

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

2000-1102 2
FORMERLY
WP 990052-R DIST 14
HWY Mun. STR SITE N/A
Casey Twp.

Wright Creek Slip Failure

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FOUNDATION INVESTIGATION REPORT

For

W.O. 990052-R, Site N/A

Wright Creek Slip Failure

Casey Twp., Lot 6/7, Conc. V

District 14, New Liskeard

INTRODUCTION:

This report summarizes the results of the foundation investigation required for the design of remedial measures for the above-noted road failure.

The fieldwork was conducted on 82 07 22 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers. This work consisted of 2 sampled boreholes/dynamic cone penetration tests.

SITE DESCRIPTION

The site is located adjacent to Wright Creek approximately 210 metres north of Pearson Bridge (Site 47-219).

Physiographically the site is located in the Cobalt Plain, a glacio-lacustrine plain of generally low local relief. At the site, the valley of Wright Creek lies approximately 3.5 metres below the plain and road.

At the time of the field investigation the slip failure extended from approximately Sta. 100 + 020 to Sta. 100 + 060. The following conditions were observed.

- the east portion of the road had slipped into the creek
- the road had been realigned to the west
- the east shoulder of the realigned road was fill material, placed after the slip failure had occurred

SUBSURFACE CONDITIONS

General

The Record of Borehole Sheets (Appendix) illustrate the conditions at the borehole locations. The locations and elevations of the boreholes are shown in Figure 1.

The survey stations and elevations refer to a temporary benchmark (Sta. 100 + 000, elev. 100.00 m).

Generally, the overburden consists of a thick deposit of clay. The surface material at the road, extending up to 1.5 metres in depth, is fill.

Fill Material

The fill material consists of a heterogenous mixture of silty clay, sand and gravel extending to a depth of approximately 1.5 m.

Clay

Clay of high to intermediate plasticity constitutes the main deposit at this site.

Physical properties of this material, as determined from field and laboratory tests, are summarized below:

| | <u>Range</u> | <u>Average</u> | <u>Median</u> |
|---------------------------------|---------------|----------------|---------------|
| Natural Moisture Content (w) | 33.0-63.5% | 49.7% | 58.5% |
| Liquid Limit (W _L) | 31.0-60.0% | 46.2% | 58.0% |
| Plastic Limit (W _p) | 16.0-22.0% | 19.4% | 19.7% |
| Shear Strength | | | |
| - field vane (undisturbed) | 15.3-34.5 kPa | N/A | N/A |
| - field vane (remolded) | 3.8-13.4 kPa | N/A | N/A |

The shear strength of the deposit generally increases with depth. The remolded shear strengths indicate sensitivities ranging from 2 to 4.

Groundwater

The groundwater was measured at elev. 95.6 m, approximately the same level as Wright Creek.

DISCUSSION AND RECOMMENDATIONS

Factors contributing to the slip failure include bank erosion and undercutting.

These recommendations pertain to design of remedial measures required for the stabilization of the slip failure.

The enclosed Figure 1 is a plan view illustrating the failure zone, and the borehole locations.

The enclosed Figure 2 is a X-section illustrating the recommended design for a typical section.

Design Data

- Refer to Figures 1 and 2.
- The stability treatment should extend across the entire failure zone (approximately Sta. 100 + 020 to Sta. 100 + 060).
- The edges of the stability treatment should be graded into the adjacent existing contours at slopes of 3:1 or flatter.
- Granular "C" should be used for the stability treatment embankment fill and the transition grading.
- The position of the edge of road shoulder will have to be determined by your requirements for road location and creek width. However, it is recommended that the river channel not be constricted.
- The elevation of the toe of the stability treatment slope will depend on your requirements for creek depth. However, it is recommended that the toe of the slope be extended to approximately elevation 94.6 to prevent scour and its associated stability problems. The material excavated from the creek should not be used for the embankment construction.

- The recommended geometry (Figure 2) is a slope of 3:1 or flatter. This geometry will require trimming of the lower slope. Benches should be excavated in the existing slope to facilitate placement of the granular fill. Refer to the enclosed MTC Standard No. DD-414 "Benching of Earth Slopes", for recommended benching procedures. In this case bench height should be approximately 1.5 m or less. The benches should be constructed starting at the bottom, and the compacted fill should be placed as soon as possible after excavation of the benches.
- Erosion protection, in the form of random rip rap (minimum blanket thickness = 0.6 m) should be placed on the slope extending from the toe to 0.6 m above the high water level. The rip rap should extend a minimum of 2 m out along the creek bottom (see Figure 2). The remaining stability treatment area and the adjacent transition zones should be protected by vegetation cover as soon as possible.

