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Resistivity survey of the Mundaring seismic observatory site, W.A.
September 1957

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# RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A,

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D.F. DYSON

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## ILLUSTRATIONS

## ABSTRACT

A resistivity survey was conducted during September, 1957, to assistin the selection of a site for a new seismic observatory at Mundaring, W.A.

A site with relatively shallow bedrock was required for constructing a vault.

Resistivity traversing was conducted within that part of the soil-covered area considered to be most favourable for the presence of shallow unweathered bedrock. A brief investigation was also conducted across the laterite-covered area and granite outcrops.

Resistivity depth probes proved that the area is generally deeply weathered.

It was also shown that granite outcrops are probably separated by more extensively weathered zones from the unweathered granites at lower level.

A possible site is suggested upon the large granite outcrop along the south-western boundary of the area but confirmation of the suitability of this site should be sought by other methods.

## 1. INTRODUCTION.

A new seismological observatory is to be established on an area within the Forestry Commission Reservation north of and bordering the Helena River, a short distance upstream from the Mundaring Weir (see Plate 1). The co-ordinates of the centre of the area are 217452 on the Mundaring 1-mile Army map.

A vault is to be constructed to house the seismographs and it is desirable that the instrument piers within the vault are founded on solid rock. Some preliminary drilling failed to show clearly the most favourable place for the vault and it was thought that a resistivity survey would help in this regard. More specifically, the objects of the survey were to ascertain whether or not the isolated outcrops of granite are continuous with the basement rock both vertically and laterally under the soil cover, and to locate areas where unweathered rock is at no great depth.

A brief geological examination of the rock outcrops within the area was made, followed by an electrical resistivity survey over a section of the area (see Plate 1). The survey was conducted during the first half of September, 1957 by D.F. Dyson, geophysicist. Three assistants were employed for the duration of the survey.

## 2. GEOLOGY.

The regional geology is outlined by Clarke et al (1955), in reference to the Darling Scarp.

The following features were noted by the writer within the observatory area :-

(i) A lateritic capping of consolidated material (the duricrust), one to two feet thick, covers most of the area north of the track (Plate 1) and also the higher level ground surface south of the track.

(ii) Granite which crops out in the southern and western sections is in contact with basic dykes which range from a few inches to many feet in width.

The granite also shows evidence of shearing and the outcrops are also intersected by narrow dykes.

(iii) Basic intrusive rocks are evident along the southern limit of the remote area from any obvious granite outcrops.

## 3. METHOD

The resistivity techniques employed were :-

(i) Constant-spacing traversing

(ii) Depth probing.

In both techniques an electrical current is applied to the ground through two current electrodes (steel spikes driven into the ground) and the potential difference is measured between two additional points which lie upon a straight line joining the two current electrodes. The ratio of the potential difference to the current flowing, multiplied by a spacing factor, is a measure of the ground resistivity. Usually, the ratio, R, of potential to current is measured directly and expressed in ohms.

As the subsurface path through which the current flows is not normally homogeneous, the resistivity value obtained is referred to as the "apparent" resistivity. When the electrodes are equally spaced at an interval of "a" centimetres the apparent resistivity ~~(Pa) 2T AR.~~ $(\rho_a) = 2\pi a R$.

It is considered that the depth penetration of the applied current in this configuration is of the same order as the electrode spacing. Jakosky (1950, p.509) states that the depth penetration ranges from ½ to 1/6 of the distance between the current electrodes.

Ordinary rock minerals have a high resistivity and in engineering work are considered to possess infinite resistivity. The resistivity of a rock depends mainly upon the rock porosity, the degree of saturation with pore solutions, and the resistivity of the pore solutions. The resistivity of a solution is inversely proportional to its salinity. Thus, while dry surface material has a high resistivity, most porous material underlying this possesses lower resistivity, and unweathered non-porous rock has high resistivity.

In constant spacing "resistivity traversing" the electrode array is moved as a whole and the depth penetration is approximately constant; thus lateral variations in resistivity may be determined.

By the use of two or more electrode spacings a series of profiles representing the apparent resistivity to different depths is obtained.

