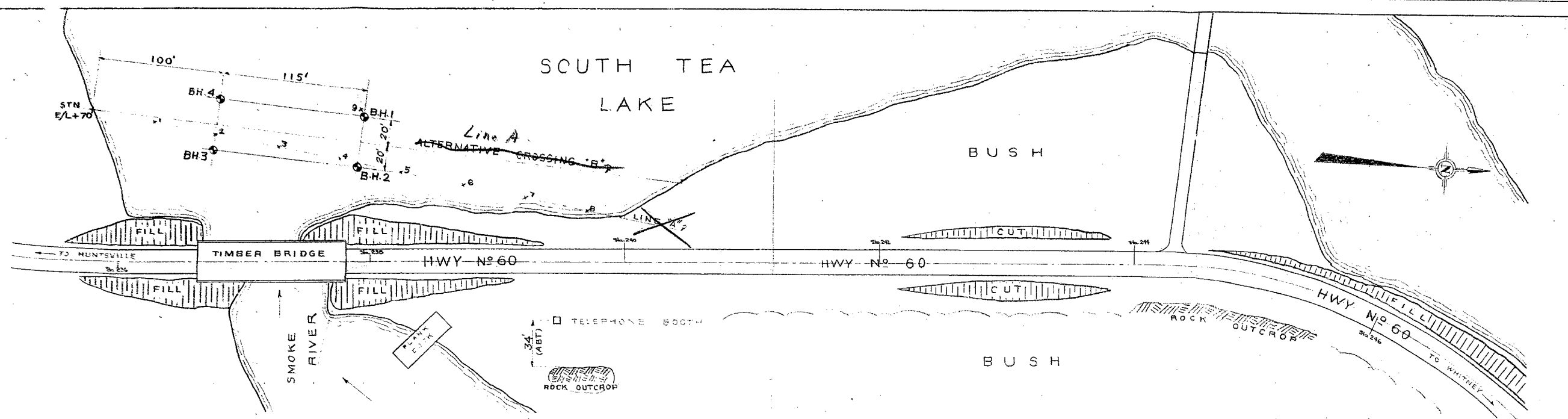
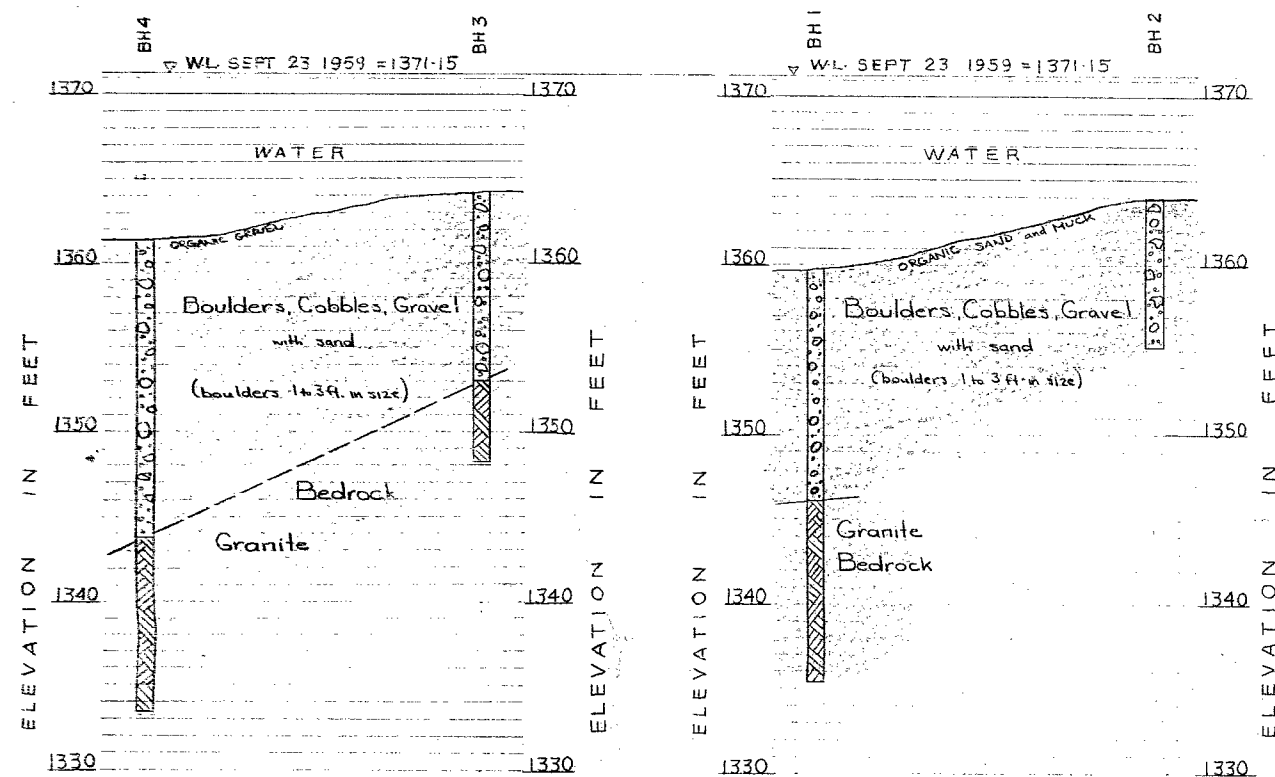