Construction Sequence

- 1) Trim existing embankment as required.
- 2) Excavate for benching.
- 3) Place granular fill.
- 4) Place rip rap.
- 5) Protect remaining stability treatment and adjacent transition zones with vegetation cover.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Mr. D. H. Dundas, Project Foundations Engineer. The report was written by Mr. Dundas and reviewed by Mr. K. G. Selby, Senior Foundations Engineer. The equipment used was owned and operated by Atcost Soil Drilling Inc.



D. H. Dundas
D. H. Dundas, P. Eng.,
Project Foundations Engineer

K. G. Selby
K. G. Selby, P. Eng.,
Senior Foundations Engineer

A P P E N D I X



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No 1

METRIC

W O 990052-R LOCATION Sta. 100 + 040, o/s 9.0 m Rt. Q Twp. Rd. ORIGINATED BY D.D.
DIST 14 HWY Mun. Casey BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY D.D.
DATUM Assumed Twp. DATE 82 07 22 CHECKED BY D.D.

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|---|----|-------------------|---|--|--|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | 'N' VALUES | | | 20 40 60 80 100 | Wp | W | Wl | WATER CONTENT (%) | | | | | |
| 99.0 | Ground Surface | | | | | | | | | | | | | | | | |
| 0.0 | Silty Clay, Sand and Gravel, Loose (Fill Material) | | 1 | SS | 7 | | | | | | | | | | | | |
| 97.5 | Clay (CH to CI) | | 2 | SS | 2 | | | | | | | | | | | | |
| 1.5 | Some Silt | | 3 | SS | PM | | | | | | | | | | | | |
| | Soft | | 4 | SS | PM | | | | | | | | | | | | |
| | | | 5 | SS | PM | | | | | | | | | | | | |
| | Firm | | 6 | SS | PM | | | | | | | | | | | | |
| | | | 7 | SS | PM | | | | | | | | | | | | |
| | | | 8 | SS | PM | | | | | | | | | | | | |
| | Firm | | 9 | SS | PM | | | | | | | | | | | | |
| 85.9 | | | | | | | | | | | | | | | | | |
| 13.1 | End of Borehole | | | | | | | | | | | | | | | | |
| 83.8 | | | | | | | | | | | | | | | | | |
| 15.2 | End of Cone Test | | | | | | | | | | | | | | | | |

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



Ministry of
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Communications

RECORD OF BOREHOLE No 2

METRIC

WO 990052-R LOCATION Sta. 100 + 040 o/s 3.0 m Rt. & Twp. Rd. ORIGINATED BY D.D.
DIST 14 HWY Mun. Casev BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY D.D.
DATUM Assumed Twp. DATE 82 07 22 CHECKED BY D.D.

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|--------------|---|------------|--------|------|-------------------------|-----------------|--|----|---------------------------------|-------------------------------|--------------------------------|------------------|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | 'N' VALUES | 20 | | | | | |
| 99.3 | Ground Surface | | | | | | | | | | | | |
| 0.0 | Silty Clay, Sand and Gravel, loose to compact (Fill Material) | | | | | | | | | | | | |
| 97.8 | Clay (CH TO CI) | | 1 | SS | 1 | | | | | | | | |
| 1.5 | Some Silt | | 2 | SS | PM | | | | | | | | |
| | Soft | | 3 | SS | PM | | | | | | | | |
| | | | 4 | SS | PM | | | | | | | | |
| | | | 5 | SS | PM | | | | | | | | |
| | | | 6 | SS | PM | | | | | | | | |
| | | | 7 | SS | PM | | | | | | | | |
| | Firm | | 8 | SS | PM | | | | | | | | |
| 86.2 | | | | | | | | | | | | | |
| 13.1 | End of Borehole | | | | | | | | | | | | |
| 84.1 | | | | | | | | | | | | | |
| 15.2 | End of Cone Test | | | | | | | | | | | | |

