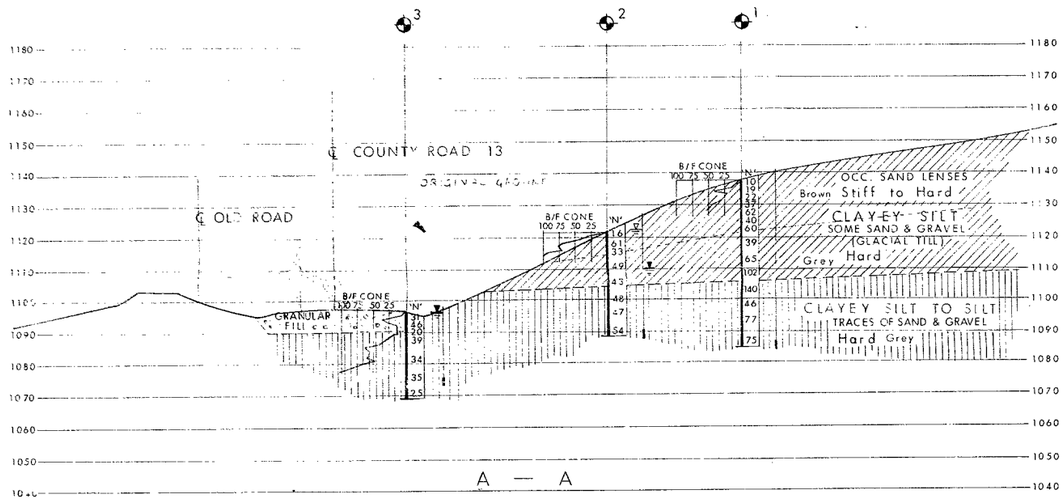
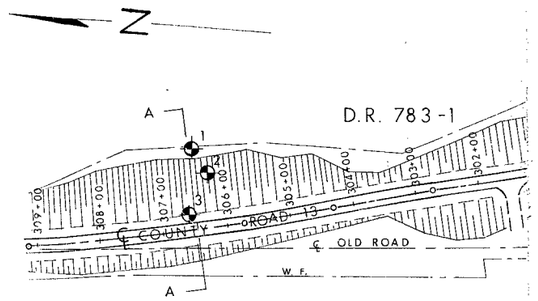
#68-F-35 R
COUNTY ROAD #13
D.R. #783-1
EUGENIA &
KIMBERLEY



SECTION

SCALE

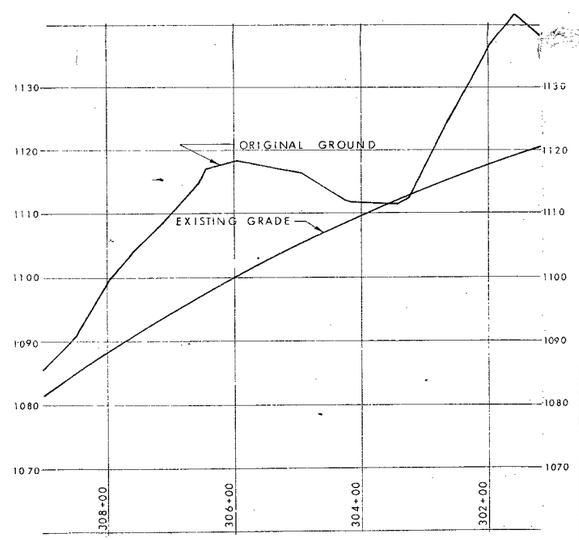
20 10 0 20 40 FT



PLAN

SCALE

100 50 0 100 200 FT

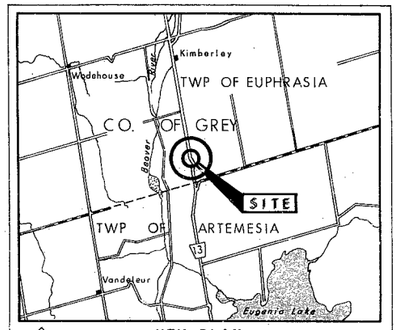


PROFILE

SCALE

HORZ. 100 50 0 100 200 FT

VERT. 10 5 0 10 20 FT



KEY PLAN

SCALE IN MILES

1 0.5 0 1 2 3

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation in Piezometer.
- Piezometer
- Water Levels in open Bore Hole APR. 1968

NO.	ELEVATION	STATION	OFFSET
1	1137.4	306+35	129' RT
2	1124.6	306+20	87' RT
3	1095.9	306+53	23' RT

– 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

PRINT RECORD		
NO	FOR	DATE

DEPARTMENT OF HIGHWAYS – ONTARIO

MATERIALS & TESTING DIVISION – FOUNDATION SECTION

COUNTY ROAD 13
D.R. 783-1

KING'S HIGHWAY NO. _____ DIST. NO. 5

CO. GREY

TWP. EUPHRASIA LOT 2 CON. IV - V

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D. C.M.	CHECKED	W.P. NO.	M.B.T. DRAWING NO. 68-F-35-A
DRAWN A.B.	CHECKED	JOB NO. 68-F-35 R	
DATE MAY 8, 1968		SITE NO	BRIDGE DRAWING NO.
APPROVED H.G. Thomas PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

REF. No A.M. MACKAY & ASS. 14

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. H. F. Gilbert,
District Engineer,
District #5 (Owen Sound)

Attn: Mr. J. Moffat,
District Municipal Engr.

From: Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

Date: May 30, 1968

Our File Ref.

In reply to

Subject:

FOUNDATION INVESTIGATION REPORT
For
Slope Failures of Cut Sections
Between Eugenia and Kimberley
Development Road #783-1
Artemesia Twp. -- Grey County
District No. 5 (Owen Sound)
W.J. 68-F-35(R)

Attached, please find twelve (12) copies of the above mentioned report for your use and distribution to interested parties.

We believe that the report deals with the problem in sufficient detail and that it provides you with all needed information.

The effectiveness of the proposed remedial measures will depend, also, on the way they are carried out. It is reasonable to assume that certain conditions could be encountered for which specific recommendations are not contained in the report. If in doubt, we suggest that you get in touch with our office and we will provide you with guidance and assistance. In any event, we would appreciate being advised of the commencement of the remedial work because we would like to observe some of the operations.

Should you wish to discuss the report, or any part thereof, please feel free to contact this office.

AGS/MdeP
Encls.

cc: Messrs. J. Moffat (12)
C. R. Wilmot (2)
J. Roy

Foundations Files
Gen. Files.

A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER

TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT
For
Slope Failures of Cut Sections
Between Eugenia and Kimberley
Development Road #783-1
Artemesia Twp. -- Grey County
District No. 5 (Owen Sound)
W.J. 68-F-35(R)

---

1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation to determine the causes of, and recommend remedial measures for a number of slope failures which have occurred during 1967 in the realigned roadway between the towns of Eugenia and Kimberley in Artemesia Twp., Grey Cty. The request was contained in a memo from the Owen Sound District (Mr. J. Moffat, District Municipal Engineer), dated April 12, 1968, and was further to correspondence and discussions already in progress between the District and this Section since October 1967. Details of the correspondence and actions taken prior to and following this investigation are summarized in Appendix II.

Subsequently, a detailed subsurface investigation was carried out by this Section at one of the more severely affected areas. Further relevant information was gathered through observations of individual side-slopes as well as by examination of test excavations, such as trenches, pits and the like, in areas of typical slips and shallow slumps. Pertinent airphotos of the affected area together with accompanying reports, were also made available for purposes of this study.

The results of the field and laboratory testing are given in this report together with recommendations for the treatment of the various slopes in order to ensure their future stability. Some aspects of the proposed recommendations given herein have already been discussed at a meeting held between this Section and representatives from the District and County on May 10, 1968.

cont'd. /2 ...

2. DESCRIPTION OF SITE AND GEOLOGY:

2.1) Site:

The site is located in the Beaver Valley Ski Resort area, some 25 miles southeast of Owen Sound. This area is reached by County Rd. #13 (D.R. 783-1) which originates a few miles south of the town of Eugenia and continues north towards Kimberley. Approximately 3 miles north of Eugenia the road enters the steeper eastern slope of the valley at about elevation 1300 and begins to slope down northwards, approaching the valley floor at Kimberley at around elevation 800. A drive from Eugenia to Kimberly along the gravel surfaced road provides a panoramic view of Beaver River and the valley. The lower reaches of the western slopes of the valley are used as grazing land, the upper portions being light to heavily wooded with occasional cleared spaces for ski runs.

In the area of the subsurface investigation, the road is situated approximately halfway up the eastern valley slope. The rim of the eastern bank of the valley is located some 1000 ft. east of the road at about elevation 1350, where rock cliffs with near vertical faces, and up to 100 ft. in height, are exposed. The ground surface slopes down from the toe of these cliffs towards the road at a gradient of 5 or 6:1 and below the road continues towards the river at a gradient of 7 or 8:1.

2.2) Geology:

The erosion of the present valley is said to have started in preglacial times. Repeated advances of ice up the valley in recent times has given it the broad-bottomed and open, steep sided character (Chapman & Putnam)*. The valley indents the Niagara Escarpment from Flesherton in the south to Thornbury on the Georgian Bay in the north.

* L. J. Chapman and D. F. Putnam -
The Physiography of Southern Ontario,
University of Toronto Press,
2nd Edition 1966.

cont'd. /3 ...

2. DESCRIPTION OF SITE AND GEOLOGY: (cont'd.) ...

2.2) Geology: (cont'd.) ...

As it emerges northwards from Flesherton, the valley widens gradually until it is approximately 1½ miles across at the crest in the area of the investigation. The valley floor between Eugenia and Kimberley is generally flat (elev. 750 - 800) and is located some 650 feet below the rim.

The upper rim of the valley is believed to be the edge of the Niagara Dolomite formation. In the area of the investigation the formation appears as vertical cliffs on both the east and west banks of the valley in isolated places. Available geological information indicates that much of the area under consideration is underlain by the Guelph and Lockport formations of the Lower Silurian Period. The glacial deposits above these formations are believed to have been influenced by the Bertie-Akron dolomite. The glacial ice, as it rode into the valley, ground up the rocky fragments mixing these closely with the glacial till. The glacial till in the area consists essentially of clayey silts, and in the valley floor, the overburden is believed to consist of clayey silts and sands.

2.3) Drainage:

Owing to the topography and geology of the area and aided by the existence of a lake on the eastern rim of the valley, numerous natural drainage systems have been developed. These consist of spring-fed streamlets, intermittently flowing surface drainage channels and occasional sink holes resulting from the solutioning and eroding action of springs. An examination of the valley slopes above the road at several locations showed the existence of springs either immediately below the cliff faces or at random locations on the valley slope. Several springs were noted to emerge on the cut slopes of the existing road in the affected sections.

cont'd. /4 ...

2. DESCRIPTION OF SITE AND GEOLOGY: (cont'd.) ...

2.4) Weather Conditions:

Precipitation data for Eugenia for 1967 is shown in Table I together with the normal average values. It is seen that the annual precipitation in 1967 was approximately twice the normal value. Also, that the precipitation in June, July and August of 1967 totalled 22.3 inches as compared with 6.4 inches, the normal or average precipitation for the area for the same months. The summer precipitation in 1967 was therefore almost 4 times greater than the average value.

TABLE I

MONTHLY PRECIPITATION AT EUGENIA (in inches)

Month	1967			NORMAL		
	Rain	Snow	Total	Rain	Snow	Total
J	0.13	31.3	3.26	0.39	20.7	2.46
F	0.97	23.4	3.31	0.33	16.1	1.94
M	0.27	7.8	1.05	0.50	13.6	1.86
A	2.36	1.6	2.52	1.12	4.4	1.56
M	1.23	TR	1.23	2.08	0.2	2.10
J	8.43	0	8.43	2.02	0	2.02
J	4.05	0	4.05	2.21	0	2.21
A	9.84	0	9.84	2.22	0	2.22
S	2.94	0	2.94	2.84	0	2.84
O	3.39	TR	3.39	2.01	1.1	2.12
N	1.76	23.7	4.13	1.54	11.8	2.72
D	3.23	16.0	3.83	0.53	19.8	2.51
Totals:	37.60	103.8	47.90	17.79	87.7	26.56

cont'd. /5 ...

3. FIELD AND LABORATORY WORK:

The field work consisted of the following:

a) Visual examination of all affected side slopes between Eugenia and Kimberley.

b) Investigation of the subsoil conditions at the location of one of the more severely affected cut sections at approximately Sta. 306+50 by means of conventional diamond drilling equipment adapted for soil sampling purposes; installation of piezometers to observe water conditions.

c) Excavation of test pits, trenches and vertical cuts between Stations 303+00 and 320+00.

Photographs were taken during each phase of the field work for purposes of reference and study, and a few are shown on Plates I and II in Appendix III of this report.

3.1) Visual Inspection:

All failed sections along D.R. 783-1 between Eugenia and Kimberley were visually examined. Starting at the bridge at Eugenia and proceeding towards Kimberley, the following observations were made:

cont'd. /6 ...

3. FIELD AND LABORATORY WORK: (cont'd.) ...

3.1) Visual Inspection: (cont'd.) ...

Mileage	Description
0.0	Bridge at Eugenia.
0.9	Crescent shaped shallow slips in cuts 7 - 12 ft. high. Movement of material along slope 6 - 12 in.
1.05 - 1.20	Wet conditions on side slopes, which are situated below dyke on Lake Eugenia. Water standing in roadside ditches. Shallow slip type failures with occasional sliding of the slumped material into the ditch. Movement of material down the slope generally 3 - 5 ft.
2.3	Minor slips, movement of material down slope 6 - 12 in.
2.7 - 2.8	Small failures, displacement down slope noticeable.
2.9 - 3.5	All slopes in this section badly defaced resulting from slump and shallow sliding type failures. Erosion has created gullies. Occasional flow of softened soil down slope.
3.5 - Kimberley	Small wet slumps - dry ground above slumped areas.

3.2) Subsoil Investigation:

A detailed programme of subsoil exploration was carried out at the location of the highest cut in the vicinity of Sta. 306+50.

