COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1959 No.80

SEISMIC RECONNAISSANCE SURVEY AT THE HELL'S GATE DAMSITE PIEMAN RIVER, TASMANIA

BY

E.J. POLAK and F.J. MOSS

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C O N T E N T S

PLATES

ABSTRACT

Details and results are given of a seismic refraction survey, made in response to an application from the Hydro-Electric Commission of Tasmania, to investigate a proposed site for a dam at Hell's Gates. The dam is to be a part of the Pieman Power Development Scheme.

The purpose of the survey was to determine the thickness of detritus in the river bed in order to assist in a preliminary assessment of the suitability of the site for the erection of the dam. The thickness of detritus on the proposed dam axis was found to be less than 15 ft. but at a distance of 200 feet upstream, it increased to a maximum measured thickness of 55 ft.

It is considered that the error in the calculated thickness of the detritus is not more than ± 15% of the true thickness.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania proposes to erect a dam on the lower reaches of the Pieman River, as part of the Pieman Power Development Scheme.

Two possible sites for the dam have been chosen by the Commission for investigation. One is at Hell's Gates, approximately 6 miles upstream from the Pieman Heads, and the other is about 21 miles further upstream, at Stringer's Creek.

At Hell's Gates the gorge is narrower and the river valley sides steeper than at Stringer's Creek, while several outcrops provide evidence of good foundation rocks. The selection of one site rather than the other depends largely upon the thickness of detritus which overlies suitable foundation rock at the river bed. Drilling at Hell's Gates beneath tidal water, frequently rough and with a maximum depth of over 120 ft. would be difficult. The Commission therefore requested the Bureau of Mineral Resources, Geology and Geophysics, to conduct a geophysical reconnaissance survey to determine the approximate thickness of the detritus at the bottom of the river, so that a preliminary assessment of the site might be made.

The survey was carried out in February, 1958, by a geophysical party consisting of E.J. Polak (party leader) and F.J. Moss, geophysicist. The Commission provided additional assistants and did the required topographical surveying.

It is desired to acknowledge the assistance given by H.E.C. geologists and surveyors and Mr. Hawkes and his staff.

2. GEOLOGY

The site of the proposed dam at Hell's Gates is in a steep sided gorge of the Pieman River on the southern slopes of Mt. Donaldson, between the mouths of the Savage and Donaldson Rivers. The only access to the site is by water from Corinna (approximately 9 miles upstream). The location of the damsite is shown on Plate 1.

The geology of the area has been described by Spry and Ford (1957).

The proposed damsite is located on Donaldson Beds of Precambrian age, which consist of quartzite, conglomerate and black slate.

The northern (right) bank of the river consists of quartzite interbedded in the thin beds of phyllites. The quartzites are both well-bedded and massive and generally white in colour. The phyllites are grey to cream and consist of fine grains of quartz, muscovite and biotite. In the area of the proposed dam the beds dip steeply upstream.

The southern (left) bank of the river consists mostly of beds of conglomerate. The boulders are mostly of quartzite and are well rounded; the matrix is argillaceous.

3. METHODS AND EQUIPMENT

The seismic refraction method of exploration was used in the survey of the Hell's Gates damsite. This method depends on