59-F-254C  
W.P. 221-59  
Hwy. # 60  
SMOKE RIVER



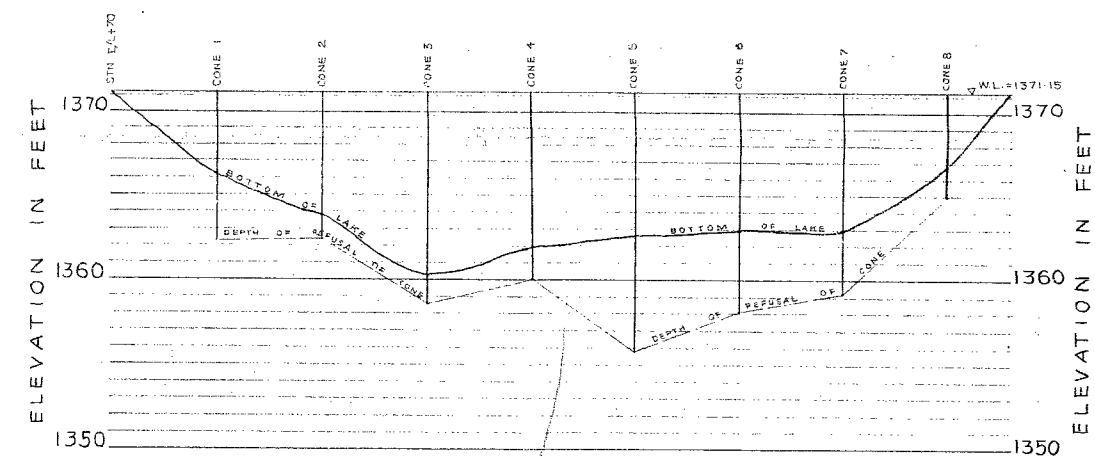
LOCATIONS OF BOREHOLES AND CONE TESTS  
SCALE: 1 IN = 40 FT



PROFILE BETWEEN BH.4 & BH.3

PROFILE BETWEEN BH.1 & BH.2

HORIZONTAL SCALE 1 IN = 10 FT  
VERTICAL SCALE 1 IN = 5 FT



PENETRATION PROFILE ALONG LINE "A"

HORIZONTAL SCALE: 1 IN = 40 FT  
VERTICAL SCALE 1 IN = 5 FT

### PROPOSED CROSSING OF SMOKE RIVER

HWY No 60 — PECK TOWNSHIP

W.P. 221-59

*William A Trow & Associates Limited*

JOB No 426 OCT 8 1959



ONTARIO  
DEPARTMENT OF HIGHWAYS

*Memo to* Mr. A. M. Toye, *Date* November 13, 1959.  
Bridge Engineer. *Subject* FOUNDATION REPORT - by  
*From* Materials & Research Section. William A. Trow & Associates.

Attention: Mr. S. McCombie.

Re: Proposed Crossing of Smoke River,  
Hwy. 60 - Peck Twp. - W.P. 221-59.  
District 11.

