COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1954, No. 5

RADIOACTIVE SURVEYING FROM A HELICOPTER

(ABRIDGED VERSION)

by

J. DALY

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This abridged version of Records 1953, No. 106 has been produced to meet the increasing demand for additional copies. It differs from the original only in that the following have been omitted:-

(1) Appendix 1 - "Application of Helicopter in Uranium Survey" by Flying Officer R. A. Scott.

(2) A number of plates which contained detailed technical matter.

C O N T E N T S

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ILLUSTRATIONS

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RADIO-ACTIVE SURVEYING FROM A HELICOPTER
(ABRIDGED VERSION)

1. INTRODUCTION

In connection with the use of airborne equipment for the detection of deposits of radio-active minerals, the Bureau has successfully used a DC.3 aircraft for the rapid coverage of large areas. It has been frequently suggested that a helicopter would have the following advantages over a conventional aircraft :-

(i) It can fly safely at lower heights and slower speeds than an ordinary aircraft, thus obtaining greater sensitivity from the detecting apparatus.

(ii) It can be used effectively and safely in mountainous areas, in which low flying by a conventional aircraft would be impossible.

(iii) It would enable the observer to locate exactly and identify from the air any small area on the ground showing radio-activity.

In order to assess the performance of helicopters, a programme of tests of helicopter-mounted equipment over selected areas in New South Wales was carried out during March, 1953. The areas selected were :-

(i) Carcoar. This is a hilly area, but not timbered.

(ii) Wunglebung, near Tenterfield. This is a mountainous, heavily timbered area.

(iii) Broken Hill. This is a relatively flat featureless area.

(iv) A test run was also made over Plen's deposit at Toongi, near Dubbo, in order to obtain a check on the sensitivity of the detecting instrument.

The survey techniques used and the results obtained in the several areas are discussed in detail below. Technically, the method showed to best advantage at Carcoar, where a picture of the distribution of radio-activity over a considerable area was obtained, a picture which probably could not have been obtained by any other method.

Results at Tenterfield were highly encouraging from a prospecting point of view, but drew attention to certain deficiencies in the detecting apparatus used.

At Broken Hill, although indications were observed over known deposits, results generally were not particularly striking, owing in part to the almost featureless topography which made accurate positioning of the aircraft very difficult, and in part to peculiarities in the distribution of radio-activity in this area, which would probably affect the performance of any airborne instrument.

The aircraft used was a Sikorsky S51 helicopter made available by R.A.A.F., who also supplied the pilot and maintenance crew. R. J. P. de Groot and L. E. Howard, geophysicists, were responsible for navigation and operation of the scintillometer during the tests.

The tests commenced at Carcoar on 27th February and were concluded at Broken Hill on 30th March, 1953.

2. DESCRIPTION OF SCINTILLOMETER

The circuit diagram of an airborne scintillometer is shown schematically on Plate 1. Gamma rays falling on the crystal cause scintillations, which are amplified by the photo-multiplier tube, and appear as voltage pulses at the photo-multiplier output. These pulses are amplified by the voltage amplifier, and are fed into the pulse shaping stage, which is a "one shot" multivibrator. Upon receiving an input pulse of amplitude greater than a certain level the multivibrator gives an output pulse of standard shape. The shaped pulses are fed into a resistance-capacity tank circuit, and a voltage appears across the tank circuit, which is proportional to the rate of arrival of the pulses. This voltage is measured by a vacuum tube voltmeter, and recorded on a pen recorder.

Available instruments differ considerably in details of construction. It is considered that the ideal instrument for use in a helicopter would provide certain facilities, which have not been provided on any of the scintillometers so far used. The principal of these are :-

(i) Provision for checking the response of the equipment. It is obvious from the schematic diagram that the scintillometer consists of two sections, the dividing line between which is shown at A on Plate 1. The response of the two sections should be checked separately. It is considered that the proper means of checking the second section would be by means of a fixed frequency pulse generator, feeding pulses in at A. When this portion of the circuit is functioning correctly, the response of the first section may be checked by the use of a standard sample.