FIG. I

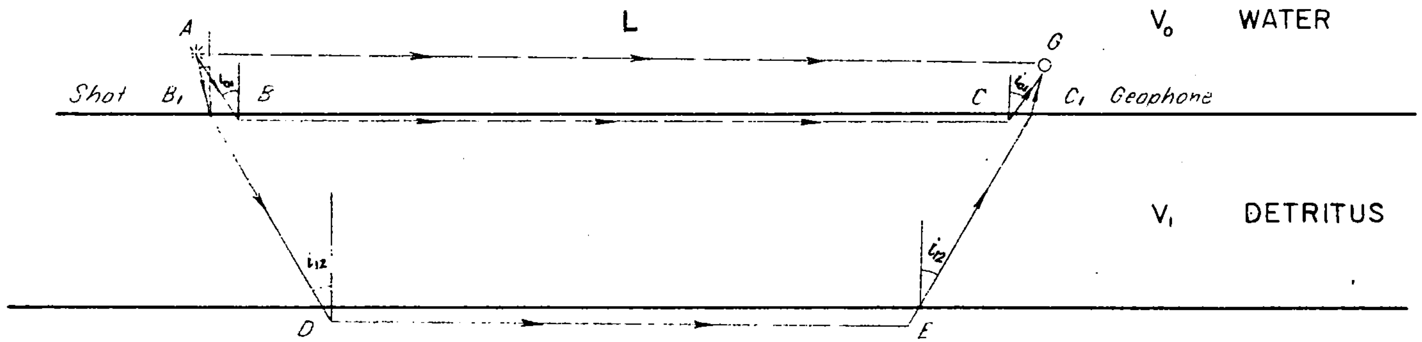

FIG. I

SEISMIC REFRACTION SURVEY,
HELL'S GATES DAMSITE,
TASMANIA

RAY PATHS OF SIGNIFICANT SEISMIC WAVES

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FIGURE 2

RECORD No 960

S.P No APPROX. E LINE AREA HELLS GATES

SHOT 18 CHARGE 1

DEPTH 50' SPREAD I

FILTER REF. DATE 1-3-58

GEO 25' AMP 6-3

PICKED E.J. POLAK WORKED E.J. POLAK

CHECKED E.J. MOSS

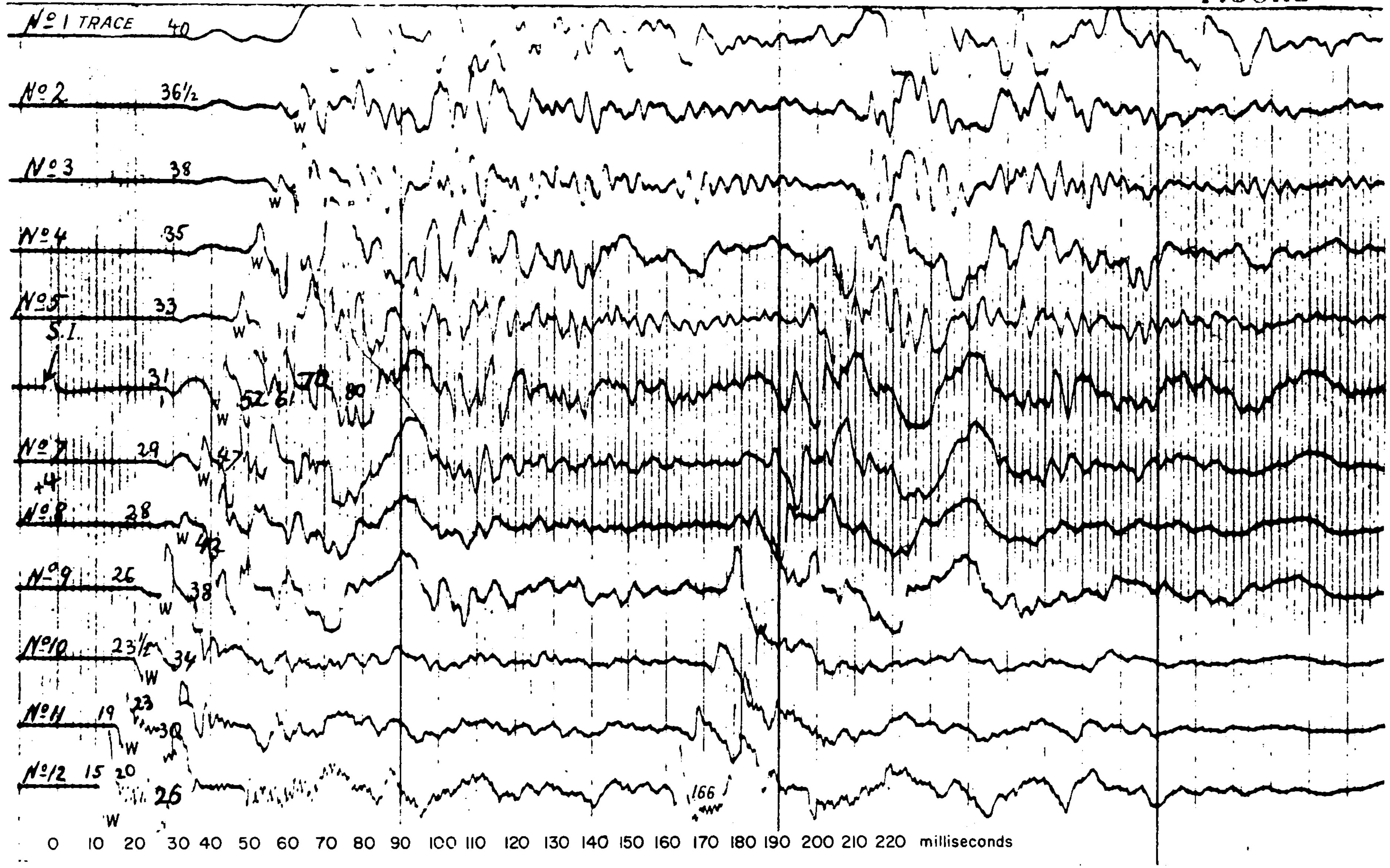

FIG. 2. SAMPLE FIELD RECORD

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FIG 3

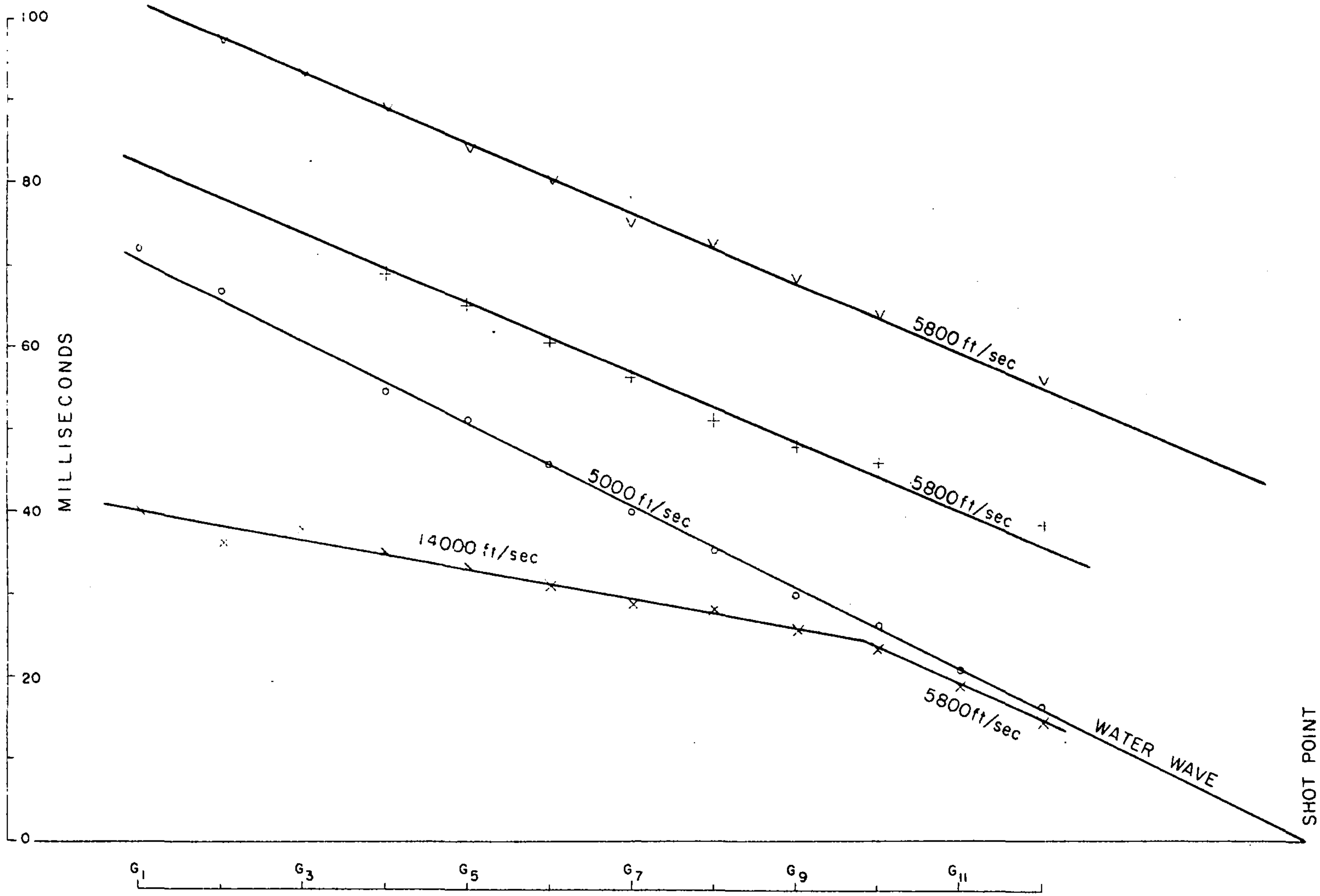

FIG. 3

SEISMIC REFRACTION SURVEY,
HELL'S GATES DAMSITE,
TASMANIA

TIME-DISTANCE CURVE, TRAVERSE I

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the degree of contrast in the velocities of propagation of elastic waves through different formations. When an explosive charge is fired in water at a shot-point the seismic waves radiate in all directions. The arrival times of these waves at geophones, stratigically placed, are measured, and the velocities of travel through the different formations calculated. Specific wave paths are shown from shot point to geophone in Fig. 1.

The seismic recording equipment used in the survey was a 12-channel portable shallow reflection-refraction seismograph manufactured by the Midwestern Geophysical Laboratory Tulsa, Oklahoma. Underwater floating geophones manufactured by the Technical Instruments Co. Houston, Texas, were used. These had a natural frequency of about 20 c.p.s.

