COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1957, No. 34

SEISMIC SURVEY OF THE COMMONWEALTH AVENUE BRIDGE SITE, CANBERRA, A.C.T.

by

L.V. HAWKINS and A. STOCKLIN.

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ABSTRACT

A seismic refraction survey of the Commonwealth Avenue bridge site, Canberra, was conducted by the Geophysical Section of the Bureau of Mineral Resources, to ascertain the thickness of the overburden and the seismic velocity in bedrock. The seismic velocity is a useful guide as to the suitability or otherwise of bedrock as foundations for the proposed bridge.

The seismic results indicate that the "bedrock" has a low velocity and a correspondingly low Young's Modulus from approximately 240 feet north of the river to 240 feet south of it, and between approximately 560 and 920 feet south of the river.

Elsewhere on the site bedrock has a higher velocity with an estimated Young's Modulus of 2.15×10^6 lbs/in^2 or greater. Depths to bedrock range from 13 to 42 feet.

The results obtained should be used as a guide for specific testing of the site.

1. INTRODUCTION

The Department of Works, Canberra, proposes to construct a new high-level bridge across the Molonglo River beside the existing Commonwealth Avenue Bridge. With a view to obtaining data concerning the sub-surface at the proposed site, the Department applied to the Bureau of Mineral Resources for a geophysical survey to be made and in June, 1956, the Geophysical Section of the Bureau carried out a seismic refraction survey of the site. The purpose of the survey was to determine the thickness of "overburden" (alluvium and very weathered rock) which overlies the "bedrock" and to measure the seismic velocity in "bedrock" along the centre line of the proposed bridge site and along three cross-traverses extending for 200 feet on each side of the centre traverse (see Plate 1). From the seismic velocity, Young's Modulus of elasticity for the bedrock can be estimated and this is a good guide as to whether or not the bedrock is suitable for foundations.

The resistivity method was also used to determine whether gravel beds within the alluvium could be mapped.

The Department of the Interior, Canberra, carried out a topographic survey of the site and supplied all necessary plans. The Department of Works, Canberra, provided four field assistants and explosives.

The geophysical party consisted of L.V. Hawkins, (Party Leader) and A. Stocklin, geophysicists, and J.Pigott, field assistant.

2. GEOLOGY

The geology of the Canberra City district has been described by Opik (1955) and is shown on the geological map of Canberra (Opik, 1953).

The greater part of the area investigated is on the flood plain of the river which extends for 1,320 feet to the south and for 150 feet to the north of the river. This flood plain is covered by alluvium overlying sediments which are very weathered immediately beneath the alluvium.

The term "bedrock" is used throughout this report to signify sediments in which the velocity of seismic energy is 6,400 ft/sec or greater, and the term "overburden" refers to the alluvium and very weathered sediments in which the velocity is much less.

Bedrock at the site appears to be the Riverside Formation, except along that part of traverse D which lies east of traverse C (Plate 1). The eastern part of traverse D extends on to the City Hill Shale, which occurs in the Bakehouse Block; this block has been down-faulted against the Riverside Formation by a minor normal fault just north of the area investigated. The City Hill Shale conformably overlies the Riverside Formation; both of these formations are part of the Canberra Group (Lower Silurian). The Riverside Formation consists of calcareous shales and mudstones, current-bedded fine-grained sandstones, prominent limestone lenses, tuffaceous sediments, tuffs and rhyolite.

The City Hill Shale consists of dark grey shale with limestone bands and lenses.

The general structure in the area is anticlinal, the axis of the Acton Anticline striking approximately north-north-west and crossing the area investigated south of the Molonglo River.

3. METHODS AND EQUIPMENT

The seismic refraction "Method of Differences" which was used on this survey is fully described by Hawkins (1957a). An explosive charge is used as a source of elastic waves which are refracted at velocity discontinuities such as that between the "overburden" and "bedrock". The travel times of the first arrival of the elastic waves from the shot point to a series of detectors (geophones) are recorded.

From the observed travel times, the depth to "bedrock" may be computed. Also, by allowing for the effect of the "overburden" on the travel times (Hawkins 1957a), horizontal changes in the velocity of the "bedrock" may be reliably estimated.

Geophone station intervals of 40 feet and 10 feet were used.

