

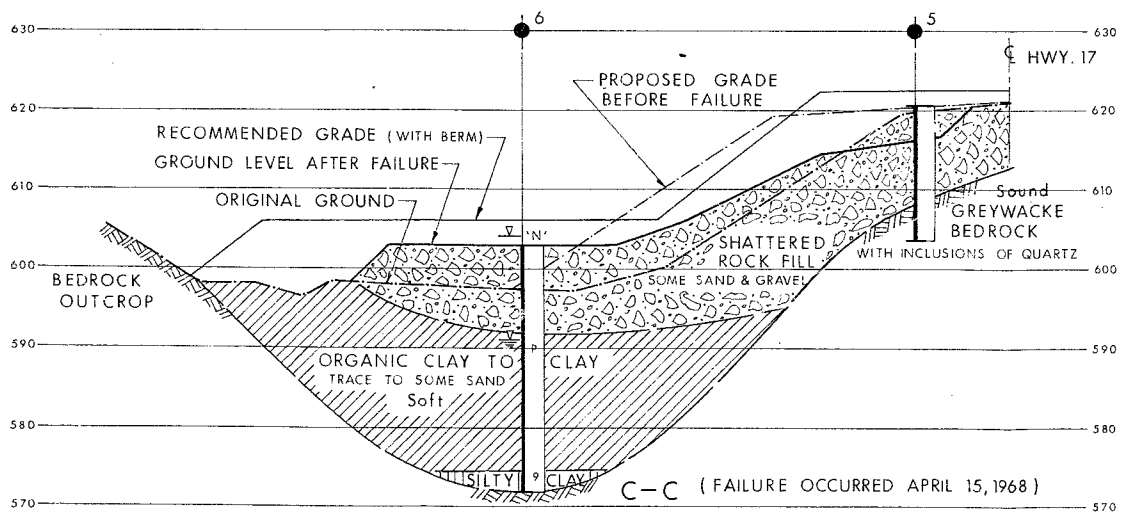
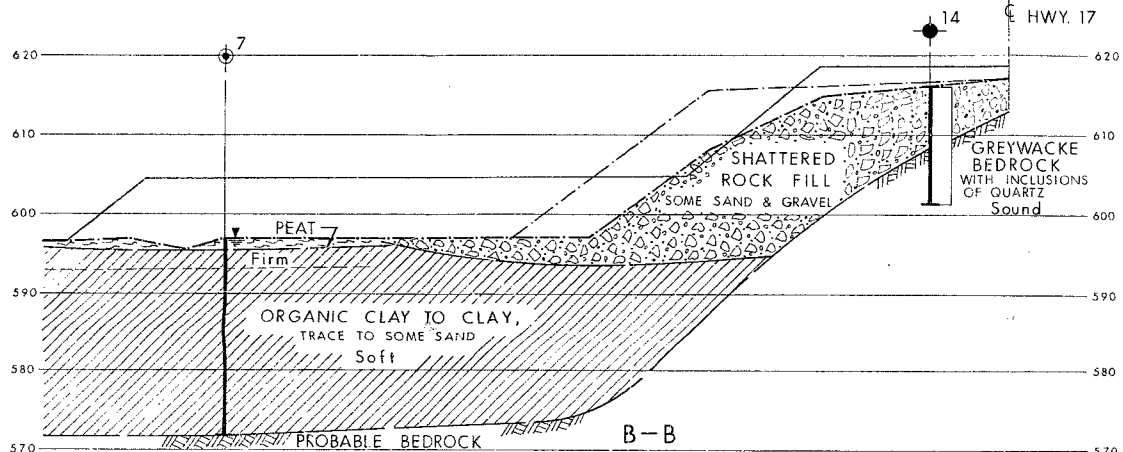
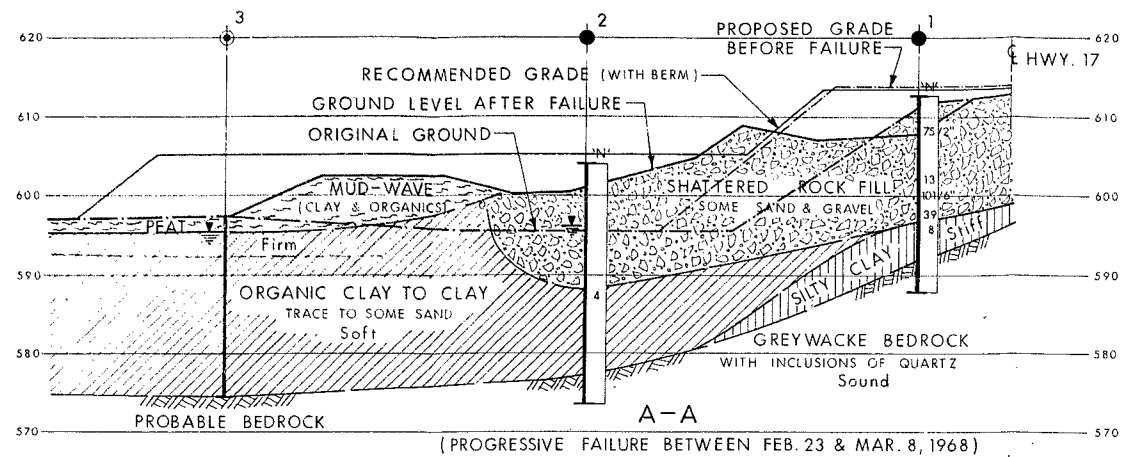
68-F-34

W.P. # 904-62

Hwy. # 17 T.C.H.

EMBANKMENT

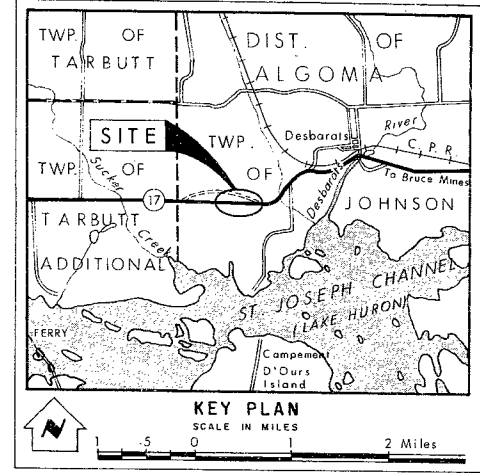
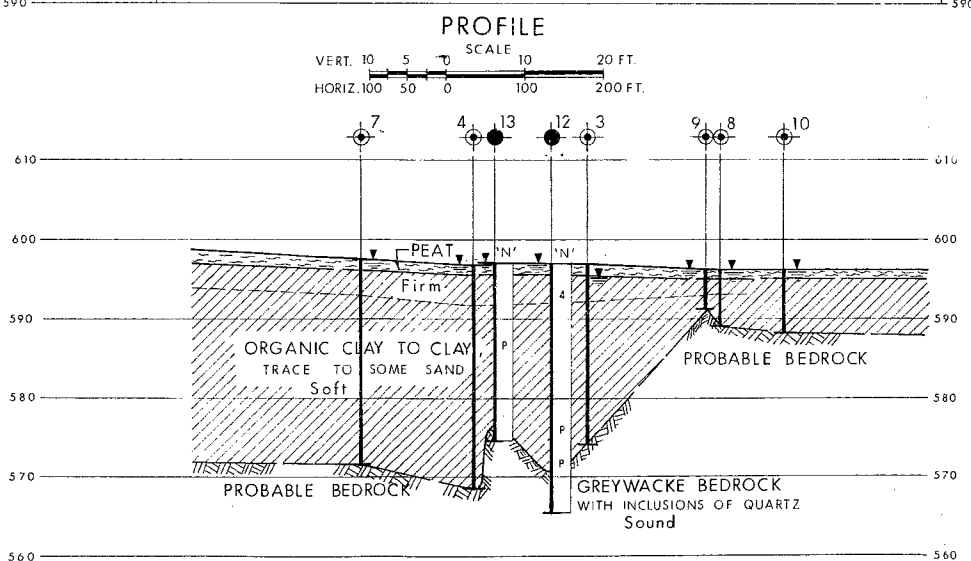
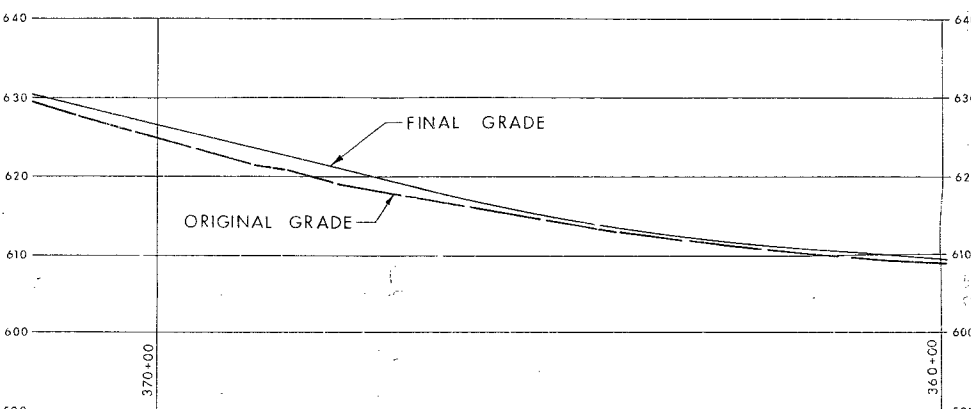
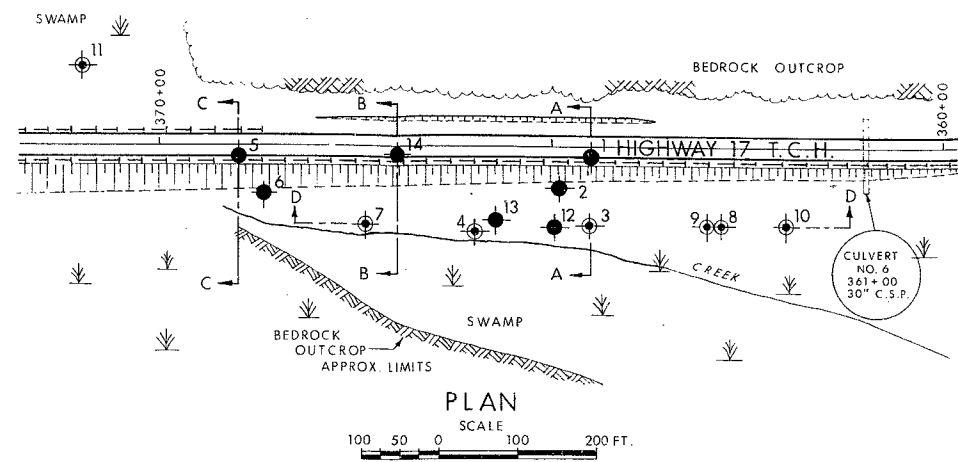
FAILURE