A sample record obtained during the survey is shown in Fig. 2. The vertical lines are timing lines spaced at two millisecond intervals. Shot instant, S.I., is shown on trace No. 6. Following the shot instant the deflections on the traces show the arrival times of the seismic waves at geophones spaced at measured intervals in a line from the shot point. In Fig. 3 the arrival times (in milliseconds) are plotted against the distance (in ft.) of the geophones from the shot point, giving a time-distance curve. The slope of the time-distance curve is the reciprocal of the seismic wave velocity.

Three different seismic waves are considered -

(i) The wave which travels from A (Fig.1) directly through the water with velocity Vo = 5000 ft/sec.

This wave is a direct wave of high frequency and deflects the traces upwards. The arrivals of this wave are marked with the letter "W" on the record and are plotted on the time-distance curve as the "water-wave". From the water-wave the direct distance from the shot point to each geophone has been calculated.

(ii) The wave which travels from A to B with velocity Vo (water velocity) and then through the material comprising the river bed. The position of point B is determined by the critical angle of incidence (i_{01}). As this refracted wave travels along the river bed at velocity V_1, a part of it is continuously refracted back at the critical angle (i_{01}). The wave through point "C" reaches the geophone G. The times of arrival of these waves on the record shown on Fig.2 will be discussed fully later.

