COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/85

TREVALLYN BRIDGE SITE GEOPHYSICAL SURVEY, LAUNCESTON,

TASMANIA 1965

by

P.E. MANN

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/85

TREVALLYN BRIDGE SITE GEOPHYSICAL SURVEY, LAUNCESTON,

TASMANIA 1965

by

P.E. MANN

CONTENTS

ILLUSTRATIONS

Note. This Record supersedes Record No. 1965/153

SUMMARY

A seismic refraction survey was made at the request of the Department of Mines, Tasmania, to determine the river detritus thickness and the position of a major fault close to a bridge site at the mouth of Cataract Gorge, Launceston.

The seismic survey confirms what was suspected from geological evidence, i.e. that the fault strikes across the mouth of the gorge about 360 feet downstream from, and approximately parallel to, Kings Bridge. On the left (north) bank it is about 100 feet downstream from the area where the bridge will possibly be founded, and on the right bank about 180 feet. Rock with a seismic velocity of 18,000 ft/s, suitable for foundations, is covered with about 40 feet of river detritus on the left bank, but probably crops out on the right bank at the same level.

Resistivity traversing shows that apparent resistivity values are higher upstream of A33 than downstream. No quantitative interpretation of the resistivity measurements is attempted.

Test drilling is recommended at three places on the left bank.

1. INTRODUCTION

To alleviate traffic congestion at the West Tamar outlet road from Launceston, the Public Works Department (PWD) of Tasmania proposes constructing another bridge across the mouth of Cataract Gorge downstream of the existing old and narrow King's Bridge. Although the bridge design is not finalised, an arch structure will be used if possible for aesthetic reasons. The approximate co-ordinates of the site are 503/895 on the Launceston sheet of the Australia 1:250,000 map series.

The Department of Mines, Tasmania, is carrying out the geological investigation of the bridge site for the PWD. The Department of Mines requested the Bureau of Mineral Resources, Geology and Geophysics, to make a geophysical survey to determine the depth to bedrock on the banks and across the river and to locate the position of a major fault close to the bridge site in order to assist them in drawing up a programme of test drilling at the site. The work was done between the 16th and 25th February 1965 by a party consisting of P.E. Mann (party leader), J.P. Pigott (geophysical assistant), and four field-hands supplied by the PWD. Survey work was done by surveyors from the North East District Office of the PWD, Launceston.

2. GEOLOGY

An interpretation of the major faulting and joint systems responsible for the recent development of the topography of Cataract Gorge is given by Carey (1947). Further information is given by Gill (1962). On the Launceston sheet of the 1-mile geological series published by the Department of Mines, a major fault, the Trevallyn Fault, downthrown to the north-east, truncates the gorge. From the geological work, foundations for the proposed bridge on the left bank are expected to be close to the edge of the fault; on the right bank the foundations can probably be sited on sound dolerite (Longman, pers. comm.)

The South Esk river has incised a deep gorge in Jurassic dolerite and upstream of King's Bridge the gorge walls are almost sheer. Downstream, the river broadens and dolerite crops out at water level on the right bank to about Traverse F (Plate 1); the left bank is covered by talus and river detritus.

In this record, bedrock is defined as the highest velocity refractor recorded on normal spreads; the term overburden is applied to material above the bedrock.

3. METHODS AND EQUIPMENT

Seismic refraction and resistivity methods were used.

The seismic method

The seismic method is described by Polak (1962a). Three different techniques were used on this survey as described below.

Method of differences. In this technique, used on Traverses A, B, C, H, and K, charges are detonated at different distances from each end of a spread of geophones or hydrophones and in line with it.

It was possible to select shot-points only at one end of the spreads on Traverses H and K to determine the velocity of the near-surface material. On Traverses A, B, and C, small charges were detonated on the river bed beneath, or within about 25 feet of, the end hydrophones to determine the seismic velocity of the river detritus. The velocity measured was 5500 ft/s. The same velocity was also found for water-saturated detritus on Traverses G, H, J, and K, by detonating charges 25 feet from one end of each of the traverses.

To record refractions from the bedrock on Traverse A, B, and C, two shot-points were used, viz. one about 350 feet upstream from King's Bridge and centred in the gorge; the other 1550 feet downstream from the bridge and adjacent to the Tamar Yacht Club floating jetty. The shot-points were in line with Traverse A and approximately in line with Traverses B and C. The upstream shot-point was also used for Traverse K. The geophone spacing was 25 feet for both land and water traverses.

This technique gives more accurate results than the other two used (described later) if the near-surface velocities are known. Although the near-surface velocity was found by shots from only one end of each of Traverses H and K, the depth to bedrock on Traverse H is considered to be more reliable than for Traverse K. On Traverse H, which was surveyed at low tide, the water-saturated river detritus probably has a seismic velocity of about 5500 ft/s at each end of the spread, and the apparent velocity was assumed to be constant along the spread. On the other hand, part of Traverse K was on ground above the water level. It was not practicable to use short weathering spreads to determine the near-surface velocities on Traverse K and the apparent velocity determined at K17 was used to calculate the depth to bedrock for the whole traverse.

It was not possible to use this technique for all the traverses because of the difficulty of locating shot-points in the built up area.

Step-out-time technique. This was used where it was possible to shoot at only one end of the spread, i.e. on Traverses G, J, and J'. The theory is given by Polak (1962b). The accuracy depends on two assumptions made, viz. that the velocity of the main refractor is constant and known, and that the average velocity of the overburden between the main refractor and the surface remains the same throughout the spread. The second assumption is probably not valid on Traverses G, J, and J', where the overburden changes along the traverses from water-saturated detrital material to unsaturated material. Thus the depth to bedrock may be in error by about 20 percent near the river, but may be less accurate away from the river.

Broadside technique. This was used on Traverses D, E, and F, where it was not possible to shoot at either end of the spread, i.e. the shot-point was offset at right angles to the spread. A charge was detonated at the upstream shot-point for each traverse. The same assumptions are made as with the step-out-time technique. Further, velocities cannot be measured, but must be determined from nearby normal spreads. The assumptions that the velocity of the main refractor is constant might not be completely true because of the joint system in the gorge.