SECTIONS
SCALE
10 5 0 10 20 FT.

NOTES

1. Field Investigation carried out between April 17-24 1968.
2. Soil Conditions shown are those existing following Failure but prior to construction of Berm to final dimensions.



LEGEND

- Bore Hole
- ⊕ Cone Penetration Hole
- ⊕ Bore & Cone Penetration Hole
- Water Levels established at time of field investigation, April 1968
- ⊕ Auger Hole
- ▽ Head Artesian Water Encountered

NO.	ELEVATION	STATION	OFFSET
1	612.7	364+50	12' LT.
2	604.1	364+90	54' LT.
3	597.1	364+50	100' LT.
4	596.7	366+00	110' LT.
5	620.4	369+00	12' LT.
6	602.9	368+70	62' LT.
7	597.5	367+40	100' LT.
8	596.3	362+85	100' LT.
9	596.3	363+00	100' LT.
10	596.2	362+00	100' LT.
11	600.5	371+00	100' RT.
12	597.0	364+95	103' LT.
13	597.0	365+75	95' LT.
14	615.7	367+00	10' LT.

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.

DATE	BY	DESCRIPTION

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

EMBANKMENT FAILURE
APPROX. 1.5 MILE WEST OF DESBARATS
(STA. 360+00 TO STA. 370+00)

KING'S HIGHWAY NO. 17 T.C.H. DIST. NO. 18
CO. DIST. OF ALGOMA
TWP. JOHNSON LOT 41 CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUB'D. E.T.D.	CHECKED	W.S. NO. 904-62	M.B.T. DRAWING NO.
DRAWN G. P.	CHECKED	JOB NO. 68-F-34	68-F-34A
DATE JUNE 1, 1968	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		

MEMORANDUM

To: Mr. J. A. Knowles,
District Engineer,
District #18,
Sault Ste. Marie, Ont.

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

DATE: June 4, 1968

FOR FILE REF.

IN REPLY TO

JUN - 4 1968

SUBJECT

FOUNDATION INVESTIGATION REPORT
For
Failures of Embankment Between
Station 363+00 and Sta. 369+00
Trans-Canada Highway #17
Contract 67-85
District #18 (Sault Ste. Marie)
W.J. 68-F-34 -- W.P. 904-62

Attached, we are forwarding to you, our investigation report on the subsoil conditions existing at the above mentioned site.

The remedial measures were discussed with you earlier. We understand, most if not all of them have been completed now.

We believe that, apart from some settlement, no other problems should be of interest. Because of the lack of a stratigraphy of the soil, settlement figures are regarded as a rough estimate. A more accurate estimate of amount and rate of settlement will be obtained by continuing to observe the suggested points along the road.

Should you have any queries regarding the report, please feel free to contact this office.

Knowles
District Engineer
District #18
Sault Ste. Marie
Ontario
Foundation Section
Gen. Files

W. J. 68-F-34
W. P. 904-62
JUN 10 1968
JOINER

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FOUNDATION INVESTIGATION REPORT
For
Failures of Embankment between
Station 363+00 and Sta. 369+00
Trans-Canada Highway #17
Contract 67-85
District #18 (Sault Ste. Marie)
W.J. 68-F-34 -- W.P. 904-62

1. INTRODUCTION:

Reconstruction of a portion of the Trans-Canada Highway #17, located immediately west of Desbarats, Ontario, was started in January, 1968. Between Station 363+00 and 372+00 the existing embankment was widened and the new centre-line shifted to the south. The re-alignment was required in order to protect a geologically significant bedrock outcrop known as "Ripple Rock"; this outcrop is located between Sta. 372+80 and 373+80.

Following the widening of the embankment, two distinct slope failures occurred, between Sta. 363+00 and 369+00, along the south slope of the reconstructed Hwy. #17 embankment.

On March 19, 1968, Mr. E. R. Saint, Regional Materials Engineer, North Bay, requested that personnel from this Section visit the site in order to make visual observations of the failure and recommend remedial measures. Mr. M. Devata, Supervising Foundation Engineer, subsequently visited the site on March 21, 1968. The remedial measures recommended were initiated shortly after this visit.

The old embankment required continual maintenance. Further, the subsoil and bedrock conditions had not been defined prior to reconstruction. It was, therefore, decided that a subsurface investigation be carried out to provide the factual data needed to determine the long-term performance of the reconstructed embankment.

This report will present all the factual information obtained by personnel from the Foundation Section and the detailed subsurface investigation program. In addition, the remedial measures undertaken and conclusions drawn, are presented.

cont'd. /2 ...

2. SITE AND GEOLOGY:

The site in question is located on Hwy. #17, between Sta. 360+00 and 373+00, about two miles west of Desbarats, Ontario. A flat-floored, east-west running valley, the surface of which is at about elevation 596, exists in this area. The width of the valley is approximately 400 feet at Sta. 360+00 (east end), decreasing to a minimal width at about Sta. 370+00 (west end). The valley is surrounded on all sides by steeply dipping bedrock outcrops. A creek, some 9 feet wide and 3 feet deep, meanders along the southern portion of the valley floor. In addition, a north-south tributary of this valley traverses Hwy. #17 at about Sta. 370+50; it is approximately 250 feet wide. The low-lying terrain is basically a swamp supporting light marshy vegetation. The bedrock outcrops are generally moss-covered and support heavy tree growth. The surficial drainage in the area is poor.

From available geological information and inspection of the area, it is known that the overburden covering the valley floor is composed of a geologically recent deposit of highly compressible lacustrine clay of variable thickness. The clay is underlain by quartzite and greywacke bedrock of the Lorrain formation, of the early Proterozoic Era.

3. CONSTRUCTION DETAILS:

3.1) Existing Embankment (Sta. 362+00 to 373+00):

The existing Hwy. #17 consists of two, 12-foot wide paved lanes, with an overall width of about 40 feet. The north shoulder is immediately adjacent to the bedrock outcrop forming the north valley bank. The south shoulder is located at the crest of the slope whose toe is on the valley floor. The grade of Hwy. #17 increases from elevation 612 (Sta. 360+00) to elevation 631 (Sta. 372+00) - i.e., the height of embankment is of the order of 15 and 25 feet at the respective stations given above.

cont'd. /3 ...

3. CONSTRUCTION DETAILS: (cont'd.) ...

3.1) Existing Embankment (Sta. 362+00 to 373+00): (cont'd.) ...

No records are available on the actual construction of the embankment. Information provided by Sault Ste. Marie District construction personnel, however, indicates that portions of the embankment sections have been settling for years, particularly between the following locations:

- 1) Sta. 363+00 to 365+00
- 11) Sta. 367+00 to 369+00

These areas have required continual maintenance over the years. It is believed that this settlement is primarily due to consolidation of the underlying highly compressible clay. In addition, some settlement of the embankment fill itself may have occurred; this component of settlement would probably be due to the fact that a portion of the fill may have been placed in adverse weather conditions, namely in the winter.

3.2) Reconstructed Embankment:

The reconstructed embankment (prior to failure) was approximately 48 feet in width - i.e., an increase of about 8 feet over that of the existing embankment. The majority of this widening took place on the south side of the existing embankment; as such, it involved placing fill directly on the overburden deposits located on the valley floor. The slope of this south face was between 1-1/4:1 and 1-1/2:1. The fills constructed were at or a few feet above the existing grade (see Sheet 7, Part A, Contract 67-85). The existing and reconstructed embankment sections are shown at three strategic locations on Drawing 68-F-34A, contained in Appendix I of this report.

Reconstruction of the embankment commenced on January 29, 1968 by end-dumping shattered rock fill over the south shoulder of the existing embankment. The rock fill placement was started at Sta. 367+00 and preceded in an easterly direction. The widening advanced at the rate of approximately 100 feet a day; by February 1

3. CONSTRUCTION DETAILS: (cont'd.) ...

3.2) Reconstructed Embankment: (cont'd.) ...

the embankment had been reconstructed as far as Sta. 364+00. The remainder of the fill placement required took place in the first week of February.