In "Resistivity Depth Probing" or "Electrical Drilling", the electrode spacing "a" is gradually increased symmetrically from a central point, and hence the depth penetration is increased. For convenient interpretation the results are plotted on logarithmic scales. This plot is normally compared with two-layer (Roman, 1930) and three-layer (Wetzel and McMurray, 1937) type curves prepared from theoretical examples and used to estimate depths to resistivity discontinuities. The reliability of the results depends upon how closely the field conditions approach the theoretical examples. In this survey the informa tion sought was the depth to unweathered rock, i.e. to material of finite resistivity. This would be indicated by an inflection in the plotted curve beyond which the factor $\frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$ 1, where $\rho_2$ = resis tivity of unweathered bedrock and $\rho_1$ = resistivity of overlying w thered rock.

As it is desirable that solid rock should not be deeper tha 15 feet at the site of the vault an initial constant electrode spaci of 50 feet was used. As a depth probe (not on outcropping granite) within a relative "high" obtained at this spacing, indicated that the penetration did not reach unweathered bedrock, traversing was then conducted at 100-ft electrode spacing.

The instruments used were a Low Resistance "Megger" Earth Test and a Geophysical Earth Testing Megger manufactured by Evershed and Vignoles Ltd, London. In general, it was found necessary to use up to three steel spikes at each electrode to ensure good contact with the ground .

## 4. RESULTS.

Prior to the commencement of the survey, a number of holes was drilled with a posthole digger by the Department of Works. These holes showed that beneath the soil adjacent to the granite outcrops,

(i) the unweathered granite does not extend far beyond where it is exposed

and(ii) beyond the unweathered granite is soft inhomogeneous mate which by the presence of angular quartz and clay mineral indicates that it is the product of weathering of igneous rocks. Beneath this soft material at irregular depths, is usually found a harder layer of granite material which cannot be penetrated with a posthole digger. These layers may well represent portion of the zone of laterization from which the surface capping has been removed by erosion.

The initial inspection of the area indicated that the portion of the area in which unweathered rock most probably occurs at relatively shallow depth is the triangular area bounded by outcrops B and C and Bench Mark 3 (BM3).

Areas considered unfavourable include :

(1) The south-eastern portion, in which outcrop A occurs, includes numerous outcropping basic dykes, and posthole investigations conducted by the Department of Works indicated very irregular subsurface conditions. The area is also subject to considerable seepage as evidenced by a water course a short distance downhill from the block boundary.

(ii) Outcropping granite in the western portion of the block exhibits fracturing and shearing and is technically an unfavourable site for the seismic vault.

(iii) The area horth of the track and the higher sections south of the track are covered mainly by laterite. A typical profile throggh the laterite is described by Clarke et al (1955 p.45) in relation to a nearby area as follows :-

> "Quarries in the Jarrah Region that are between 700 and 1000 feet above sea-level show an upper foot or so of consolidated material - the duricrust - beneath which are several feet of uncemented "gravel", in turn underlain by a variable thickness of weathered rock that passes down gradually into unweathered rocks."

Engineers of the Department of Works have stated that a similar profile is exposed in severalmof the Department of Works gravel pits.

Plate 1 shows the traverse layout to investig .the area bounded byoutcrops B and C and Bench mark Be. The traverses were surveyed using electrode spacings of 50 feet and 100 feet.

In addition traverse (LL') was surveyed at 100 feet spacing across the laterite [illegible] to the north of the triangular area. The results are plotted as profiles on Plate 2.

On these traverses which terminated near granite outcrops it was impossible to obtain electrode contacts on the bare rock. Contacts were possible along Traverse CC', which passes over granite, as a thin layer of soil covers the solid granite.

The following features are indicated on the resistivity profiles

(i) The resistivity values are relatively low in many places adjacent to outcropping granite. Traverse CC', between 350W and 400W, exemplifies this feature, which may be attributed to deep weathering adjacent to the outcropping granite.

(ii) The profiles for 50-foot spacing show higher resistivity values than those for the 100-foot spacing along Traverse AA', between 200W and 450W, and along Traverse QQ', south from 100N. As an increase in resistivity values is recorded on both spacings, it is reasonable to assume that the principal contributing factor to the higher values is the higher resistivity of that ground penetrated by the 50 foot spacing.

(iii) Traverse DD' passes across outcrop C. The two peaks in the 50-ft. spacing profile within the general high between 100W and 275W are not repeated in the profile for 100-foot spacing. A large/near-surface (unweathered) boulder within a generally less-weathered zone could be responsible for the type of profile obtained.

Based upon the results of the resistivity traversing, depth probes were conducted at AA'300W, AA'400W, CC'150W, CC'575W, DD'175W and LL'1300E. The results of these probes are shown on Plate 3. The plotted data from most of the depth probes indicate the multilayer nature of the ground and are not adaptable to precise interpretation using the theoretical two layer curves.