Enclosed herewith is the foundation report on the above structure submitted by W. A. Trow & Associates. The subsoil conditions, as shown in this report, are such that no problems need be anticipated with respect to instability of the rock-filled causeway sections. The heterogeneous granular subsoil which overlies the bedrock, contains boulders up to 3 feet in diameter.

Sheet piles or 'H' piles could not be successfully driven into this type of subsoil.

The Consultants, in their report, have recommended either rock-filled timber cribs for the support of the structure or, alternatively, abutments founded directly upon the rock-filled causeway.

The alternative of placing abutment footings directly on the rock fill, should not be adopted. We would suggest that consideration be given to the use of rock-filled cribs for intermediate piers, whereas, at the abutment locations, fine-grained granular fill be placed, and that short end-bearing piles be driven through this fill to bear upon the dense natural subsoil.

There are several design alternatives for this typical situation where a shallow depth of water overlies a dense subsoil material. We would be pleased to discuss these alternatives with you, in detail, with your Design Group, when this structure is being considered.

cont'd. /2 ...

If there are any questions in connection with the contents of this report, or our foregoing comments, please do not hesitate to call our office.



LGS/MdeF  
Attach.

L. G. Soderman,  
PRINCIPAL SOILS & FOUNDATION ENGINEER.

cc: Messrs. A. M. Toye (2)  
H. A. Tregaskes  
D. G. Ramsay  
G. K. Hunter  
H. C. Dernier  
P. Arkema  
A. Watt

Foundation Section.  
Gen. Files.

BA 963  
59-E-254C

WILLIAM A. TROW AND ASSOCIATES LTD.

SITE INVESTIGATIONS  
AND  
SOIL MECHANICS CONSULTATION

W. A. TROW, M.A.S.C., M.E.I.C., P.ENG.

Project: J426

884 WILSON AVE.,  
DOWNSVIEW, ONT.  
ME. 5-5921

Mr. A. Rutka,  
Department of Highways of Ontario,  
Materials and Research Branch,  
Parliament Buildings,  
Toronto 5, Ontario.

October 23, 1959

Attention: Mr. L.G. Soderman, P. Eng.,  
Principal Soils and Foundation Engineer.

Re: Foundation Investigation -  
Proposed Crossing of Smoke River,  
Highway 60 - Peck Township.

Dear Sirs:

Enclosed herewith is our report on the lake bed conditions existing along the site of the proposed relocation of Highway 60 across Smoke River in Peck Township.

The material below the lake bed at this site consists of numerous stones up to 3 feet in size in a matrix of sand and gravel. The water ranged from 6 to 11 feet deep at the time of the investigation. Granite bedrock lies 18 to 28 feet below the lake surface at this location.

No penetration of piles into the lake bed gravel and rocks can be obtained and therefore support on the surface of this material will be required. Two methods of bridge support, involving the placement of abutments directly on the compacted rock fill of the causeway or the use of rock-filled timber cribs, have been suggested. A discussion of these proposals is given in the report.

We shall be pleased to discuss any matters that may come to mind after you have reviewed the conditions at this site.

Thank you for the opportunity to be of service on this occasion.

Yours very truly,

*W. Trow*

William A. Trow, P. Eng.

WAT/kb  
ENC.

WILLIAM A. TROW AND ASSOCIATES LTD.

DEPARTMENT OF HIGHWAYS OF ONTARIO  
MATERIALS AND RESEARCH BRANCH  
PARLIAMENT BUILDINGS, TORONTO, ONTARIO

FOUNDATION INVESTIGATION  
PROPOSED CROSSING OF SMOKE RIVER  
HIGHWAY 60 -- PECK TOWNSHIP

Project: J426

Oct. 22, 1959

William A. Trow & Associates Ltd.

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a) Support of Abutments on Rock Fill	3
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ENCLOSURES

Plan Showing Borehole Locations and Soil Stratigraphy	Drawing 1
Borehole Logs	2 - 5
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FOUNDATION INVESTIGATION  
PROPOSED CROSSING OF SMOKE RIVER  
HIGHWAY 60 - PECK TOWNSHIP  
W.P. 221-59

This report describes the soils investigation carried out at the above site. The types of bridge foundation most suitable for the conditions outlined by this investigation are discussed in detail.