3.2.1) Drilling Operations:

Three boreholes, each with an accompanying dynamic cone penetration test, were advanced by means of a conventional diamond drill rig adapted for soil sampling purposes. Samples were recovered in a 2" O.D. split-spoon sampler, which was hammered into the soil in accordance with the specifications for the Standard Penetration Test. The same method was used to advance the dynamic cone penetration tests. Porous stone or brass type piezometers were installed at each borehole location in order to observe groundwater levels.

cont'd. /7 ...

3. FIELD AND LABORATORY WORK: (cont'd.) ...

3.2) Subsoil Investigation: (cont'd.) ...

3.2.1) Drilling Operations: (cont'd.) ...

The locations and elevations of the borings are shown on Drawing 68-F-35A together with the estimated stratigraphical profile across the slope.

All samples were subjected to a careful visual examination in the field and subsequently in the laboratory. Following this examination, laboratory testing was carried out on selected representative samples to determine the following physical properties of the soil:

Natural Moisture Contents
Atterberg Limits
Grain-Size Distributions

The results of this testing are plotted on the Record of Borelog sheets as well as on Figures 1 to 5 of Appendix I.

3.2.2) Excavation of Test Pits, Cuts, Trenches:

Several small test pits, as well as vertical cuts were carried out at various locations on the side slopes between Stations 303+00 and 320+00 in order to observe soil and water conditions. In addition to these, a 5 to 7 ft. deep trench of about 2 ft. width was excavated at the crest of the slope between approximately Stations 307+50 and 308+00 (see Plate I, Appendix III). Periodic observations of seeping water were made within the trench. The sides of the trench revealed a sand lense of irregular shape approximately 10 ft. in length and about 1 ft. in height. Water was noted seeping out initially through this lense for some time, the flow gradually subsiding and re-occurring a few hours later from below the lense through tiny fissures in the glacial till.

cont'd. /8 ...

4. SOIL CONDITIONS:

4.1) General:

Since only the side slope at Sta. 306+50 was investigated for subsoil conditions, it is not possible to discuss in this report the subsoil conditions at all locations where failures have occurred. However, sufficient detailed information was gathered from the test excavations to indicate that the subsoil conditions would, in general, be similar to those reported herein.

The surficial stratum consists of a brown to grey fissured clayey silt with some sand and gravel (glacial till). The glacial till stratum extends down to about elevation 1106 where a stratum of clayey silt to silt is encountered extending at least to about elevation 1070. A detailed description of the subsoil conditions follows:

4.2) Clayey Silt with some Sand and Gravel (Glacial Till):

This stratum was encountered at Boreholes 1 and 2 to respective depths of about 32 and 17 feet, that is, to about an average elevation of 1106. The stratum is brown in colour and contains fissures to depths of 15 and 9 feet, respectively, at Boreholes 1 and 2; the colour then changes to grey.

A summary of the physical properties of the stratum, as determined in the field and the laboratory, is given on Figure 1 in Appendix I. The moisture content decreases with depth from an average value of about 15% at elevation 1135 to 12% at elevation 1110. The same trend is noticeable in respect of the Atterberg Limits; the liquid limit decreases from 25% at elevation 1135 to about 18% at elevation 1110, whereas the plastic limit ranges between 17% and 13%. It should be pointed out that without exception, the natural moisture content of the deposit is below the plastic limit indicating that the deposit has been subjected to very high pressures in the past. This would also explain the presence of fissures in the deposit. The Atterberg limits are also plotted on the Plasticity Chart, Figure 2, which indicates the soil to be a clayey silt of low

cont'd. /9 ...

4. SOIL CONDITIONS: (cont'd.) ...

4.2) Clayey Silt with some Sand and Gravel (Glacial Till): (cont'd.) ...

plasticity. Typical grain-size distribution curves for selected samples are shown on Figure 4. Referring to Figure 1, it is seen that the grain-size distribution is fairly consistent with depth and indicates the following composition: gravel: 12%, sand: 14%, silt and clay: 74%.

The Standard Penetration Resistance 'N' values (Figure 1) in this deposit generally increase with depth from a value of about 20 blows/ft. at elevation 1135 to 100 blows/ft. at elevation 1106. Based on these 'N' values, the upper brown fissured zone is considered to be of stiff to hard consistency, and the lower grey zone is considered to be generally hard.

4.3) Clayey Silt to Silt:

This stratum was encountered below the glacial till deposit at Boreholes 1 and 2, and immediately below the granular fill at Borehole 3. The silt content in this deposit was found to increase with depth. The deposit changes to silt below about elevation 1090 at Borehole 3. Within the silt stratum, occasional seams of clayey silt or silty sand were encountered.

The physical properties of the clayey silt and silt strata are summarized on Figure 1. The moisture content is nearly constant or decreases very slightly with depth, averaging about 18%. The liquid limit ranges between 22% and 26%, averaging 24%, and the plastic limit averages about 16%. The Atterberg limits shown on the Plasticity Chart, Figure 3, indicate the soil to be a clayey silt or silt (CL-ML or ML in the Unified Soil Classification System, October 1963). Grain-size distribution curves for representative samples are shown on Figure 5 and the results are summarized on Figure 1.

The 'N' values varied between about 10 and 80 blows/ft. As shown on Figure 1, the average 'N' value is about 40 blows/ft. although a slight tendency to decrease with depth is indicated by

cont'd. /10 ...

4. SOIL CONDITIONS: (cont'd.) ...

4.3) Clayey Silt to Silt: (cont'd.) ...

the plot. On this basis, the stratum is considered to be of a hard consistency for the clayey silt portion, and dense for the silt portion.

4.4) Slumped Material:

On November 13, 1967, a soil survey was carried out by the Regional Materials and Testing Section of the Department of Highways, Ontario, along the county road (D.R. 783-1) between Stations 275+00 and 391+00 in order to examine the properties of the slumped material. During the course of this survey, several samples were obtained at shallow depths from the slumped and adjacent undisturbed material from the affected areas. The results of laboratory testing on these samples indicated that the average moisture content in the slumped material ranged between 24% and 38%, the higher values being obtained for the clayey silt material and the lower values for the glacial till. The corresponding moisture contents for the undisturbed material at the same sampling depths ranged between 14% and 24%. These results indicate that the moisture content of the slumped material is higher than the liquid limit for the same soil type, and is greater than the natural moisture content by values ranging from about 10% to 20%.

5. WATER CONDITIONS:

In order to observe the water conditions, a piezometer was installed in each borehole in the vicinity of Sta. 306+50. The types of piezometers used, method of installation and water level readings, are summarized in Table II, which follows:

cont'd. /11 ...

5. WATER CONDITIONS: (cont'd.) ...

TABLE II

BH No.	Piezometer Type	Tip Elev.	Ground Elev.	WATER LEVEL ELEVATIONS - 1968				
				Apr. 18	Apr. 22	Apr. 23	Apr. 24	Apr. 25
1	Geonor - Porous Brass Driven	1084.7	1137.4	1127.2	Below 1120.4	Below 1119.6	-	Below 1124.4
2	Geonor - Seal @ El. 1095	1088.5	1124.6	-	1109.8 1118.7*	1109.5	Below 1109.6 1122.8*	Below 1111.6 1122.1*
3	Porous Stone - Seal @ El. 1085	1073.0	1095.9	-	-	1096.2 (4"Above G.L.)	1096.6 (8"Above G.L.)	1096.7 (10"Above G.L.)

*Water Level in open hole.

These observations indicate that, in general, the groundwater table is well below the surface of the slope. A slight artesian condition some 10" above ground surface is observed in the silt stratum at Borehole 3.

On the high slope between Stations 303+00 and 308+00, excavation of small cuts near the top of the slope revealed a spring or source of water in the vicinity of the slump, or flow type failures that had occurred on the slope (see Fig. 1, Plate II, Appendix III). In some cuts the water was noted flowing out of small sand pockets, whereas in others the water was found to be coming through very thin

cont'd. /12 ...

5. WATER CONDITIONS: (cont'd.) ...

cracks or fissures in the glacial till deposit. Between about Stations 312+00 and 316+00 the surface of the cut slopes is generally dry with the exception of an isolated wet zone in the vicinity of Sta. 315+00. A cut was made into this wetted zone and it was found that the wetness was caused by a spring located approximately 3 ft. below the top of the wetted zone (see Figure 2, Plate II, Appendix III). The spring was found to be emerging from fissures in the subsoil.

A trench was excavated at the top of the high slope, as described earlier in Section 3.2.2. Water accumulation, as a result of seepage through the walls of the trench on either side from preferential and thus more permeable zones, was rather rapid. The trench was excavated with near vertical sides which stood up for about an hour after exposure. With water seeping in, however, the sides of the trench began to cave, at first in the zones through which the water was seeping, and later adjacent to these zones. The caving of the sidewalls occurred generally near the base of the trench at first, extending later towards the top.

It is concluded from these observations that the groundwater level is some 15 to 20 feet below the surface of the existing slope. However, the existence of permeable zones, such as fissures, sand lenses and the like within the subsoil, has created a preferential but random subsurface drainage pattern, resulting in the emergence of springs.

cont'd. /13 ...

6. DISCUSSION AND RECOMMENDATIONS:

6.1) History of Construction:

Development Road #783-1 extends in a northerly direction for a distance of about 7 miles from the intersection of County Roads #11 and #13 to the northern limits of the town of Kimberley. According to available information, construction of the road was started at the south end in early 1966. By the Fall of 1966, cuts' to about Sta. 270+00 had virtually been completed. In that same period of time, partial excavation to depths of 7 to 10 feet was carried out between Stations 300+00 and 310+00, resulting in an earth cut of about 15,000 cubic yards. Construction in this section of the road was resumed in May and completed in June, 1967.

Failures of the cut slopes in several sections of the roadway occurred in July, 1967. The affected slopes were retrimmed in August, 1967. In September, more failures occurred in the section of the road between Stations 303+00 and 310+00. These failures were corrected by subexcavation and backfilling with an estimated 11,000 tons of granular backfill. However, in the Spring of 1968, further deterioration of the slopes between Stations 303+00 and 310+00 was observed, but no remedial work was undertaken pending the results of this study.

6.2) Reasons for the Failures:

The investigation reveals that the subsoil and water conditions are such that they preclude the possibility of deep-seated base failures for cut sections with 2:1 side slopes. It is established that the main reasons for the failures in the area are the lack of effective surface drainage measures and control of seepage from springs within the cut slopes. Observations which support these conclusions, are listed below:

a) All the failures are shallow in nature.

b) Material which has failed is unusually wet; failures are of the "slump" or "flow" type and occur randomly.

cont'd. /14 ...

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

6.2) Reasons for the Failures: (cont'd.) ...

c) The soil is susceptible to erosion. The overburden contains occasional fissures or sand seams which have created preferential drainage paths for local springs.

d) The absence of interceptor ditches [illegible] of the cuts has accelerated erosion of the side [illegible] by surface runoff from the catchment area [illegible] the cuts. Excessive rainfall during construction [illegible] 1967, aggravated the problem.

6.3) Recommendations:

As discussed in the preceding section, the main [illegible] for the failures are the effects of seepage from springs [illegible] cut slopes and the lack of effective surface drainage. [illegible] recommended, therefore that remedial measures for the affect[illegible] areas at the site be implemented as discussed in detail [illegible] following paragraphs.

6.3.1) Drainage [illegible]:

A drainage blanket [illegible] of a [illegible] 3 ft. of granular material [illegible] should be provided [illegible] The affected [illegible] and [illegible] stoi[illegible]

areas

areas

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

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

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

6.3.1) Drainage Blanket: (cont'd.) ...

Slopes which are greater than 30 ft. in height should be provided with a midslope ditch and subdrain. A bench of minimum width of 10 ft. will be required for construction purposes. The subdrain should consist of a trench at least 6 ft. in depth provided with a 6-inch diameter perforated pipe and backfilled with granular fill similar to that used for the drainage blanket. The midslope ditch should be sodded. Typical details showing the granular blanket, surface and subsurface drain installations, are given on Figure 6 in Appendix I.

According to the available information, the cut slopes had been provided with a cover of topsoil which was then seeded and mulched. If this can be carried out satisfactorily after placing the granular blanket, the same procedure may be adopted. If this procedure creates considerable difficulties, however, consideration should be given to sodding and wire meshing with stakes as per current D.H.O. Standard DD-403.

6.3.2) Interceptor Ditch at Crest of Slope within Right-of-Way:

For cuts deeper than about 20 ft. and in those sections where the slope of the ground behind the cuts is high and sparsely covered with vegetation, adequately designed interceptor ditches should be constructed at the top of the cuts within the R.O.W. These ditches should be proportioned so as to prevent the spill-over of surface runoff on to the surface of the side slope during heavy rains or spring thaw. In sections involving shallow cuts, where the ground behind the cuts does not slope appreciably and has a reasonable vegetative cover of trees or brush, the construction of intercepting ditches at the top of such cuts would be desirable but not necessary. Therefore, it is not possible to make specific recommendations regarding the ditch proportions to be used at specific sections along the roadway, since these would depend on

cont'd. /16 ...

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

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

6.3.2) Interceptor Ditch at Crest of Slope within Right-of-Way: (cont'd.) ...

the R.O.W., depth of cut and other considerations as discussed in preceeding paragraphs. The interceptor ditches should be suitably drained into a satisfactory toe drainage system.

The existing roadside drainage system along certain sections of the roadway, was found to be in an unsatisfactory condition resulting from the effects of the failures. Appropriate measures should, therefore, be taken to renew the roadside drainage system, as necessary, and to incorporate the drainage blanket installation into this system. The actual details will depend on local conditions at each affected section of the roadway.

7. SUMMARY:

A foundation investigation for slope failures in the section of Development Road #783-1 between Eugenia and Kimberley in Artemesia Twp., Grey Cty., is reported.

The site, geology and drainage conditions of the area are described, and it is shown that excessive rainfall was received in the area during the construction season in 1967.