The results of the depth probes are discussed briefly :-

(1) AA'300W. Two probes were conducted, one along Traverse AA' and the other along Traverse QQ'. The results obtained verify those obtained with the constant-spacing profiles, in which the resistivity at 50-ft. spacing is greater than that at 100-ft. spacing.

A discontinuity occurs between the near-surface higher resistivity layer and the underlying lower resistivity materials corresponding to a surface electrode spacing of 25±5 feet. Low-resistivity material persists to beyond the depth penetration from a spacing of 160 feet. Thus unweathered rock would not be shallower than a depth in excess of 80 feet, assuming Kakosky's factor of 1/6 to be the maximum penetration.

(ii) AA'400W. Two probes were conducted, one along Traverse AA' and the other along Traverse RR'. There is no evidence that unweathered rock is penetrated to any extent by the current from an electrode spacing of 125 feet; that is, the depth to unweathered rock is greater than 60 feet.

(iii) CC'150W. Along Traverse CC'. The inflection in the plotted results, where $\frac{\rho_2 - \rho_1}{\rho_2 + \rho_1} \rightarrow 1$, occurs at a point for which the electrode spacing is about 100 feet. The depth at which unweathered rock occurs is therefore between 50 and 75 feet.

(iv) CC'575W. Along Traverse CC'. Readings for the electrode spacings up to 5 feet may be affected by surface irregularities. With spacings greater than this, unweathered rock is indicated. An inflection at 100-foot spacing may be caused by a narrow shear at a minimum depth of 50 feet, or by a surface irregularity.

(v) DD'175W. Along Traverse DD'. Beyond a spacing of 3 ft., relatively high resistivity material is indicated, but this is underlain by an inhomogenous material of relatively lower resistivity to a spacing of 100 feet, beyond which high resistivity (considered as probable unweathered rock) is revealed. The minimum depth to this material is about 50 feet.

(vi) LL' 1300E. Along Traverse LL'.

Due to the difficulty in obtaining electrode contacts on the solid laterite, the Geophysical Earth Testing Megger was used for this depth probe. This instrument has a lower range, with a maximum reading of 30 ohms. Hence readings could not be obtained for spacings less than 25 feet when values were greater than 30 ohms. The apparent resistivity of the near-surface material is particularly high. This material is underlain by a material of low resistivity to a depth corresponding to a spacing of more than 100 feet, below which unweathered rock may exist; the depth at which this may be expected is in excess of 65 feet.

Investigations were conducted with a posthole digger in the area near Traverse AA' and bounded by Traverse QQ' and RR'. Impenetrable material was encountered at depths between 3 feet and 6 feet. The resistivity depth probes indicate low-resistivity material extending to much greater depths. The impenetrable material may be a partially cemented weathered rock, the cementing being associated with earlier laterization which occurred throughout the area.

5. CONCLUSIONS.

Except in those areas where granite crops out, the thickness of weathered rock is in excess of that permissable for suitable foundations. These outcrops, some of which are large, are associated with shearing and basic dykes, which adjoin, and to a lesser extent intersect, the exposed rock.

The outcrops along which the south-western coundary of the block extends is a relatively massive, and should, without any major discontinuity, extend to a depth at which the adjoining granitic rocks are unweathered. Other granite outcrops in the area would appear to be weathered and/or sheared at depth.

A site at about CC'575W (see depth probe result) within this area of outcropping granite should be fairly suitable for the establishment of a seismic vault, although some rock excavation would be necessary. The construction of a suitable access road to this point would not present any difficulty.

The presence and extent of possible shears in depth should be checked by diamond drilling; A small unit such as a Mindrill Minor should be sufficient for this purpose.