The seismic equipment used was a portable 12-channel refractor seismograph type P19 manufactured by South-western Industrial Electronics Co., Houston, Texas. TIC geophones of natural frequency of about 20 c/s were used on Traverses G, H, J, J', and K. EVP-5 pressure type hydrophones, manufactured by Electro-Technical Labs., Houston, Texas, were attached to a cable floated by plastic buoys and suspended about three feet below the water surface on Traverses A, B, C, D, E, and F.

Hydrophone spreads approximately parallel and perpendicular to the river were anchored to the banks, King's Bridge, or mooring buoys in the river. The position of the hydrophone spread was measured wherever practicable from known survey points on both banks or determined by surveyors using theodolites. On Traverse A, the positions of stations A24 to A35 were calculated from the arrival time of the direct water wave from small charges detonated at surveyed shot-points.

The tidal variation of the river was recorded by visually observing a temporary tide gauge (see Plate 1) attached to a pile near the Tamar Rowing Club building. A correction was applied to the water depth contours to allow for the tide, which had a range of up to 11 feet. The tide gauge was surveyed in to the survey datum.

In this survey, because charges were detonated on the river bed and the hydrophones were floated about three feet below the water surface, it is necessary to refer all times used in the calculations to a reference datum. For convenience, the river bed was selected as reference datum and all travel times were reduced by a small correction (Mann, 1964).

In the U-shaped gorge a hydrophone spread close to the water surface would record refracted first arrivals from that part of the bedrock surface which, by the geometry of the U-shaped section, is closest to the spread. The refracted first arrivals could originate from either wall of the gorge (as is probable for Traverses B and C) or from some point of the unweathered bedrock beneath the river detritus (as is probable for Traverse A). However, in each instance, this information does not indicate the depth to bedrock but defines a minimum distance to the refractor from the hydrophone. For convenience, these distances are plotted as ordinates below the datum in the form of a cross-section in Plate 2.

Similarly on Traverse D, E, and F, refracted first arrivals from charges detonated broadside to the traverses define a minimum distance to the refractor from the hydrophone. Hydrophone stations close to the intersection points of Traverses A, B, and C, with Traverses D, E, and F probably record arrivals from the same point of the refractor boundary because a common shot-point was used. The minimum distances to bedrock given by broadside shooting are relative values only. The distance must be determined at one of the hydrophones either from drill hole information or by reference to a hydrophone on a normal spread. Hydrophones on Traverse A were used as a reference to calculate the minimum distance of the bedrock from hydrophones on Traverses D, E, and F; the results were checked at the intersection points of Traverses B, C, G, and K. On Traverses D, E, and F, each bedrock profile is drawn as a smooth curve through a set of arcs (not shown in Plate 2). Each arc was centred at the hydrophone and represented the minimum distance to the bedrock. The minimum distance shown on the cross-sections actually represents the minimum distance between bedrock and hydrophone in three dimensions.

Similar considerations have to be applied to interpret the seismic velocities measured on Traverses A, B, and C. Geological evidence suggests a shear zone in the bedrock of the gorge. Seismic energy transmitted through unsheared dolerite with a higher velocity than through sheared dolerite would arrive earlier at a hydrophone. Thus, if there is a relatively wide shear zone in the bedrock of the gorge and the siesmic velocity measured on Traverses B and C is high, the first arrivals probably originate from unsheared bedrock, i.e. possibly the walls of the gorge. On Traverse A there is probably a greater chance of first arrivals originating from the shear zone. However, if the shear zone is narrow, first arrivals on each traverse could originate from any part of the unsheared bedrock, and it could remain undetected.

The resistivity method

The resisitivity method used on this survey is referred to as 'resisitivity traversing' (Dobrin, 1952, p. 297).

Unweathered dolerite usually has a high resistivity, but dolerite in a shear zone has a low resitivity. The river detritus, silt, sand, and gravel and sedimentary rocks such as sandstone, siltstone, and shale have a low resisitivity. The seismic work had indicated a shear zone near A_{28} and that the river detritus, relatively thin along most of Traverse A, thickened near A35 (Plate

2). Hence resistivity traversing was used in an attempt to disclose the shear zone in the bedrock or the thickening of the detrital material or both. A symmetric four-electrode system and marker buoy were trailed along the river bed from a boat. The spacing between potential and current electrodes was 16 feet and between the current or outer electrodes 300 feet. Measurements were taken with a "Tellohm" resistivity meter. The position of the marker buoy was observed by surveyors on traverses between the upstream and downstream shot-points and approximately along Traverse A. The resistivity profiles show a small and gradual decrease in apparent resistivity, approximately near A33. Upstream of A33 the apparent resistivity values are higher than downstream. Unfortunately, some of the resistivity stations were not observed by the surveyors. No quantitative interpretation of the resistivity measurements has been attempted.

4. RESULTS

Table 1 shows the characteristic velocities of the longitudinal seismic waves observed for the different media.

TABLE 1

Characteristic velocities of the different media

Rock type	Seismic velocity (ft/s)
Water	5000
River detritus	5500
Dolerite bedrock in shear zone	10,000 to 11,000
Unweathered dolerite bedrock	18,000

The seismic results are shown as cross-sections in Plate 2. On Traverses A, B, C, H, and K the bedrock is deeper at the downstream end of the traverses than upstream. On Traverses H and A, the depth increases sharply near H7 and probably near A31, respectively, but on the other traverses the increase in depth is gradual near B3, C8, and K13. The depth to the bedrock at A35 is estimated from the intercept time of the time/depth curve for the charge detonated at the Yacht Club. Between stations A33 and A35, first arrivals were recorded from the bedrock for the upstream shot but not for the downstream shot.

On Traverses A and H the seismic velocity decreases markedly near A23 and H9 from about 18,000 ft/s to 11,000 ft/s. The time/depth curves for Traverses B, C, and K suggest that the seismic velocity of the bedrock is lower near B2, C11, and K16, i.e. that Traverses B, C, and K terminate at the edge of a shear zone. However, Traverses B, C, and K do not extend far enough to give the seismic velocity or width of the shear zone.

These factors indicate the presence of a shear zone accompanied by a sudden increase in the depth to the bedrock approximately along the line joining K16, C11, A22, B3, and H7. This result agrees reasonably well with the strike and position of the Trevallyn Fault interpreted from geological work.

The seismic velocity on Traverses A, B, and C is 18,000 ft/s, indicating sound rock beneath the river. However, a narrow shear zone could be present in the bedrock but remain undetected owing to the unfavourable geometry of refractor and hydrophone.