4. SUBSURFACE CONDITIONS:

4.1) General:

The field work consisted of putting down seven sampled boreholes using a conventional diamond drill rig adapted for soil sampling purposes. In addition, seven hand auger holes were carried out by a North Bay Region Survey Crew. Samples of the cohesive valley floor deposits were recovered in 2-inch I.D. Shelby tubes, which were manually pushed into the soil. At the hand auger hole locations representative samples were obtained with a peat sampler. Where possible, field vane tests were carried out at various depth intervals in order to determine the undrained shear strength of the cohesive stratum. Bedrock was proven in six of the borings by obtaining AXT size rock core samples. The detailed description of the soil types encountered, together with their properties, are presented on the Record of Borelog sheets attached.

The locations and elevations of the boreholes, which were surveyed by Sault Ste. Marie District Engineering Surveys personnel, are shown on Drawing 68-F-34A, together with estimated stratigraphical profiles across the site.

Laboratory testing was carried out on selected samples to determine the physical properties of the overburden deposits. The results of these tests are plotted on the Record of Borelog sheets and summarized on the figures, all contained in Appendix I of the report.

cont'd. /5 ...

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

4.2) Under Old Embankment:

The borings put down through the old embankment shoulder (B.H.'s 1, 5 and 14), encountered between 12 and 17 feet of shattered heterogeneous rock fill. In B.H.'s 5 and 14 the rock fill overlies sound greywacke bedrock. At B.H. #1 a 3-1/2 foot thick layer of stiff mottled grey silty clay is sandwiched between the rock fill and the sound bedrock. From this, it is concluded that only negligible amounts of compressible material underlies the old embankment.

4.3) Beneath Valley Floor:

The valley floor is surficially covered with between 1 and 2 feet of soft peat. The peat is underlain by a stratum of brown to grey organic clay to clay with a trace to some sand. The thickness of the cohesive stratum varies from about 5 feet (at Sta. 363+00) to 29 feet, (at Sta. 369+00), generally increasing in a westerly direction. Occasional laminated and varved zones are located randomly throughout the deposit. Grain-size distribution curves, obtained on samples of the cohesive deposit, are plotted on Figure 1. The organic content (by weight) of this zone, as determined from laboratory tests, ranges from 3% to 8%.

Seven Atterberg limit tests, carried out on samples of the organic clay to clay stratum, gave values for the liquid and plastic limits ranging from 119 to 176 and 38 to 55, respectively. The natural water content is between the liquid and plastic limits as represented by liquidity indices varying between 0.58 and 0.88, being typically about 0.7. These limit values are summarized on the Plasticity Chart, Figure 2.

The results of the undrained shear strength testing, carried out within the stratum, gave values ranging from about 600 p.s.f., immediately below the peat, to 200 to 300 p.s.f. with depth. Based on these values the consistency of the stratum is estimated to range from firm, in the upper 3 to 5 feet, becoming

cont'd. /6 ...

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

4.3) Beneath Valley Floor: (cont'd.) ...

soft with depth. A summary of the results is plotted on the Undrained Shear Strength versus Elevation profile plotted on Figure 3.

The clay stratum is underlain by sound greywacke bedrock.

Two borings (B.H.'s #2 and #6) were put down outside the toe of the reconstructed embankment, through a rock fill berm. At these locations up to 16 feet of rock fill was encountered. The rock fill overlies the compressible organic clay to clay stratum which, in turn, overlies sound bedrock. The bottom of the rock fill is now some 8 to 10 feet below the original ground surface which indicates it has displaced some of the parent material.

4.4) Groundwater Conditions:

Water level observations, carried out in the borings during the period of the investigation, are recorded on the borelog sheets and summarized on Drawing 68-F-34A. The borings put down through the shoulder of the existing embankment were dry to the depth penetrated. The groundwater level on the valley floor, however, was at or a few feet below original ground surface, which corresponds closely with the water level in the creek (Elev. 594).

An excess pore water pressure was encountered at about elevation 592 in B.H. #6. Once the casing reached this elevation the water rose to about elevation 604 - i.e., some 4 to 5 feet above original ground level. It is considered that this pore water pressure was built up due to the excessive shear strains induced in the clay subsoil following the placement of rock - i.e., the pore pressure is associated with the failure condition.

cont'd. /7 ...

5. DESCRIPTION OF FAILURES:

Following the reconstruction, two distinct slope failures occurred: the first between Sta. 363+50 and Sta. 365+50, and the second between Sta. 367+50 and Sta. 369+00. These failures will be discussed separately below.

5.1) Failure at Sta. 363+50 to 365+50:

The height of the embankment in this area varied from about 15 to 18 feet. The visual observations made during the period in which the embankment was showing signs of distress, are given below:

<u>Date</u>	<u>Degree of Embankment Movement</u>	<u>Remarks</u>
Feb. 23/68	- Shoulder started to settle.	Section brought back to grade by adding additional rock fill.
Feb. 29/68	- Shoulder settled 2 ft.	-
Mar. 4/68	- Shoulder settled additional 3 ft. (i.e., total 5 ft.).	-
Mar. 6/68	- Shoulder settling as fill placement progresses - failure evident.	Attempting to bring section back to grade by adding additional rock fill.
Mar. 8/68	- Total shoulder settlement ~ 10 to 12 ft.	Mud-wave fully developed - (see Drawing 68-F-34A).
Mar. 10/68	- Settlement negligible.	-

A typical cross-section taken following the failure is plotted on Section A-A shown on Drawing 68-F-34A.

The following can be noted about this failure area:

cont'd. /8 ...

5. DESCRIPTION OF FAILURE: (cont'd.) ...

5.1) Failure at Sta. 363+50 to 365+50: (cont'd.) ...

i) A mud-wave composed of remoulded and displaced clay and organic material was formed about 80 feet from the centre-line of the re-aligned roadway. The maximum height of the wave is about 5 feet.

ii) The shoulder of the embankment slumped some 8 to 10 feet; the crest of the failed slope was about 3 feet away from the edge of the existing pavement.

iii) The average stabilized slope following failure is approximately 5:1.

5.2) Failure at Sta. 367+50 to Sta. 369+50:

The height of the embankment in this area varies from about 22 to 25 feet. Visual observations made during the period in which the embankment was showing distress is given below:

<u>Date</u>	<u>Degree of Embankment Movement</u>	<u>Remarks</u>
Mar. 21/68	- Negligible - slight slumping.	Tension cracks noticeable in Eastbound lane - (signs of impending failure).
Apr. 15/68	- Shoulder settled approx. 5 ft.	Rapid failure occurred.

Typical cross-sections taken following the failure are plotted on Sections B-B and C-C shown on Drawing 68-F-34A. The following can be noted about the failure:

cont'd. /9 ...

5. DESCRIPTION OF FAILURE: (cont'd.) ...

5.2) Failure at Sta. 362+50 to Sta. 369+50: (cont'd.) ...

i) At this location no appreciable mud-wave was formed. The toe of the failure area was probably restricted by the bedrock outcropping immediately south of the creek.

ii) The shoulder of the embankment settled some 5 feet; the crest of the failed slope was about 4 feet away from the edge of the existing pavement.

iii) The average stabilized slope following failure is approximately 5:1.

In addition to the above, severe tension cracks were noticed between Sta. 362+50 and 363+50.

6. REMEDIAL MEASURES:

6.1) Site Visit:

Mr. M. Devata, Supervising Foundation Engineer, and Mr. E. R. Saint, Regional Materials Engineer, North Bay, visited the site on March 21, 1968. Based on their visual observations and information provided by the Sault Ste. Marie District construction personnel, it was concluded that the surcharge loading of the embankment fill overstressed highly compressible clay and organic deposits located on the valley floor. This in turn created a condition of instability and thus a failure occurred with the associated lateral movement of the relatively soft cohesive deposits.

Based on this assessment, the following remedial measures were recommended:

cont'd. /10 ...

6. REMEDIAL MEASURES: (cont'd.) ...

i) that a berm be placed between Sta. 363+25 and 369+00. This berm should be placed at the mid-height of the slope and should extend at least 10 feet past the toe of the mud-wave.

ii) a blanket, some 2 feet thick, composed of either granular material (sand and gravel) or finely crushed rock should be placed over the soft cohesive strata. Such a blanket would provide a mattress for the rock fill and thus reduce the tendency for it to penetrate into the underlying soft clay.

iii) the organic material in the mud-wave area should be excavated prior to placing the blanket.

iv) It was recommended that the surface of the berm be sloped towards the main core of the embankment at a slope of 20:1. By doing so, additional weight will be placed on the toe, which will have the tendency of counter-balancing the weight applied in the vicinity of the main embankment core; and

v) In order to assess the performance of the reconstructed embankment, particularly with respect to the differential settlement between the old and reconstructed portions, settlement plates should be installed at the following locations:

Sta. 364+50	--	O/S	23' Lt. of Centre-line
Sta. 365+00	--	O/S	23' Lt. of " "
Sta. 367+00	--	O/S	23' Lt. of " "
Sta. 369+00	--	O/S	23' Lt. of " "

These settlement plates should be constructed of concrete slabs approximately 1 foot by 1 foot square by 1 foot thick, located about 6 inches below the existing grade. Elevations should be taken on these plates periodically, say once a week, for the next few months. In this manner the settlement of the reconstructed embankment can be monitored. The advantages of installing settlement plates will be discussed further in Section 7.3).

cont'd. /11 ...