A 'Century Geophysical Corporation 12-channel, portable refraction seismograph was used, with 'T.I.C.' geophones of natural frequency 20 cycles per second.

4. RESULTS

The location of the seismic traverses and of zones of low seismic velocity within the "bedrock" are shown on Plate 1, and vertical sections showing the "bedrock" profiles on Plate 2.

The "overburden" on the flood plain of the river is predominantly alluvium with an average velocity of 1,900 ft/sec and a calculated thickness ranging from 13 to 42 feet south of the river, and from 15 to 36 feet north of the river. On the northern bank of the river the calculated "overburden" thickness decreases along traverse C from 32 feet at station 40 to 6 feet at Station 400. South of the flood plain of the river the average measured velocity of the overburden, predominantly soil and very weathered sediments, increases from 1,900 to 2,600 ft/sec., and the calculated thickness of the "overburden" ranges from 13 to 42 feet.

The seismic velocities in the "bedrock", which are shown on Plate 2, give an indication of the quality of the rock for engineering purposes, and may be expressed in terms of the Young's Modulus of the rock (Hawkins, 1957a). Table 1 shows the approximate values of Young's Modulus (E) for values of the seismic velocity recorded in "overburden" and "bedrock". The Young's Modulus values are calculated from the empirical formula $E = V^{2.34} \times 10^{-3}$ lbs/in^2., and are considered to have a maximum error of $\pm$ 30 per cent for competent rocks.

TABLE 1.

Rock Type	Seismic Velocity (ft/sec)	Young's Modulus	
		lbs/in^2	dynes/cm^2
"Overburden"	1900 (average)	0.05×10^6	0.034×10^{11}
	2600 (average)	0.1×10^6	0.069×10^{11}
"Bedrock"	6500 - 7200	0.88×10^6 1.08×10^6	0.605×10^{11} 0.744×10^{11}
	8000	1.4×10^6	0.965×10^{11}
	9500 - 11,000	2.15×10^6 3.0×10^6	1.45×10^{11} 2.06×10^{11}
	14,000 - 18,000	5.2×10^6 9.4×10^6	3.58×10^{11} 6.48×10^{11}

Several areas of low-velocity "bedrock" are indicated by the seismic results.

A broad low-velocity (6,600 to 6,800ft/sec) zone extends some 240 feet south from the river to about station A 240. It seems likely that this zone also extends northwards under the river; no seismic measurements were made under the river.

Between stations C00 and C160, along the centre line of the bridge north of the river, the "bedrock" velocity is 8,000ft/sec; cross traverse D also shows "bedrock" with a velocity of 8,000 ft/sec. extending about 50 feet on either side of the centre line of the proposed bridge. Rock with this velocity is most likely partly weathered; the calculated Young's Modulus is about 1.4×10^6 lbs/sq. in. On traverse D on either side of the 8000ft/sec velocity "bedrock", the "bedrock" velocity decreases to 6,500 ft/sec which indicates very weathered rock with a Young's Modulus about 0.88×10^6 lbs/sq. in.

North of station C160, between stations C160 and C240, a low-velocity zone (6,500 ft/sec) is indicated more clearly on a deeper refractor than the "bedrock" any may be caused by a deep shear.

Other low-velocity zones occur between stations A560 and A680 (7,200 ft/sec) and between stations A800 and A920 (6,500 ft/sec). Also, a 6,400 ft/sec velocity zone occurs along traverse E, east from about 120 feet east of the centre line of the proposed bridge.

Elsewhere, the "bedrock" has a velocity between 9,500 and 18,000ft/sec, which indicates a Young's Modulus between 2.15×10^6 and 9.4×10^6 lbs/sq. in. These velocities are in the range that applies generally to relatively unweathered sedimentary rocks. The lower velocities may correspond to sandstones, shales and tuffs etc., and the higher velocities (16,000 to 18,000 ft/sec) to limestone lenses or possibly rhyolites.

Drilling results from about one mile upstream, at King's Avenue Bridge site (Hawkins, 1957b), showed the seismic depth estimates of the thickness of "overburden" at the site to be about 20 per cent too large; the drill holes there were located within the very weathered zone close to the river and the systematic error revealed does not necessarily apply to the Commonwealth Avenue results.