On Traverse J the bedrock is about 40 feet deep between J1 and J4. Between J4 and J8 there is a pronounced dip in the bedrock profile; the remainder of Traverses J and J' suggests that the depth to bedrock decreases towards J11 and J'11.

5. CONCLUSIONS

On the right bank the bedrock is shallow and will probably provide a sound foundation for a bridge. On the left bank the depth to bedrock is about 40 feet and the foundation of an arch bridge would have to be sited on bedrock close to a major fault. A narrow shear zone may exist in the gorge and the possibility of the relative movement of the abutments should be considered in the bridge design.

To check the seismic results and the quality of the bedrock, test drilling is recommended near H1, H7, and J4.

6. REFERENCES

CAREY, S.W.	1947	Geology of the Launceston District, Queen Victoria Museum, Launceston, Records 2, (1).
DOBRIN, M.B.	1952	Introduction to Geophysical Prospecting. New York, McGraw-Hill Book Co. Inc.
GILL, E.D.	1962	The geology of Tasmania-Cainozoic non-marine succession. J. Geol. Soc. Aust. 9(2), 236-237.
MANN, P.E.	1964	Pieman River seismic reconnaissance survey, Tasmania 1962. Bur. Min. Resour. Aust. Rec. 1964/83.
POLAK, E.J.	1962a	Railton geophysical survey, Tasmania 1959-60. Bur. Min. Resour. Aust. Rec. 1962/181.
POLAK, E.J.	1962b	Queen Victoria Hospital site seismic survey, Launceston, Tasmania 1961. Bur. Min. Resour. Aust. Rec. 1962/180.

PLATE 1

Based on Department of Public Works Plan 4692-1/P2, 4692-2/P1 and Launceston Flood Protection Board Plan No 1102