6. REMEDIAL MEASURES: (cont'd.)

6.2) Reconstruction Following Failure:

Berm construction commenced on the week of March 25, 1968. The rock fill berm was constructed to within 10 feet of the proposed width between Sta. 362+50 and 369+00; the surface of the berm was at about elevation 604, which is some 2 feet below that proposed. The berm was brought up to final grade the week of April 22, 1968. A sandwich blanket of finely crushed rock was placed between the soft cohesive subsoil and the rock fill in all pertinent areas, as called for in Section 6.2) ii); only a minimal amount of organic matter was removed as per Section 6.2) iii). The proposed finalized sections are plotted on Drawing 68-F-34A.

The reconstruction of the south shoulder of the embankment, in the failure areas, was started on April 19, 1968. End-dumping of rock fill commenced at about Sta. 363+00 and proceeded in a westerly direction. Reconstruction between Sta. 367+00 and 369+00 was started on April 22, 1968.

During and following the berm construction and south shoulder reconstruction, the failure areas appear to have performed satisfactorily - i.e., up to this date no signs of instability have been evident. During this period the embankment section in the most easterly failure area (Sta. 363+50 to 365+50) has not undergone any appreciable settlement. However, in the failure area between Sta. 367+00 and 369+00, some differential settlement did occur between the old embankment and the reconstructed south shoulder. This settlement, which was of the order of 1 to 1-1/2 feet, primarily occurred immediately following the end-dumping of the fill. According to information provided to us, only negligible settlement has been recorded in this area since April 24, 1968. In summary, at the present time, the remedial measures initiated appear to have stabilized the embankment sections in the problem areas.

cont'd. /12 ...

7. CONCLUSIONS:

7.1) General:

Based on the results of the subsurface investigation, and the observations made during the site visits, the following conclusions can be drawn:

i) In the vicinity of the old embankment the bedrock dips very steeply towards the south flattening out on the valley floor, the edge of which is located a few feet south of the old toe.

ii) There does not appear to be any appreciable quantities of compressible material beneath the old embankment section in the area under investigation. Any compressible material that did exist obviously has been displaced. This probably explains the satisfactory performance of the existing section.

iii) Appreciable compressible cohesive material exists on the flat valley floor, particularly between Sta. 363+00 and 369+00; between these stations the thickness varies between 20 and 29 feet. The rock fill end-dumped over the south shoulder of the old embankment was, therefore, placed directly on a soft highly compressible deposit. Further, the heights of the embankment are highest in this section. It is significant to note that this is the area in which the embankment failed.

iv) In the area east of Sta. 363+00 only nominal thicknesses (between 5 and 10 feet) of compressible cohesive deposits exist. The embankment height in this area is of the order of 15 feet, which is relatively low. No signs of instability were noticed in this area and thus remedial measures were not required.

7.2) Stability of Embankment:

As discussed elsewhere, appreciable rock fill was placed on a considerable thickness of soft cohesive strata in the vicinity of the failure areas. It is considered that this fill induced shear stresses within the soft, normally consolidated deposits. These stresses exceeded the limiting equilibrium level which the soft strata could support and thus the overall embankment section

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

7.2) Stability of Embankment: (cont'd.) ...

became unstable. Large lateral strains occurred with resulting lateral movement of the compressible material. To corroborate this hypothesis, total stress stability analyses ($\phi = 0$) were carried out on a typical embankment section prior to failure (at Sta. 364+50). In this method of analysis, stability is governed by the applied loads and by the stress-strain and undrained shear strength properties of the embankment and foundation soils. The assumed stratigraphy, engineering properties of the embankment and subsoil, as well as the results of the computations, are summarized on Figure 4.

The stability analyses carried out indicate that the factor of safety of the reconstructed embankment (prior to failure), was slightly less than 1.0 (about 0.95). The analyses carried out on the section incorporating a berm, however, indicate that the factor of safety was increased by at least 30% - i.e., 1.3 or greater. It is considered that this is acceptable to ensure the long-term stability of the section.

7.3) Settlement and Maintenance Considerations:

Settlement of the cohesive deposits underlying the reconstructed shoulder and berm has occurred; additional settlement is also expected. This settlement is of a consolidation nature and as such, can be expected to take place over an extended period of time. Settlement computations were carried out in order to estimate the maximum amount of settlement likely to occur. Based on these computations it was estimated that, between Sta. 367+00 and 369+00, a differential settlement of up to 2 feet could be expected between the old embankment and the reconstructed south shoulder. As discussed in Section 6.2), between 1 and 1-1/2 feet of settlement has already taken place. It is, therefore, considered that between 6 inches and 1 foot of additional settlement may occur in the future at this location. The settlement at the other critical section, namely between Sta. 363+50 and 365+50, should be a fraction of the above - i.e., should not exceed 6 inches.

cont'd. /14 ...

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

7.3) Settlement and Maintenance Considerations: (cont'd.) ...

If settlement of the foregoing magnitude occurs, some maintenance of the embankment will be required. To determine the magnitude of the settlement involved, settlement plates should be installed as per Section 6.2) iv). The elevations taken on the plates should periodically be forwarded to the Foundation Section. If appreciable settlement is still taking place, it may be advantageous to postpone final paving as long as possible.

8. MISCELLANEOUS:

The field work, performed between April 17 and 24, 1968, was supervised by Mr. B. T. Darch, Senior Foundation Engineer, who also wrote this report.

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

The equipment used was provided and operated by Canadian Longyear Limited.

June 1968.

APPENDIX I

MATERIALS & TESTING DIVISION

FOUNDATION SECTION

JOB 68-F-34

LOCATION Hwy. #17 (Desbarats) Sta. 364+50 o/s 12' Lt. of C

ORIGINATED BY BTD

W. P. 904-62

BORING DATE April 17 & 18, 1968

COMPILED BY BTD

DATUM Geodetic

BOREHOLE TYPE Diamond Drill, NX, BX, AX Casing - AXT Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— W _L PLASTIC LIMIT ——— W _P WATER CONTENT ——— W			BULK DENSITY P C F	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P. S F. +Field Vane					WATER CONTENT %				
612.7	Ground Level						200	400	600	800	1000					
0.0	Shattered heterogeneous rock with some sand and gravel. (Embankment Fill) (Max. rock size up to 2 to 3' in diameter) (Brown & grey)		1	SS	75/2"	610										Borehole dry during Drilling operations
			2	SS	13	606										
			3	SS	101	600										
			4	SS	39											
			5	SS	8	595										
596.2	Silty clay with a tr. of root fibre & related organics. (Mottled Grey & Brown) Stiff		6	AXT RC	75%											
592.7	Grey-wacke Bedrock with inclusions of quartz. (Grey)		7	AXT RC	95%	590										
587.8	Sound															
24.9	End of Borehole					585										

FOUNDATION SECTION

ORIGINATED BY BTD

COMPILED BY BTE

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 68-F-34 LOCATION Hwy.#17 (Desbarats) Sta. 364+50 o/s 100' Lt. of R ORIGINATED BY BTD
W.P. 904-62 BORING DATE April 18, 1968 COMPILED BY BTD
DATUM Geodetic BOREHOLE TYPE Hand Auger CHECKED BY af

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— % PLASTIC LIMIT ——— % WATER CONTENT ——— %			BULK DENSITY pcf	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	SHEAR STRENGTH P S F + Field Vane					WATER CONTENT %			
597.1	Ground Level						200	400	600	800	1000				
0.0 595.3	Peat. Very Soft. Black					595									▽ W.L. in open hole at elev. 595. Apr. 1968
1.8															
592.1	Firm									+3.5					
5.0	Organic clay to clay with a trace to some sand. (Grey to grey-brown)		1	Pt.S.	PM	590	+5.0								
							+4.0								
							+3.5								
						585									
			2	Pt.S.	PM		+3.0								
	Soft					580	+3.0								
							+2.0								
574.1			3	Pt.S.	PM	575	+2.5								
23.0	End of Auger Hole Practical refusal to augering (Probably Bedrock)					570									
+ sensitivity Pt.S. - Peat Sampler															

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 68-F-34

LOCATION Hwy. #17 (Desbarats) Sta. 366+00 o/s 110' L. of Ø

ORIGINATED BY LTD

W.P. 904-62

BORING DATE April 17, 1968

COMPILED BY LTD

DATUM Geodetic

BOREHOLE TYPE Hand Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P S F + Field Vane					WP	W	WL		
596.7	Ground Level						200	400	600	800	1000	50	100	1500		
595.4 1.3	Peat, Very Soft Black					595										
591.7 5.0	Firm		1	Pt.S. PM												
	Organic clay to clay with a trace to some sand.		2	Pt.S. PM		590										
	(Grey to grey-brown occasional varved zones with silt varves up to 1/4" thick)		3	Pt.S. PM		585										
	Soft to firm.		4	Pt.S. PM		580										
			5	Pt.S. PM		575										
568.7 28.0	End of Auger Hole Practical refusal to augering. (Probably Bedrock)					570										

+ s = sensitivity

Pt.S. - Peat Sampler

W.L. in open
hole @ elev
596.7.
Apr. 17/68

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 68-F-34

LOCATION Hwy. #17 (Desbarats) Sta. 369+00 o/s 12' Lt. of C

ORIGINATED BY BTD

W. P. 904-62

BORING DATE April 18, 1968

COMPILED BY B.T.D

DATUM Geodetic

BOREHOLE TYPE Diamond Drill-NX, AX Casing - AXT Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— W _L PLASTIC LIMIT ——— W _P WATER CONTENT ——— W _c			BULK DENSITY P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLCT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.	WATER CONTENT %				
620.4	Ground Level											
0.0	Shattered rock with some sand & gravel (Embankment Fill) (Max. rock size up to 2 to 3' in diameter)	X				620						Borehole dry during Drilling operations
	Grey	X				615						
		X				610						
608.1		X										
12.3	Greywacke Bedrock with inclusions of quartz up to 5" thick throughout. (Grey) Sound	X	1	AXT-RC	100%							
			2	AXT RC	92%	605						
603.2												
17.2	End of Borehole					600						