(ii) Provision for reducing the overall sensitivity of the equipment. This should be done by reducing the sensitivity of the pen recorder, by means of suitable shunts.

(iii) Provision for operating the equipment at maximum sensitivity, whatever the general level of activity present. This would involve switching known backing-off currents through the recorder.

3. CARCOAR SURVEY

(a) Previous work.

The occurrence of uranium in the cobalt deposits mined at Carcoar has been known for many years. The area surrounding the workings has been investigated by field parties from the Bureau, and their reports contain details of the geology (Matheson, 1952a) and the level of radio-activity observed (Daly, Dyson and Pearce, 1951).

The known deposits occur in a relatively small area, which is a contact zone between diorite and slates. Close traversing on the ground with portable Geiger counters revealed small areas of high activity on the dumps, and a wide area over which some slightly high readings were obtained. It was hoped that when observed with a very sensitive instrument from a height of 100 feet the integrated effect from this area would be detectable, and would serve to characterize the area, and that other areas showing similar effects might be discovered. Such areas could be considered favourable for prospecting for deposits similar to those already worked.

(b) Method of operation.

The area is hilly and lightly timbered in places. An attempt was made to fly parallel traverses 200 feet apart, using a truck as a marker at one end. Traverses 1 to 14 were flown in this manner and are shown on the map (Plate 2) in their theoretical position. However, it was found quite impossible to position these traverses with any approach to accuracy. The position of the actual flight paths probably differs considerably from that shown, but as the recordings on these traverses showed nothing of interest it was considered that re-flying was not justified.

For the remainder of the traverses a different method of surveying was used. The area was divided into sections. For each section a map feature, such as a road, a creek, or ridge, on each side was chosen, and traverses were flown between these features, the beginning and end of each traverse being identified on a map. The map used was a section of the Blayney 1-mile sheet, enlarged to a scale of 8 inches to the mile. The distance of 200 feet between traverses was estimated (it will be noted from the map that distances were generally under-estimated.) This method of location proved satisfactory, in that the actual points at which the map features were crossed could be located accurately in this type of country. It has the disadvantage that the direction of the traverses is controlled by the map features, and cannot always be chosen to suit the strike of geological formations. Due to the topography to the west of Carcoar, the traverses flown have a general east-west direction. North-south traverses would be very difficult to fly in this area. However, the radio-active high area has a northerly strike, so that east-west traverses are best suited to outline it.

(c) Accuracy of positioning.

The position of traverses flown and a portion of the results are shown on Plate 2.

Inaccuracies in positioning are due to the following causes :-

(i) The impossibility of maintaining constant ground speed in country of this type.

(ii) The effect of wind, which cannot be allowed for readily with a helicopter, especially when flying in very hilly country.

(iii) Inaccuracy of recording the beginning and end of each traverse.

(iv) Difference between the actual flight length of traverse and the map length due to the aircraft following the slope of the country.

A measure of the effect of these may be seen in Appendix 1 which shows the overall chart length per mile of map covered along traverses 15 to 115 flown at Carcoar. It will be observed that the divergences are serious, although they tend to average out in a contour plot of a broad anomaly such as that shown, because each end of each traverse has been fixed with fair accuracy.

(d) Results.

In general, results over the area surrounding the cobalt workings were disappointing. Small definite anomalies were observed when the aircraft flew directly over the dumps, but no general effects were observed over this area. Very definite anomalies were observed on numerous traverses along the western boundary of the area surveyed. It was found possible to contour some of the traverses, and this method of presentation of the results has been adopted in Plate 2.

So that the contours may present a picture of results as obtained, including inaccuracies, smoothing and adjustment of the data have been kept to a minimum. It is considered that the displacement of the contours on traverses 64 to 68 shows the effect of inaccuracies of positioning. Traverses 1 to 47 were flown in one block, and contours derived are shown in full lines. Traverses 48 to 83 were flown on the next day and contours are shown in dotted lines. It will be noted that there is a slight break in level between the two sets of contours. This is due to a different adjustment of the background setting of the instrument.