+3, x5: Numbers refer to 20
Sensitivity 15 ÷ 5 (%) STRAIN AT FAILURE
10

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

| c_u (kPa) | 0 - 12 | 12 - 25 | 25 - 50 | 50 - 100 | 100 - 200 | > 200 |
|-------------|-----------|---------|---------|----------|------------|-------|
| | VERY SOFT | SOFT | FIRM | STIFF | VERY STIFF | HARD |

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

| N (BLOWS/0.3m) | 0 - 5 | 5 - 10 | 10 - 30 | 30 - 50 | > 50 |
|----------------|------------|--------|---------|---------|------------|
| | VERY LOOSE | LOOSE | COMPACT | DENSE | VERY DENSE |

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND /OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

| RQD (%) | 0 - 25 | 25 - 50 | 50 - 75 | 75 - 90 | 90 - 100 |
|---------|-----------|---------|---------|---------|-----------|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

JOINTING AND BEDDING:

| SPACING | 50mm | 50 - 300mm | 0.3m - 1m | 1m - 3m | > 3m |
|----------|------------|------------|------------|---------|------------|
| JOINTING | VERY CLOSE | CLOSE | MOD. CLOSE | WIDE | VERY WIDE |
| BEDDING | VERY THIN | THIN | MEDIUM | THICK | VERY THICK |

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

| | | | |
|-----|---------------------|-----|----------------------------|
| S S | SPLIT SPOON | T P | THINWALL PISTON |
| W S | WASH SAMPLE | O S | OSTERBERG SAMPLE |
| S T | SLOTTED TUBE SAMPLE | R C | ROCK CORE |
| B S | BLOCK SAMPLE | P H | T W ADVANCED HYDRAULICALLY |
| C S | CHUNK SAMPLE | P M | T W ADVANCED MANUALLY |
| T W | THINWALL OPEN | F S | FOIL SAMPLE |

MECHANICAL PROPERTIES OF SOIL

| | | |
|----------------|-----------------------|--------------------------------------|
| m_v | kPa^{-1} | COEFFICIENT OF VOLUME CHANGE |
| C_c | 1 | COMPRESSION INDEX |
| C_s | 1 | SWELLING INDEX |
| C_α | 1 | RATE OF SECONDARY CONSOLIDATION |
| c_v | m^2/s | COEFFICIENT OF CONSOLIDATION |
| H | m | DRAINAGE PATH |
| T_v | 1 | TIME FACTOR |
| U | % | DEGREE OF CONSOLIDATION |
| σ'_{vo} | kPa | EFFECTIVE OVERBURDEN PRESSURE |
| σ'_p | kPa | PRECONSOLIDATION PRESSURE |
| τ_f | kPa | SHEAR STRENGTH |
| c' | kPa | EFFECTIVE COHESION INTERCEPT |
| ϕ' | -° | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| c_u | kPa | APPARENT COHESION INTERCEPT |
| ϕ_u | -° | APPARENT ANGLE OF INTERNAL FRICTION |
| τ_R | kPa | RESIDUAL SHEAR STRENGTH |
| τ_r | kPa | REMOULDED SHEAR STRENGTH |
| S_i | 1 | SENSITIVITY = $\frac{c_u}{\tau_r}$ |

STRESS AND STRAIN

| | | |
|--------------------------------------|-----|-------------------------------|
| u_w | kPa | PORE WATER PRESSURE |
| r_u | 1 | PORE PRESSURE RATIO |
| σ | kPa | TOTAL NORMAL STRESS |
| σ' | kPa | EFFECTIVE NORMAL STRESS |
| τ | kPa | SHEAR STRESS |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | PRINCIPAL STRESSES |
| ϵ | % | LINEAR STRAIN |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | % | PRINCIPAL STRAINS |
| E | kPa | MODULUS OF LINEAR DEFORMATION |
| G | kPa | MODULUS OF SHEAR DEFORMATION |
| μ | 1 | COEFFICIENT OF FRICTION |