Description of Site

The Smoke River empties into South Tea Lake at the site of the proposed highway crossing. The new structure will actually be built in what is now South Tea Lake. Causeway approaches, leading from shore to the bridge, will be required.

The portion of Algonquin Park in which this site is situated lies in an area of heavy relief and virgin bushland. Steep hills and knolls surround the lake and river. The existing highway cuts through the side of one of these knolls a few hundred feet north of the site, exposing a high vertical face of rock. The banks and shore of the river and lake are strewn with large boulders. No bedrock is evident along the lake in the vicinity of the crossing but a small outcrop exists a short distance up the Smoke River.

The existing bridge is of timber pile construction with rock-filled cribs. This structure is some 120 feet long. Broken rock fill with a soil topping makes up the long approach from the north and the much shorter south approach to the existing bridge. This filling is of the order of 10 feet high above the lake with side slopes of about 1 to 1.

Field Work

A series of penetration tests was carried out along the recommended location line given in DHO Plan 1-B-588. They were made at 50 foot intervals across the water between the two shorelines. In this test a standard "A" rod, equipped with a hardened steel point was driven to refusal under an energy of 350 ft.lbs. per blow. The depth of water and the point of refusal has been plotted as a profile in drawing 1.

On completion of the penetration profile it was learned that the most probable line for the new highway had been shifted slightly to the west. This change evidently decreased the amount of rock cutting required on shore immediately north of the site. Accordingly, the four borings, put down on the probable location of the proposed structure, were based on this new line as staked by DHO. The locations of these borings are indicated in drawing 1.

Because of the boulder-strewn nature of the lake bed, operations in the four borings, consisted essentially of drilling and cleaning out standard BX casing. Whenever it appeared feasible, attempts were made to obtain a sample of the soil using a standard 2 inch O.D. split spoon. An energy of 350 ft.lbs. per blow was used to drive the sampler into the soil. In all cases but two the sampler reached refusal before penetrating  $1\frac{1}{2}$  feet.



Because normal sampling procedures proved impractical a standard AX coring bit and 5 foot barrel were drilled ahead of the casing. The type of core recovered, the amount of water return and the contents of the wash water were recorded. The results obtained by this procedure cannot be reported readily on the normal form of borehole logs. Because of this, a summary sheet has been prepared for each hole as shown in drawings 2 to 5. These summary sheets contain the descriptive logs of the borings and the numerous notes or remarks that were made as each boring progressed.

Lake elevation as provided by a DHO survey party on September 23rd was used to reference all borings. Corrections were made on a day to day basis for variations in lake level.

#### Soil Types Encountered

A heterogeneous mixture of gravel and boulders with sand lies under the lake at the proposed crossing. Refusal to the A rods was reached after very little penetration into this material (see drawing 1). Some samples were obtained of the thin layer of organic muck and gravel that form the lake bottom. Other than these, only short lengths of core were recovered from the coring bit probings into this overburden material. Observations made on the lake bottom indicated the average boulder size to be 2 feet although some stones ranged up to 3 feet.

Bedrock was encountered at relatively shallow depth in all but hole No. 2. In this instance very hard rock - thought to be a large boulder - was encountered at a depth of about 13 feet. After drilling nearly 4 feet, refusal to further progress was reached. In holes 1, 3 and 4 bedrock was met at 25 ft., 18½ ft. and 28 ft. respectively below lake level.

Estimated soil profiles, presented in drawing 1, are based on the information recorded in the boring logs.

#### Foundation Considerations

In view of the bouldery nature of the lakebed and the consequent difficulty experienced when boring and sampling below it, attempts to drive any type of pile to support the proposed structure will be unsuccessful. For the same reason it will be very difficult to place concrete abutments or piers "in the dry" since the lakebed will be too uneven for the formwork and the material is much too permeable for successful dewatering. It is conceivable that the concrete for abutments can be placed underwater although the placement of formwork will be difficult and considerable preparation of the footing base will be required.