(e) Checks on ground.

Tests were made on the ground, using portable Geiger counters in order to correlate the observed anomalies with the geology. It was found, however, that the sensitivity of the airborne scintillometer is so high compared with the portable instruments that it was difficult, without a very thorough examination, to observe sufficient range in the readings obtained on the ground and obtain definite results. The areas of high radio-activity in the neighbourhood of the cemetery appear to be associated with outcropping granite, on which readings up to twice background were observed by Geiger counters. The long area of high readings on the western edge of the area could not be associated with any geological formation. This area lies on a very steep slope, and outcrops are few. A generally high reading of up to twice background was observed over the soil cover. Recent geological mapping (Matheson, 1952a) indicates that this portion of the area consists of basic rocks, possibly sheared. It is considered that the readiest method of interpreting the results would be to extend the survey by helicopter considerably to the north and west and re-examine the geology in the light of the findings of the extended survey.

Typical records over the Carcoar area are shown on Plate 3.

The total amount of flying time on the Carcoar survey was about 7 hours.

(f) Assessment.

The results obtained at Carcoar show that the inaccuracies of positioning the aircraft are such that this method could not be used economically to search for small anomalies, such as those associated with the cobalt deposits. The results obtained over the western portion of the area, however, show the method in a very favourable light. It appears that if it is desired to obtain a picture of the regional distribution of radioactivity over an area too hilly for the use of the DC.3, and for which detailed photomosaic or map coverage is available, the use of helicopter-mounted scintillometer equipment is superior in speed and sensitivity to any method of ground surveying.

Results of geological interest would certainly be obtained by extending the work at Carcoar to the north and west. It cannot, of course, be presumed at the present stage that such results would necessarily have any direct usefulness in the search for deposits of radio-active minerals of commercial value.

4. TENTERFIELD SURVEY

(a) Previous work.

The Wunglebung area lies about 25 miles south-east of Tenterfield. Here, molybdenite has been mined from small pipe-like deposits, adjacent to a contact of granite with porphyry. The deposits worked are described briefly by Andrews (1916), but owing to the extreme roughness of the country the area has not been thoroughly prospected.

It was discovered, during the programme of radio-active testing of specimens in mineral collections carried out by the Bureau during 1948, that molybdenite specimens from Wunglebung showed radio-activity. A brief visit was paid to the workings by a geophysical party during 1948, and it was observed that the main spur upon which the workings lie shows general high activity, readings on a portable Geiger counter ranging up to five times background. The area was selected as giving the opportunity of testing the performance of the helicopter in mountainous, heavily timbered country.

(b) Method of operation.

Operations were seriously interfered with by bad weather. It appears that work in this area should be confined to late spring and early summer. Persistent low cloud prevented any flying for two days, and only two flights to the Wunglebung area were possible. The aircraft was based on Tenterfield, and test flights were made over various features in the neighbourhood of the town.

A feature of the Tenterfield area generally was the number and magnitude of the radio-active anomalies encountered. A preliminary test flight was made over the Wunglebung area, and it was found that over much of the area the recorder was continuously off scale. For the remainder of this flight the bias setting was adjusted to keep the recorder reading on scale. For more thorough coverage of the area near the workings a set of flight lines following the tops of the ridges was laid out, using a portion of the Tenterfield 1-mile map sheet, enlarged to a scale of two inches to the mile. These were flown, starting in each case from the highest point of the traverse. Flights were also made following the course of the main creeks. For these traverses, a shunt was fitted to the milliammeter, for the purpose of reducing its response by one half. As resistors of the correct values were not available, the performance of the shunt was only approximately as designed and the sensitivity of the shunted recorder being rather lower than that aimed at.

(c) Results.

