the Ministry to carry out a subsurface investigation at the above-mentioned location. The purpose of the investigation was to determine the subsurface conditions at each embankment, to assess the causes of the apparent settlement, and to provide recommendations with regard to remedial measures for future maintenance requirements. A subsurface investigation report has been prepared by Golder Associates and we have reviewed the draft report for technical content and format. The final report is enclosed along with this memorandum and our comments are as follows:

The Q.E.W. at this location was reconstructed from 1970 to 1972 and this reconstruction involved the realignment of the Q.E.W. as well as the construction of bridges and fill embankments. Some of the embankments were new while others were heightened and or partially widened. The fills up to 11.5 metres high have been in place for over 10 years and have settled as much as 457 mm since reconstruction.


The major cause of settlement is the use of poor quality fill material immediately behind retaining walls, abutments, and inadequate compaction of fill material during construction. Future settlements are estimated to be as much as 7 mm to 50 mm due to the compression of the clay fill and underlying cohesive soil.

In the area behind Retaining Wall #6, poorly compacted fill was found for a depth of about 4 metres below the pavement depth. In our opinion, this must be subexcavated and replaced with well compacted earth material to prevent future settlements.

It should be noted that the remedial measures to minimize future maintenance requirements could only be incorporated based on cost effective analysis.

The concrete approach slabs are proving to be successful in eliminating sudden depressions at the approaches to the structures. However, the voids now existing underneath the approach slabs should be grouted.

We believe the aforementioned comments together with the enclosed report will be adequate for your interim and long-term requirements. Should you require further clarification or additional queries, please contact us.


M. Devata, P. Eng.
Senior Foundations Engineer

MD:syc

cc: G.C.E. Burkhardt
P.D. Billings
J. Smrcka
J. Childs
K. Bassi
B.J. Giroux
R. Hore

R. Fitzgibbon (Cover Only)
T.J. Kovich (Cover Only)

Encl.