(iii) The wave which travels from A to B, with velocity V_o, from B to D with velocity V_1; and through the bedrock with velocity V_2. A refracted wave say from E, travels through the river bed to C, with velocity V_1 and thence to G with velocity V_o.

The first arrivals on record Fig.2 when plotted on the time-distance curve lie on two straight lines. The first, corresponding with a velocity of 14,000 ft/sec. is obtained from the times recorded on traces Nos.1 to 9. These are the arrival times of the wave refracted from the bedrock and recorded at geophones Nos.1 to 9. The second, corresponding to a velocity of V_1 = 5,800 ft/sec. is obtained from times recorded on traces Nos.10 to 12. These are the arrival times of the wave travelling through the detritus comprising the river bed. This wave arrives at geophone Nos.1 to 9 later than the wave refracted through the bedrock and its arrival times are difficult to read on traces already disturbed by the wave from the bedrock. Following the recording of the water wave there are other recorded waves which, when plotted, show a velocity of 5,800 ft/sec. which is the velocity in the detritus in the bottom of the river. It is impossible to indicate the paths of all of waves, but two waves are identified. The wave arriving at geophone No. 6 (Trace 6) at 61 milliseconds is the wave which travelled upwards from the shot point to the surface of the water. There it was reflected and subsequently it refracted at the bottom of the river to travel to the geophones through the detritus. The wave at 80 milliseconds was reflected at the top of the water, then at the bottom, and at the top again before being refracted to travel through the detritus. The wave recorded on trace No. 12 at 166 milliseconds, is produced by the first bubble pulse, resulting from the collapse of the gas bubble of the explosive fired. The collapse of the bubble produces a set of waves analogous to the waves produced by the original explosion.

At the Hell's Gates survey two different types of seismic spreads were used:

(i) Normal Spreads. The geophone interval was 25 ft. and shot point were at distances 25 ft. and 100 ft. (approx.) from both ends of the spread and in line with it. These spreads were placed along the river (Spreads H & I Plate 2). These traverses were calculated using the method of differences (Heiland, 1946, p.548).

(ii) Broadside Spreads. The geophones were located 25 ft. apart and shots were fired on lines perpendicular to the spread 50 ft. and 100 ft. away. These spreads were placed across the river (Spreads B,C,D. Plate 2). In this method the thickness of detritus at the bottom of the river under each of the geophones is related to the thickness calculated using the method of differences in places where the normal spread crosses the broadside spread. The geophones were lowered into the water and they sank to the bottom except for traverse "B", where they were suspended in the water. The shots used in the calculation of the thickness of the detritus were fired at the bottom. Additional shots were fired at the surface to check the positions of the geophones.

4. RESULTS

In the interpretation of the results the following velocities of the compressional seismic wave were used as characteristic for different media.

Water	5,000ft/sec.
Detritus at the bottom of the river	5,800ft/sec.
Bedrock (quartzite)	14,000ft/sec.

(i) The velocity in water was determined on a special spread with the geophones floating just below the surface of the water. The velocity found there corresponds with that found on the normal spreads H and I.

(ii) The velocity in the detritus was determined on traverses H and I. The velocity 5,800 ft/sec. is higher than the velocity found in the silt and gravel and the bottom of the Derwent River at Hobart Bridge. The higher velocity may be an indication of the coarser nature of the unconsolidated deposits at Hell's Gates than that at the Hobart Bridge. Elsewhere in Tasmania (i.e. Great Lake, Cluny and Upper Repulse areas) velocities within the scree, which consists of large boulders, have been found to be greater than in talus, which is composed of boulders and clays. Hamilton, Shumway, Menard and Shipek, 1956, showed that there is an increase of velocity with an increase in the grain size in coarse sand in the sea bed.

(iii) The velocity in the bedrock was determined on a special weathering traverse on the left bank of the river and on traverses H and I in the river. This velocity is lower than the maximum value found on the Owen Conglomerate (a similar but younger rock) at the Murchison Damsite near Tullah.

The interpretation of the results from the seismic survey is shown on plates 2-5.

Plate 2 shows the contours of the river bed below the mean water level. The contours are based on the measurements made when lowering the weighted explosive charges to the bottom and when lowering the anchors attached to the geophone cable. The depths of water obtained in this way were checked from the times of the seismic waves reflected from the surface of the water. Both depths agreed to within 5-10 ft; the depth calculated from seismic times were generally shallower than those measured.

Plate 3 shows the thickness of the detritus at the bottom of the river, calculated from the seismic data.

Plate 4 shows the contours in the bedrock using the data from plate 3.

Plate 5 shows the contours of the thickness of the detritus in the bottom of the river. The thicknesses were obtained from plate 3, and are measured normal to the bedrock surface.

The determination of the thickness of the detritus is considered to be within ± 15% of the true thickness.

5. CONCLUSIONS

The seismic survey provided information on the thickness of the detritus on the bottom of the river. The thickness of the detritus is least on traverse B, where the river is narrowest, and the current is fatest.