The lines flown are shown on Plates 4 and 5. The test flights around Tenterfield showed numerous very definite and isolated anomalies, and their positions are shown on Plate 4. Time did not permit of the location of these anomalies on the ground. Their significance is therefore not known, but it seems possible that some at least are associated with radio-active molybdenite veins. An attempt was made to locate the anomaly south of Bluff Rock during the return trip, as the traverse was flown along the road. Some hours were spent testing the area with portable Geiger counters, and readings of twice background were obtained beside the road for a distance of over a mile. It is considered, however, that these readings are insufficient to account for the observed anomaly. It is possible that the anomaly was due not to radio-active material below the aircraft, but to strong activity in the high ground south of Bluff Rock itself, which would be on a level with the aircraft in flight. Such anomalies would be located most readily by spotting the area of highest activity by manoeuvring the aircraft rather than by flying a definite course from a map.

High activity was observed in the Wunglebung area. The anomalies appeared as high readings along considerable lengths on the flight lines, and their locations are shown on Plate 5. The nature of the anomalies suggests the presence of large areas of low grade mineralisation, rather than the known small, pipe-like molybdenite deposits. If it were possible to operate the scintillometer at maximum sensitivity, it might be possible to detect isolated anomalies superimposed on the main activity and due to molybdenite pipes. Without further geological examination and laboratory tests on samples, it is not possible to offer an estimate of the significance of the Wunglebung anomalies with any confidence.

(d) Assessment.

It is considered that the results obtained in the Tenterfield area give a very favourable impression of the capabilities of helicopter-mounted equipment in country of this type, much of which would be inaccessible to conventional aircraft. All flights made followed the tops of ridges; however, around Tenterfield itself, semi-routine coverage, similar to that flown at Carcoar, would be possible. The most efficient use of a helicopter in this country would be as an adjunct to a full-scale geological survey party. The aircraft could then be used, either for routine coverage of a small area as required, or for prospecting flights on which actual anomalies could be spotted on to a photomosaic and investigated immediately.

A typical record from the Tenterfield area is shown on Plate 6.

Total flying time was about 8 hours.

5. BROKEN HILL SURVEY

(a) Previous work.

Tests were made over portions of the Broken Hill field as this area is very similar in physical characteristics to a large part of the Pre-Cambrian area of Australia. The general distribution of radio-activity in this area has been investigated on the ground by the Geophysical Section (Daly and White, 1952).

(b) Method of operation.

Test flights were made over the following areas :-

(i) The known radio-active deposits (Balaclava Copper Blow, Hen and Chickens, Great Western).

(ii) Patterson and Polkinghorne's prospect (a recently discovered radio-active occurrence).

(iii) Outcrops south of the racecourse, and in the Rockwell Paddock area, which have been found to show radio-activity rather greater than normal (Daly and White, 1952).

The positions of these areas are shown on the map (Plate 7). An attempt was made to cover the area around the Balaclava Copper Blow systematically, by flying north-south traverses 200 feet apart, marking the northern ends by means of a truck. It was found, however, that it was quite impossible to locate the position of the aircraft with any accuracy in flat featureless country of this type.

(c) Results.

Anomalies were observed over all known deposits. As was expected, the largest anomaly was a narrow one over the Warren shaft at the Balaclava Copper Blow, where the main radio-active anomaly has been found on the ground. A feature of the Broken Hill district, previously noted by Daly and White (1952) is the general high level of radio-activity in the country rocks. This has affected the results in two ways :-

(i) On the scintillometer used, the means provided for setting the response of the instrument to the background activity affects the overall sensitivity, with the result that the instrument, when adjusted according to the makers' recommendations, is less sensitive in areas where the general level of activity is high. The effect of the high back-ground may be seen in the strong negative anomaly obtained over Umberumberka reservoir (see Plate 9, Sheet 1).

(ii) On all profiles, numerous small anomalies are present, due to the passage from rock outcrop to soil cover. These may be seen in the profiles over the Rockwell area and the racecourse. (Plate 9, Sheets 2 and 3). These complicate the records and could possibly obscure readings of greater significance. It is possible that results obtained using the DC.3 aircraft will be affected similarly.