Field work consisted of a visual examination of all the failures as well as a subsurface investigation by means of three boreholes put down in the vicinity of Sta. 306+50.

The investigation has revealed the subsoil to be a competent glacial till overlying a deposit of hard clayey silt or dense silt.

Test pits and trenches exhibited unusual groundwater conditions due to the presence of numerous isolated springs.

cont'd. /17 ...

7. SUMMARY: (cont'd.) ...

Details of road construction and the occurrence of failures are described in the main body of the report.

It is concluded that the main reason for the failures of the slopes is the presence of numerous isolated springs in the subsoil along the cut surfaces. These springs emerge from the ground through preferential drainage paths such as fissures and sand seams in the overburden.

Remedial measures required to control the seepage effects of the springs within the cut slopes, include the construction of a 2-ft. thick granular drainage blanket in all affected areas of the roadway. Details of the granular blanket and interceptor ditches required at the top of the cuts are discussed within the report.

8. MISCELLANEOUS:

The field work, performed during the period April 17 - 25, 1968, together with the preparation of this report, was undertaken by Mr. C. Mirza, Project Foundation Engineer.

Equipment used was owned and operated by Dominion Soil Investigation Ltd.

The project was carried out under the general supervision of Mr. M. Devata, Supervising Foundation Engineer, who also reviewed the report.

May, 1968.

APPENDIX I

FORM DB M-126

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

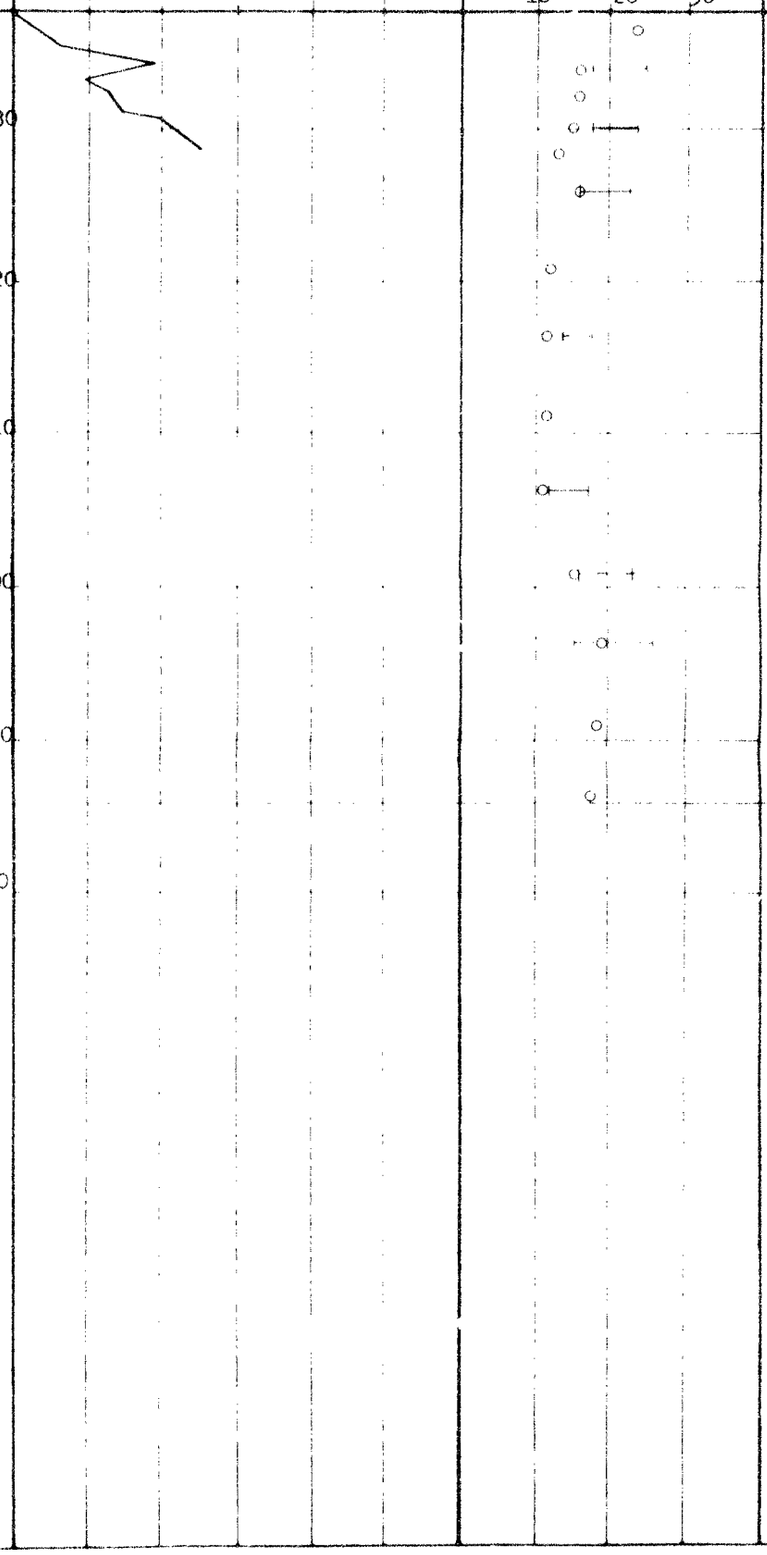
JOB 68-F-35(R) LOCATION Tang. Sta. 306 + 35 ℄ o/s 129' Rt. ORIGINATED BY CM

W P — BORING DATE April 17-18, 1968 COMPILED BY CM

DATUM Geodetic BOREHOLE TYPE Diamond Drill - BX Casing CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	REMARKS (Gr.Sa.Si.Cl)
1137.4	Ground Level					
0.0		1	SS	10		
		2	SS	19		13 14 63 10
	Clayey silt with some	3	SS	22		
	sand & gravel.	4	SS	37	1130	
	(Glacial Till)	5	SS	62		
	Occ. sand lenses.	6	SS	40		12 14 64 10
	Stiff to Hard					
1122.2	(Brown, Fissured)					
15.2		7	SS	60	1120	
	Hard					
	Grey	8	SS	39		12 17 62 9
		9	SS	65	1110	
1105.4		10	SS	102		3 19 69 9
32.0	Clayey silt to silt.					
		11	SS	140	1100	
	Trace of sand & gravel.					
		12	SS	46		
	Hard					
		13	SS	77	1090	0 3 90 7
	Grey					
1085.9		14	SS	75		1 14 78 7
51.5	End of Borehole					Gennor Piezometer
					1080	W.L. in Piez. below elev. 1119.6 on Apr.23/68.

SOIL PROFILE — STRAT PLOT — SAMPLES — DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100 — SHEAR STRENGTH P S F — LIQUID LIMIT w_L — PLASTIC LIMIT w_P — WATER CONTENT w — w_P w w_L — WATER CONTENT % 10 20 30 — BULK DENSITY γ P C F



FORM CB-MT-25
66 4545

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB 68-F-35(R) LOCATION Tang. Sta. 306 + 20 Ø o/s 87' RT ORIGINATED BY CM
W P — BORING DATE April 19, 1968 COMPILED BY CM
DATUM Geodetic BOREHOLE TYPE Diamond Drill - BX Casing CHECKED BY

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (20 40 60 80 100) / SHEAR STRENGTH P S F	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w — WATER CONTENT % (1.0 2.0 3.0)	BULK DENSITY γ P C F	REMARKS Gr.Sa.Si.Cl
1124.6	Ground Level									
0.0	Clayey silt with some sand & gravel. (Glacial Till) Stiff to hard.		1	SS	16					
						1120				
1115.1	(Brown, Fissured)		2	SS	61					Apr.25/68 (open hole)
9.5	Hard Grey		3	SS	33					16 14 63 7
						1110				
1107.6			4	SS	49					Apr.23/68 (piezometer)
17.0	Clayey silt to silt, trace of sand.		5	SS	43					0 3 77 20
						1100				
	Hard		6	SS	48					
	Grey		7	SS	47					
						1090				
1088.1			8	SS	54					5 4 87 4
36.5	End of Borehole									
						1080				

FORM 108 MT-106
66-4545

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

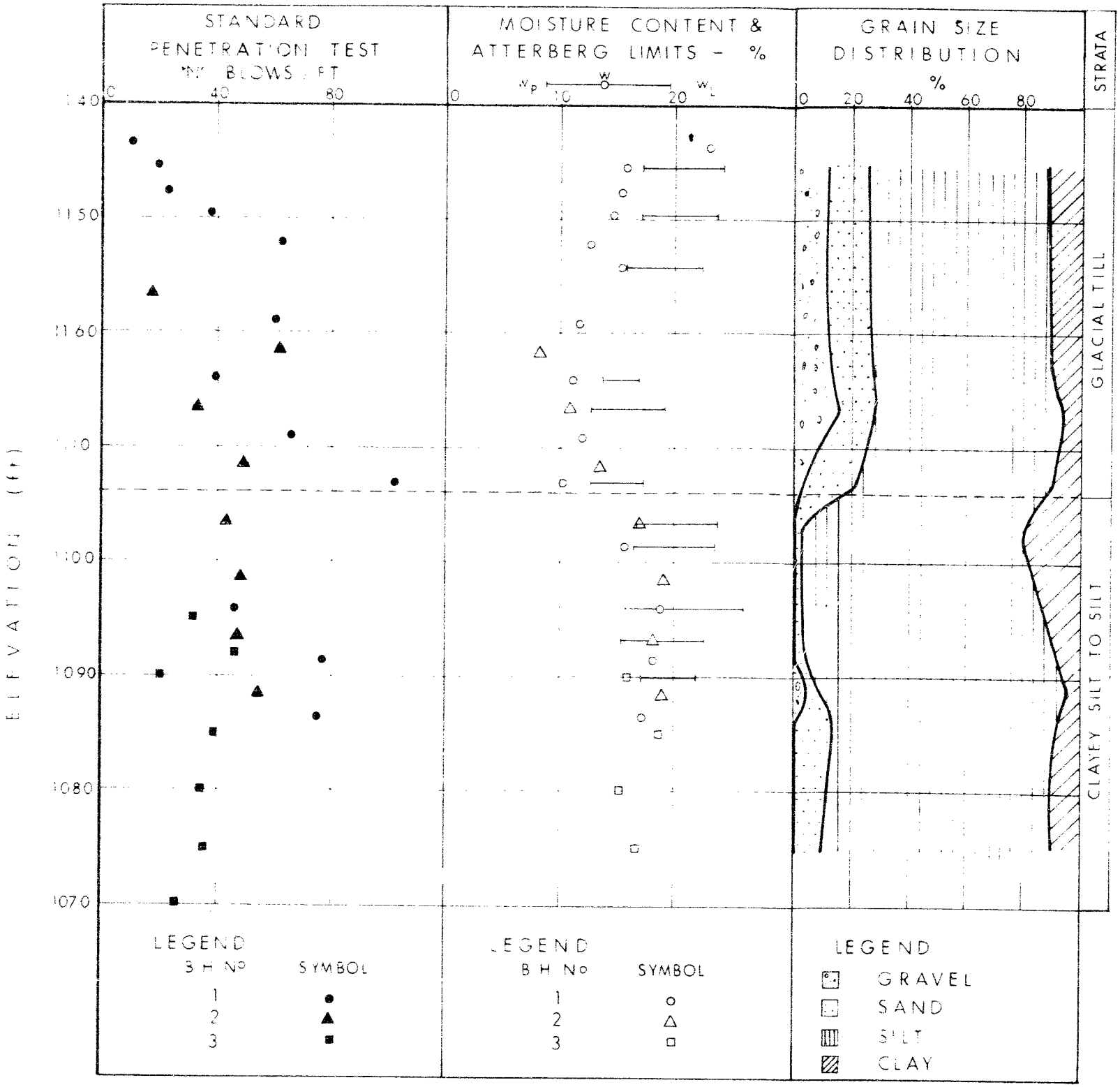
JOB 68-F-35(R)
W P
DATUM Geodetic

LOCATION Tang. Sta. 306 + 53 Ø o/s 23' Rt.
BORING DATE April 22, 1968
BOREHOLE TYPE Diamond Drill - BX Casing