LAUNCESTON, TAS. 1965

TREVALLYN BRIDGE SITE, GEOPHYSICAL SURVEY

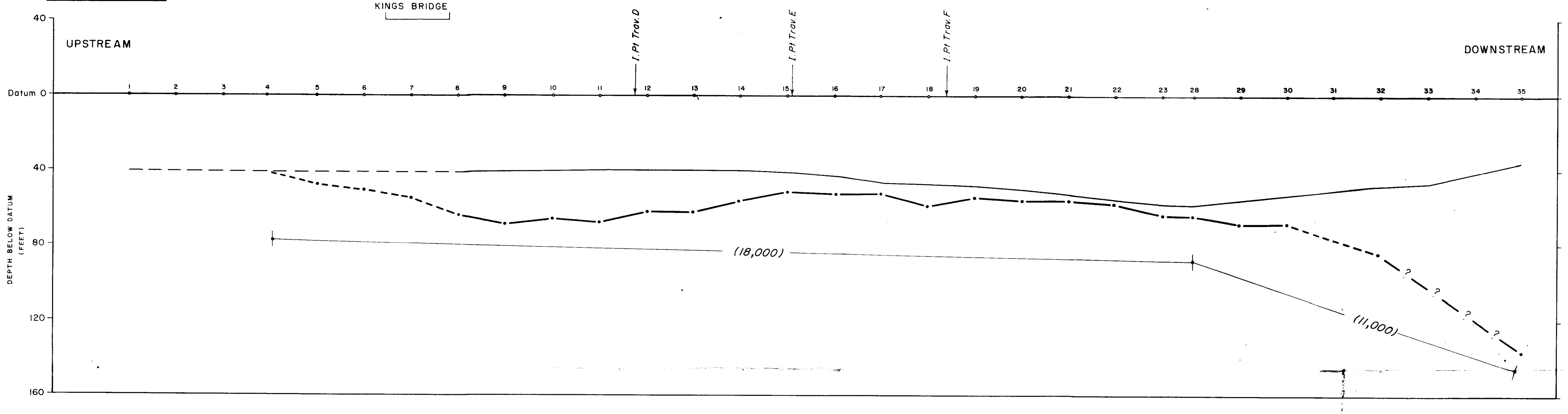
LOCALITY MAP, SEISMIC TRAVERSES AND WATER DEPTH CONTOURS

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B5-80

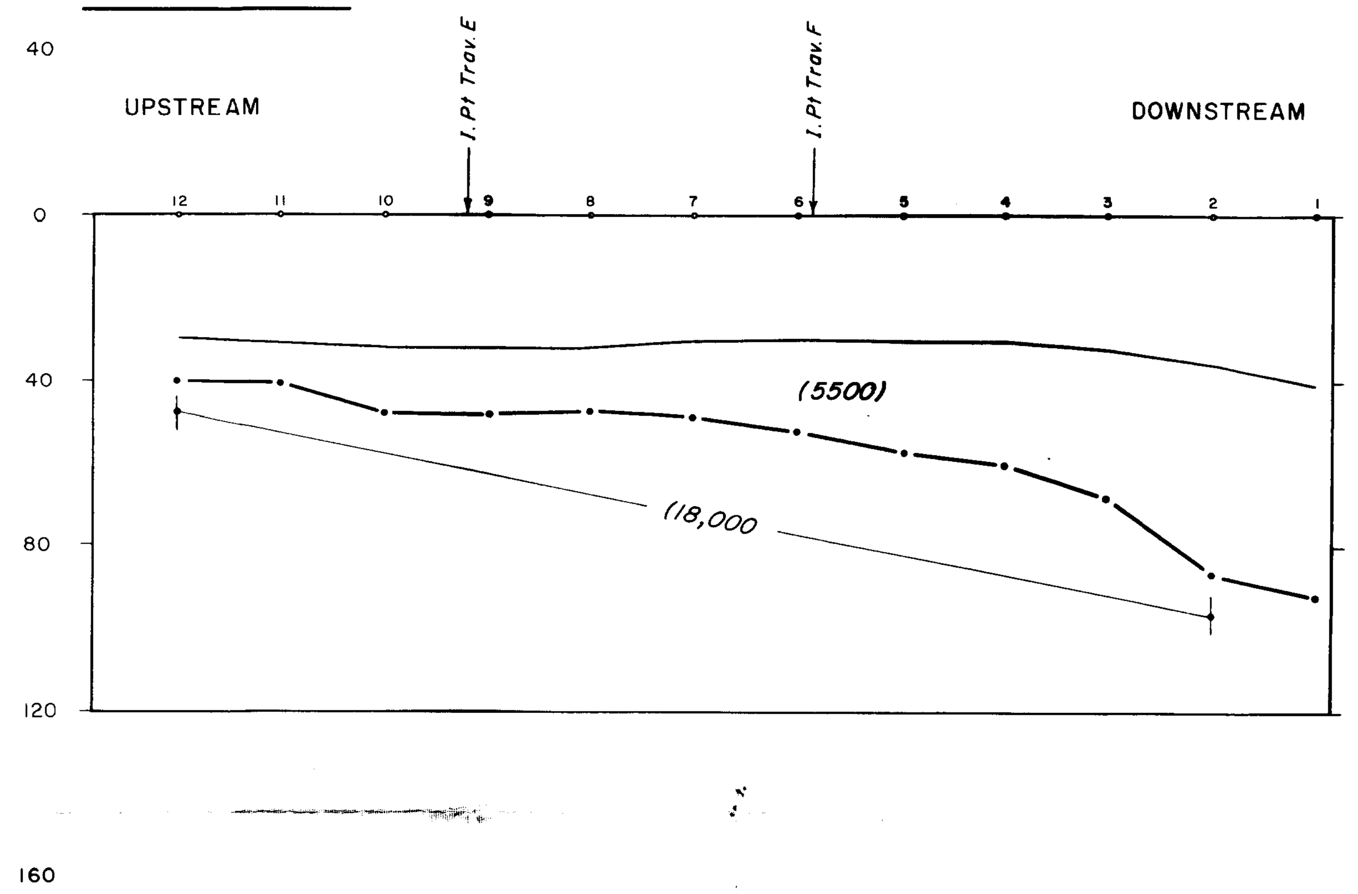
TO ACCOMPANY RECORD NO. 1966/85

SEISMIC CROSS-SECTIONS