From these discussions it is evident that some form of foundation, which bears directly onto the lake bed surface of gravel and boulders, will have to be resorted to. When choosing suitable construction methods consideration must be given to the facts that the lake bed slopes away from shore on a gradient of approximately 10 percent and that a thin veneer of organic muck, up to 2 feet thick, covers the gravel and boulders.

At least two methods of construction appear to be applicable for this site condition. One of these involves the support of the bridge abutments directly on the rock fill approaches; the other incorporates the use of rock-filled timber cribs. A brief discussion of some of the requirements for these two schemes is presented under the following subheadings:

a) Support of Abutments on Rock Fill The merits of this scheme are that the rock fill can be end-dumped from trucks up to and beyond the abutment site location by the same methods used in the construction of the causeway approaches. No preparation of the lake bed will be required since the organic muck either will be displaced or it will be squeezed up into the voids between the rock-fill. The horizontal fill pressures against the abutments will be much smaller than would be the case if support at lake bed level was required.

One of the uncertainties in this construction procedure is that the compressibility of the rock fill beneath the abutments will not be known. In addition the extent of filling required in front and on each side of the abutments must be determined. Assuming that the abutments are founded at or near existing lake level, the thickness of underlying rock fill will range from 8 to 13 feet. Conceivably, this material could be in a loose condition after it comes to rest in the water at the front of the causeway. The weight of additional fill may not alter this condition appreciably. Therefore some compactive effort will be necessary in order to ensure that the fill is brought to a dense stable state. Unfortunately little is known concerning the compactive effort required for heavy rock fill and therefore there will be no basis for controlling the contractor's operations.

Despite this uncertainty it seems reasonable to assume that a heavy weight dropped onto the fill will certainly produce a rearrangement of rock fragments into a denser state. It is suggested, therefore that the rock fill be compacted in the abutment areas by dropping a weight of about two tons from a height of approximately 10 feet onto it. This would be done when the fill is up to lake surface level. About 4 blows for each square foot of surface area are suggested although there is no factual basis for this recommendation. Since there is no satisfactory method of determining whether the rockfill will settle some additional amounts after the structure has been built, the bridge should be simply-supported.

Experience with the settlement of high rock fill dams in the United States may be of some use in estimating the order of movement to be expected at this location if no compaction is used. It has been found that unsluiced fill has settled as much as 5% of its height or more after placement while dams constructed of materials that have been monitored during placement, have only settled about 2% of their height. Assuming the latter condition to apply at this site a vertical movement of 2 to 3 inches could be expected for the 8 to 13 feet of fill under the abutments. Since the fill depths are the same at each abutment location, settlements should be of the same order at each end of the bridge. They should be quite small if the fill is compacted as suggested.

An analysis has been made to determine the stability of the abutments and their foundations when acted upon by the thrust of 16 feet of rockfill of the causeway approach to the bridge. This study was made in order to determine how much filling was required in front of the abutments. The results of the analysis, shown in drawing 6, indicate that the factor of safety against slope failure is approximately 1.17 when the fill extends 10 feet in front of the abutments. In these computations, the angle of internal friction of the fill was assumed equal to its angle of repose or about 36 degrees; the most critical circle was not determined.

This preliminary computation indicates that a considerable apron of rock fill will be required before the slope can be considered to be stable. Consequently it would seem that spill-through type abutments would be more suitable for this structure. With this arrangement horizontal pressures from the approach fill are not a matter of concern.

b) Rock-Filled Crips. In order to prepare for this type of abutment support the bottom of the lake must be cleared of muck and levelled or alternatively, the crib can be placed on a rock-fill pad. The advantage of the latter procedure is that no excavating equipment will be necessary and the organic muck can pass up to the voids of the rock. A pad of broken rock ranging from 1 to 5 feet thick should suffice to absorb most of the muck as well as to provide a level base over the width of the bridge. This rock pad should extend well beyond the outside perimeter of the crib.