ORIGINATED BY CM
COMPILED BY CM
CHECKED BY

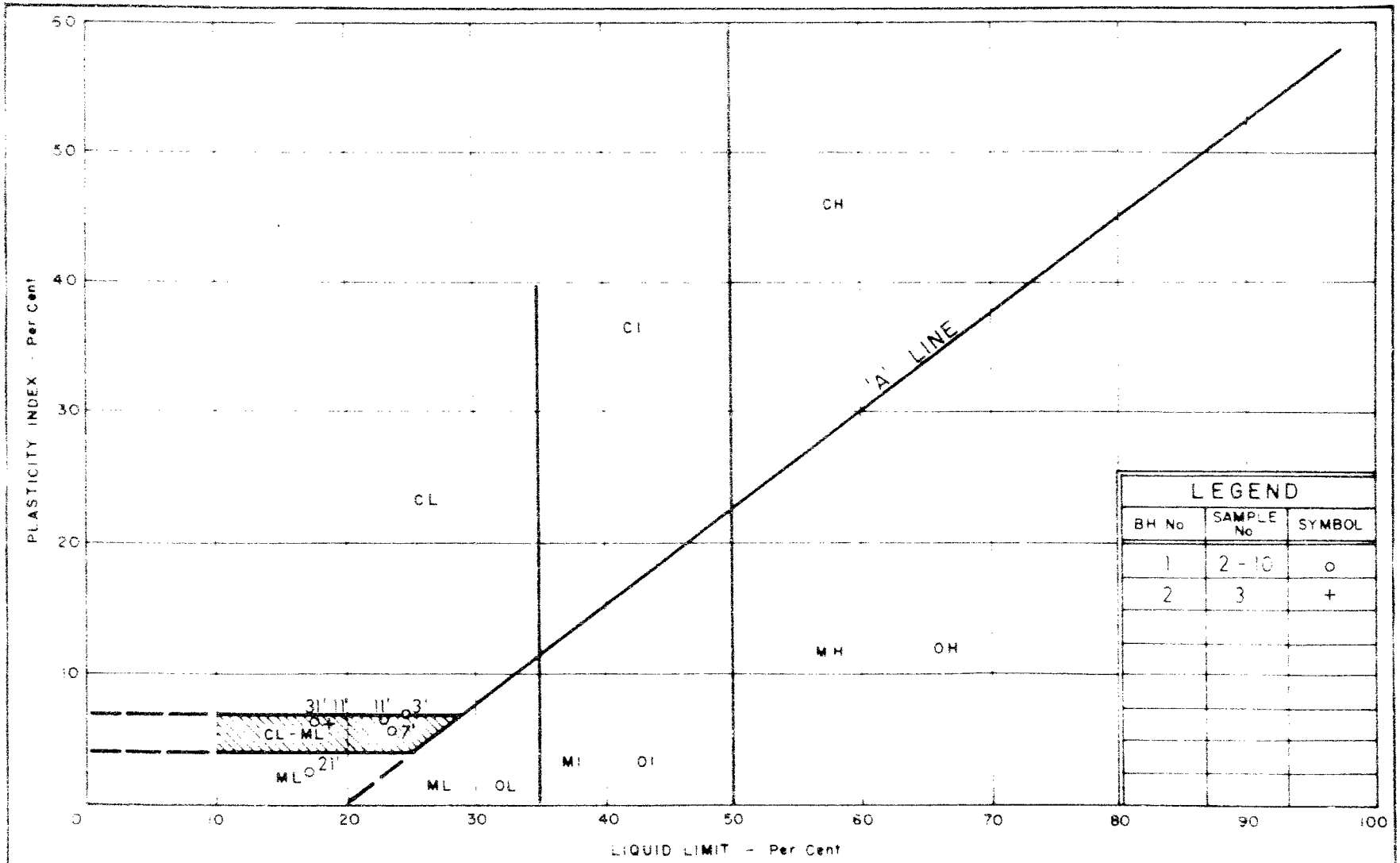
SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (20 40 60 80 100) / SHEAR STRENGTH P S F	LIQUID LIMIT — w_L / PLASTIC LIMIT — w_P / WATER CONTENT — w (WATER CONTENT % 10 20 30)	BULK DENSITY γ P C F	REMARKS
1095.9	Ground Level									Apr.26/68
0.0	Granular Fill		1	SS	31					Gr.Sa.Si.Cl
			2		46					
1090.7 / 5.2	Clayey silt to silt,		3		20	1090				
			4	SS	39					
	Trace of sand.									
			5	SS	34	1080				
	Stiff to hard.									
			6	SS	35					0 10 79 11
	Grey.									
1069.4 / 26.5	End of Borehole		7	SS	25	1070				
						1060				

SUMMARY of FIELD & LAB. RESULTS



68-F-35R FIGURE 1.

FORM DB-MT-35J
REVISED JULY [illegible] 1966

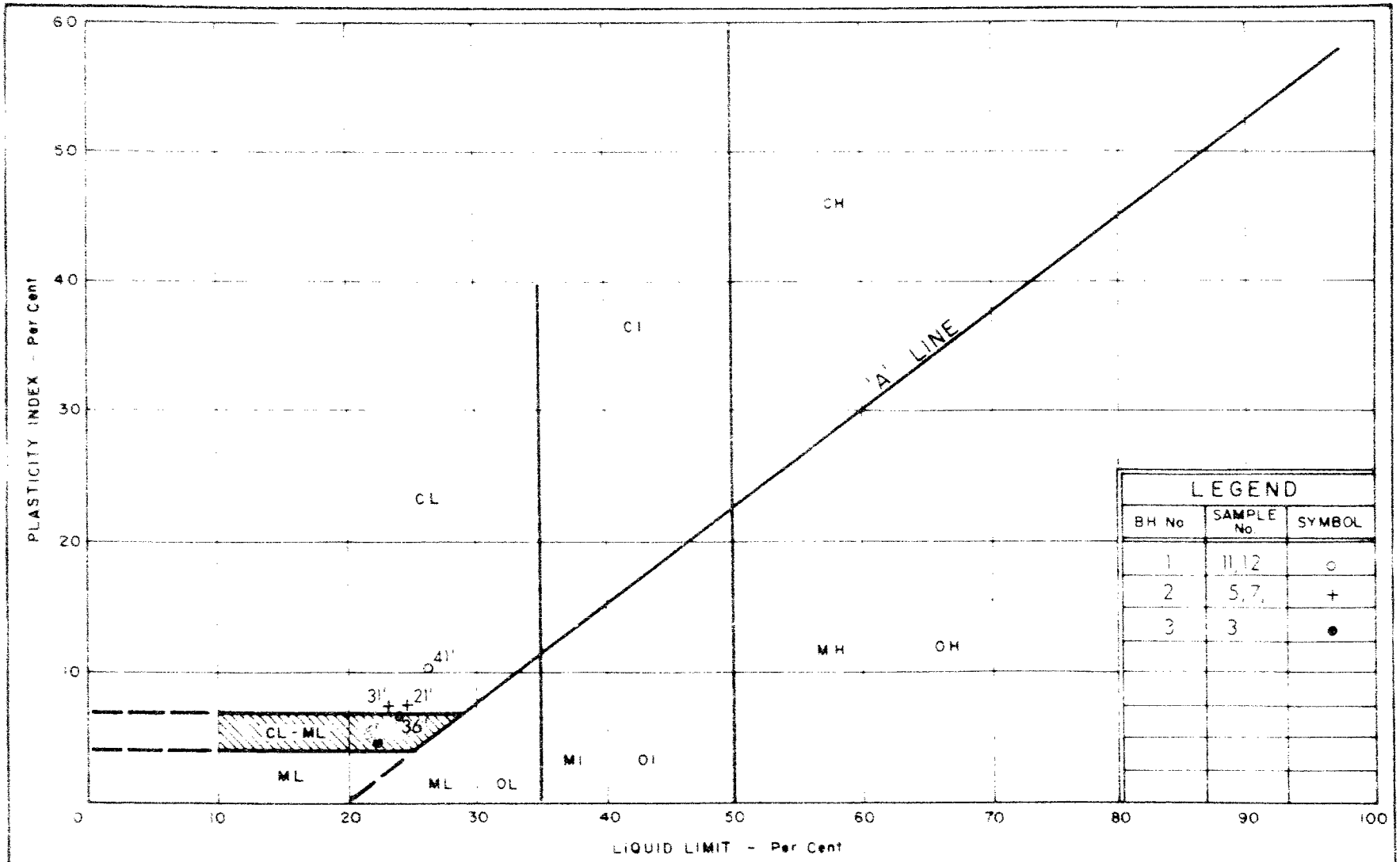


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART
GLACIAL TILL

W.P. No.
JOB No. 68 - F - 35 R
FIGURE 2

FORM OB-MT-352
REVISED JULY 1966



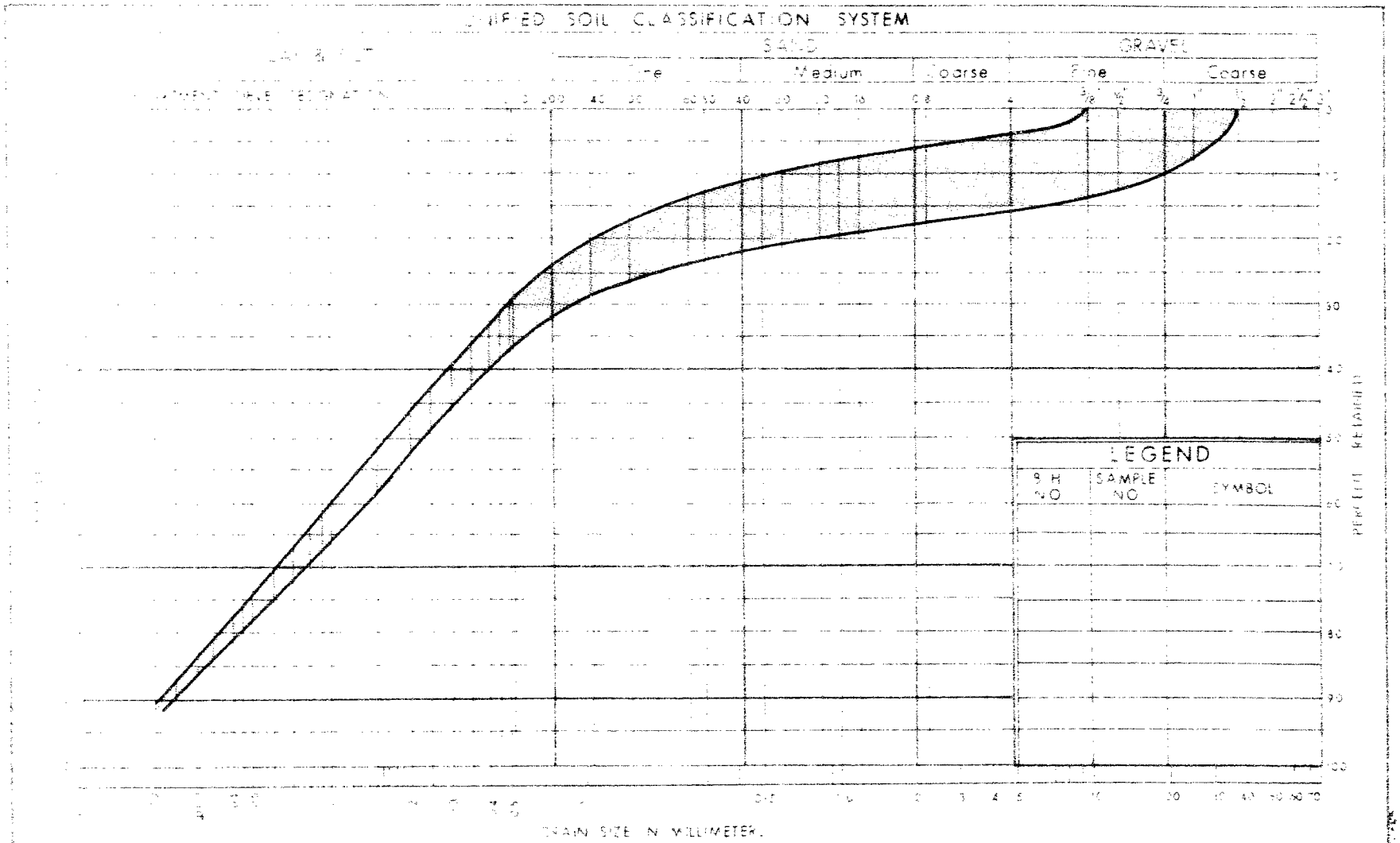
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART
CLAYEY SILT TO SILT

W.P. No.

JOB No. 68-F-35 R

FIGURE 3



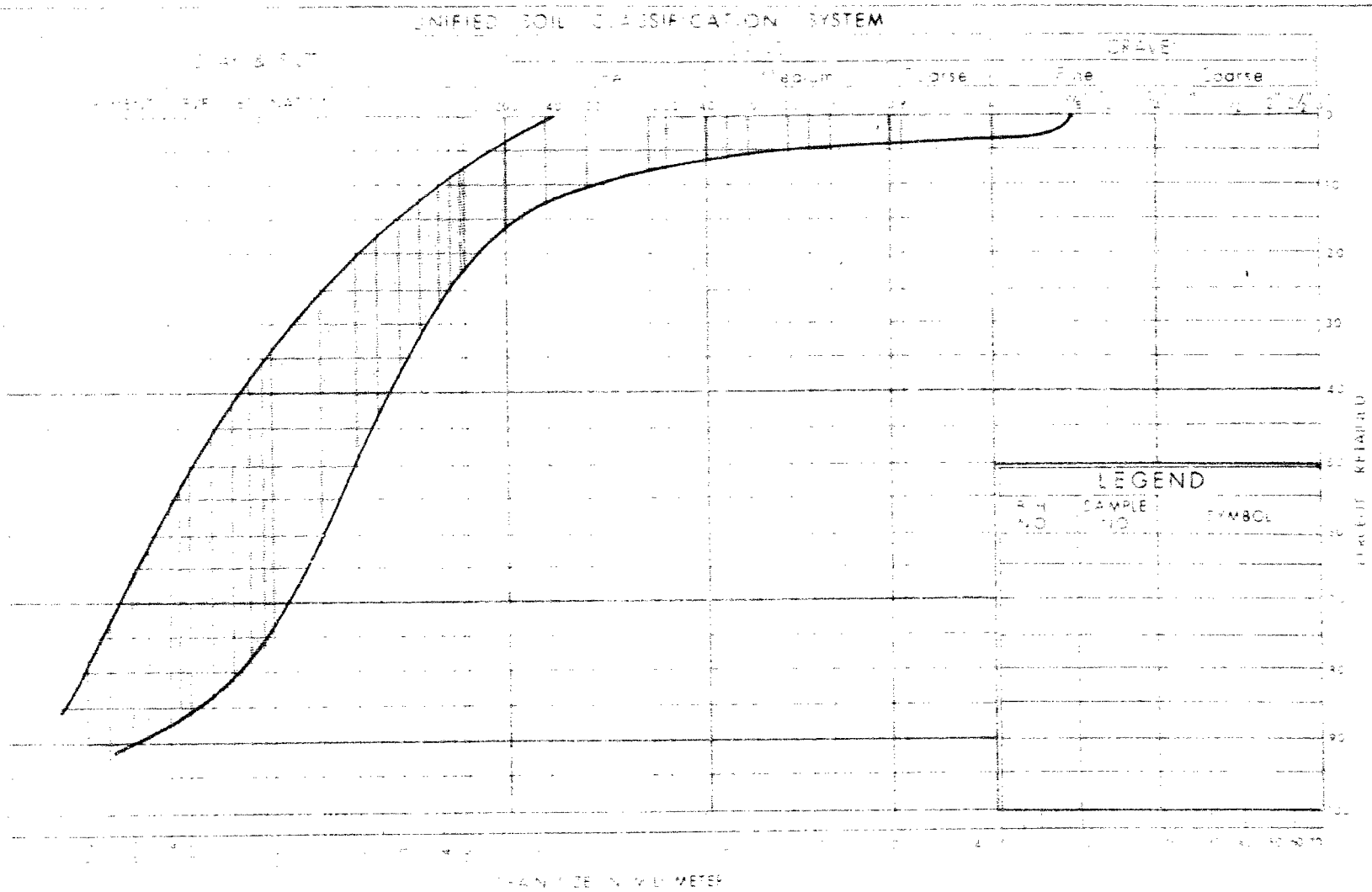
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

GRAIN SIZE DISTRIBUTION
GLACIAL TILL

W.P. No.