PHYSICAL PROPERTIES OF SOIL

| | | | | | | | | |
|-----------------------|------------------------|--------------------------------|------------|------|---|------------|------------------------|--|
| ρ_s | kg/m^3 | DENSITY OF SOLID PARTICLES | e | 1, % | VOID RATIO | e_{\min} | 1, % | VOID RATIO IN DENSEST STATE |
| γ_s | KN/m^3 | UNIT WEIGHT OF SOLID PARTICLES | n | 1, % | POROSITY | I_D | 1 | DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$ |
| ρ_w | kg/m^3 | DENSITY OF WATER | w | 1, % | WATER CONTENT | D | mm | GRAIN DIAMETER |
| γ_w | KN/m^3 | UNIT WEIGHT OF WATER | S_r | % | DEGREE OF SATURATION | D_n | mm | n PERCENT - DIAMETER |
| ρ | kg/m^3 | DENSITY OF SOIL | w_L | % | LIQUID LIMIT | C_u | 1 | UNIFORMITY COEFFICIENT |
| γ | KN/m^3 | UNIT WEIGHT OF SOIL | w_p | % | PLASTIC LIMIT | h | m | HYDRAULIC HEAD OR POTENTIAL |
| ρ_d | kg/m^3 | DENSITY OF DRY SOIL | w_s | % | SHRINKAGE LIMIT | q | m^3/s | RATE OF DISCHARGE |
| γ_d | KN/m^3 | UNIT WEIGHT OF DRY SOIL | I_p | % | PLASTICITY INDEX = $w_L - w_p$ | v | m/s | DISCHARGE VELOCITY |
| ρ_{sat} | kg/m^3 | DENSITY OF SATURATED SOIL | I_L | 1 | LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$ | i | 1 | HYDRAULIC GRADIENT |
| γ_{sat} | KN/m^3 | UNIT WEIGHT OF SATURATED SOIL | I_C | 1 | CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$ | k | m/s | HYDRAULIC CONDUCTIVITY |
| ρ' | kg/m^3 | DENSITY OF SUBMERGED SOIL | e_{\max} | 1, % | VOID RATIO IN LOOSEST STATE | j | KN/m^2 | SEEPAGE FORCE |
| γ' | KN/m^3 | UNIT WEIGHT OF SUBMERGED SOIL | | | | | | |

← New road
← Existing road
Distance 'X'

Edge of shoulder roundings

H

W

Existing slope to be stripped before benching

Compacted fill to be brought up in stages with benching

Original ground

MAX HEIGHT AND WIDTH OF BENCHES

H = Height, W = Width

| Existing slopes | Fills 3.5m or more | | Fills under 3.5m | |
|-----------------|--------------------|-----|------------------|-----|
| | W | H | W | H |
| 3:1 to 2:1 | 2.50 | Var | 1.25 | Var |
| 2:1 | 1.25 | Var | 600 | Var |

NOTES:

- This standard applies to widening of fills where the distance 'X' is 1.0m or more at new subgrade level.
- Benching is not required on existing slopes flatter than 3:1 or where it is deemed unnecessary by the Engineer.
- Benches are to be excavated one level at a time and the compacted fill brought up before the next benching level is excavated.
- All dimensions are in millimetres or metres unless otherwise specified.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

No DD-414

BENCHING OF EARTH SLOPES

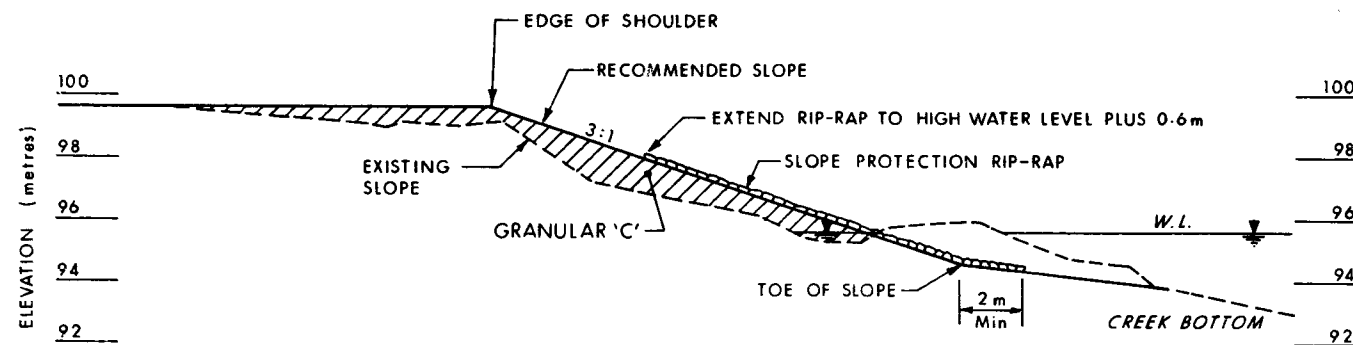
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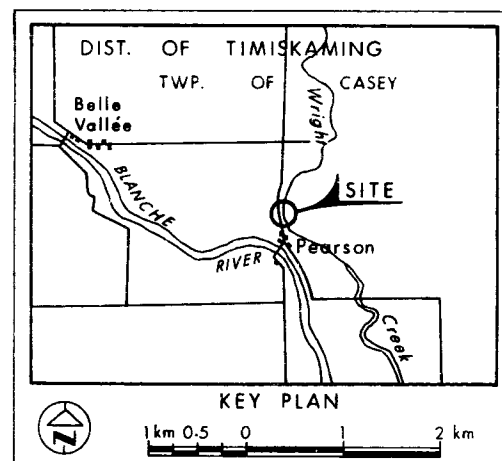
Rev