~~The establishment at the site of a portable seismograph over a period may assist in assessing the possible suitability of the site~~

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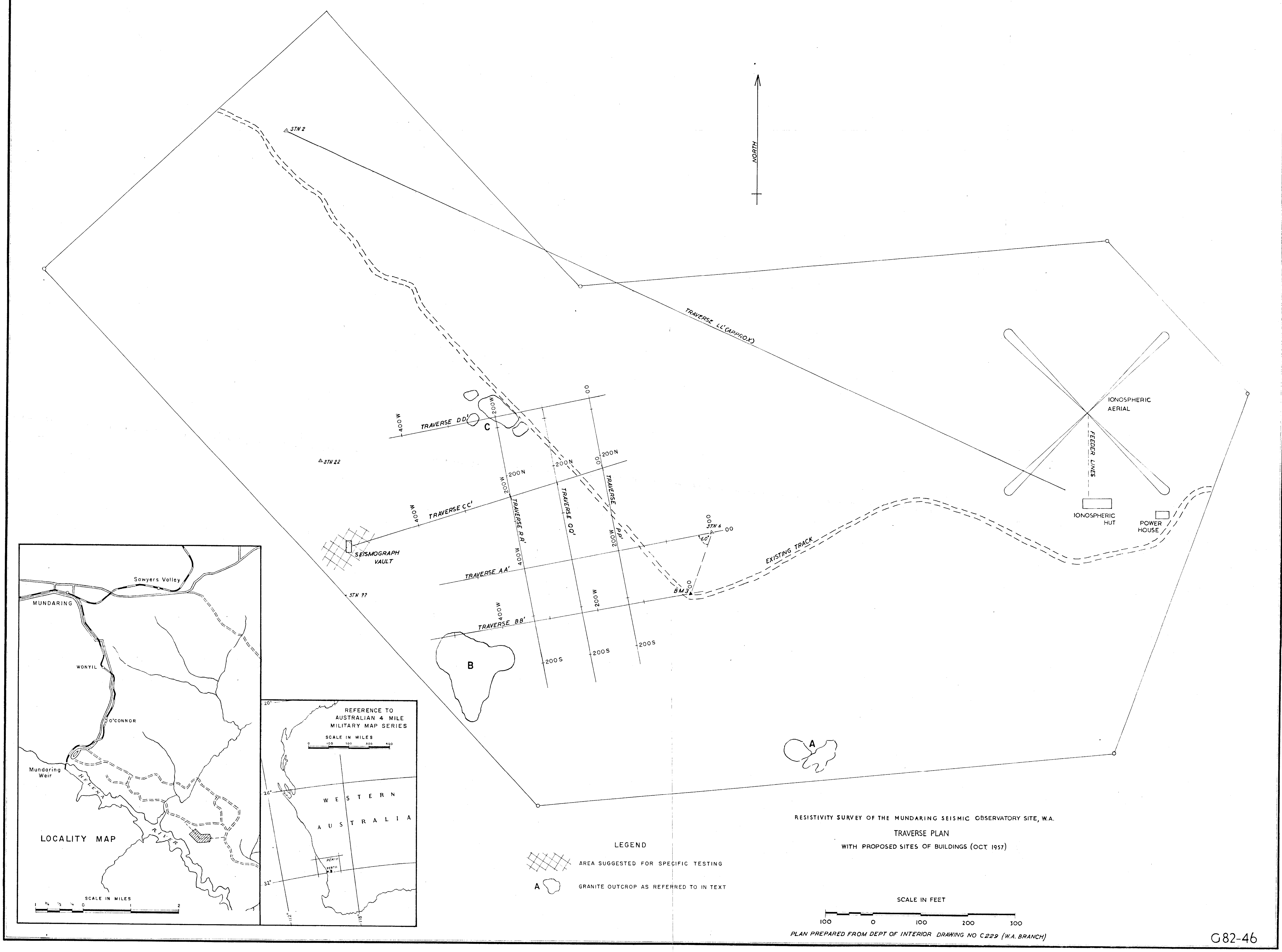
PLATE I