JOB No. 68 - F - 35 R

FIGURE 4



MATERIALS AND TESTING DIVISION

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILT

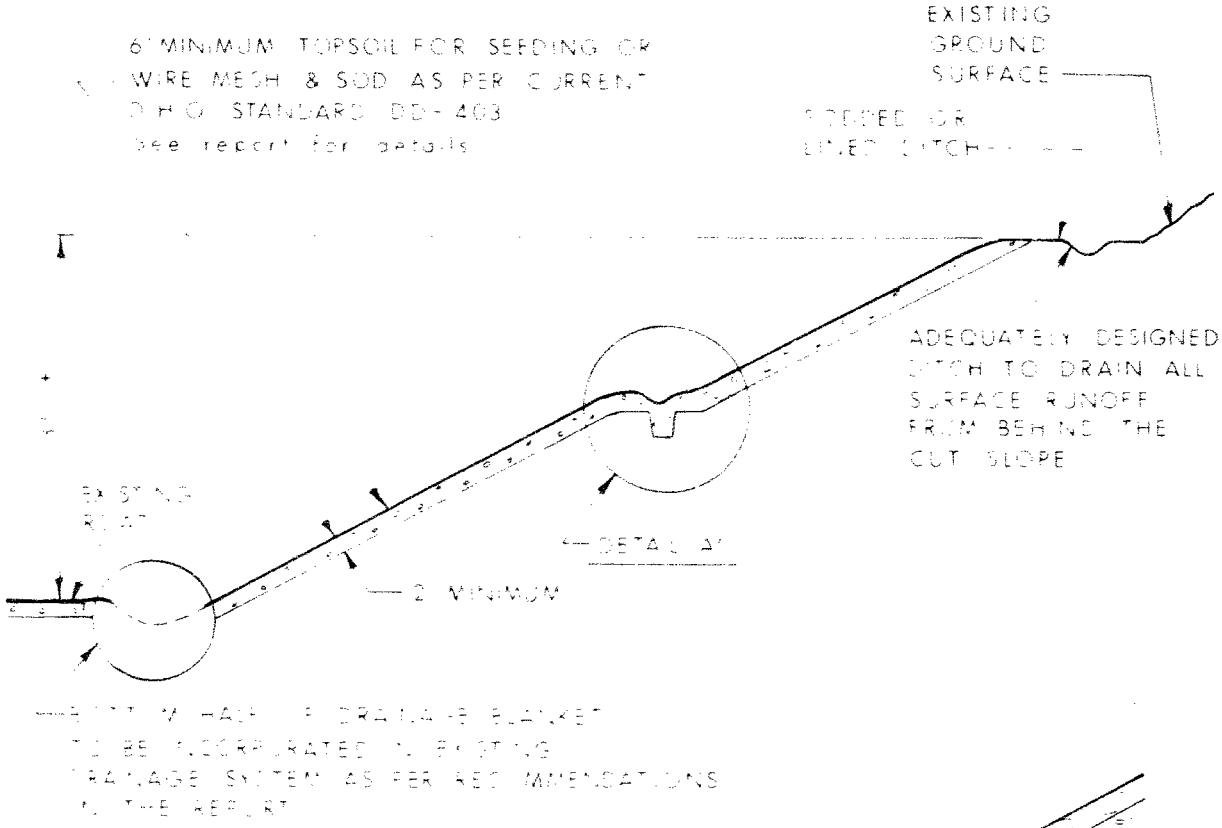
M.P. No

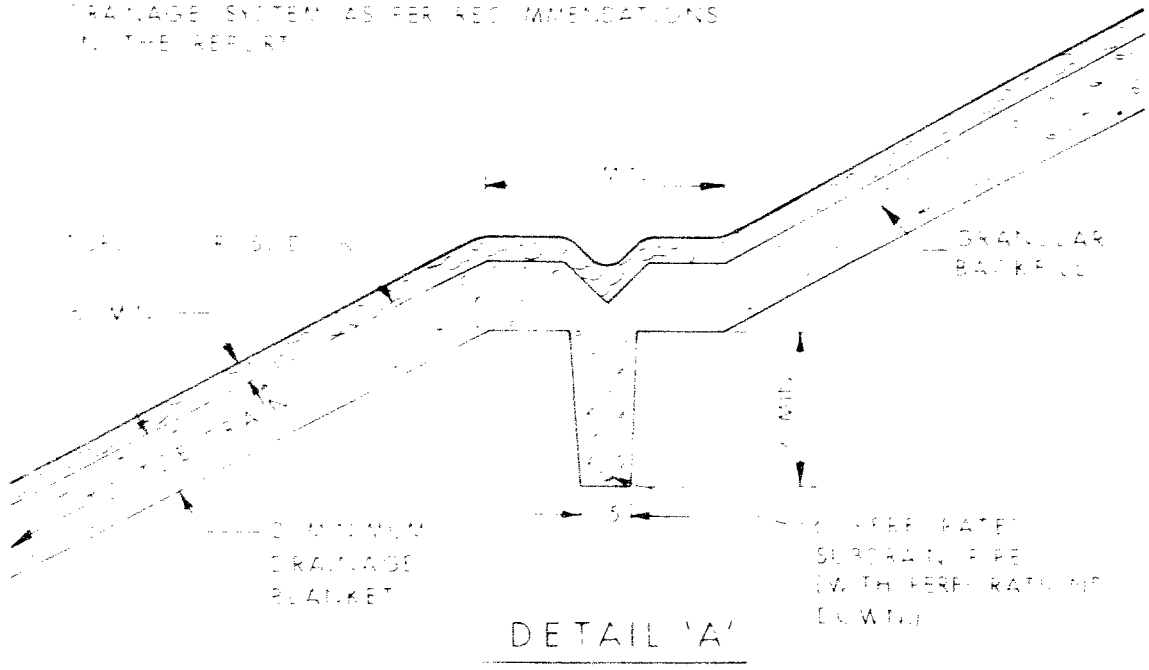
JOB No 68 - F - 35 R

FIGURE 5

RECOMMENDED TYPICAL DRAINAGE BLANKET, SUBDRAIN & SURFACE DRAIN INSTALLATIONS DEV RD. 783 – 1

(NOT TO SCALE)





DETAIL 'A'

FIG 6

68 – F – 35 R.

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 :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
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

Qu	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F V	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	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
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT — IN TERMS OF EFFECTIVE STRESS
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION — IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION — IN TERMS OF TOTAL STRESS
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION — IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 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

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	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
β	ANGLE OF SLOPE TO HORIZONTAL

APPENDIX II

Summary of Correspondence and Actions Taken re. Failures of Cut Sections on Development Road 783-1.

Oct. 30, 1967	-	Memo from J. Moffat, District Municipal Engineer to A. G. Stermac, Principal Foundation Engineer, requesting meeting on site between Nov. 13 - 17. J. Roy, Regional Materials Engineer (London) to be present, if possible.
Nov. 8, 1967	-	Memo from S. Mathur, Airphoto Interpretation Engineer, to A. G. Stermac - reference to discussion earlier in the week between the two re. airphoto study; report of Nov. 8 attached.
Dec. 12, 1967	-	Memo from S. Mathur to A. G. Stermac re. conversation on Nov. 30 between the two. Field investigation report dated Nov. 13 by K. Pask of Soil Section, attached.
Dec. 12, 1967	-	Memo from A. G. Stermac to J. Moffat with attached reports by S. Mathur and K. Pask. Remedial measures to be decided separately for each trouble area after review with District. Suggest meeting Spring, 1968.
Mar. 19, 1968	-	Memo from P. G. Parker (for H. F. Gilbert, District Engineer) to A. G. Stermac. Suggest meeting first week in April, except Thursday.
Mar. 25, 1968	-	Memo from A. G. Stermac to attention of P.G. Parker, proposing April 10 as meeting date.
Mar. 26, 1968	-	Teletype from P. G. Parker to A. G. Stermac confirming April 10 date. Confirmation obtained by Parker, from J. Roy and D. Parks.
Apr. 9, 1968	-	Teletype - reconfirming April 10 as date of meeting.
Apr. 10, 1968	-	Meeting held between County and District personnel and A. G. Stermac, Foundation Section.
Apr. 17, 1968	-	Drilling programme commenced .
Apr. 22, 1968	-	Memo from J. Moffat to attention of M. Devata, Supervising Foundation Engineer, authorizing physical work at site, confirming telephone conversation of April 19 between the two.

cont'd. .....

Appendix II (cont'd.) ...

Apr. 22, 1968	-	Drilling programme completed.
Apr. 22, 1968	-	Surveyors from County Office on site to survey large slope.
Apr. 22, 1968	-	Small test pits excavated on large slope by manual labour. M. Devata present in P.M. on site. Harry Parker to arrange for power equipment.
Apr. 23, 1968	-	Larger test pits, trenches, vertical cuts made on large slope with small dozer and backhoe - (County equipment).
Apr. 24 - 25, 1968	-	Water level readings taken in piezometers.
Apr. 29, 1968	-	A. G. Stermac and M. Devata visit site and re-examine slopes.
May 10, 1968	-	Meeting held in Room 104, Lab. Bldg., D.H.O. between representatives of District and County and Foundation Section. Problem presented, slides shown, solution suggested.
May 17, 1968	-	Telephone conversation between Mr. H. Parker and Mr. C. Mirza, Project Foundation Engineer, concerning details of road construction in 1966 and 1967.

APPENDIX III

PLATE I

1. 7'± deep trench at top of slope, Sta. 307+50 - 308+00. Water beginning to accumulate at bottom one hour after excavation.

2. Close-up of trench - water accumulation two hours after excavation.

3. View of bottom of trench showing softened soil oozing out from beneath east wall.

SUPER IMPOSED DOCUMENT MAY APPEAR AS MULTI-FEED ON FILM.

PLATE I

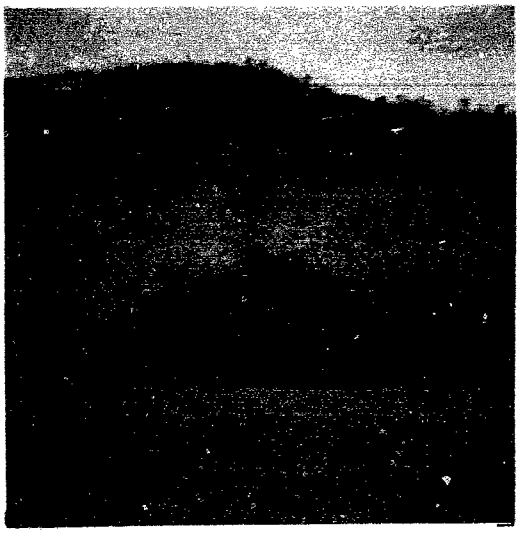
1. 7'± deep trench at top of slope, Sta. 307+50 - 308+00. Water beginning to accumulate at bottom one hour after excavation.

2. Close-up of trench - water accumulation two hours after excavation.

3. View of bottom of trench showing softened soil oozing out from beneath east wall.

PLATE II

1. Accumulation of water from spring at a test pit excavation near the crest of the slope at approx. Sta. 306+00.

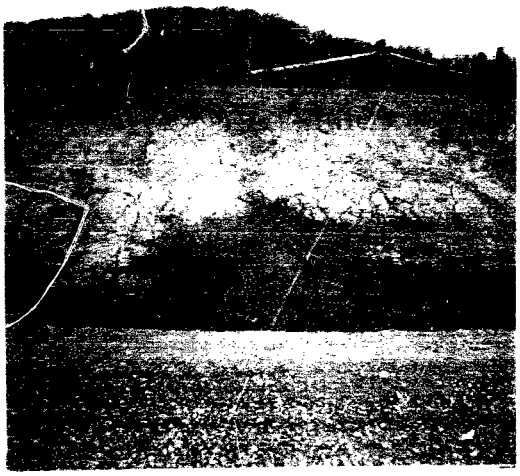


2. 10'± high side slope near Sta. 315+00. Excavation revealed spring nearly 3' below boundary of wet and dry soil. Ground behind fence was dry. Note cliffs in background.

SUPER IMPOSED DOCUMENT MAY APPEAR AS MULTI-FEED ON FILM.

PLATE II

1. Accumulation of water from spring at a test pit excavation near the crest of the slope at approx. Sta. 306+00.



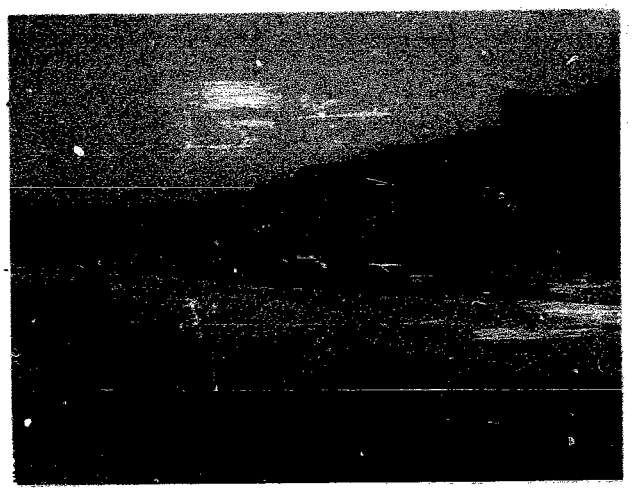
2. 10'± high side slope near Sta. 315+00. Excavation revealed spring nearly 3' below boundary of wet and dry soil. Ground behind fence was dry. Note cliffs in background.

SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-View of large slope.

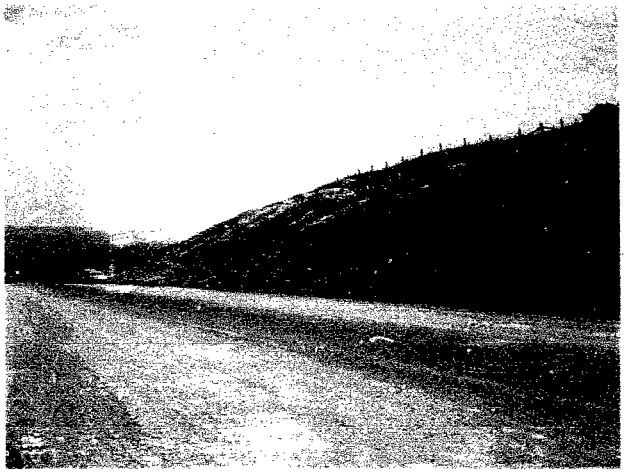
-Large cut.



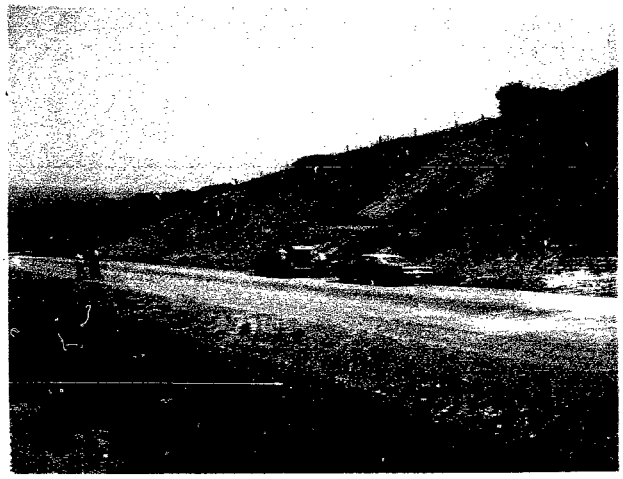
-View of failure south of large slope.

68-F-35(R)

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968



-View of large slope.

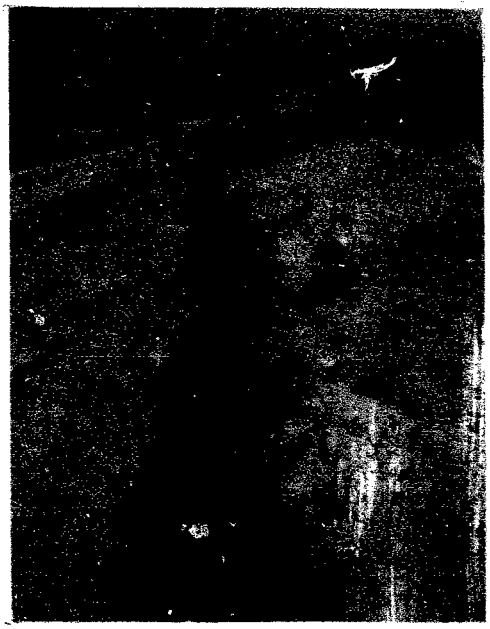


-Large cut.

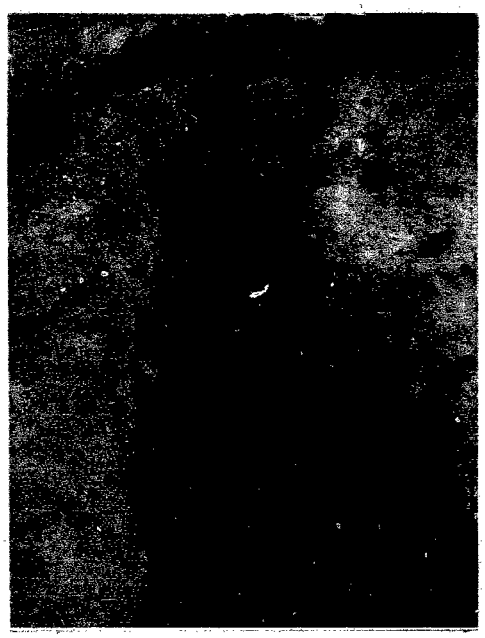
-View of failure south of large slope.

68-F-35(R)

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968



-Looking north along trench on top of big slope.



-Trench at top of big cut showing wet bottom.

-Closeup of big cut looking north.

SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

68-F-35(R)

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-Looking north along trench on top of big slope.

-Trench at top of big cut showing wet bottom.

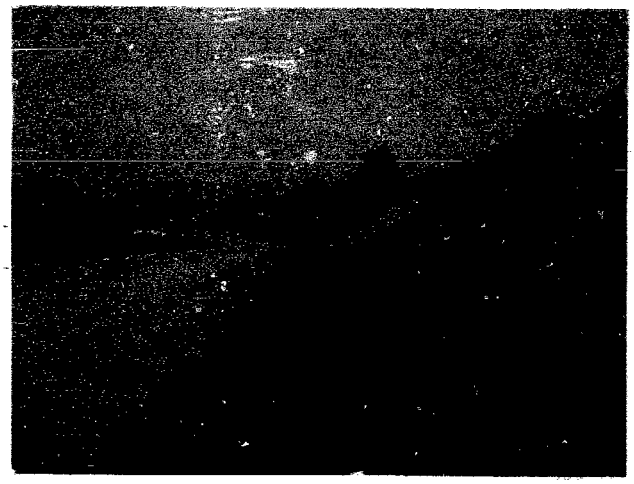
-Closeup of big cut looking north.

68-F-35(R)

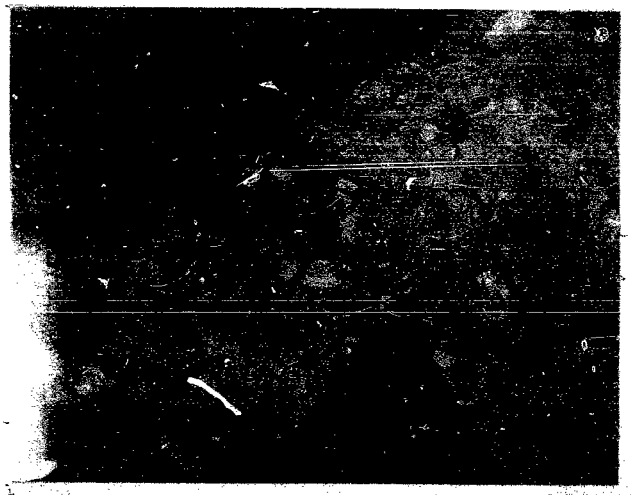
SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-View of large failures along three locations. Big cut failure is last in picture.



-View of 3 slope failures with largest cut slope in background.



-View of spring water emerging from toe of cut slope.

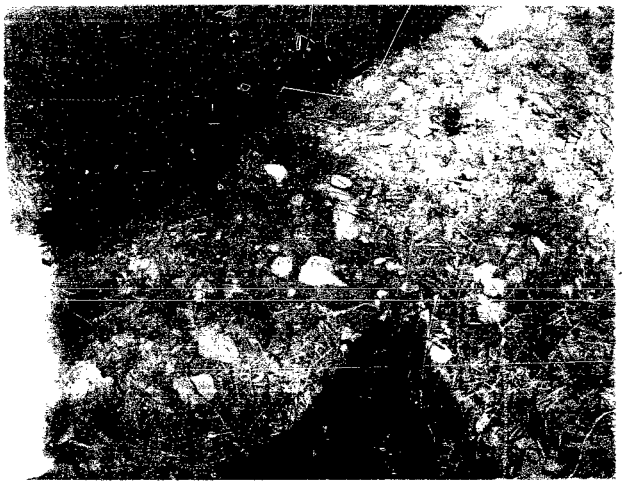
68-F-35(R)

SUPER IMPOSED DOCUMENT MAY

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-View of large failures along three locations. Big cut failure is last in picture.

-View of 3 slope failures with largest cut slope in background.

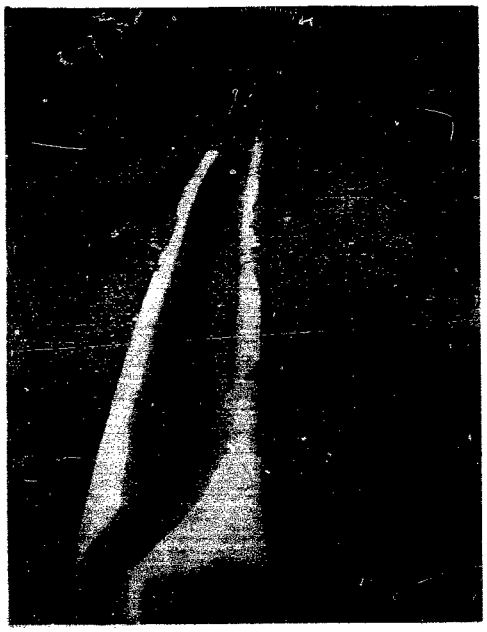


-View of spring water emerging from toe of cut slope.

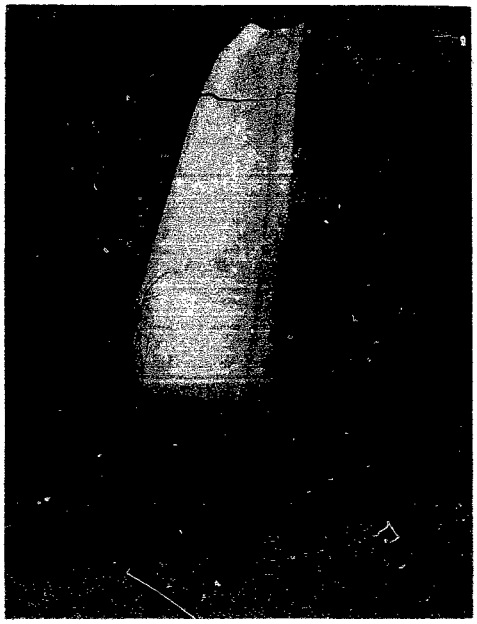
68-F-35(R)

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-Water flowing from concrete drain as it did in April 1968. No water in concrete drain in background which has cracked due to removal of soil support beneath it by erosion of springs.



-Water flowing-spring located at top centre of picture.



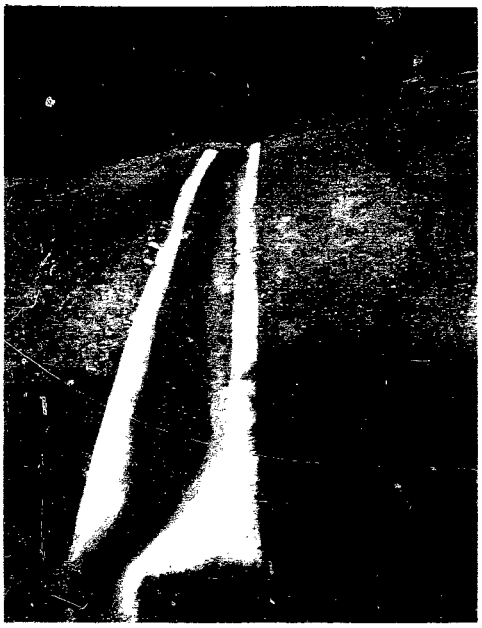
-Ponded water, collected from spring flowing beneath cracked concrete drainway.

SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

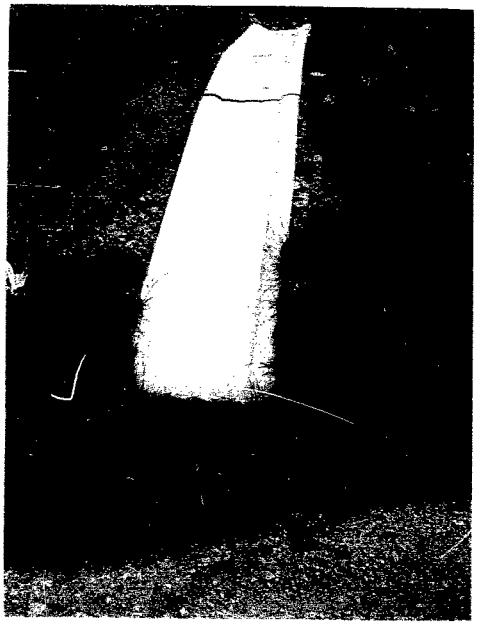
68-F-35(R)

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-Water flowing from concrete drain as it did in April 1968. No water in concrete drain in background which has cracked due to removal of soil support beneath it by erosion of springs.



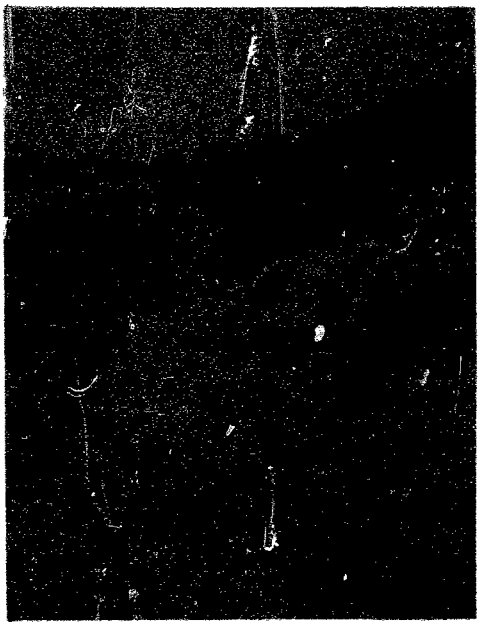
-Water flowing-spring located at top centre of picture.



-Ponded water, collected from spring flowing beneath cracked concrete drainway.