It is considered likely that the detritus contains many relatively large blocks of rock and may not contain much of the finer sands and silt. This conclusion is based on the seismic velocity which is higher than that normally found in unconsolidated underwater deposits elsewhere.

The errors in calculations of thickness are expected to be not more than ± 15%.

6. REFERENCES

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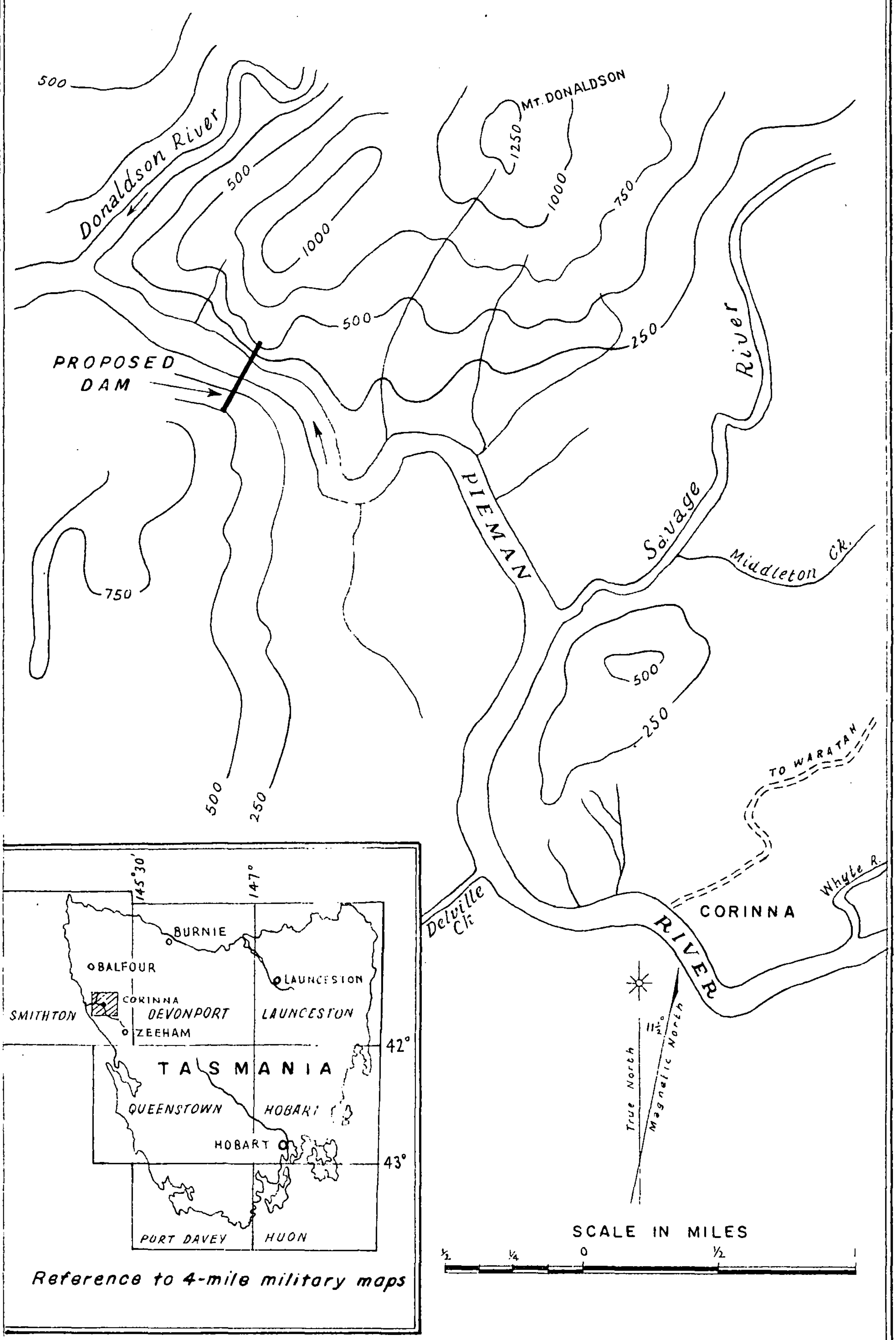
PLATE I



SEISMIC REFRACTION SURVEY,
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TASMANIA