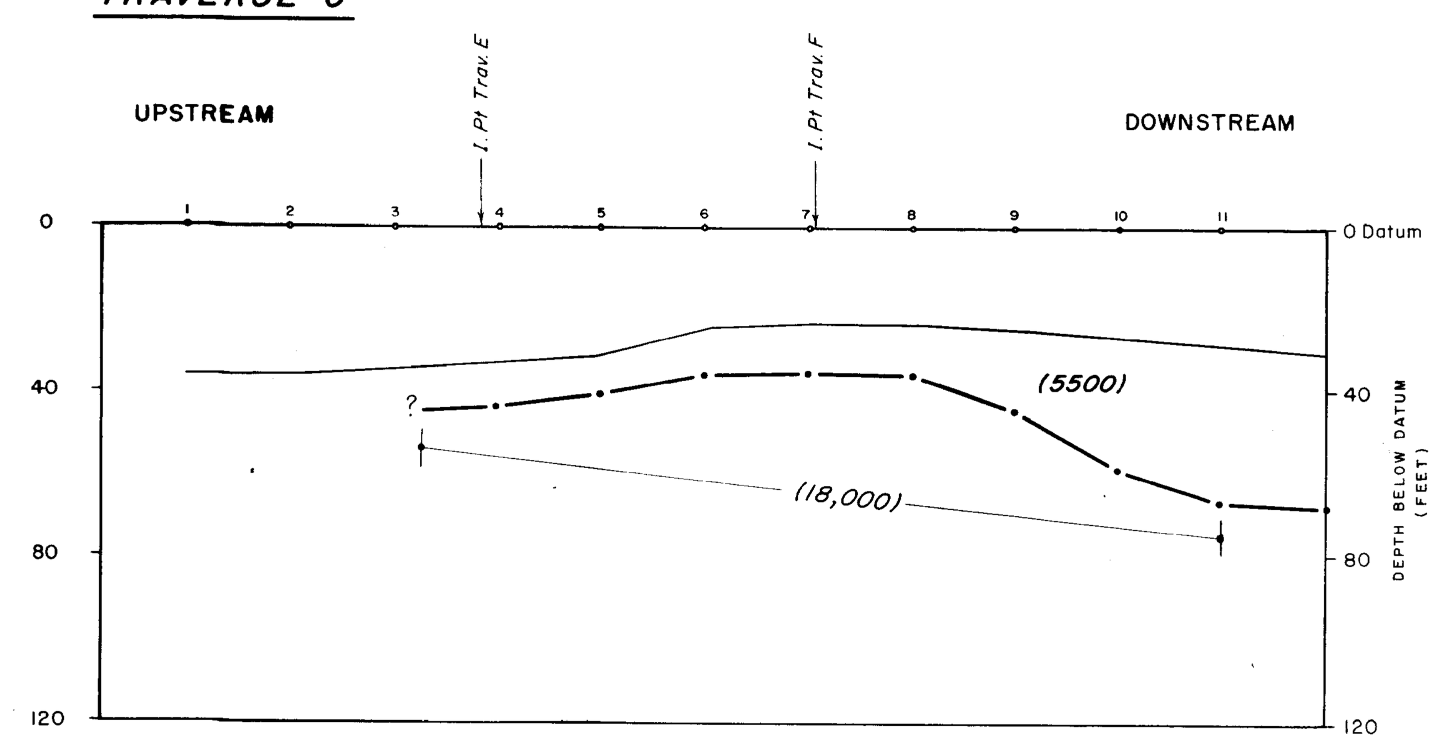
TRAVERSE A



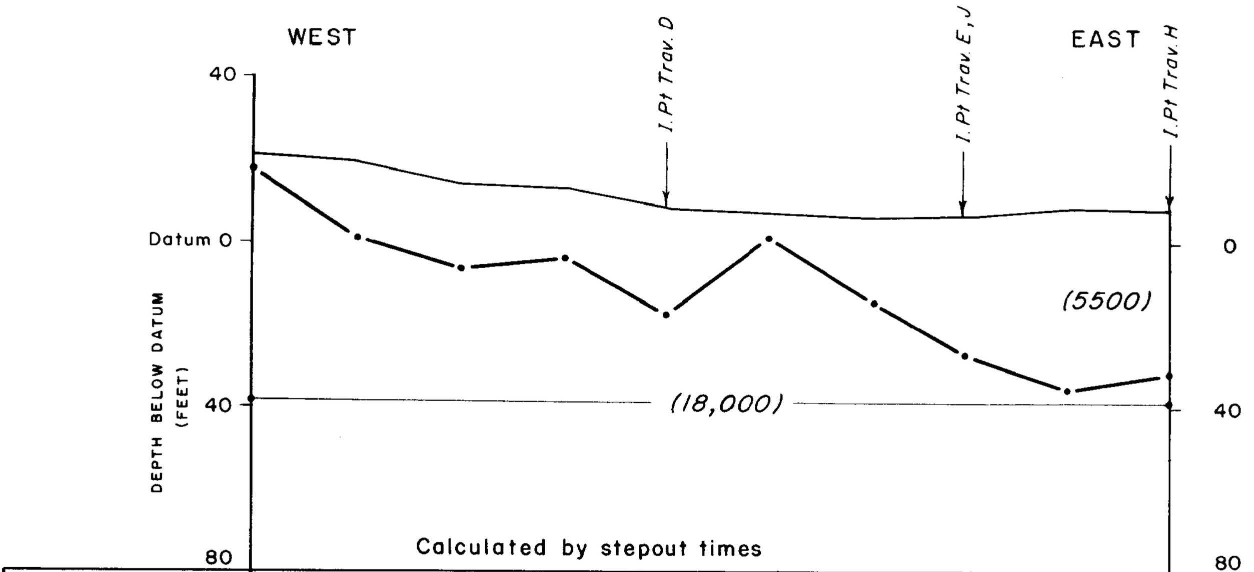
TRAVERSE B



TRAVERSE C

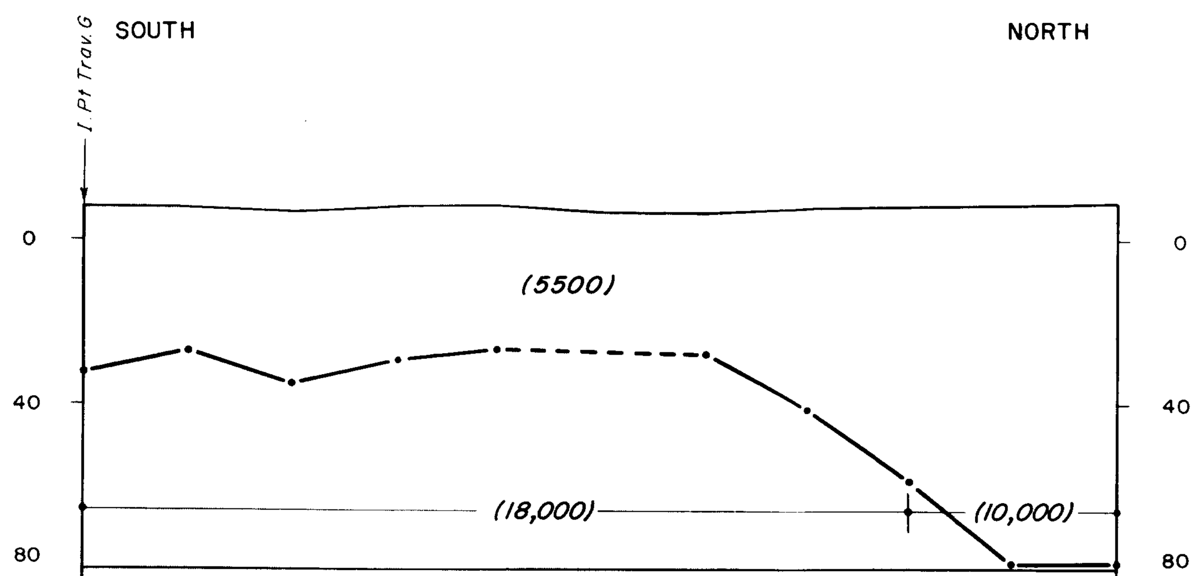


TRAVERSE G



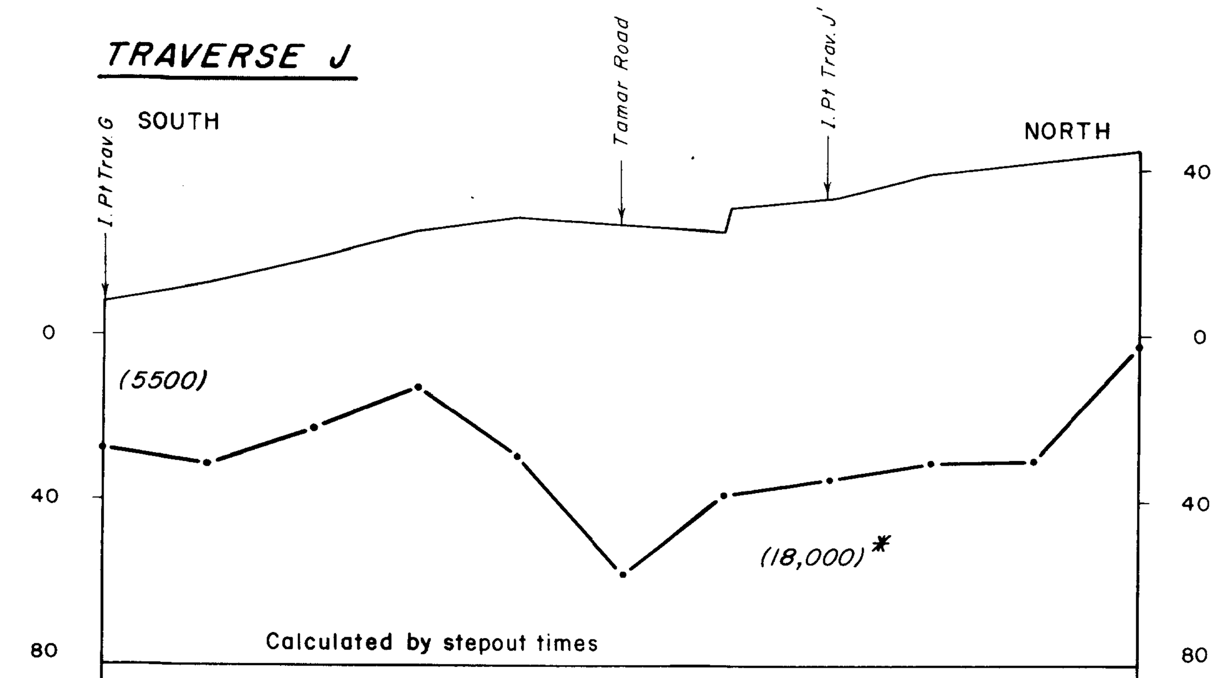
STATION NUMBER	10					5				1
STATION ELEVATION	20	19	14	13	8	7	6	7	8	8
DEPTH TO BEDROCK	3	18	21	18	26	6	21	35	44	41