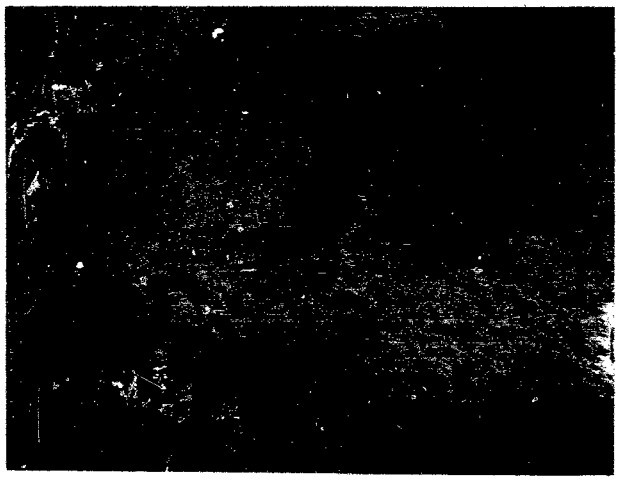
68-F-35(R)

COUNTY ROAD Nº 13
EUGENIA To KIMBERLEY
JULY 12, 1968



-Water in roadside ditch; evidence of springs in slope.

-Spring water emerging from toe of cut slope.



-Water still present in trench cut into cut slope to locate spring-April 1968. This indicates that the springs may be perennial.

SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

COUNTY ROAD № 13
EUGENIA To KIMBERLEY
JULY 12, 1968

-Water in roadside ditch; evidence of springs in slope.

-Spring water emerging from toe of cut slope.

-Water still present in trench cut into cut slope to locate spring-April 1968. This indicates that the springs may be perennial.

68-F-35(R)

68-F-35 (R)

DEPARTMENT OF HIGHWAYS ONTARIO

376-7350

MEMORANDUM

To: MR. A. STERMAC,
PRINCIPAL FOUNDATION ENGR.

Attn: Mr. Devata.

From: JOHN MOFFAT,
DIST. MUNICIPAL ENGR.,
DIST. #5, OWEN SOUND.

Date: April 22, 1968.

Our File Ref.

In reply to

Subject: County of Grey - Dev. Road #783-1 - Side Slope Slips.

This letter will confirm our telephone conversation of Friday, April 19, 1968, on the above noted matter. Our original letter of October 30, 1967, requested only a site meeting with Mr. Stermac, however, as a result of that meeting, Mr. Stermac wished some physical checks made at the site to confirm his findings and, therefore, his recommendations.

This letter will confirm our request that such physical work as is necessary to reach a solution to this problem be done.

JOHN MOFFAT,
DIST. MUNICIPAL ENGR.

John Moffat

JM:ecm

for H. F. GILBERT,
DISTRICT ENGINEER.

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. A. Stermac,
Principal Foundations Eng.
Room 107, Lab. Bldg,
DOWNSVIEW.

From: Materials and Testing Division.

Date: December 12th, 1967.

Our File Ref.

In reply to

Subject:

Re: County Road, From Kimberley s'ly to 3.0 miles north of Eugenia

Further to our conversation of November 30th, I am enclosing a copy of the field report (along with a photo mosaic and Laboratory results) prepared by Mr. K. Pask as a follow up of the preliminary report already with you.

As mentioned earlier, the slumping along the cut-slopes seems to be caused by the surface drainage which saturates the material along the surface thus causing local sloughing. The soil samples taken from the sloughed material showed a high percentage of moisture. It was also observed that only a few feet of the saturated surface material were involved. The slumping was more pronounced along the major cuts.

For recommendations you may refer to the preliminary report.

Please feel free to get in touch with us incase we could be of any further assistance in this matter.

S. Mathur,
AIRPHOTO INTERPRETATION ENGINEER.

SM/sg
Enclosed

ENGINEERING SOIL SURVEY OF COUNTY ROAD

FROM KIMBERLEY TO ABOUT 3.0 MILES NORTH OF EUGENIA

FIELD INVESTIGATION

INTRODUCTION

Further to a preliminary survey report of Nov. 8th, 1967, a detailed field investigation was performed on Nov. 13th. The results of this investigation appear in this report along with the borehole information obtained from Soils Profile No. L-805A-14 and shown on the accompanying mosaic. (Approx. Scale 1" = 400')

SAMPLING METHOD

Samples were taken using a tile spade and a hand auger at the locations and depths shown in the table. The samples were immediately placed in moisture proof jars and sent to D.H.O. Laboratory at Downsview for testing.

Samples 1,3,5,7, & 9 were taken from the body of the slumped material at approx. 3" depth.

Samples 2,4,6,8, & 10 were taken from the undisturbed face of the slump plane at approx. 6" - 9" depth. Samples 1 & 2; 3 & 4; etc., being taken at the same location.

Samples 10 & 11 were taken where no slump had occurred. They were included to get an overall impression of the soil types.

RESULTS

The results are shown in Table 1 and Graphs 1 & 2

SITE OBSERVATIONS

1. The slumps were "local" in nature, the largest slump being approx. 3' deep x 20' long x 10' wide.

2. The "areas of local slumping," shown on the mosaic, consist of "local slumps" with no individual slump larger than specified above, and the majority considerably smaller.

3. Between the "areas of local slumping" there were many individual small slumps which did not merit detailed investigation.

4. The cut slope lies at the foot of a long natural slope (1000 ft. +) which is shedding surface water over the cut slope. There is no ditch at the head of the cut slope to intercept this surface water.

5. The slumped material had a very high moisture content and appeared very nearly saturated.

6. The face of the slip plane was drier and very much harder than the slumped material, necessitating the use of the tile spade to "chip out" a sample.

7. The thickness of the slumped material was approx. 2 feet, the material underneath looking and feeling very similar to the material in (6).

8. The gradient of the slope was steep, looking to be in the region of 2:1 to 1 1/2:1.

9. The fill slope to the road showed no signs of slipping.

CONCLUSIONS

The slumping is mainly caused by the large amount of surface water, the steep slope and the nature of the material.

RECOMMENDATIONS

As per Preliminary Survey Report, November 8th.

Kevin R Pask.

K. Pask,
PROJECT SOILS ENGINEER.

T A B L E 1

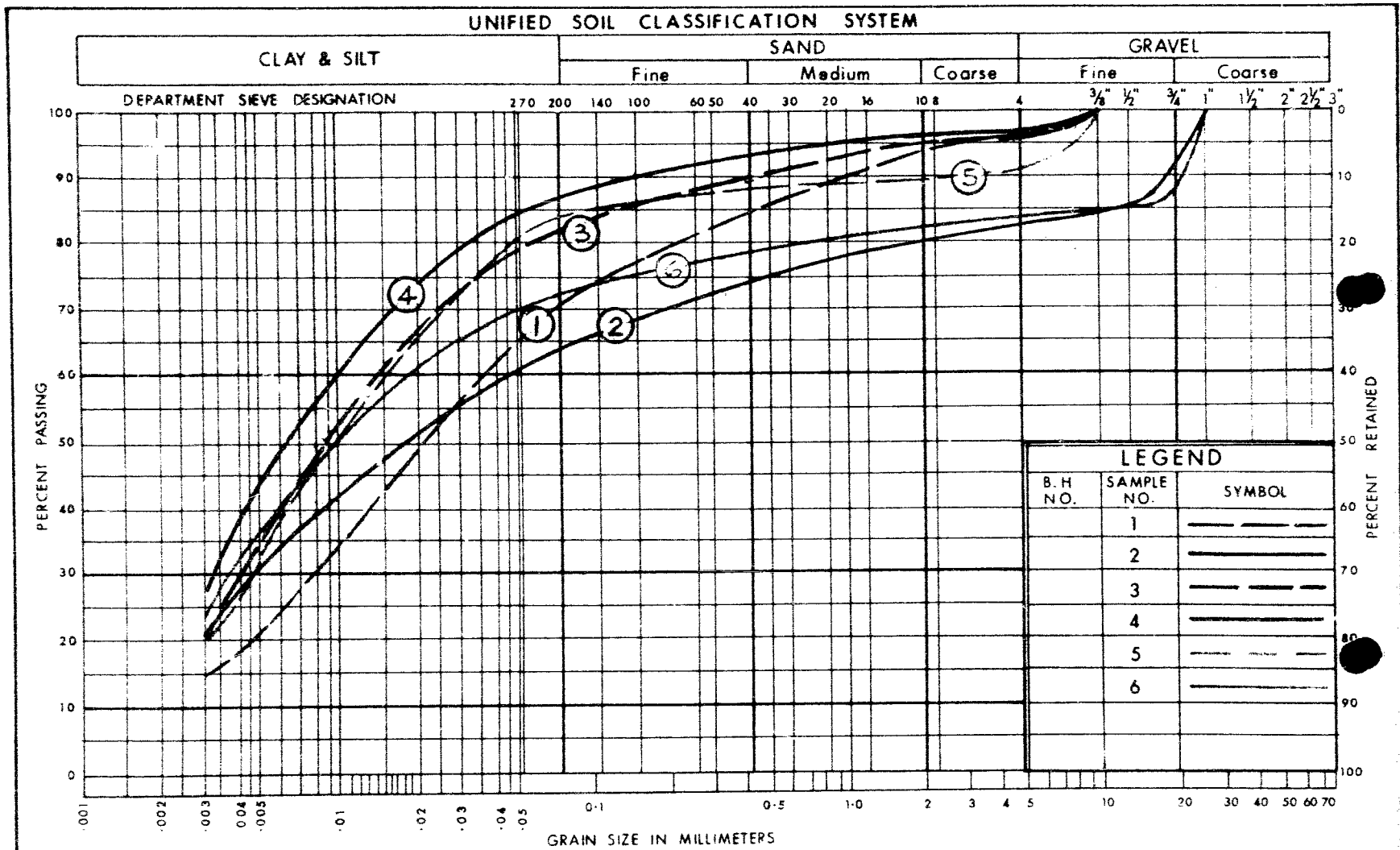
Station	Sample No.	Distance Right of ℄	Depth Taken	% Passing #4	% Passing #200	% Moisture	Laboratory Textural Class
275+00	1*	45'	3"	96.1	70.6	38.0	Clayey Laom
	2	47'	6"-9"	82.3	64.1	16.3	Light Clay
291+50	3*	35'	3"	96.0	82.0	24.5	Light Clay
	4	37'	6"-9"	97.6	87.2	20.4	Light Clay
303+50	5*	50'	3"	91.1	84.5	24.0	Medium Clay
	6	52'	6"-9"	83.3	72.5	13.7	Light Clay
311+00	7*	50'	3"	100	94.4	24.0	Silty-Clayey Loam
	8	52'	6"-9"	100	95.5	21.1	Silty Loam
[illegible]+50	9*	30'	3"	92.7	80.8	29.9	Light Clay
	10	32'	6"-9"	100	77.6	24.1	Light Clay
360+00	11	25'	1'6"	97.5	89.0	30.4	Light Clay
391+00	12	30'	1'0"	100	64.4	36.0	Clayey Loam - Light Clay

* - denotes sample taken in slumped material

FORM OB MT-17
REV. APR. 1965
NS-414

— — DENOTES SAMPLE TAKEN IN DUMPED MATERIAL
——— DENOTES SAMPLE TAKEN IN STABLE MATERIAL

GROUP No. 7



DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION

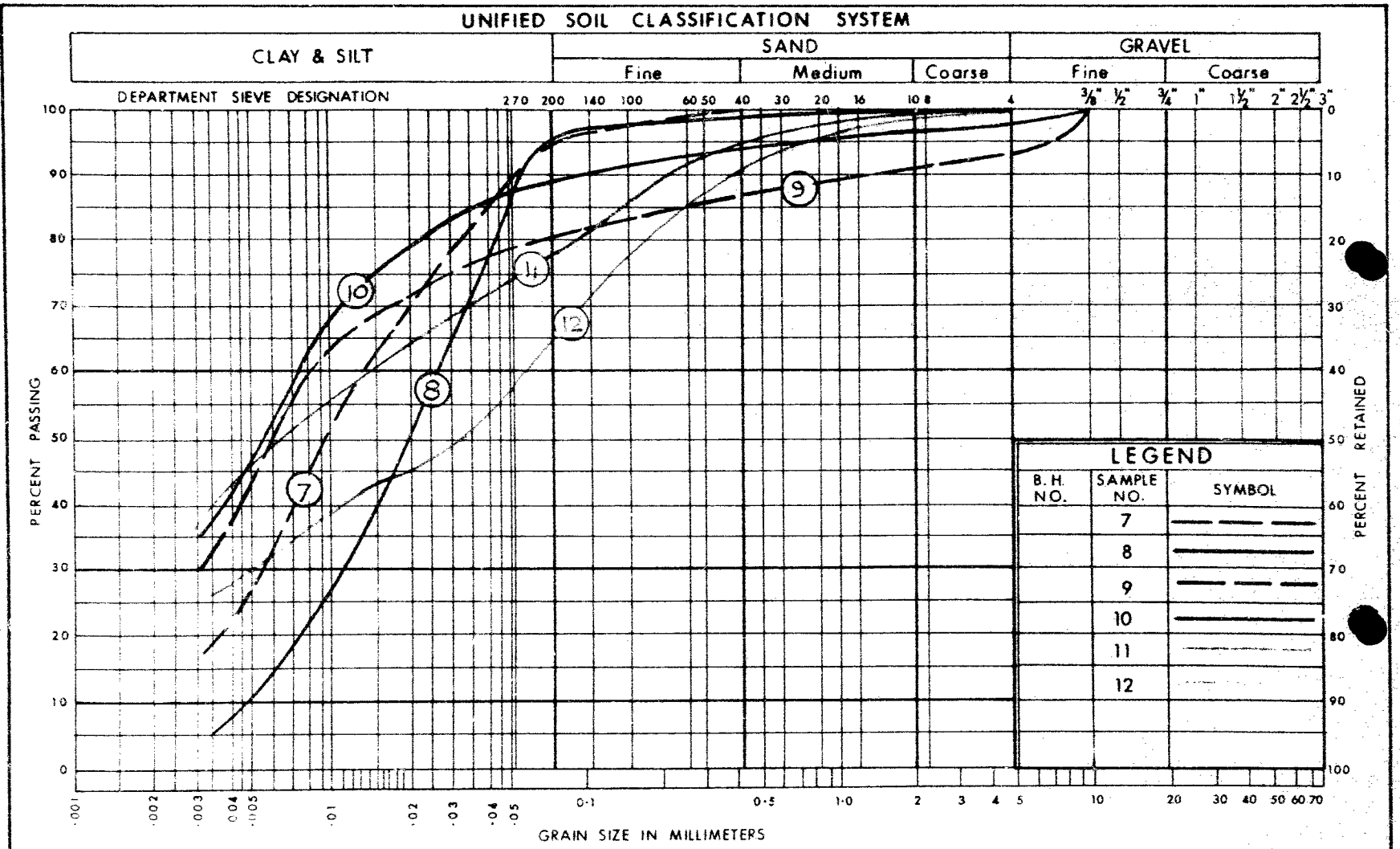
W.P. No.