The results may be considered to have a maximum error of $\pm$ 15 per cent.

The tests which were made using the resistivity method were unsuccessful, as the gravel beds are too thin to be detected by this technique.

5. CONCLUSIONS

The seismic results showed that on the traverses surveyed the thickness of the "overburden" ranges from 6 to 42 feet, and its average seismic velocity ranges from 1900ft per second to 2600ft per second. Young's Modulus corresponding to these velocities is 0.05×10^6 and 0.1×10^6 lbs/in^2 respectively. It seems unlikely that the "overburden" would provide suitable foundations for a bridge so that the bridge piers would have to be founded on "bedrock".

Assuming that seismic velocities of 8000 feet per second or less indicate poor quality foundation rock then poor foundations are indicated for approximately 240 feet both north and south of the river and probably continue under the river and also between 560 and 920 feet south from the river. Young's Modulus for these rocks is between 0.88×10^6 and 1.4×10^6 lbs/in^2.

Elsewhere suitable foundation rock should be encountered at or near the prescribed depths to "bedrock" and Young's Modulus for such rocks is 2.15×10^6 lbs/in^2 or greater. Whether or not the "bedrock" is suitable for foundations can only be determined by drilling or pitting but the seismic velocities may be used as a reliable guide.

6. REFERENCES.

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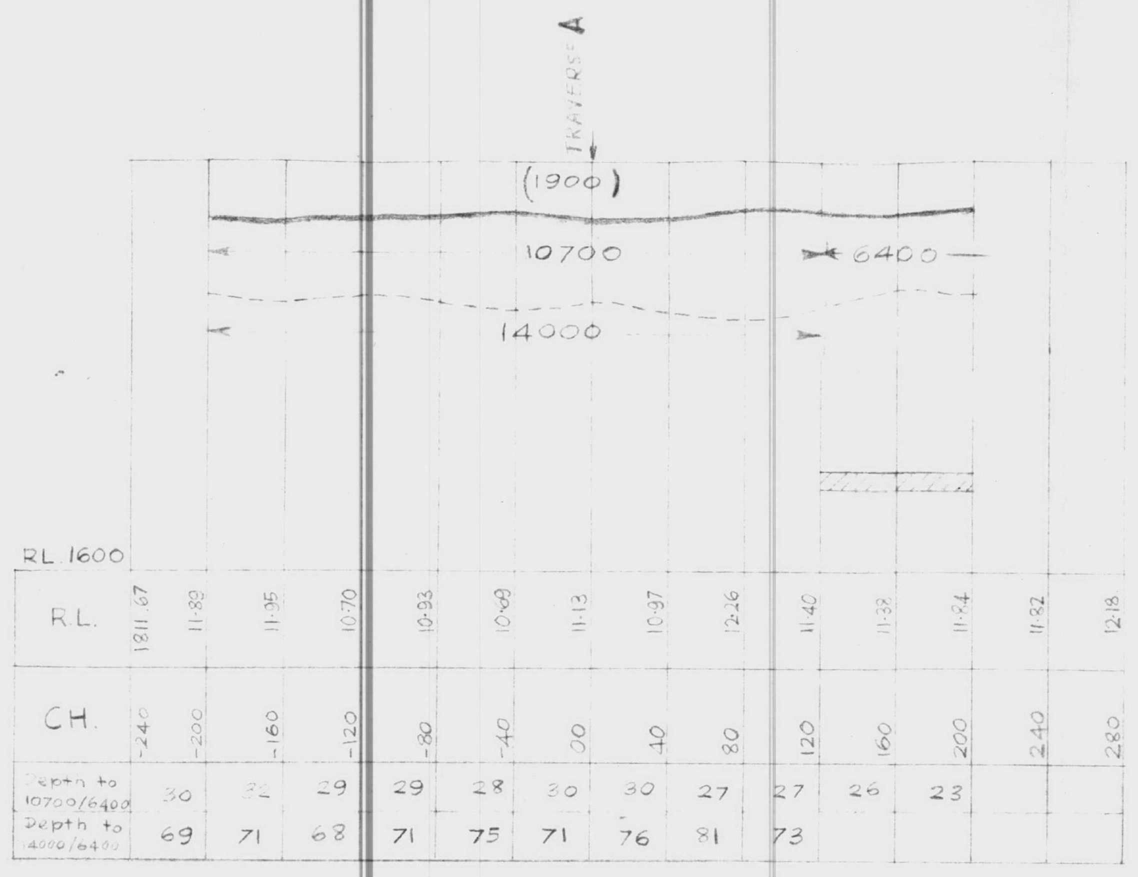
PLATE 1