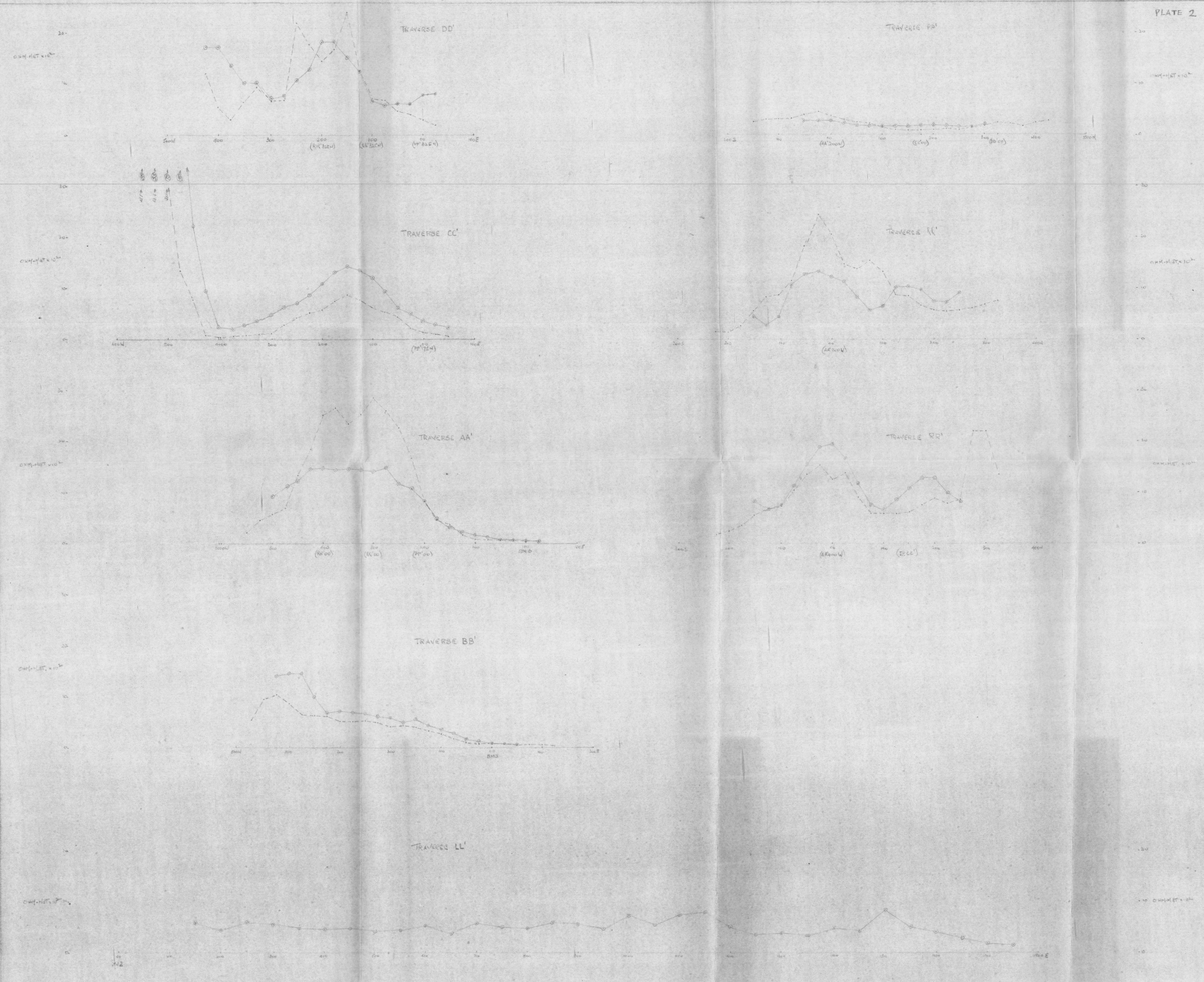

RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A.

TRAVERSE PLAN

WITH PROPOSED SITES OF BUILDINGS (OCT. 1957)

PLAN PREPARED FROM DEPT OF INTERIOR DRAWING NO C229 (W.A. BRANCH)