LOCALITY MAP

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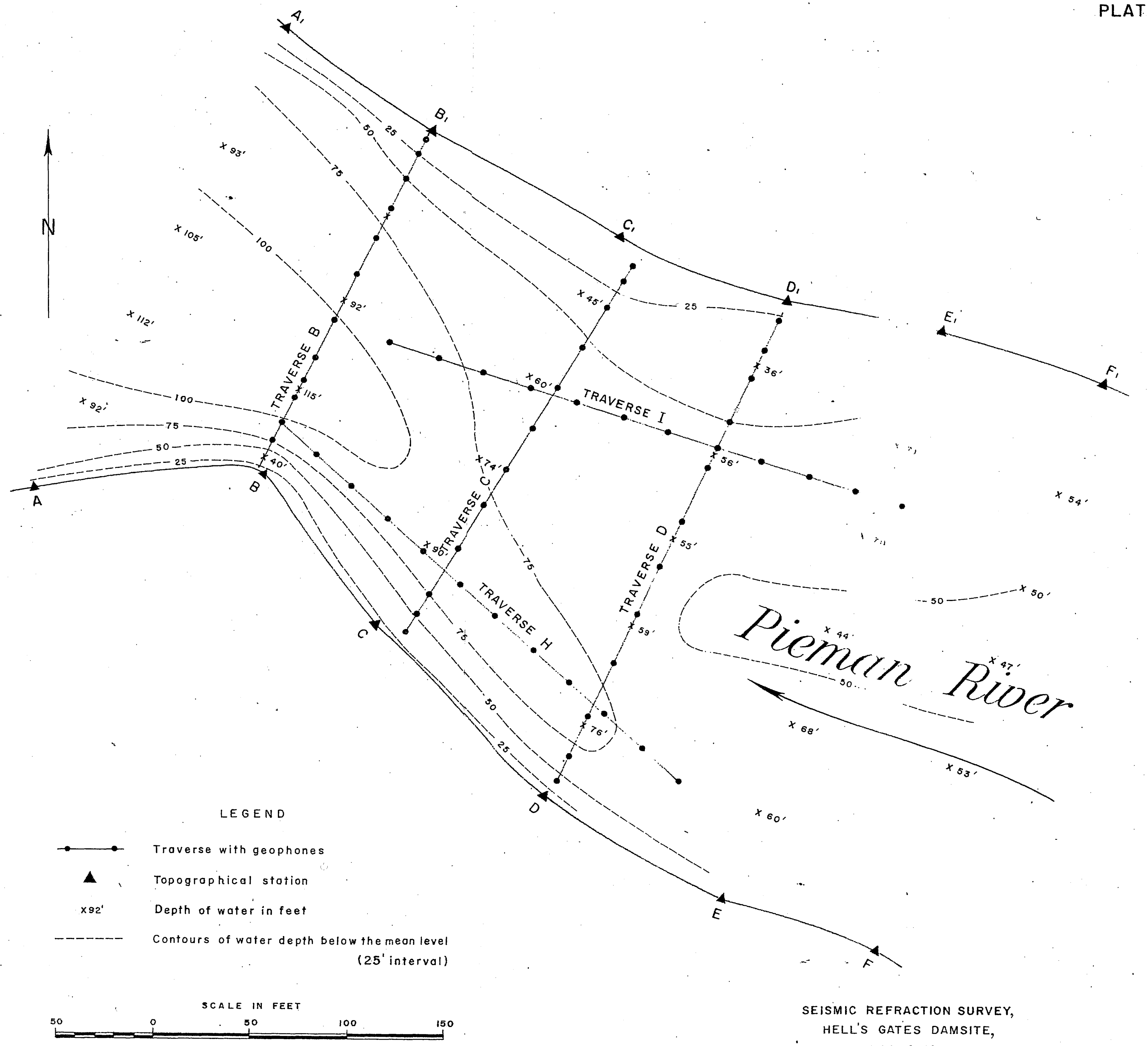