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 68-F-34 LOCATION Hwy.#17(Dasbarats) Sta. 368+70 o/s 62' Lt. of E ORIGINATED BY BTD
W P 904-62 BORING DATE April 22, 1968 COMPILED BY BTD
DATUM Geodetic BOREHOLE TYPE Diamond Drill - NX Casing CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT						LIQUID LIMIT ——— W _L PLASTIC LIMIT ——— W _P WATER CONTENT ——— W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. ○ Unconfined + Field Vane x Lab Vane					WATER CONTENT % 50 100 150				
602.2	Ground level						200	400	600	800	1000					Artesian
0.0	Shattered heterogeneous rock with a trace of sand and gravel (Fill) (Max. rock size up to 3' in diameter) (Brown and Grey)					600										W.L. in NX casing rose to elev. 604 Apr. 22/68
591.4						595										
11.5	Organic clay to clay with a trace to some sand. (Grey brown to grey) Soft		1	SS	PM	590		+4.5								Artesian Water pressure encountered @ elev. 591. Apr. 22/68
			2	TW	PM	585		+4.0								Note: Once NX casing advanced to elev. 587.4 artesian water flow terminated.
			3	TW	PM	580		+2.5								
			4	TW	PM	575		q x							81 Org. 4.4%	
573.9								+ 2.5								
29.0	Silty clay with some sand & gravel. (Red-brown & grey) Firm		5	SS	q											
571.6																
31.3	End of Borehole (Probably Bedrock)					570										
								15-5 10		% Starin						

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 68-F-34 LOCATION Hwy.#17(Desbarats) Sta. 367+40 o/s 100' Lt. of E ORIGINATED BY BTD
 W. P. 904-62 BORING DATE April 17, 1968 COMPILED BY BTD
 DATUM Geodetic BOREHOLE TYPE Hand Auger CHECKED BY SC

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB	68-F-34	LOCATION	Hwy.#17(Desbarats) Sta. 362+85 o/s 100' Lt. of C	ORIGINATED BY	BTD
W.P.	904-62	SPRING DATE	April 18, 1968	COMPILED BY	BTD
DATUM	Geodetic	BOREHOLE TYPE	Hand Auger	CHECKED BY	

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— L PLASTIC LIMIT ——— P WATER CONTENT ——— W		BULK DENSITY PCF	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P S F.	WATER CONTENT %			
596.3	Ground Level						+Field Vane 200 400 600 800 1000				
595.0	Peat. Very Soft. Black					595					
1.3	Firm										
592.8											
3.5	Organic clay to clay with a trace of sand. Grey.		1	Pt.S.	PM		+5.5				
589.3	Very soft to soft.					590	+3.0				
7.0	End of Auger Hole Practical refusal to augering. (Probably Bedrock)					585	+3.0				
							+ s = sensitivity Pt.S - Peat Sampler				

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 68-F-34 LOCATION Hwy.#17(Desbarats) Sta. 363+00 o/s 100' Lt. of E ORIGINATED BY BTD
W P 904-62 BORING DATE April 18, 1968 COMPILED BY BTD
DATUM Geodetic BOREHOLE TYPE Hand Auger CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					W _P — W — W _L WATER CONTENT %				
596.3	Ground Level															
595.0	Peat, Very Soft. Black					595										
1.3	Organic clay to clay with a trace of sand. Grey) Soft.															
591.3																
5.0	End of Auger Hole Practical Refusal to augering. (Probably Bedrock)					590										
						585										
		</														

W.L. in open
hole @ elev.
596.3
Apr. 18/68

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

JOB	68-F-34	LOCATION	Hwy. #17 (Desbarats) Sta. 362+00 o/s 100' Lt. of E	ORIGINATED BY	BTD
W. P.	904-62	BORING DATE	April 18, 1968	COMPILED BY	BTD
DATUM	Geodetic	BOREHOLE TYPE	Hand Auger	CHECKED BY	

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— W _L PLASTIC LIMIT ——— W _P WATER CONTENT ——— W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.	W _p	W	W _L		
596.2	Ground Level											
595.2	Peat. Very soft. Black.											
1.0	Organic clay to clay with a trace to some sand. Grey to grey-brown. Soft		1	Pt.S.	Pt	595						W.L. in open hole @ elev 596.2
588.2						590						Apr. 18/68
8.0	End of Auger Hole Practical refusal to augering. (Probably Bedrock)					585						

Pt.S. - Peat Sampler

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION


RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 68-F-34 LOCATION Hwy. #17(Desbarats) Sta. 371+00 o/s 100' Rt. of 0 ORIGINATED BY BTD
W P 904-62 BORING DATE April 18, 1968 COMPILED BY BTD
DATUM Geodetic BOREHOLE TYPE Hand Auger CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— % PLASTIC LIMIT ——— % WATER CONTENT ——— %			BULK DENSITY P C F	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P S F.					WATER CONTENT %				
600.5	Ground Level															
0.0	Peat. Very Soft.					600										
598.5	Black															
2.0	Organic clay with a trace of sand, occas. root fibre.															
595.5	(Grey-brown) Soft		1	Pt.S	PM	595										
5.0	Organic clay to clay with a trace to some sand.															
	(Grey-brown to grey)		2	Pt.S	PM	590										
	Soft to Firm.															
			3	Pt.S	PM	585										
580.5			4	Pt.S	PM	580										
20.0	End of auger hole Practical refusal to augering. (Probably sand & gravel)															

Pt.S. - Peat Sampler


W.L. in open hole at elev. 598, Apr. 18/68

Pt.S. - Peat Sampler

W.L. in open hole at elev. 598, Apr. 18/68

RECORD OF BOREHOLE NO. 12

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 68-F-34

LOCATION Hwy. #17 (Desbarats) Sta. 364+95 o/s 103' Lt. of g

ORIGINATED BY

W.P. 901 - 62

BORING DATE April 20 & 21, 1968

COMPILED BY B. T. D.

DATUM Geodetic

BOREHOLE TYPE NX Casing - AXT Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W _p		BULK DENSITY γ PCF	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ Unconfined ● Undrained Triaxial x Lab. Vane				
597.0	Ground Level						200 400 600 800 1000	WATER CONTENT % 50 100 150			
598.5	Peat. Very soft.					595					M.L. in open hole at elev 597, Apr. 21
598.5	Black		1	SS	L						
598.5	Organic clay to clay with trace to some sand.		2	TW	PM	590	+2.5			Org. 7.8%	
598.5	(Grey, with occasional irregular red-brown laminations throughout)		3	TW	PM	588	x qqa			Org. 8.5% L. 1%	
598.5	Very soft to soft.					580	+3.5				
598.5			4	TW	PM		+3.0				
598.5			5	SS	PM	575	+3.0				
598.5	Mixed with sand and gravel.		6	SS	PM	570					
598.5	Greywacke bedrock with inclusions of quartz up to 3" thick (grey)		7	AXT RC 100%							
598.5	Sound					565					
598.5	End of Borehole										