G82-46




HORIZONTAL SCALE IN FEET
100 75 50 25 0 100 200 300

VERTICAL SCALE 1" = 10 OHM-MET x 10²

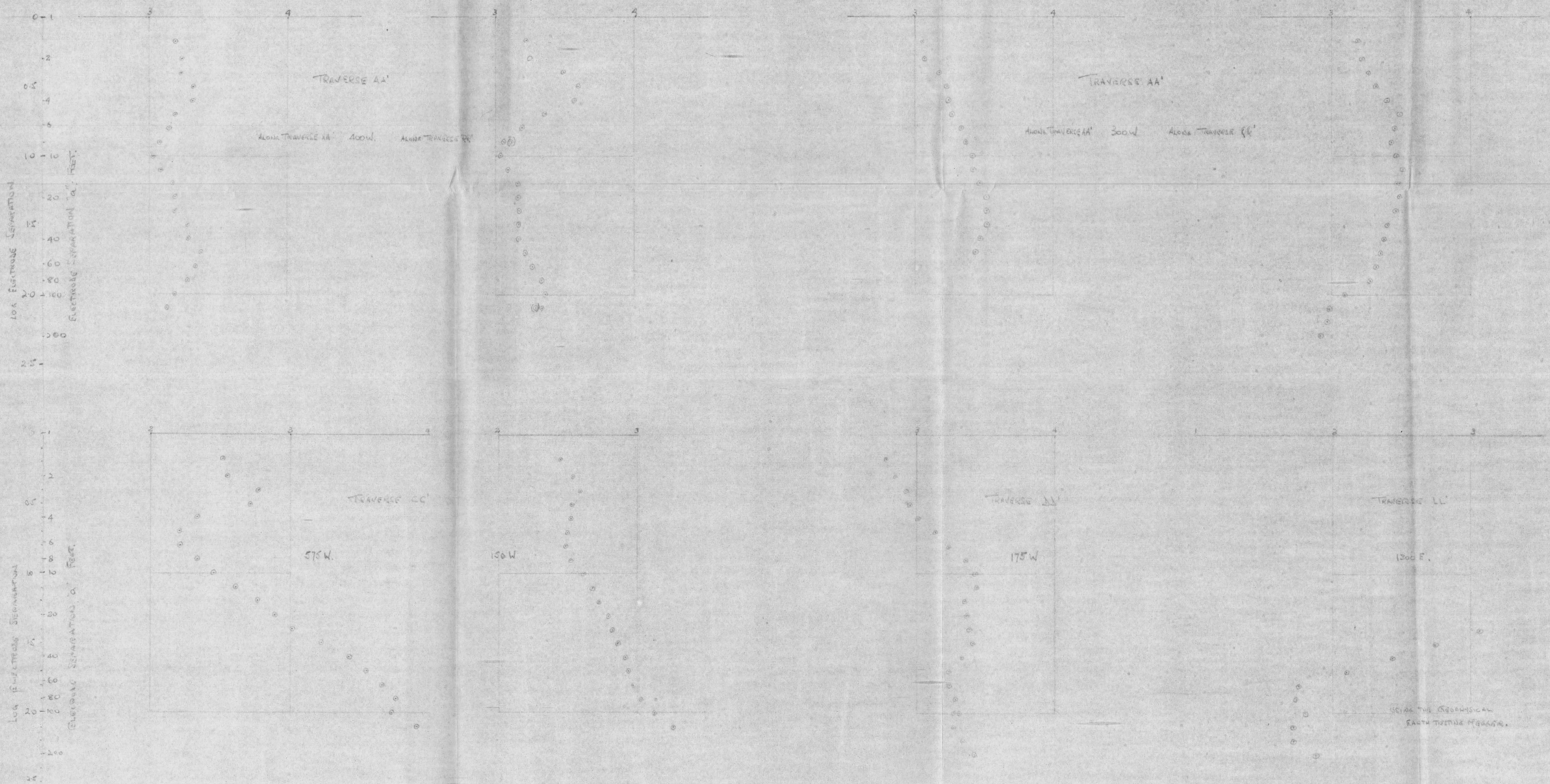
50 FEET ELECTRODE SPACING

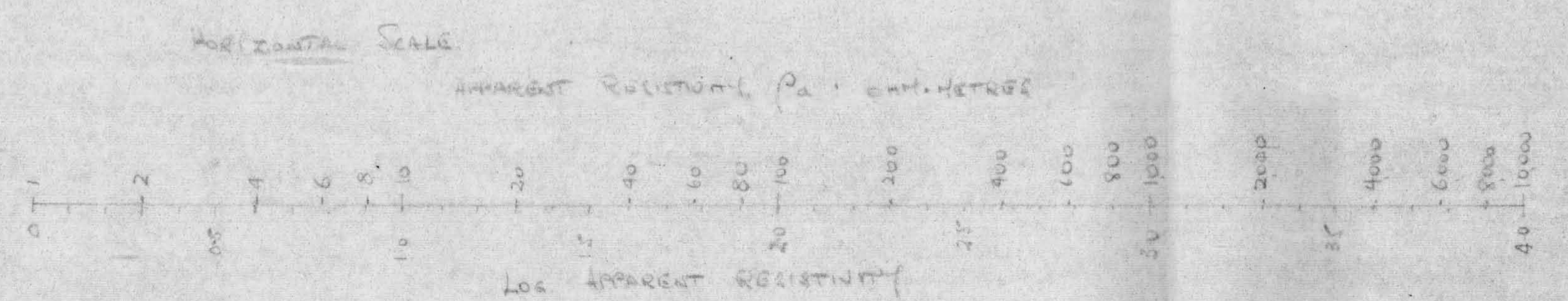
100 FEET ELECTRODE SPACING

RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A.