It will be necessary to support the crib in an upright position as the initial filling program proceeds. It is assumed that the rock-fill pad will be quite uneven in these early stages. In order to provide a level firm base for the timber sides of the crib, it is suggested that the first two feet of fill consist of gravel. This material should be placed both inside the crib and around the outside of the crib walls. The gravel will tend to move under the timber sides at the locations where depressions in the rock fill exist and in this way a more uniform base for the support of the crib will be obtained. As rock fill is dropped onto it this gravel will be compacted and forced further into the voids between the rock. After the abutment cribs have been filled coarse gravel and then rock should be placed around their outside perimeter in order to prevent the possibility of undermining by river scour.

Assuming a horizontal pressure coefficient for the rock fill equal to 0.25, moist and submerged weights equal to 110 and 65 pcf respectively, it can be shown that a fill pressure just in excess of 10 kips per running foot will act against the crib. The crib must be 15 feet wide in order to keep the resultant forces within the middle third of its base.

Summary of Observations and Conclusions

Bedrock exists at depths ranging from about 18 to 28 feet below the lake surface at this site. It is overlain by 11 to 18 feet of boulders and gravel overburden. The boulders, from 1 to 3 feet in size, and the cobbles and gravel form a dense compact stratum. Boulders rise above the average lake bottom level and organic muck or sands fill the depressions between them.

Penetration of piles into the boulder-strewn lake bed will not be possible and therefore support for the bridge structure must be obtained at or above the bed of the lake.

Two types of bridge support are suggested. One scheme involves the placement of abutments directly on compacted rock fill at or just above lake level. Some small settlement may be experienced with this arrangement but this movement should not be detrimental to a simply supported bridge. The other proposal is to support the bridge deck on rock-filled timber cribs. Cribs 15 feet wide will be required to resist the horizontal pressures from the adjacent rock-fill causeway. Some preparation of the lake bed will be required with this arrangement.

DHS/kb  
Oct. 23, 1959  
J426



*D.H. Shields*  
D.H. Shields, P. Eng.

Hole 1 - Top of Hole at Elevation = 1371.2 (Lake Surface)

## Log

- 0 - 11½ - Water.  
 11½ - 13½ - Organic muck.  
 13½ - 25 - Gravel and boulders, little sand.  
 25 - 36 - Bedrock (granite).

## Notes

Refusal to sampling spoon at 14' 0".  
 Drilling AX core barrel 16' 0" to 17' 0", recover 8" boulder core.  
 Refusal to sampling spoon at 18' 3".  
 Drilling AX core barrel 18' 3" to 20' 1", recover 7" boulder core,  
 continuous "on pressure".  
 Refusal to cone point at 23' 9".  
 Drilling AX core barrel 23' 9" to 24' 11", recover 8" of gravel sizes.  

"	"	"	25' 1" to 25' 5",	"	4" of rock core.
"	"	"	25' 5" to 27' 11",	"	21" " "
"	"	"	27' 11" to 28' 9",	"	11" " "
"	"	"	28' 9' to 33' 11",	"	61" " "
"	"	"	33' 11" to 35' 11",	"	24" " "

Sampling spoon driven from 11½ to 13½ ft., blows required were 1-2-0-1  
 for 6 inches of penetration.

Little or no water return drilling ahead of casing to depth of 23½ ft.

Full water return drilling ahead of casing below 23½ ft.

Thin sand seam noted at 26½ ft.

93% core recovery in bedrock.

BOREHOLE LOG

Dwg. 3

Hole 2 - Top of Hole at Elevation 1371.6 (Lake Surface)

## Log

- 0 - 7½ - Water.  
 7½ - 8½ - Organic sand.  
 8½ - 16½ - Gravel and boulders with sand.

## Notes

Drill AX core barrel 10' 4" to 11' 5", recover 11" of boulder core.  
 " " " 11' 5" to 11' 7", " 2" " "  
 " " " 11' 7" to 11' 10", " 2" " "  
 " " " 11' 10" to 12' 8", " 6" " "  
 " " " 12' 8" to 15' 10", " 35" rock? core.  
 " " " 15' 10" to 16' 5" (two attempts) 1" recovery.

Sampling spoon driven from 7½ to 9 feet. Blows required were 0 - 1 - 16 for 5 inches penetration.

Full water return throughout except for 20% loss at 12½ feet.

Extremely hard drilling below 12' 8", virtual refusal to drilling at 16' 5".