SEISMIC REFRACTION SURVEY,
HELL'S GATES DAMSITE,
TASMANIA

DEPTH OF WATER AND ARRANGEMENT OF TRAVERSES

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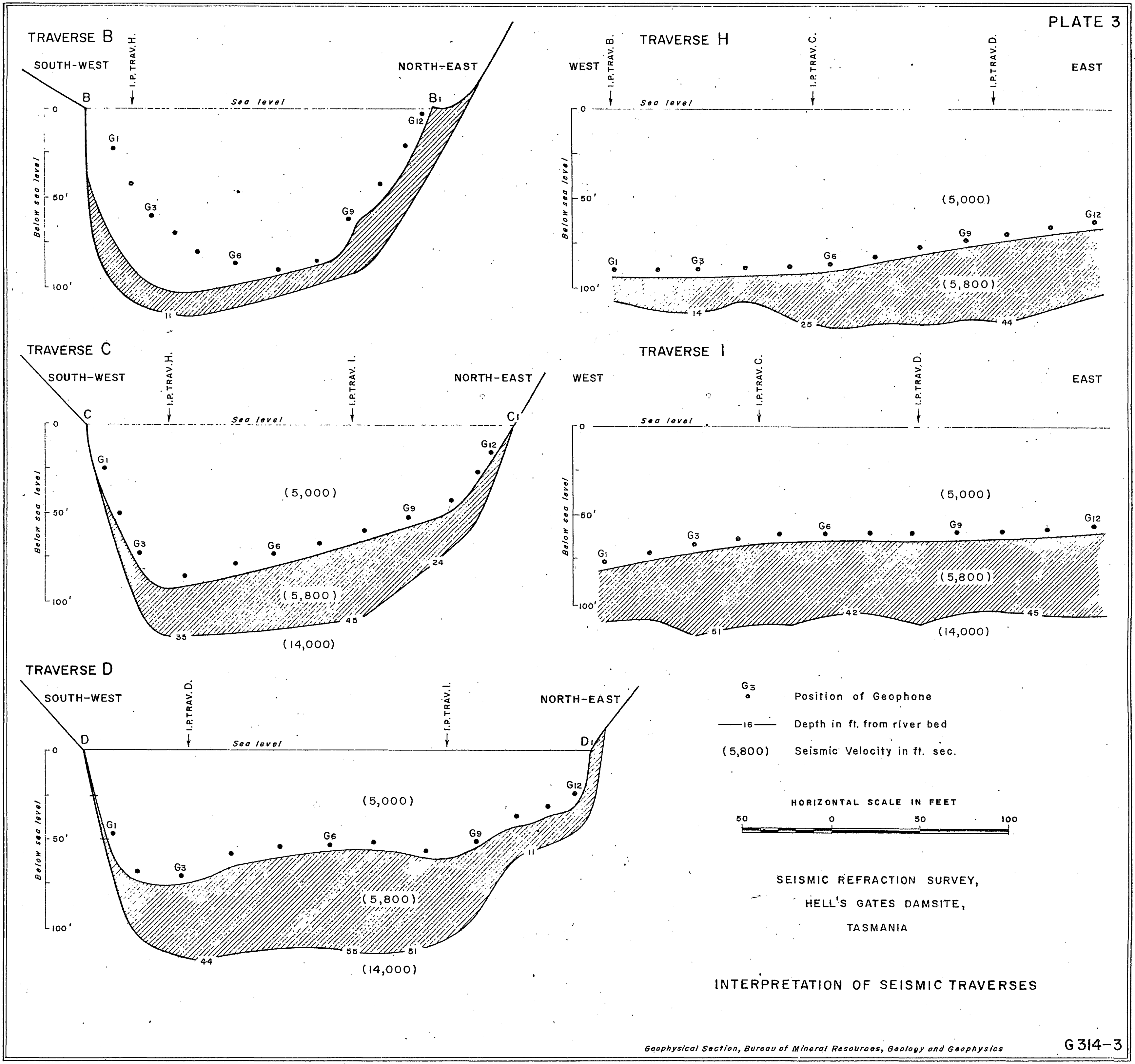

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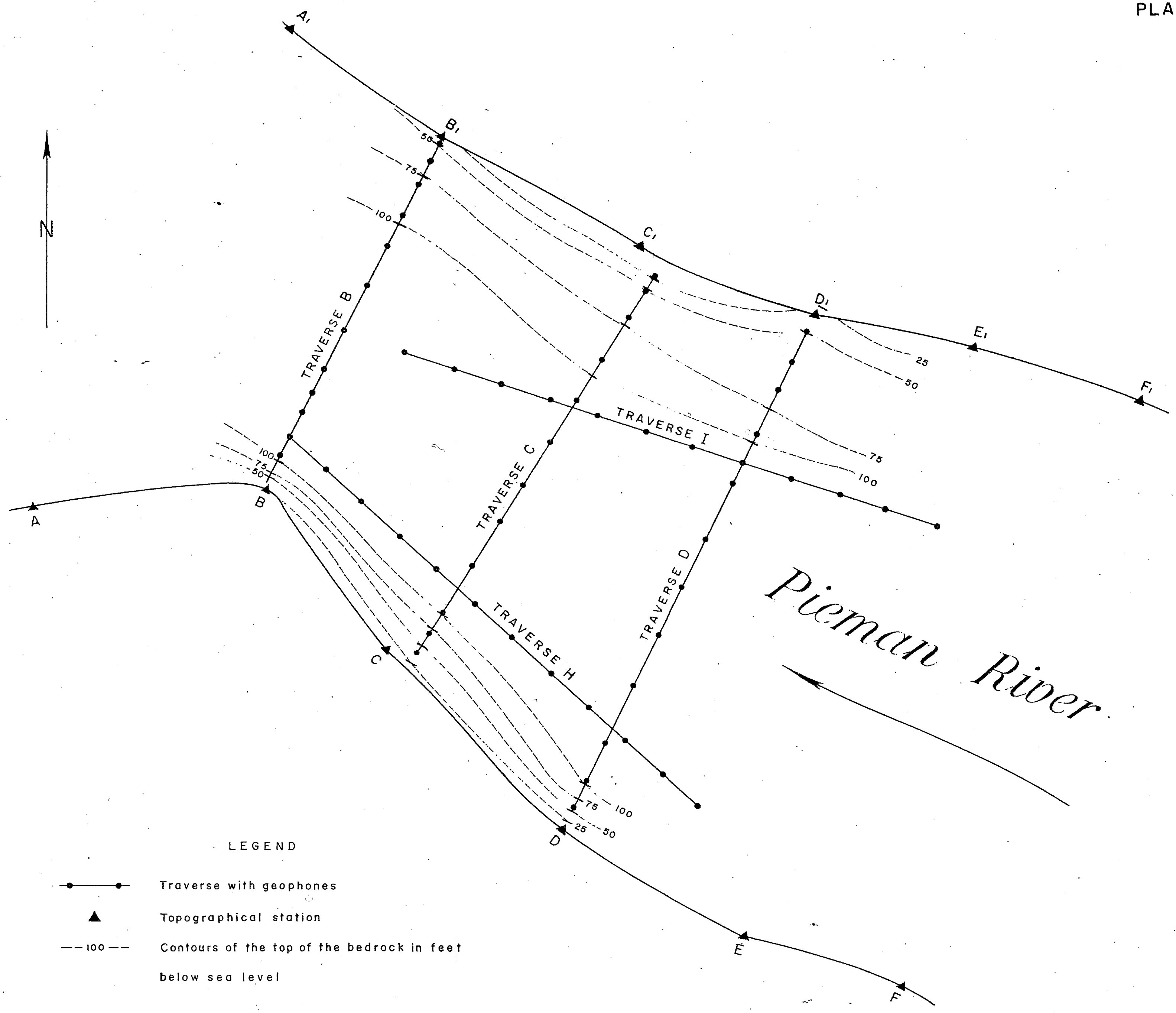