JOB No.

FORM OB MT-1
REV. APR. 1965
65-414

—— —— DENOTES SAMPLE TAKEN IN SLUMPED MATERIAL
——— DENOTES SAMPLE TAKEN IN STABLE MATERIAL

GROUP No. 2



DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION

W.P. No.

JOB No.

cc: Foundations Files (Rm. 110)

Mr. E. P. Gilbert,
District Engineer,
District #5,
OWEN SOUND.

Attn: Mr. John Moffat,
District Municipal Engr.

Foundation Section,
Materials & Testing Division,
Room 107, Lab. Bldg.

December 12, 1967

Re: County of Grey - Development Road #783-1
(Beaver Valley Rd.) - County Road #13

In your letter of October 30, 1967, regarding the slope problems along the above mentioned road, you suggested a site inspection. Due to the deterioration of weather conditions, the meeting never took place and consideration of the problem was postponed till spring 1968.

However, in the meantime, we have asked Mr. G. Mathur, our Airphoto Interpretation Engineer, to look at the airphotos you have sent us. He also looked at some larger scale photos and Mr. K. Park go to the site and take a few samples.

Attached, we are forwarding to you Mr. Mathur's findings and interpretations, which are self-explanatory.

It would appear to us that the remedial measures will have to be decided separately for each trouble area. However, we would not like to make any specific comments before we have the opportunity of reviewing the site with you. We would suggest, therefore, that we meet at the site sometime in the spring of next year, should you consider such a meeting desirable. We will leave this entirely to you.

A. L. Sternac
PRINCIPAL FOUNDATION ENGINEER

ALS/dmf
Attach.

cc: Mr. J. Loy

Foundations Files
Gen. Files

P.S. -- Attached, we are also returning your aerial photographs.

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. A. Stermac,
Principal Foundation Engr.,
Materials & Testing Division.

From: Materials & Testing Division,
Soils Office,
Room 134, Lab. Bldg.

Date: November 8, 1967.

Our File Ref.

In reply to

Subject:

Further to our discussion last week about the county road from Kimberley southerly to about three miles north of Eugenia, I am forwarding you our findings in the attached report.

It seems that there will be some delay in getting the desired enlargements of the photos for the presentation of data at a suitable scale. These enlargements will be sent to you as soon as possible.

Please feel free to let us know if we can be of any further assistance.

S. Mathur,
AIRPHOTO INTERPRETATION ENGR.

Att.,
SM/js.

ENGINEERING SOIL SURVEY OF COUNTY ROAD FROM KIMBERLEY TO ABOUT 3.0 MILES NORTH OF EUGENIA

LOCATION

The study area is located in Gray County, and can be referred to on Markdale Militia Sheet, E 1/2.

DESCRIPTION OF SURFICIAL DEPOSITS

Much of the area under consideration is underlain by the Guelph and Lockport (L.S.) formations. The glacial deposits above these formations were influenced by the Bertie-Akron dolomite. These dolomites were carried into this area from elsewhere by glaciers. The glacial ice ground-up rock fragments and mixed them closely with the till. In some parts of the country this material is deposited in level tracts while in others it assumed a knob and kettle topography or a rolling topography. The depth of bedrock in the vicinity of the work project varies from 12 feet to 25 feet from the grade level.

The soil types in the vicinity of the study area are mostly silty clays to clays (CL) with variable amounts of stones or rock fragments dispersed in the fine matrix. Soils of this composition generally retain high moisture contents and are subjected to slumping if the slopes are steep and the surface drainage is inadequate.

It is recommended that:

(1) Considering the heterogenious nature of the material

involved, proper side slopes of cuts should be provided.

(2) Interceptor ditches should be provided for major cuts and these ditches preferably should be lined.

(3) To check erosion, the seeding of the road banks, side ditches, and disposal ditches with perennial grasses is recommended as per D.H.O. Specification #412, revised July 1965. The mulching of steep slopes soon after seeding avoids washing before the newly sown cover crop has developed an adequate root system.

S. Mathur,
AIRPHOTO INTERPRETATION ENGR.

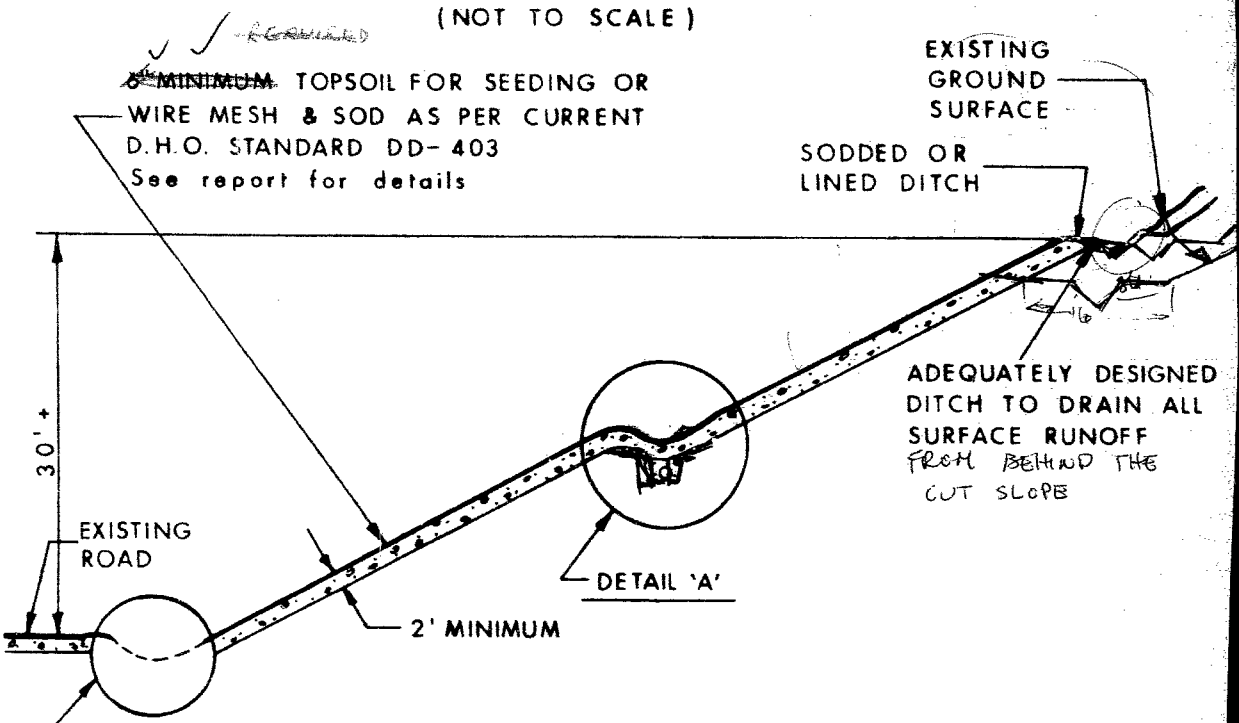
Att./aerial photos.
SM/js.

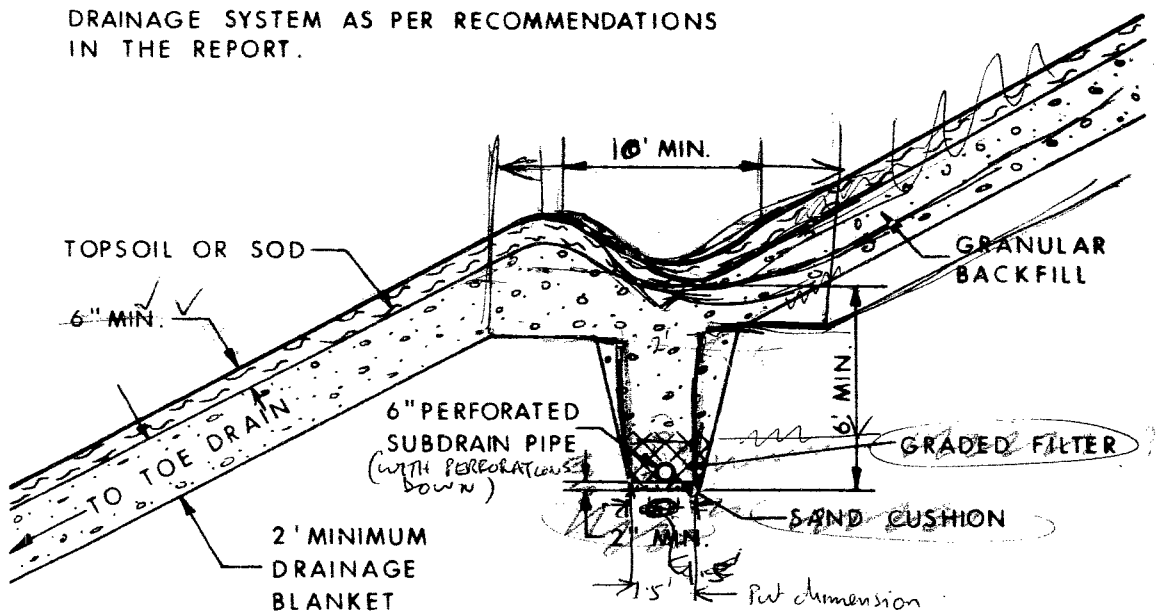
OVER

RECOMMENDED TYPICAL DRAINAGE BLANKET, SUBDRAIN & SURFACE DRAIN INSTALLATIONS

DEV. RD. 783 – 1

(NOT TO SCALE)



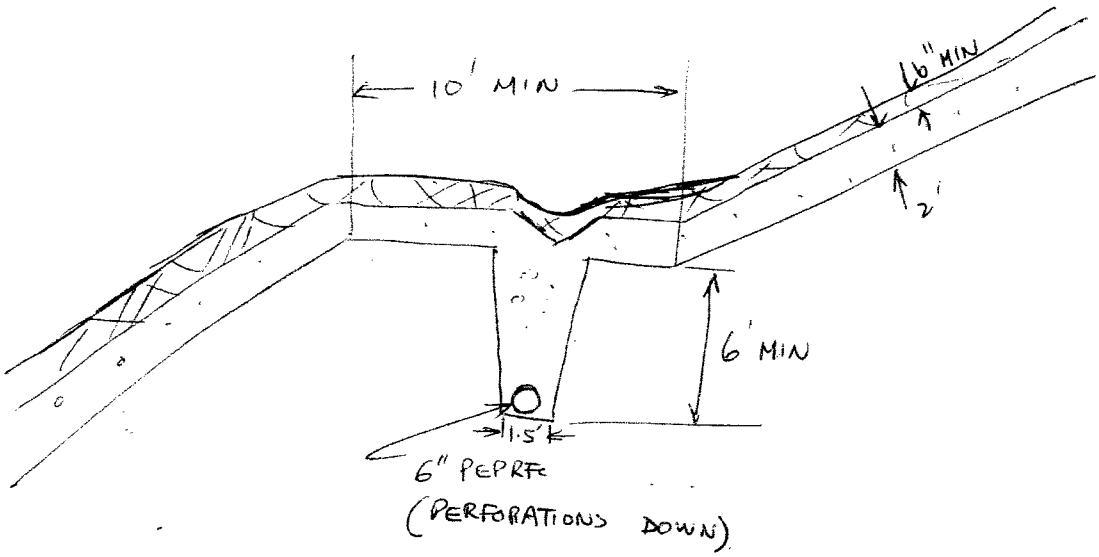


DETAIL 'A'

FIG. 6

68 – F – 35 R.

OVER


10' MIN
6" MIN
2'
6' MIN
1.5'
6" PEPRF
(PERFORATIONS DOWN)

DEPARTMENT OF HIGHWAYS ONTARIO

376-7350

MEMORANDUM

To: MR. A. C. STERMAC,
PRINCIPAL FOUNDATION ENGR.

From: JOHN MOFFAT,
DIST. MUNICIPAL ENGR.,
DIST. #5, OWEN SOUND.

Date: October 30, 1967.

Our File Ref.

In reply to

Subject: County of Grey - Development Road #783-1 (Beaver Valley Road) - County Road #13.

The above noted phase of Development Road #783 has just been completed. This phase of the D.R. is from the intersection of Cty. Roads #'s 11 and 13 to the north limits of Kimberley, a distance of some seven miles. We have had cut slope erosion problems during the construction of this section. Some still exist and will probably deteriorate further during the winter and next spring.

Mr. W. D. Parks, Grey Cty. Engineer, hired Spartan Air Services Ltd., Ottawa, to do some investigation work and we have a few aerial photographs in the office showing their findings. Their letter indicated that, "this is a very difficult area complicated by sink holes and underground drainage." The photographs show micro drainage, intermittent drainage, perennial drainage and sink holes.

We are sending a copy of this letter to Mr. John Roy, Reg. Materials Engineer in London, and suggest that an on site meeting be arranged with both of you in attendance, if possible. The most convenient time for me would be the week of November 13 to 17.

We do not expect to take further remedial measures this year but hope to do the work in the spring of 1968. We feel, though, that it would be advantageous if you and Mr. Roy could view the site at this time.

JOHN MOFFAT,
DIST. MUNICIPAL ENGR.

John Moffat

JM:ecm

for H. F. GILBERT,
DISTRICT ENGINEER.

c.c. J. R. Roy,
Reg. Materials Engr.