J. Callaghan
Director Design and Construction Branch

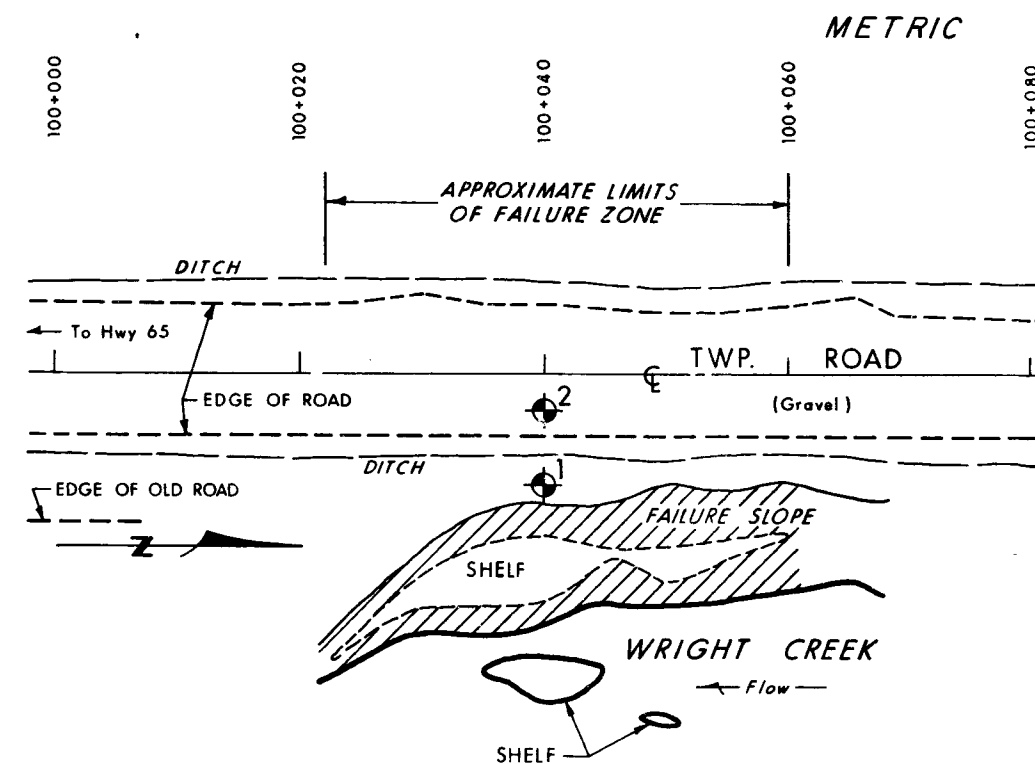
OVERSIZE DRAWING(S)



DESIGN FOR TYPICAL SECTION
Fig. 2



| LEGEND | | | |
|--------|------------------|---------|---------|
| | Bore Hole & Cone | | |
| | Water Level | | |
| No | ELEV. | STATION | OFFSET |
| 1 | 99.0 | 100+040 | 9.0m Rt |
| 2 | 99.3 | 100+040 | 3.0m Rt |



SITE PLAN SCALE 1:400
Fig. 1

NOTE 1
FOR SUBSOIL CONDITIONS REFER TO
RECORD OF BOREHOLE SHEETS.

Geocres No 31M-46



WRIGHT CREEK SLIP FAILURE
RECOMMENDED DESIGN

DIST. 14, TWP OF CASEY, LOT 6 & 7, CON 5

DATE Oct 12, 1982

WO 990052-R

FIG No 1 & 2