A prospecting flight to the south, along the border fence was made. The approximate course of this flight is shown on Plate 8. No strong anomalies were encountered on this flight. The general level of activity along the border fence was rather less than that on the return flight, probably due to the fact that outcrops are fewer along the fence.

Total flight time was about 9 hours.

(d) Assessment.

The results obtained at Broken Hill drew attention to the difficulties of the operation in country of this type. Some of these difficulties are due to geological causes, which would probably affect any airborne equipment to some extent. Routine coverage is practically impossible with the helicopter. There is one possible way of covering the field in some detail. Most of the area has been carefully mapped by the geologists of Zinc Corporation Ltd., and maps are available on which all creeks of any importance are marked. If all these creeks were systematically flown with the helicopter, a fairly good general coverage of the known field would be obtained. This work could be completed in about three weeks, and it is possible that the results could be more readily correlated with the geology than results obtained from routine coverage with the DC.3 aircraft. On the other hand, it should be noted that the country around Broken Hill is ideally suited to the operation of the DC.3 with Shoran positioning, and any major anomalies would be located much more rapidly by this means than by the use of the helicopter.

6. TESTS AT TOONGI.

In order to obtain definite information on the sensitivity of the scintillometer, a test flight was made over a deposit of trachyte, showing high radio-activity at Toongi, near Dubbo. The location of this area is shown on Plate 10. This outcrop, known as Plen's deposit, had been examined previously (Matheson, 1952b). The outcrop consists of a low hill approximately half a mile wide, which records about eight times normal background reading on a portable Geiger counter.

A very strong anomaly was observed over this deposit. Several profiles were run across the outcrop in different directions at heights up to 500 feet, using different bias settings of the scintillometer. The results are shown on Plate 11.

On the return flight from Toongi to Blayney, a strong anomaly was observed about 4 miles south of Plen's deposit. (See Plate 10). Profiles over this anomaly are shown on Plate 11, Sheet 3. The region was visited and the radio-active area was located. It lies about ½ mile east of Eulandool homestead, and consists of three hills of considerable size. Tests with a portable Geiger counter gave readings of about five times background generally over the surface of the hills. The rock in the area is identical in appearance with that at Plen's deposit.

This test was undertaken purely as a check on the performance of the scintillometer. It indicates that the helicopter could be used to search for other deposits similar to Plen's and the Eulandool deposit. However, such a search could be carried out much more rapidly in this type of country by using the DC.3 aircraft.

7. SUMMARY AND CONCLUSIONS.

The present report covers a series of tests made over selected areas in New South Wales, in order to assess the suitability of scintillometer equipment mounted in a helicopter in the search for deposits of radio-active minerals. Attention was directed primarily to regions of high topographic relief, over which the use of an aircraft of conventional type would be difficult or impossible. The aircraft used was a Sikorsky helicopter, Type S51, made available by the Royal Australian Air Force. The aircraft was flown at a speed of about 70 miles per hour, and a height of 100-150 feet. No attempt was made to use the hovering capabilities of the helicopter.

The following conclusions are drawn from the results of the tests :-

(i) The sensitivity of a scintillometer of suitable design used in this way is adequate to detect any significant radio-activity.

(ii) Due to the comparatively low speed and altitude at which the aircraft is flown, the record of surface radio-activity is more detailed than could be obtained using an aircraft such as a DC.3. Such a record is advantageous since it can be correlated with the areas of radio-activity with a minimum of radio-active survey on the ground.

(iii) None of the usual methods of determining the position of the aircraft, such as photography or the use of radio navigation aids, is applicable with the helicopter. Navigation must be by eye, using photomosaics, or maps showing equivalent detail. The accuracy of positioning depends on the rapidity with which a definite point on such a mosaic or map can be located accurately, and is therefore greatest in areas of considerable topographic relief, or in areas on which features such as roads or fences are numerous.

(iv) For a routine air survey over a large area, the most economical method of coverage is to fly the aircraft along straight parallel traverses, the spacing of which is accurately maintained. The helicopter is quite unsuited to this type of work.