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

FOUNDATION SECTION

ORIGINATED BY BTD

COMPILED BY BTD

BOREHOLE TYPE NX Casing - AXT Core

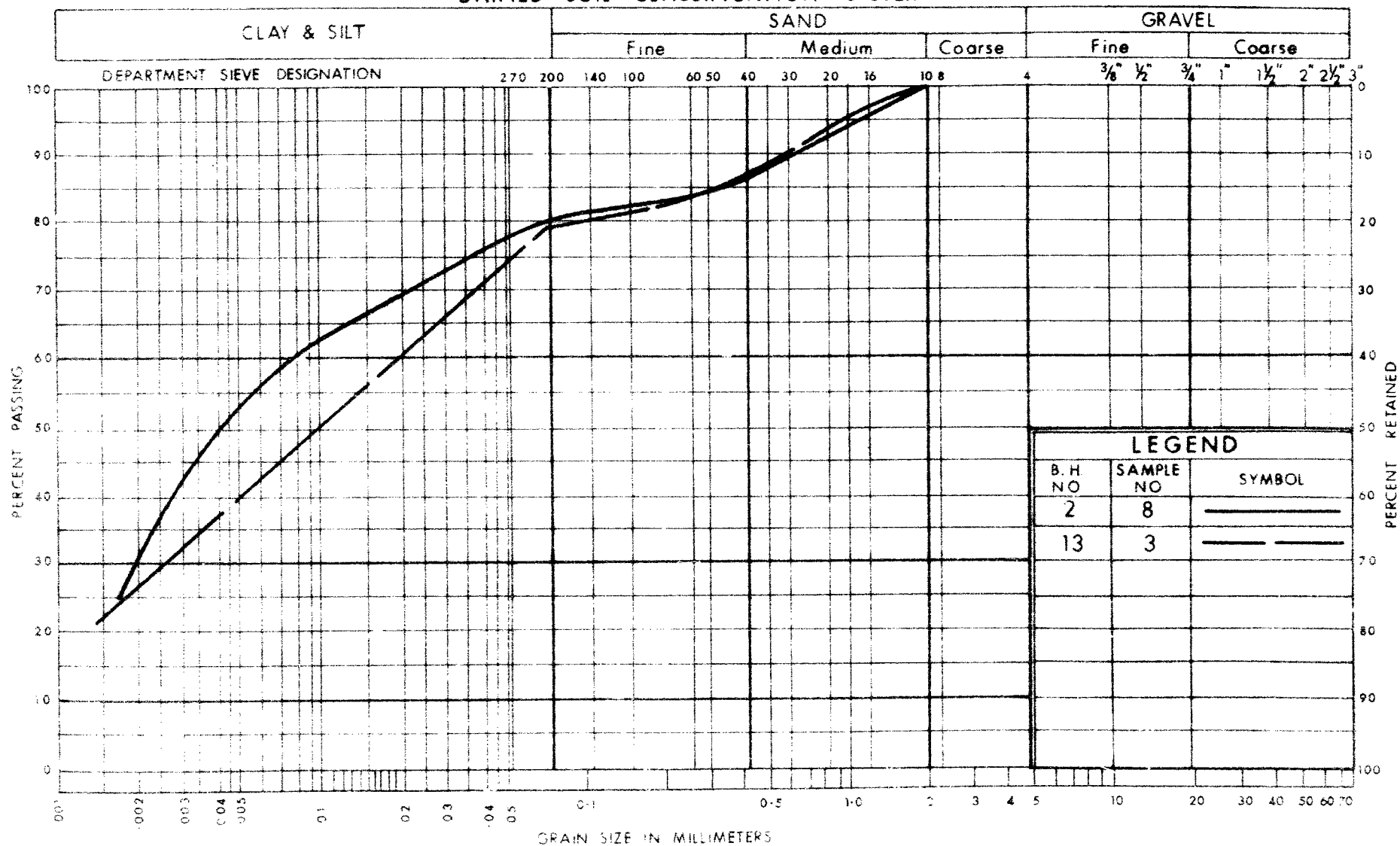
CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO		RECORD OF BOREHOLE NO. 14		FOUNDATION SECTION	
MATERIALS & TESTING DIVISION					
JOB <u>68-F-34</u>	LOCATION <u>Hwy. #17 (Desbarats) Sta. 367+00 o/s 10' Lt. of Ø</u>	ORIGINATED BY <u>BTD</u>			
W.P. <u>904-62</u>	BORING DATE <u>April 23, 1968</u>	COMPILED BY <u>BTD</u>			
DATUM <u>Geodetic</u>	BOREHOLE TYPE <u>NX - AXT Core</u>	CHECKED BY <u>[Signature]</u>			

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE						LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W Wp — W — WL WATER CONTENT %	BULK DENSITY PCF	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT								
615.7	Ground Level														
0.0	Shattered heterogenous rock with some sand & gravel. (Embankment Fill).	[Stratigraphic Column Diagram]				615									Borehole dry during drilling operations
608.5	Grey		1	BXT RC	28%	610									
7.2	Greywacke Bedrock with quartzite inclusions up to 1' thick. (Grey)		2	BXT RC	100%										
			3	BXT RC	100%	605									
601.2	Sound														
14.5	End of Borehole					600									

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION ORGANIC CLAY TO CLAY STRATUM

W.P. No. 904 - 62

JOB No. 68 - F - 34

FIG. NO. 1

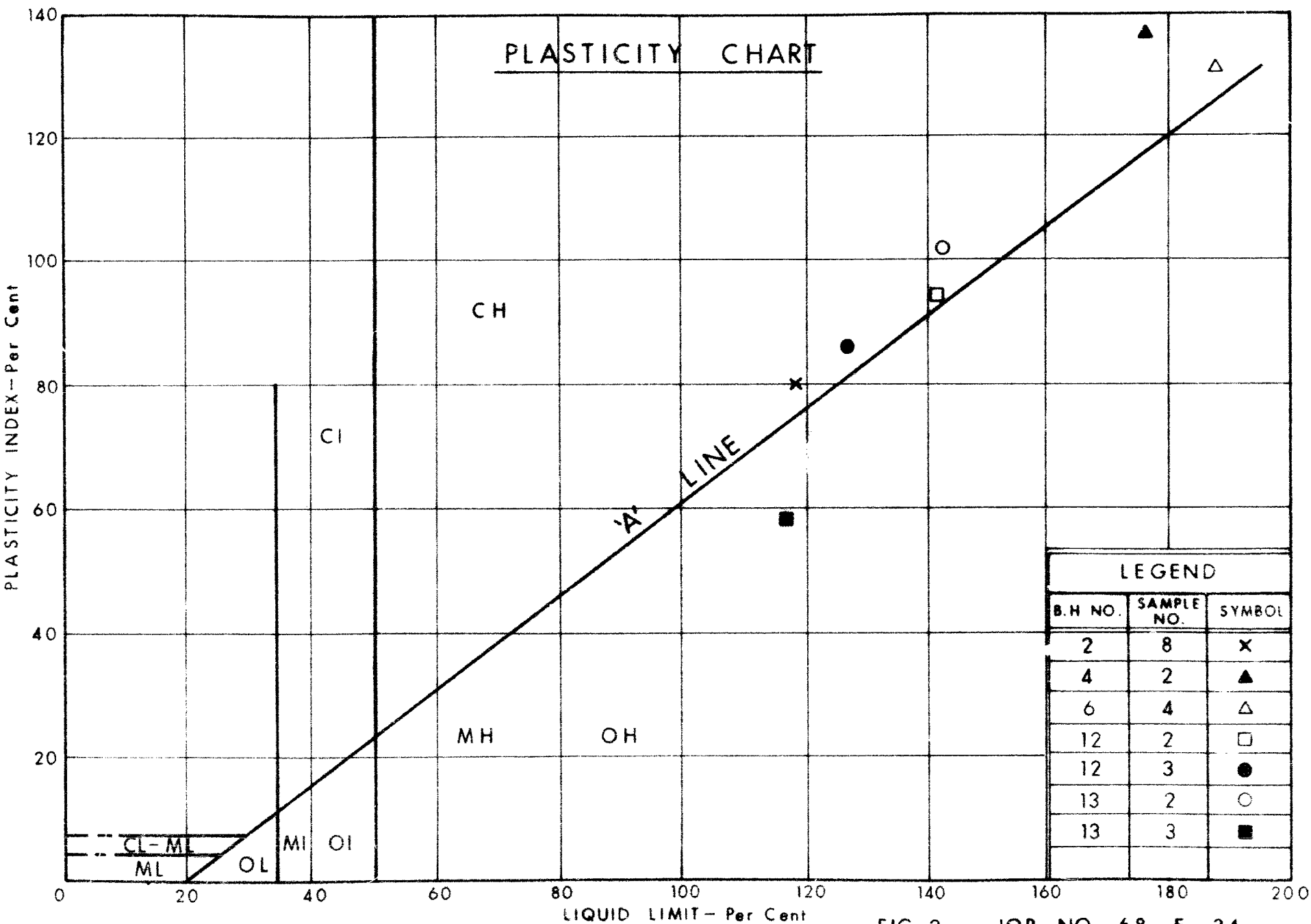


FIG. 2 JOB NO. 68-F-34

UNDRAINED SHEAR STRENGTH vs ELEVATION

(ORGANIC CLAY TO CLAY STRATUM)