RESISTIVITY PROFILES

G82-47



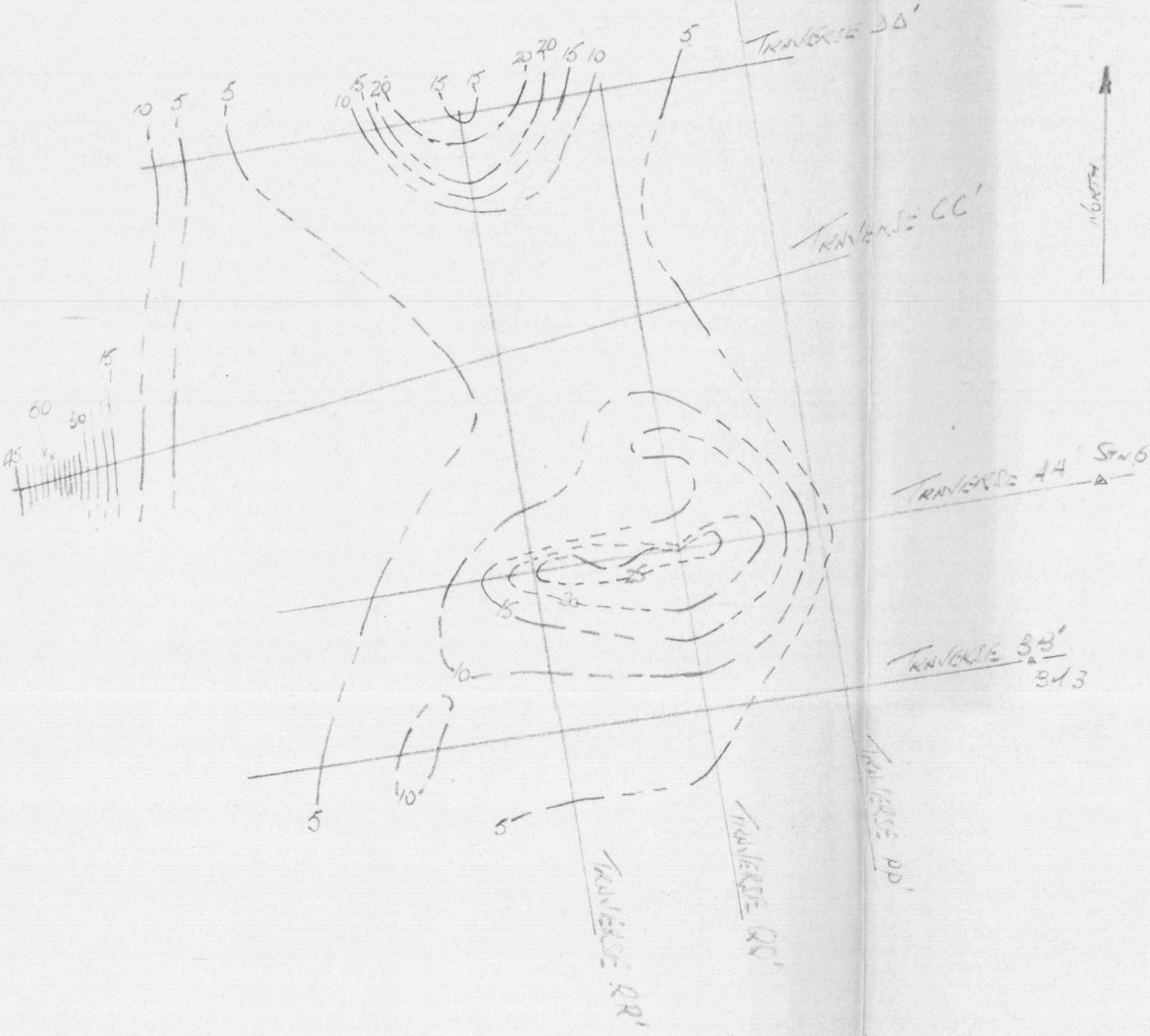




RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A.

RESISTIVITY DEPTH PROBES

G 82-48

PLATE 4




RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A.