SEISMIC REFRACTION SURVEY
OF THE COMMONWEALTH AVENUE BRIDGE SITE,
CANBERRA, A.C.T.
LOCALITY MAP AND SEISMIC TRAVERSES

SCALE IN FEET

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. G 203-5



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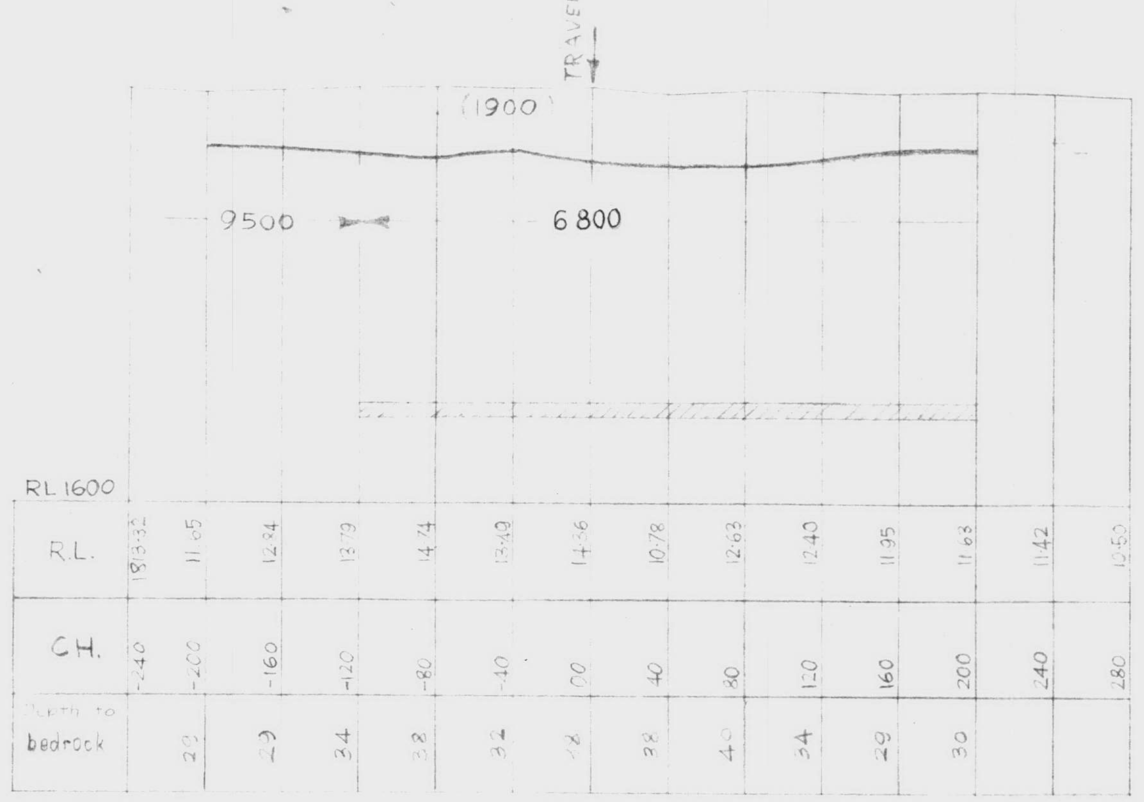