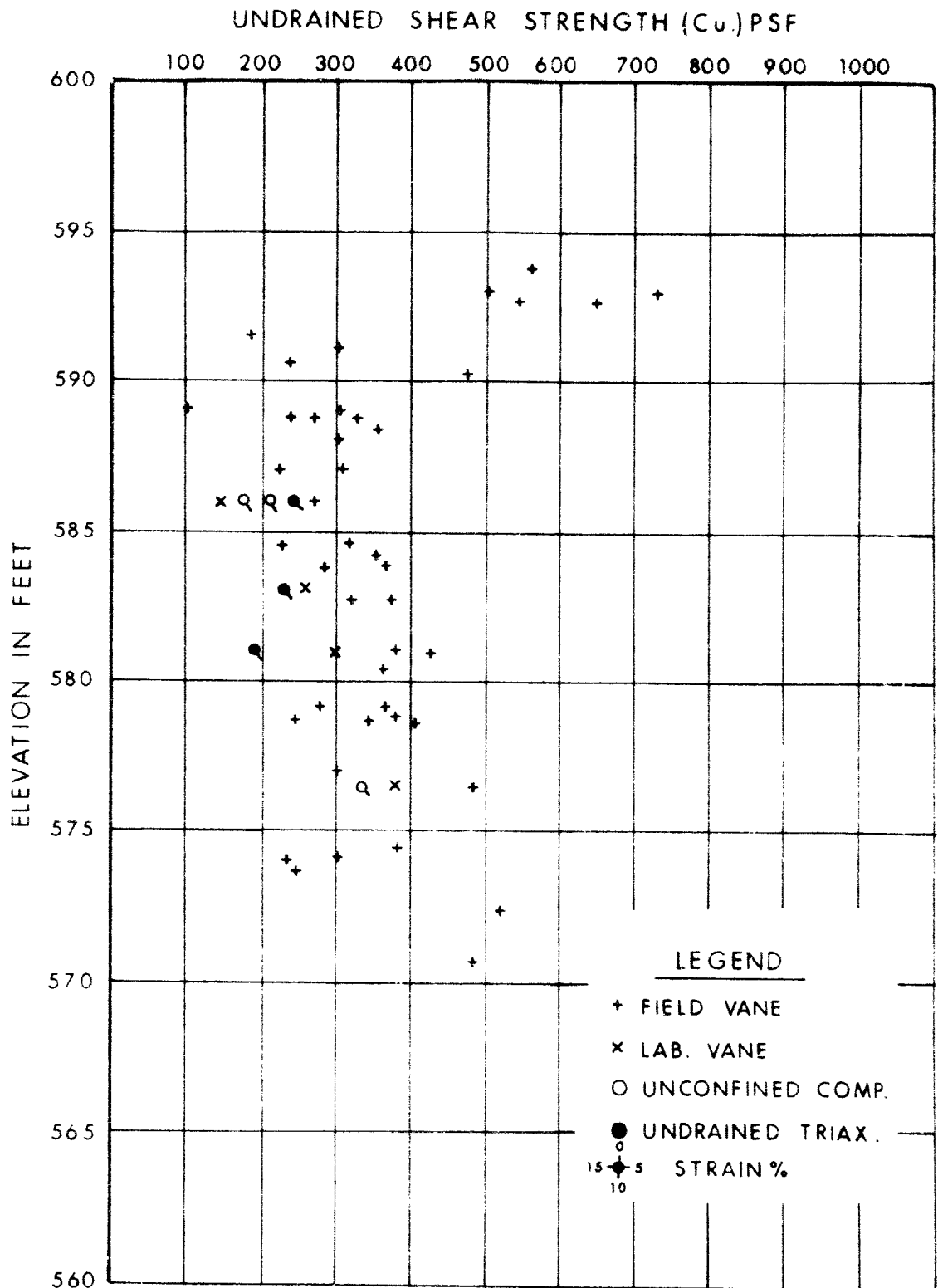
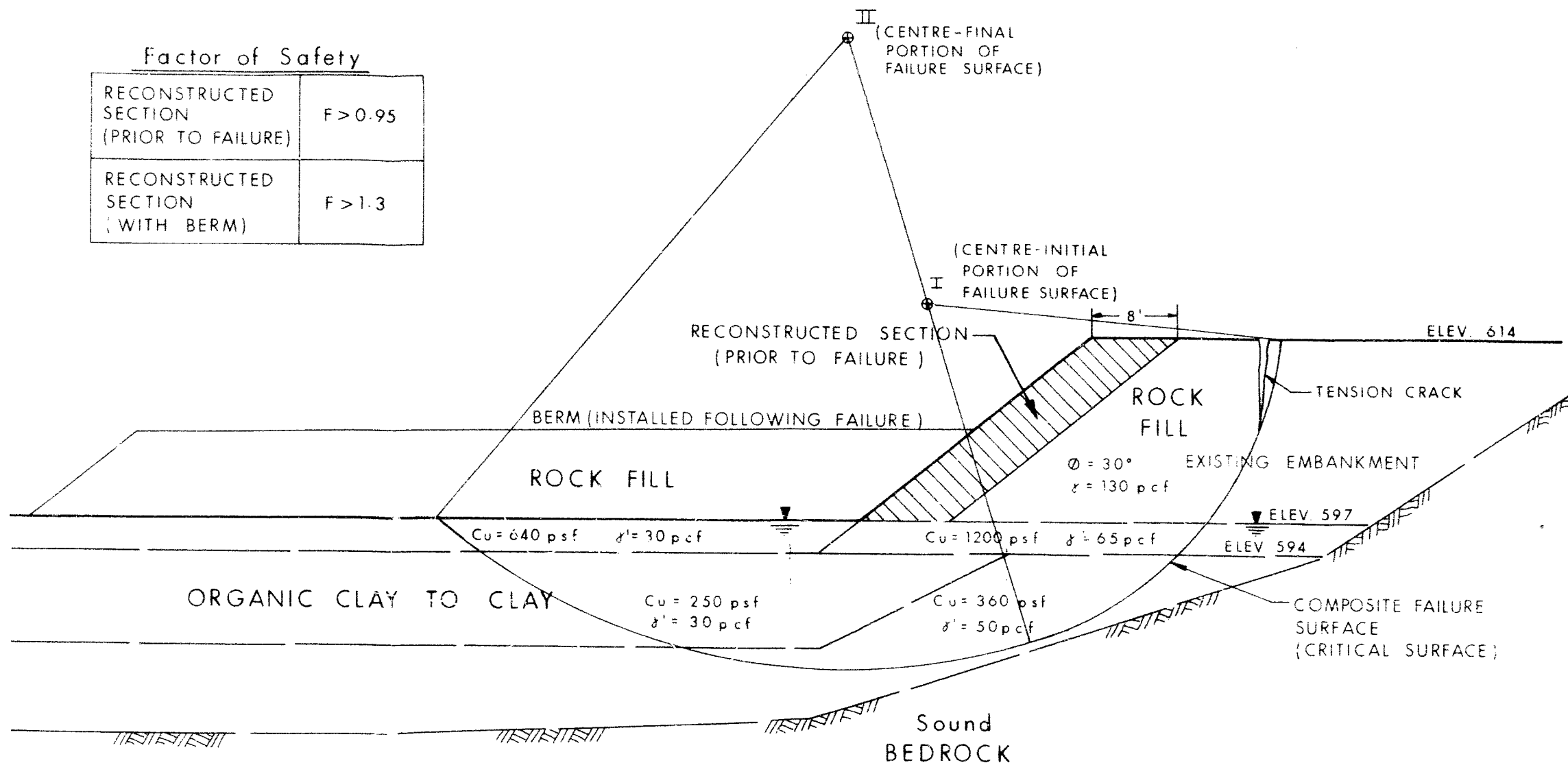


FIG. 3

Factor of Safety

RECONSTRUCTED SECTION (PRIOR TO FAILURE)	$F > 0.95$
RECONSTRUCTED SECTION (WITH BERM)	$F > 1.3$



SECTION A-A (STA. 364+50)

SCALE 1" = 10'



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

ONTARIO

SUMMARIZED RESULT OF STABILITY ANALYSES
RECONSTRUCTED EMBANKMENT

W.P. 904-62

DIST. 18

JOB 68-F-34

DATE JUNE 3, 1968

APPROVED

FIGURE NO. 4

FAILURE OF RECONSTRUCTED EMBANKMENT



SOUTH SHOULDER OF HIGHWAY NO. 17
STA. 363 + 50 TO 365 + 00
(MARCH 1968)

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

FAILURE OF RECONSTRUCTED EMBANKMENT



SOUTH SHOULDER OF HIGHWAY NO. 17
STA. 363+50 TO 365+00
(MARCH 1968)

SUPER IMPROVED DOCUMENT MAY
APPEAR AS MODIFIED OR NULL

FAILURE OF RECONSTRUCTED EMBANKMENT



MUD-WAVE FORMED SOUTH OF TOE
STA. 363+50 TO 365+00
(MARCH 1968)

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

FAILURE OF RECONSTRUCTED EMBANKMENT



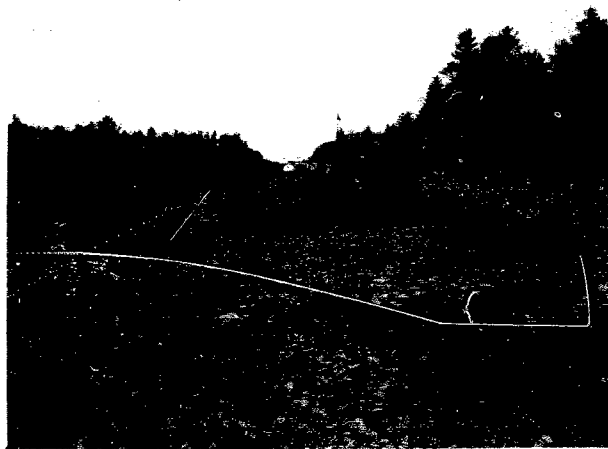
MUD-WAVE FORMED SOUTH OF TOE
STA. 363+50 TO 365+00
(MARCH 1968)

SUPERIMPOSED DOCUMENT MAY
APPEAR AT WILD REED IN AREA

RECONSTRUCTION FOLLOWING FAILURE



DRILL RIG SET UP AT BORE HOLE NO. 1 STA. 364+50
SHOWING RECONSTRUCTED EMBANKMENT AND BERM
STA. 363+00 TO 367+00
(APRIL 18, 1968)



RECONSTRUCTING SOUTH SHOULDER FOLLOWING FAILURE
STA. 363+00 TO 365+00
(APRIL 19, 1968)

SUPER IMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM

RECONSTRUCTION FOLLOWING FAILURE



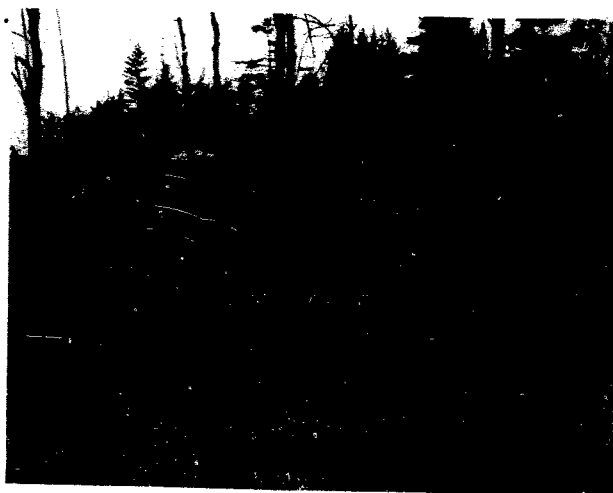
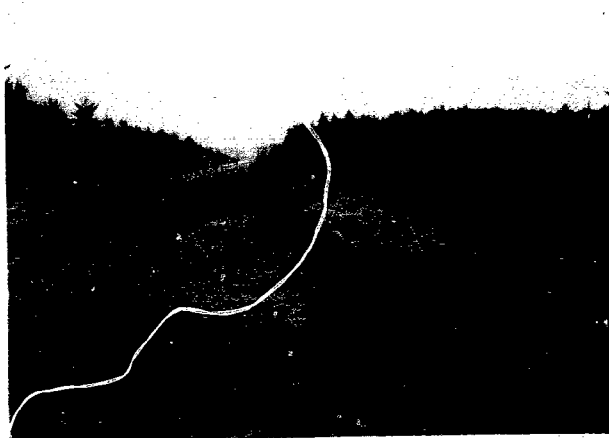
DRILL RIG SET UP AT BORE HOLE NO. 1 STA. 364+50
SHOWING RECONSTRUCTED EMBANKMENT AND BERM
STA. 363+00 TO 367+00
(APRIL 18, 1968)