BOREHOLE LOG

Dwg. 4

Hole 3 - Top of Hole at Elevation 1371.7 (Lake Surface)

## Log

- 0 -  $7\frac{1}{2}$  - Water.  
 $7\frac{1}{2}$  -  $18\frac{1}{2}$  - Boulders and gravel, little sand.  
 $18\frac{1}{2}$  -  $23\frac{1}{2}$  - Bedrock (Granite)

## Notes

- Drill AX core barrel 10' 5" to 15' 4", recover 13" of boulder core.  
" " " 15' 4" to 20' 4", " 37" of core (last 21" rock).  
" " " 20' 4" to 23' 5", " 31" of rock core.  
" " " 23' 5" to 23' 6", " 6" of rock core.

Lake bottom strewn with boulders.

Sand  $15\frac{1}{2}$  ft. to 16 ft.

Sand seams at  $16\frac{1}{2}$  ft. and 17 ft.

Full water return throughout.

98% core recovery in bedrock.

BOREHOLE LOG

Dwg. 5

Hole 4 - Top of Hole at Elevation 1371.7 (Lake Surface)

## Log

- 0 - 10 $\frac{1}{4}$  - Water.  
 10 $\frac{1}{4}$  - 10 $\frac{3}{4}$  - Organic gravel.  
 10 $\frac{3}{4}$  - 28 - Sand, gravel and boulders.  
 28 - 38  $\frac{1}{3}$  - Bedrock (granite).

## Notes

Drill AX core barrel 11' 10" to 12' 7", recover 6" of boulder core.  
 " " " 12' 10" to 13' 1", " 3" " "  
 " " " 13' 1" to 13' 4", " 3" " "  
 " " " 15' 8" to 16' 10", " 12" of broken core.  
 " " " 17' 3" to 18' 11", no recovery (sand and gravel).  
 " " " 19' 5" to 20' 5", recover 2" gravel size.  
 " " " 20' 5" to 27' 1", recover 20" of gravel & boulder core.  
 " " " 27' 5" to 28' 7", recover 7" of rock core.  
 " " " 28' 7" to 33' 6", recover 59" of rock core.  
 " " " 33' 6" to 38' 1", " 50" " "  
 " " " 38' 1" to 38' 4", " 4" " "

Sand and gravel noted from 13 $\frac{1}{2}$  ft. to 19 ft.

Sand in wash at 22 and 25 ft. and from 26 ft. to 27 ft.

96% core recovery in bedrock.

5 inches of core remained in hole at end.

Full water return throughout.