RESISTIVITY CONTOURS – 50 FOOT ELECTRODE SPACING

LEGEND

—— RESISTIVITY CONTOUR

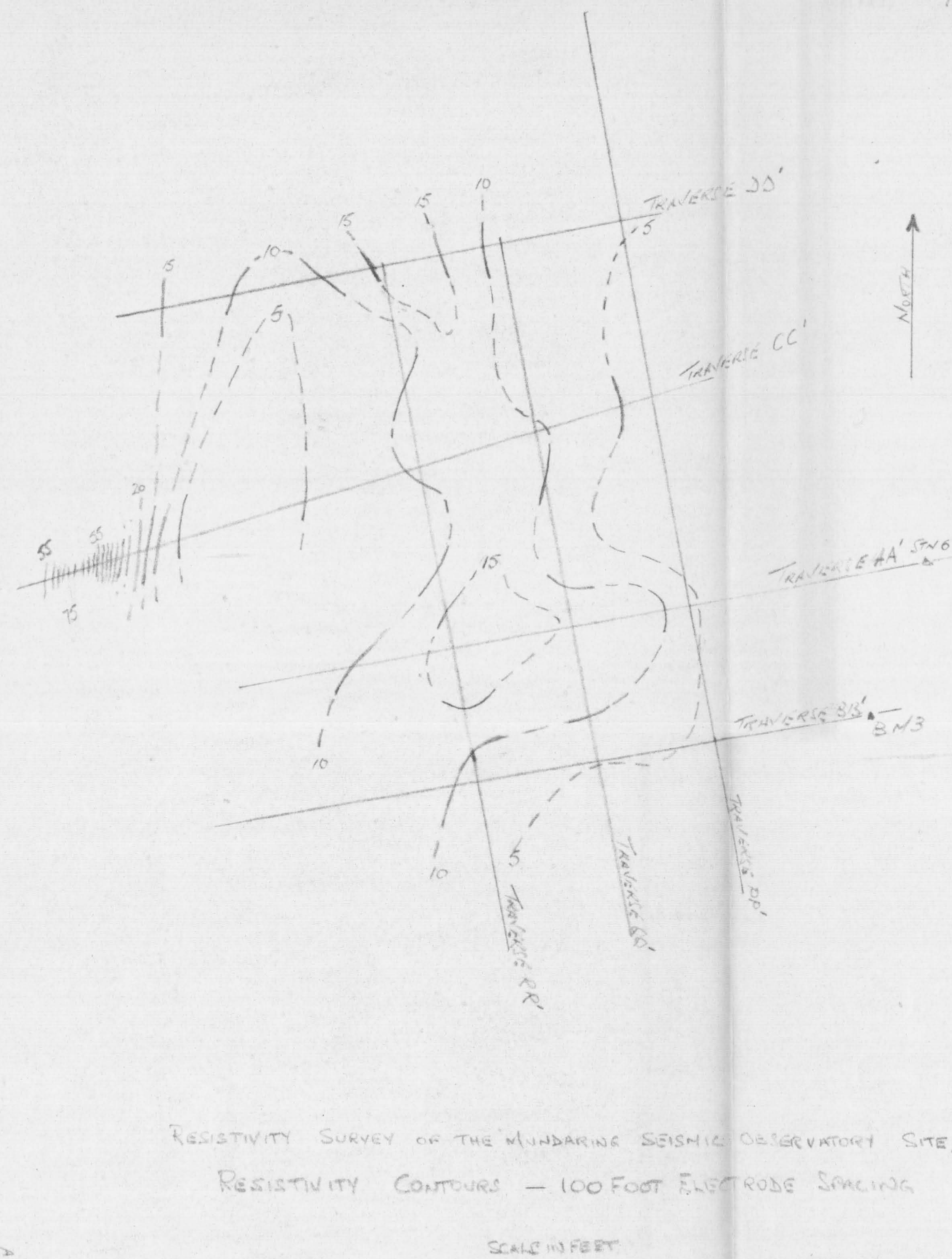
– – – RESISTIVITY CONTOUR (INTERPOLATED OR APPROXIMATE)

SCALE IN FEET

100 0 100 200 300

CONTOUR INTERVAL 5 OHM-METRES

G 83-11




RESISTIVITY SURVEY OF THE MUNDARING SEISMIC OBSERVATORY SITE, W.A.

RESISTIVITY CONTOURS — 100 FOOT ELECTRODE SPACING

LEGEND

—— RESISTIVITY CONTOUR

– – – RESISTIVITY CONTOUR (INTERPOLATED OR APPROXIMATE)

SCALE IN FEET

100 0 100 200 300

CONTOUR INTERVAL 5 OHM-METRES.

G 83-12