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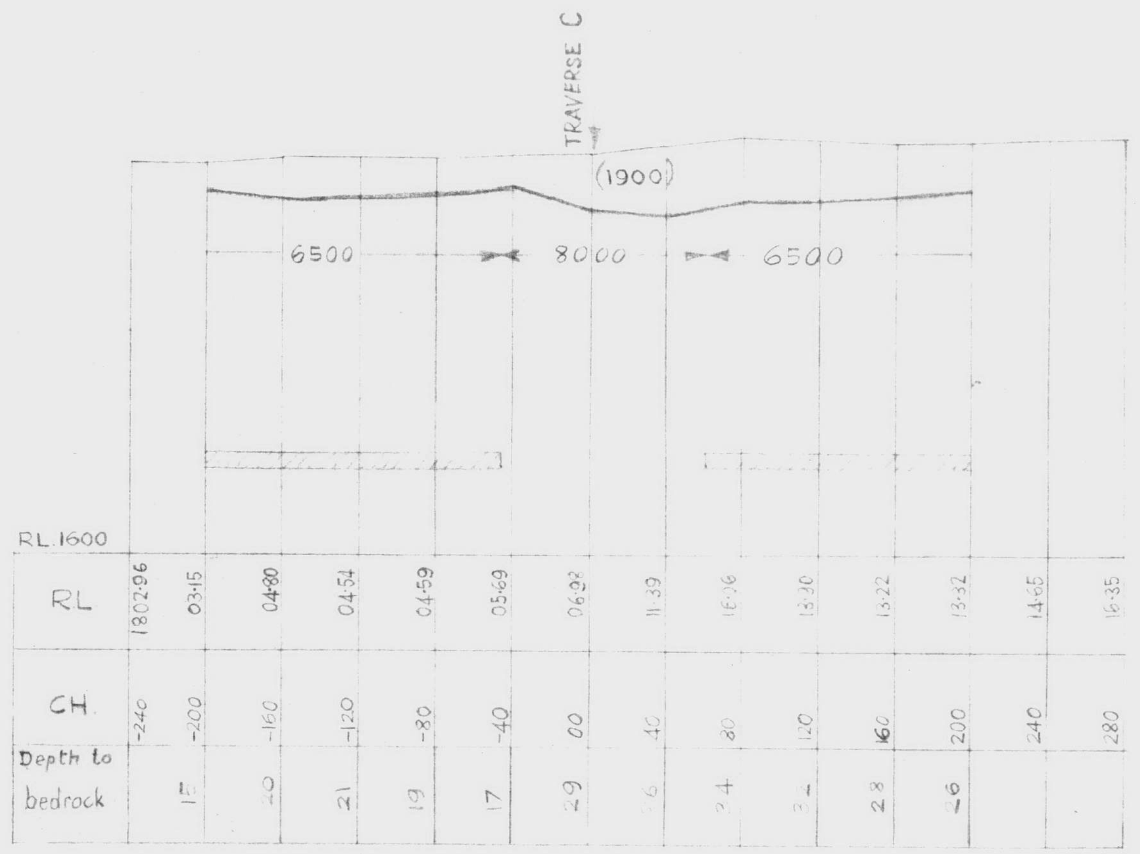