# STABILITY ANALYSIS

ROCKFILL EMBANKMENT ADJACENT TO BRIDGE ABUTMENTS

factor of safety = 1.17

Elev. 1388

Concrete Abutment

10' Apron

Elev. 1372

Lake Elev.  $\approx$  1369

Rock Fill

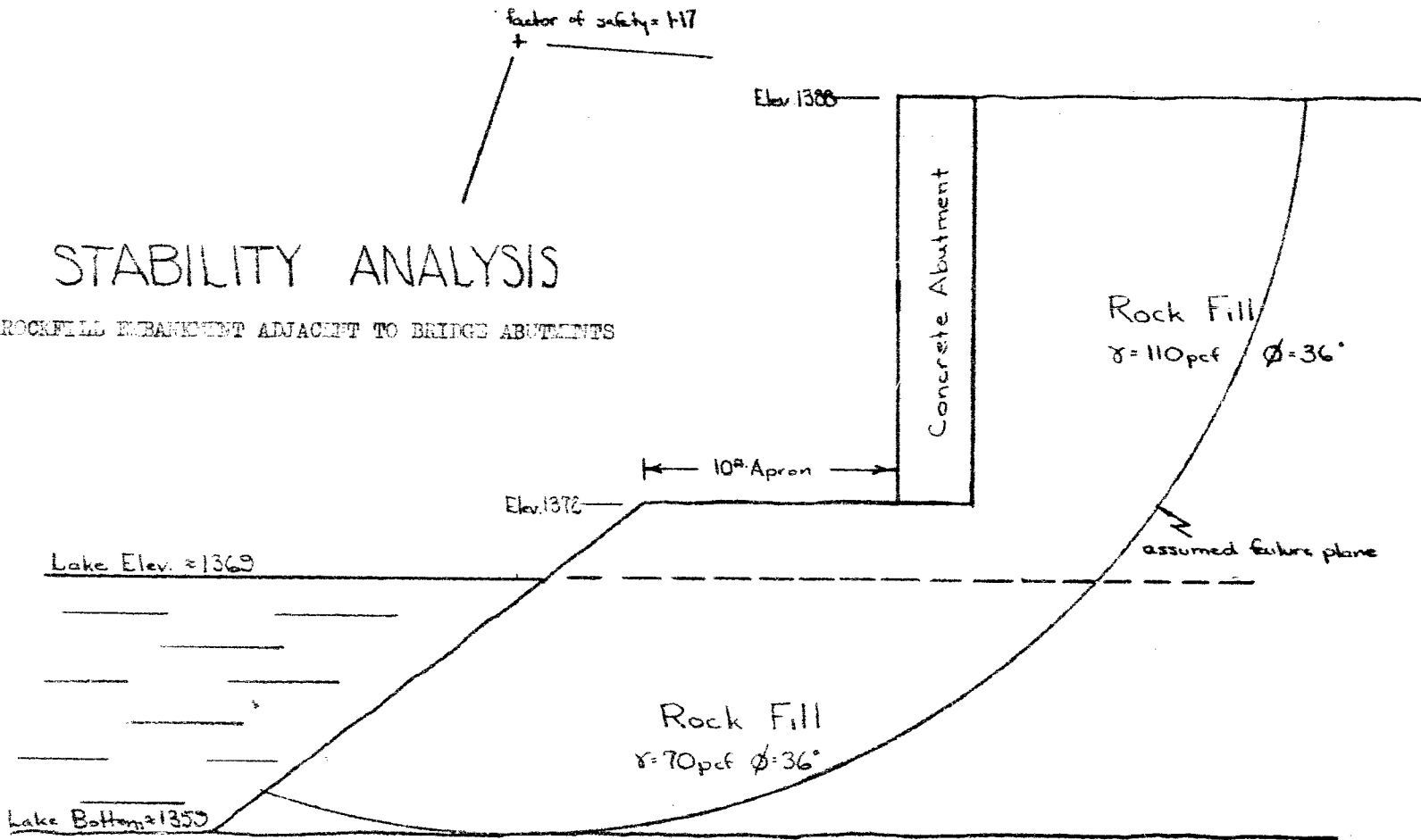
$\gamma = 110 \text{ pcf}$   $\phi = 36^\circ$

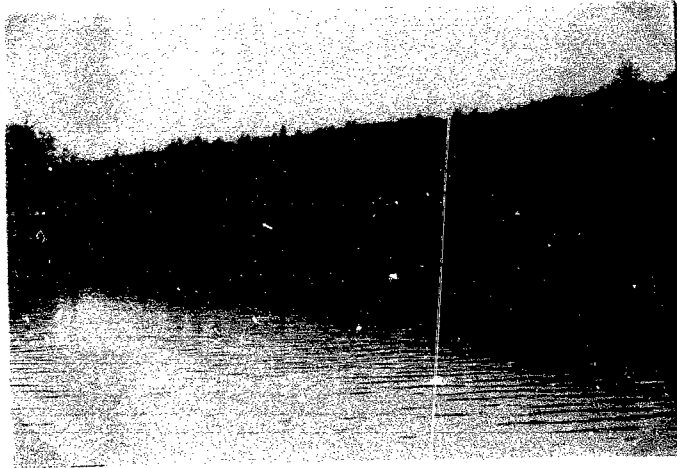
assumed failure plane

Rock Fill

$\gamma = 70 \text{ pcf}$   $\phi = 36^\circ$

Lake Bottom  $\approx$  1355





Existing Timber Bridge - Looking East



North West Corner of Existing Timber Bridge



Existing Timber Bridge - Looking East



North West Corner of Existing Timber Bridge



View Looking North along Line B  
Drill on Hole No. 4



Looking South along Line B  
Drill on Hole No. 4



View Looking North along Line B  
Drill on Hole No. 4



Looking South along line B  
Drill on Pole No. 4