TRAVERSE H



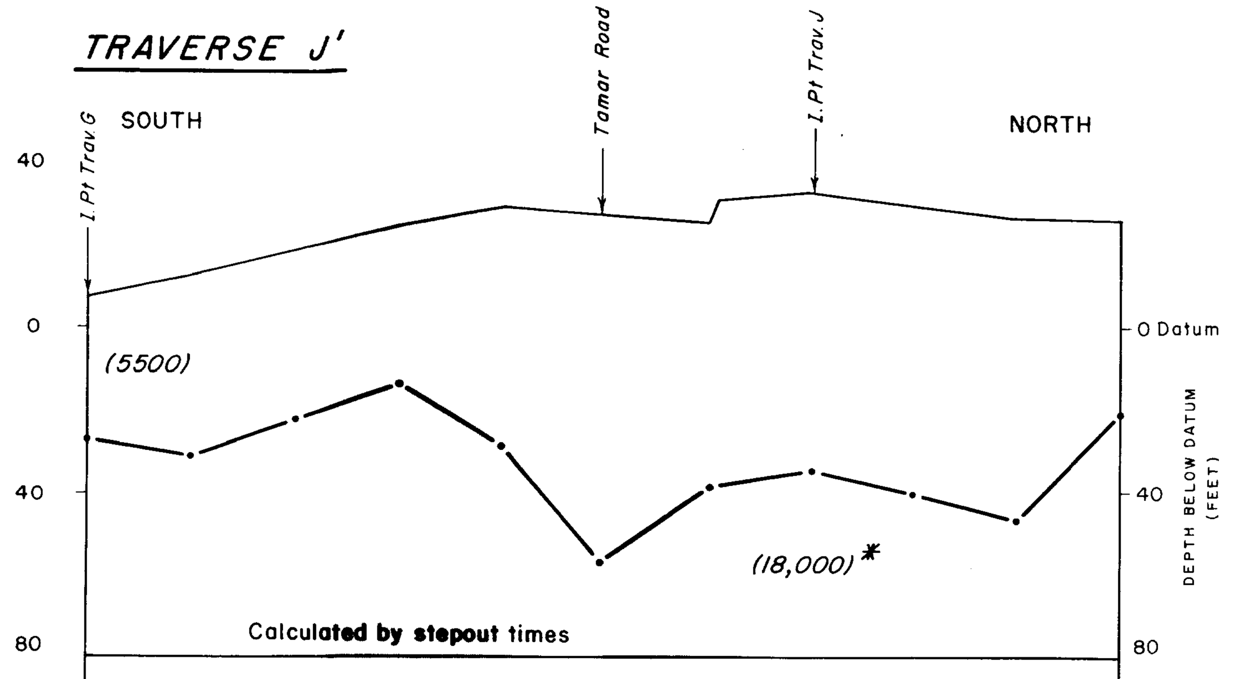
STATION NUMBER	1				5					10	11
STATION ELEVATION	8	7	6	8	8	6	6	7	8	8	9
DEPTH TO BEDROCK	41	35	41	38	35		35	49	67	87	89

TRAVERSE J



STATION NUMBER	1				5					10	11
STATION ELEVATION	7	12	18	24	28	(26)	25	33	39	42	45
DEPTH TO BEDROCK	35	44	41	38	58	84	64	68	70	73	47

TRAVERSE J'



STATION NUMBER	1				5					10	11
STATION ELEVATION	7	12	18	24	28	(26)	25	33	29	26	26
DEPTH TO BEDROCK	35	44	41	38	58	84	64	68	70	73	47

LEGEND

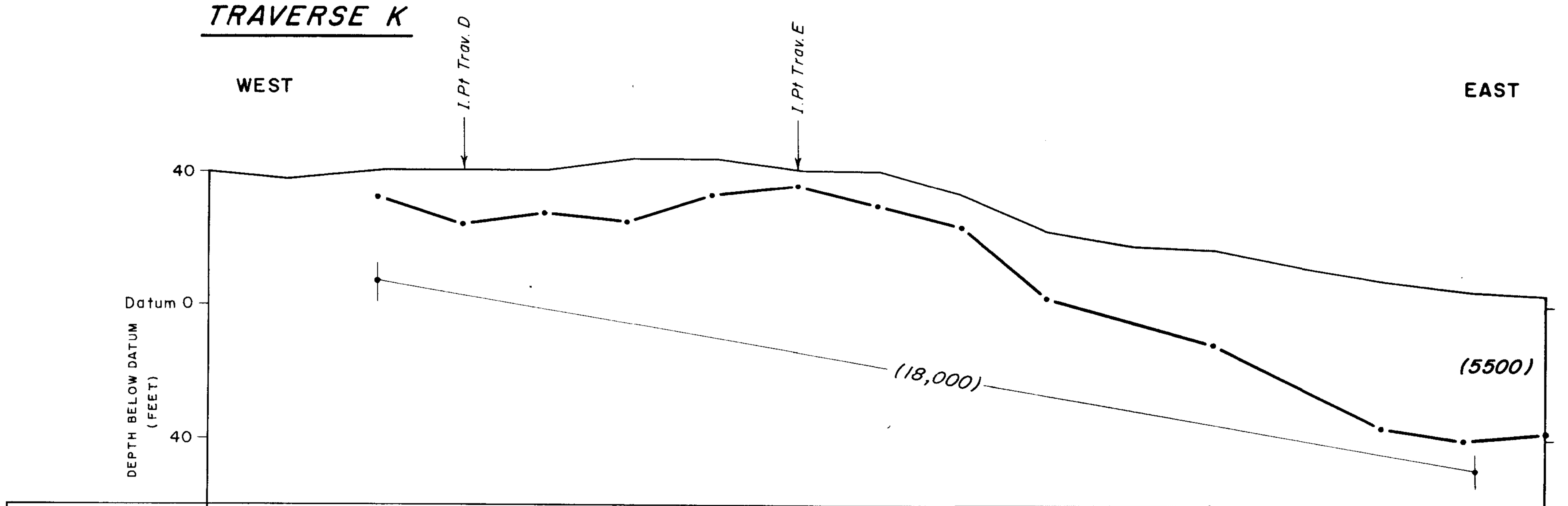
- Highest velocity refractor boundary
- Interpolated highest velocity refractor boundary
- (5500) Seismic velocity (ft/s) in formation
- (18,000)* Assumed velocity of highest velocity refractor