(v) In order to make economical use of an expensive aircraft such as a helicopter, it is essential that all flying be as systematic as possible. Two main modes of operation may be envisaged :-

(a) Systematic coverage of an area. This would be done by flying sets of traverses so chosen that their course may be established with reference to easily identifiable map features. For this type of flying, a crew of four would be desirable and would consist of a pilot, a co-pilot to act also as navigator and direct the pilot along the flight line, an instrument operator, and an observer keeping a detailed flight log.

(b) Spotting of anomalies for later investigation on the ground. This would be done by following flight lines generally along ridges, and either marking the positions at which high readings were obtained directly on a map or photomosaic, or dropping a ground marker of some type from the aircraft. It is understood that a marker suitable for this purpose has been used by the R.A.A.F., consisting of a grenade, filled with fuze, exploder, and a charge of aluminium powder.

(vi) It is possible that, in a particular case, the helicopter could be used for following up anomalies recorded by a fast aircraft such as the DC.3, although the use of such an expensive aircraft for this purpose would be fundamentally uneconomical. If a radio-active anomaly were discovered by the DC.3 aircraft in a completely featureless area such as the Mulga scrub country to the south of Broken Hill, a ground party might have great difficulty in locating the radio-active area. It is possible, however, that the anomaly could be re-located with a helicopter by a restricted amount of flying, and the spot marked with a marker grenade as suggested in (v) above, or some other means adopted of guiding the ground party. Such an operation as this would be resorted to only in very special circumstances.

(vii) Due to the inevitable uncertainty in positioning, the helicopter should be used only as an adjunct to a geological party large enough to permit of immediate following up of indications. The programme of flying for the aircraft would be decided on a day-to-day basis.

(viii) The hovering capabilities of the helicopter are not as great as is popularly supposed, and it is considered that they will not be found particularly useful for this type of work under Australian conditions.

(ix) The helicopter best suited to the type of operations described above appears to be the Sikorsky, Type S55. Considerable use could be made of a smaller machine, such as the Sikorsky S51 or the Bristol, Type 171. The use of a helicopter smaller than these would be so restricted as to be uneconomical.

8. ACKNOWLEDGMENTS

It is desired to acknowledge the assistance rendered by the following :-

The R.A.A.F. authorities for making the helicopter available.

The pilot, Flying Officer R. A. Scott, and the maintenance crew of the aircraft.

The officers of the Lyndhurst Shire Council, Blayney, and the Tenterfield Shire Council.

Mr. C. Mulholland, Government Geologist, and Mr. E. O. Rayner, Geologist, New South Wales Department of Mines.

Mr. B. P. Thompson of Zinc Corporation Ltd.

The officers of Australian National Airways Ltd., Broken Hill.

The owner of Billyrimba Station, and Mr. M. West, Tenterfield.

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October, 1953.