SEISMIC REFRACTION SURVEY,
HELL'S GATES DAMSITE,
TASMANIA

CONTOURS OF THE TOP OF THE BEDROCK

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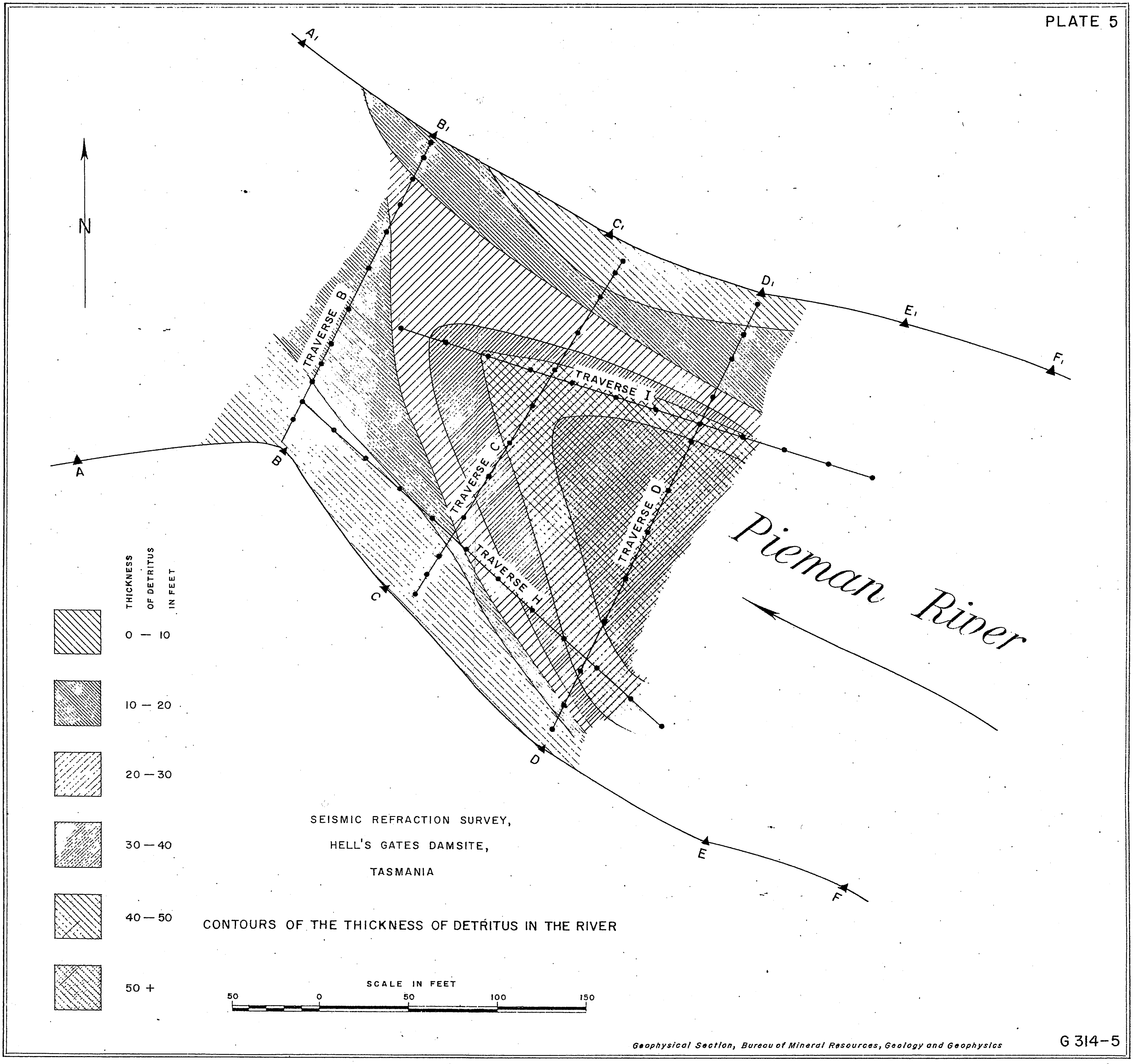

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