FEET 40 20 0 40 80 120

(Horizontal and Vertical)

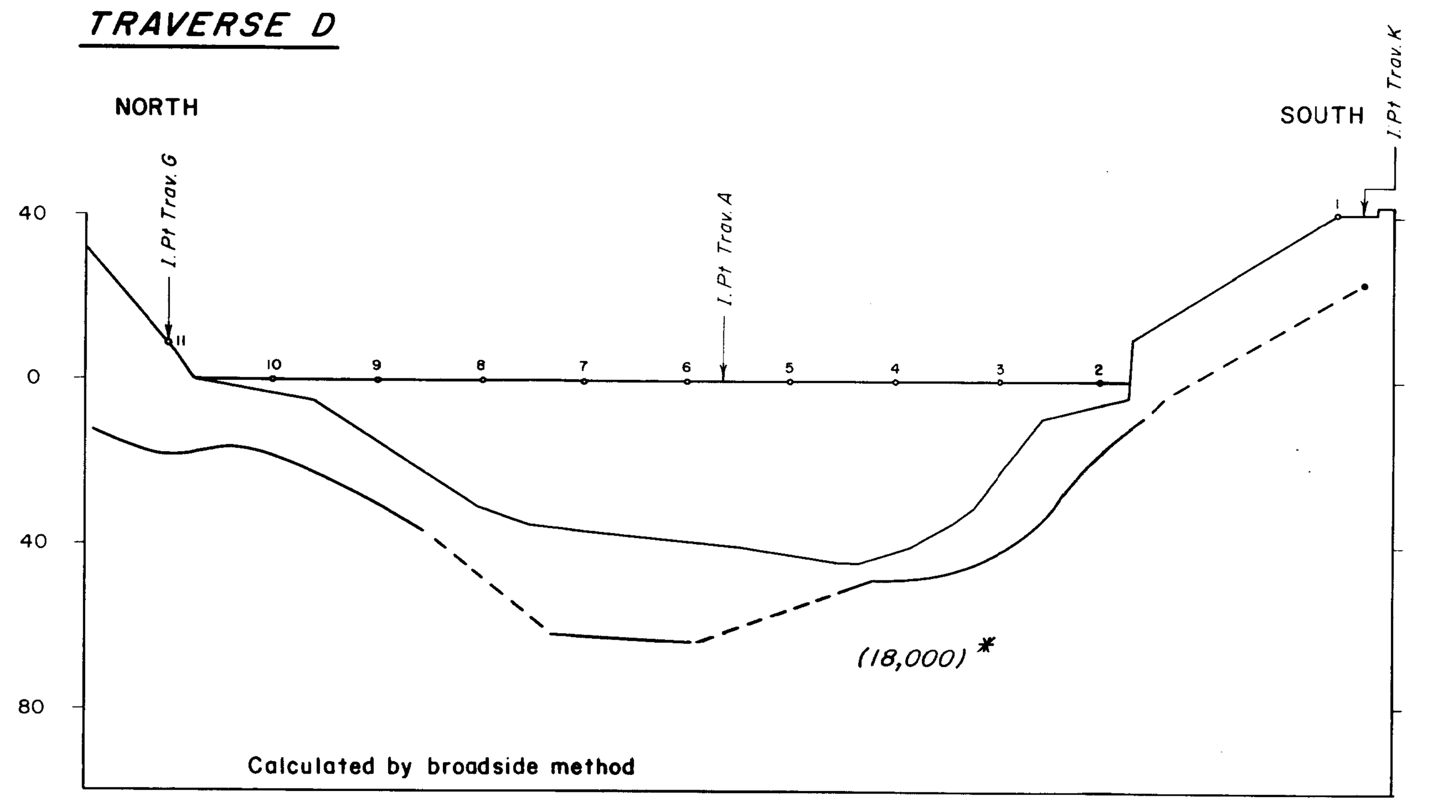
Level Datum: Launceston City Council datum