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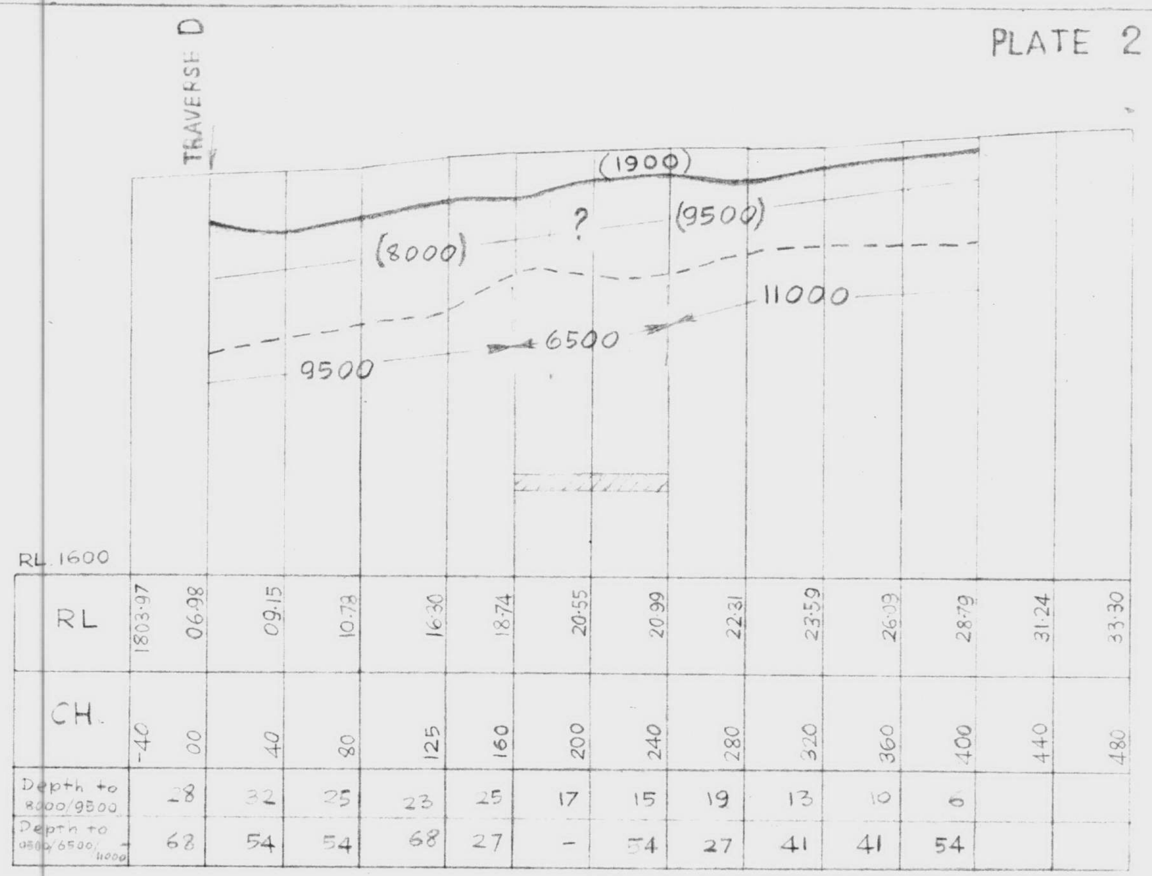

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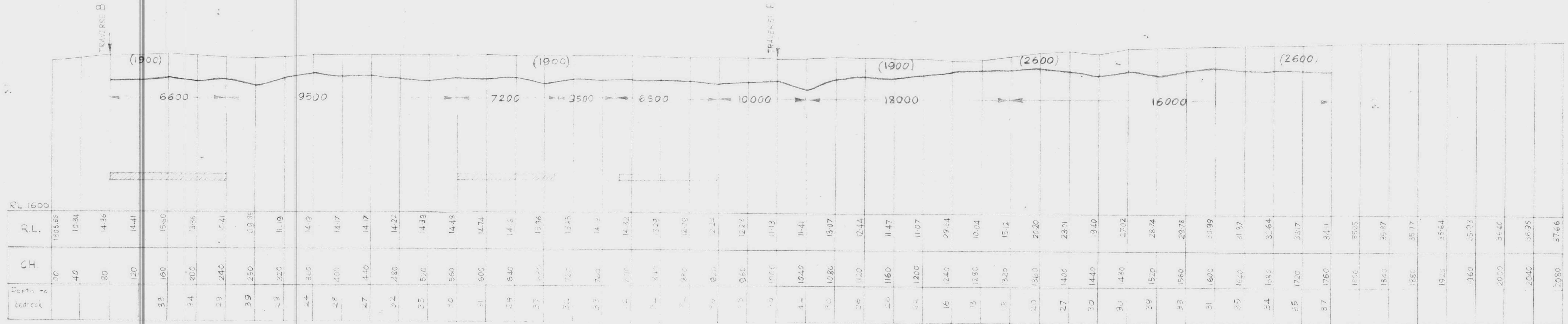

TRAVERSE "A"

LEGEND

BOUNDARY BETWEEN "OVERBURDEN" AND "BEDROCK"

ZONE OF LOW-VELOCITY "BEDROCK"

10,000 RECORDED SEISMIC VELOCITY

(1900) AVERAGE " " IN OVERBURDEN

SEISMIC REFRACTION SURVEY
OF THE COMMONWEALTH AVENUE BRIDGE SITE
CANBERRA, A.C.T.

VERTICAL SECTIONS SHOWING SURFACE
AND BEDROCK PROFILES

SCALE IN FEET

GEOPHYSICISTS

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G283-4