RECONSTRUCTING SOUTH SHOULDER FOLLOWING FAILURE
STA. 363+00 TO 365+00
(APRIL 19, 1968)

STATE OF ALASKA
DEPARTMENT OF HIGHWAYS
ALASKA HIGHWAY DEPARTMENT
1968

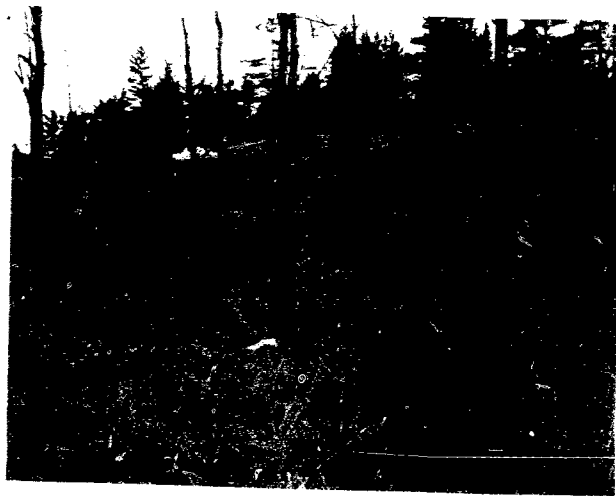
RECONSTRUCTION FOLLOWING FAILURE



SHOWING HIGHWAY NO. 17 EMBANKMENT AND BERM
STA. 363+00 TO 367+00
(APRIL 22, 1968)

SUPERIMPOSED DOCUMENT MAY
APPEAR AS MULTI-FEED ON FILM.

RECONSTRUCTION FOLLOWING FAILURE



SHOWING HIGHWAY NO 17 EMBANKMENT AND BERM
STA 363+00 TO 367+00
(APRIL 22, 1968)

APR 22 1968

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

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

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

DESCRIPTION OF SOIL

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

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

TYPE OF SAMPLE

SS	SPLIT SPOON	TW	THINWALL OPEN
WS	WASHED SAMPLE	TP	THINWALL PISTON
SB	SCRAPER BUCKET SAMPLE	OS	OESTERBERG SAMPLE
AS	AUGER SAMPLE	FS	FOIL SAMPLE
CS	CHUNK SAMPLE	RC	ROCK CORE
ST	SLOTTED TUBE SAMPLE		
	PH	SAMPLE ADVANCED HYDRAULICALLY	
	PM	SAMPLE ADVANCED MANUALLY	

SOIL TESTS

Qu	UNCONFINED COMPRESSION	LV	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	FV	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
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
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 (YOUNG'S 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_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

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

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

1968 DEC 9 PM 1:54

11233

11271

68 F-34

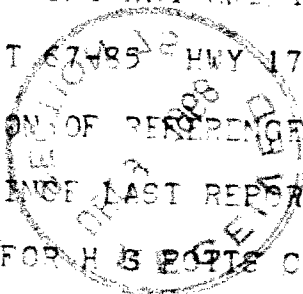
MS SAUL DECEMBER 9/68 1:42
DOWN 4 M DEVATA NAT AND TEST
NEAR 1 E R SAINT NAT AND TEST

RE: CONTRACT 67-85 HWY 17, DESBARATS TO PINE ISLAND

ELEVATION OF REFERENCE POINTS ON ROCK FILL AREA
NO CHANGE SINCE LAST REPORT.

C D MCLURE FOR H B POTTS CONST ENGR

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1968 DEC 2 PM 2:51

MX SAUL DEC 2/68 2:41

DOWN 13 M DEVATA MAT AND TEST

NBAR 2 E R SAINT MAT AND TEST

RE: CONT 67-85, HWY 17, DESBARATS TO PINE ISLAND ELEVATION OF
REFERENCE POINTS ON ROCK FILL AREA

NO CHANGE IN ELEVATION SINCE LAST REPORT.

C D MCLURE FOR H G POTTS CONST ENGR

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1969 NOV 25 AM 11:42

68.F-34

X SAUL NOV 25/69 11:15

DOWN 3 F DEWATA MAT AND TEST

NEAR 1 F D SAINT MAT AND TEST

RE: CONTRACT 57-35, MAY 17, SEPARATE TO FINE ISLAND

NO CHANGE IN ELEVATIONS OF REFERENCE POINTS OF ROCK FILL AREA SINCE
LAST REPORT.

C. G. MOUSE FOR F. G. POTTS CONST. ENGR.

LY

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

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1968 NOV 19 AM 11:35

24 CALL NOV 19/68 11:12

FROM 3 1 DEWATA MAT AND TEST

NEAR 2 3 R SAINT MAT AND TEST

RE: CONTRACT 47-25 NOV 17. DESEARATS TO PINE ISLAND

ELEVATION OF REFERENCE POINTS ON ROCK FILL ARE NOW 15
TO CHAIN IS FROM PREVIOUS IT.

R. J. THROCK F.O.S.

LY

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

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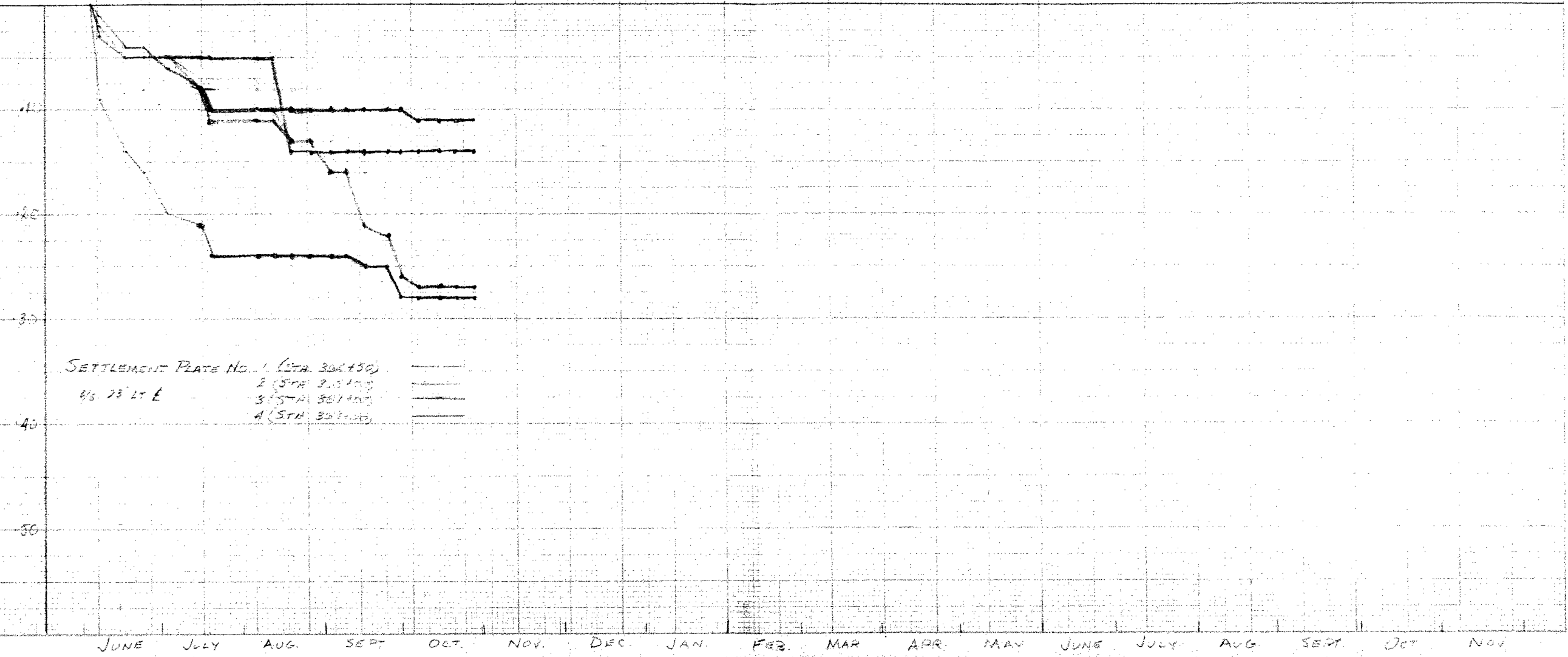
SETTLEMENT READINGS - TRANS-CANADA HWY #17 STA 363+00 to Sta 369+00

DESBARATS - GEF 34

HEIGHT OF FILL (FT)

DOWN READ

SETTLING



SETTLEMENT PLATE NO. 1 (STA 364+50)
 2 (STA 365+00)
 3 (STA 367+00)
 4 (STA 369+00)

1968

1969