TRAVERSE K

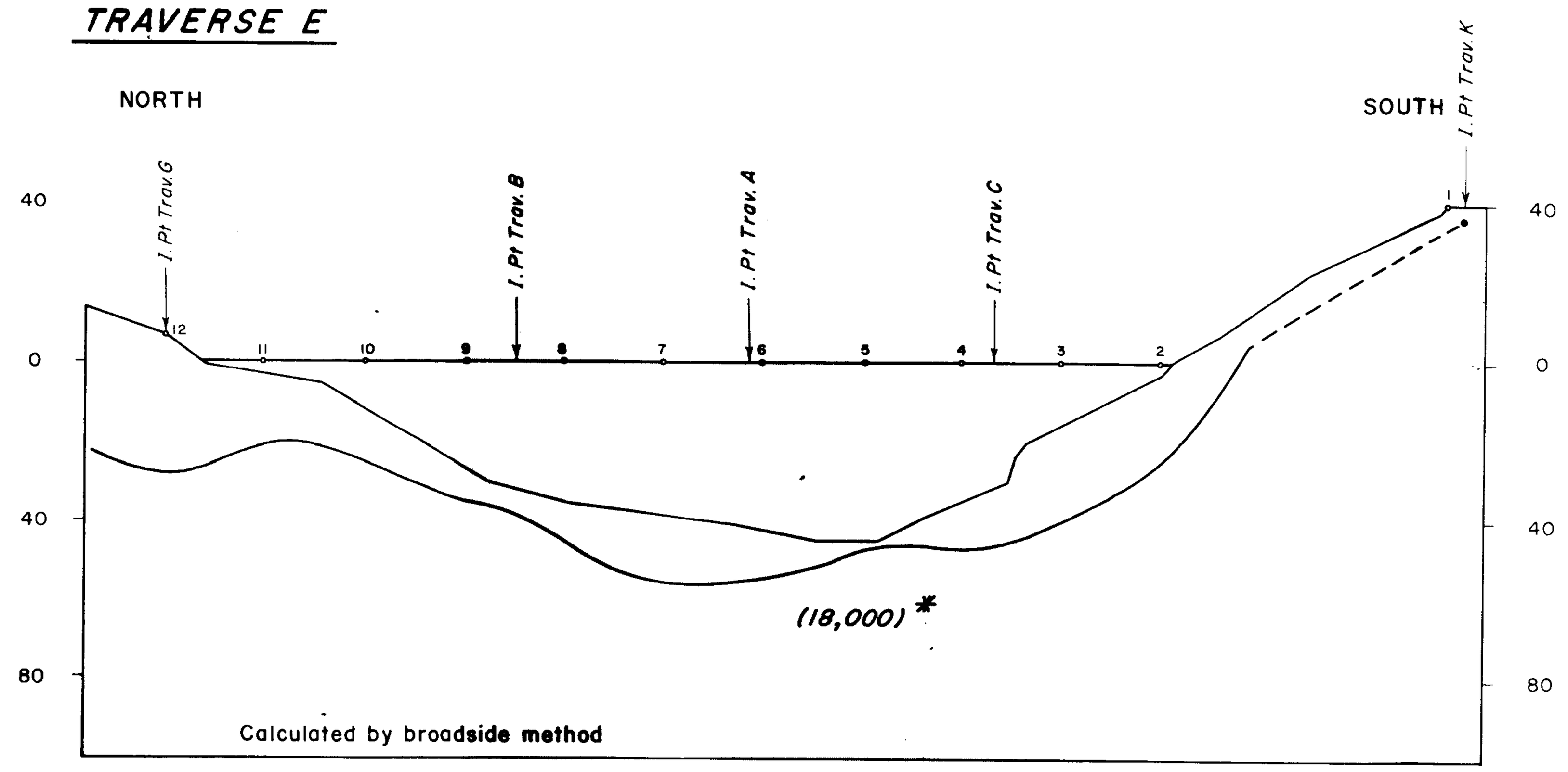


STATION NUMBER	1				5					10					15		17
STATION ELEVATION	40	39	41	41	41	44	43	41	40	33	22	18	17	12	7	5	3
DEPTH TO BEDROCK			9	17	14	19	10	6	10	10	20		29		44	46	41

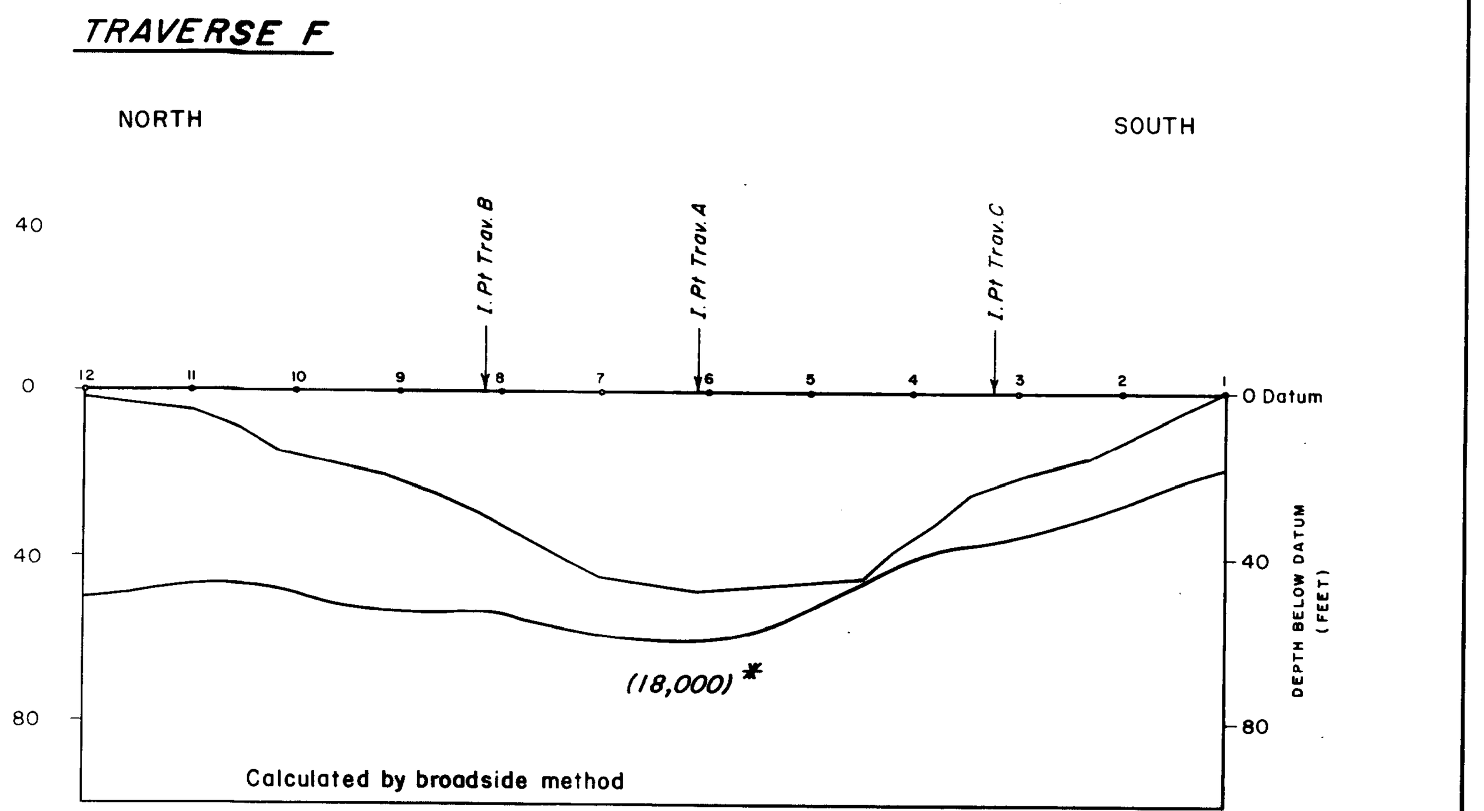
TRAVERSE D



TRAVERSE E



TRAVERSE F



GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B5-81

TO ACCOMPANY RECORD NO. 1966/85