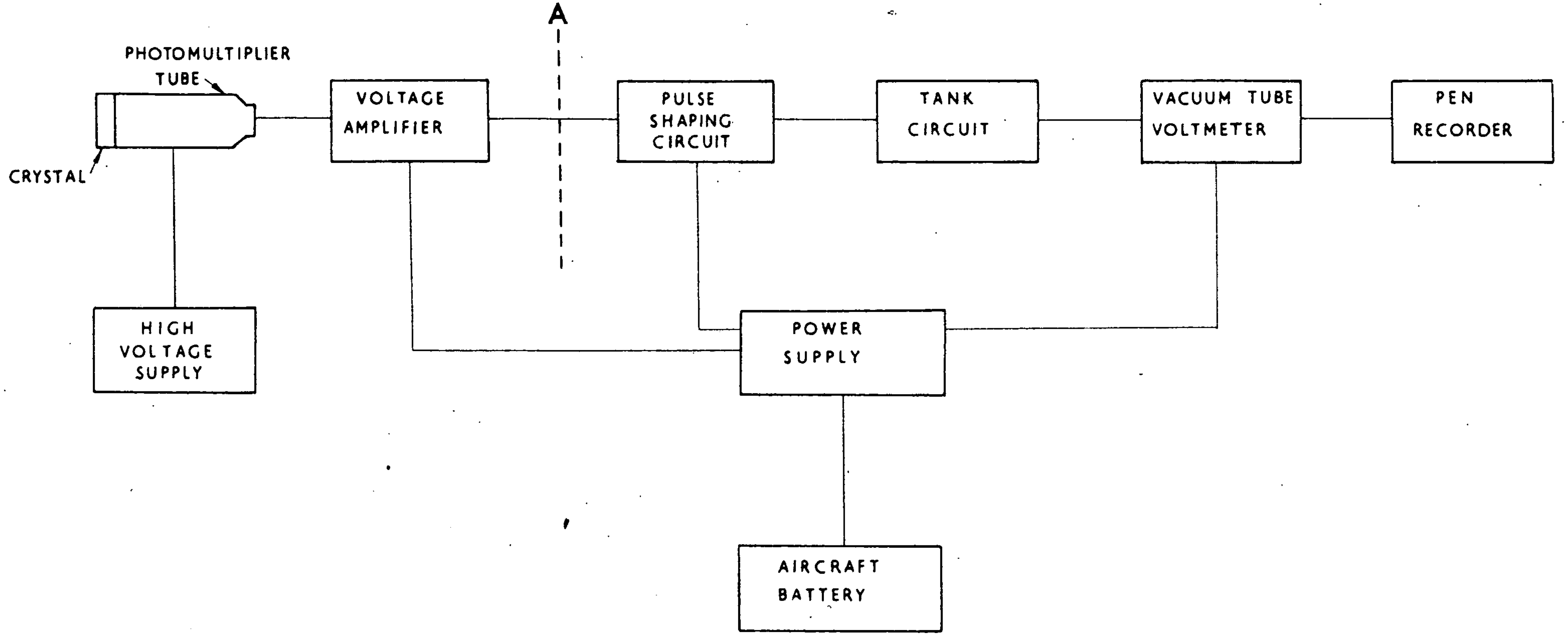
APPENDIX 1.

THE CONSISTENCY OF THE DISTANCE SCALE OF THE SCINTILLOMETER RECORDS.

As a measure of the accuracy of surveying attained on the tests, the quantity length of record per mile of traverse is tabulated below for traverses 15-115 flown at Carcoar :-

Traverse No.	Length of Record per mile (inch)	Traverse No.	Length of Record per mile (inch)
15	5.5	63	2.7
16	3.1	64	2.4
17	3.1	65	2.7
18	2.8	66	2.3
19	2.8	67	2.7
20	2.7	68	2.3
21	3.3	69	2.7
22	2.5	70	2.6
23	2.6	71	2.7
24	2.4	72	2.6
25	2.7	73	2.5
26	2.8	74	2.3
27	2.7	75	2.5
28	2.9	76	2.0
29	3.2	77	2.2
30	2.5	78	2.3
31	3.1	79	2.4
32	2.9	80	2.4
33	3.3	81	2.3
34	3.4	82	2.8
35	3.6	83	2.8
36	3.6	89	2.7
37	3.8	90	2.9
38	3.5	91	2.8
39	3.3	92	2.6
40	3.0	93	2.5
41	2.9	94	2.6
42	2.9	95	2.4
43	3.1	96	2.5
44	3.1	97	2.5
45	3.1	98	2.5
46	2.7	99	2.4
47	2.9	100	2.5
48	2.4	101	3.3
49	2.6	102	3.4
50	2.5	103	3.4
51	2.6	104	2.5
52	2.6	105	3.4
53	2.5	106	2.4
54	2.5	107	3.2
55	2.3	108	2.4
56	2.5	109	3.3
57	2.6	110	2.5
58	2.7	111	3.2
59	2.5	112	2.1
60	2.5	113	3.3
61	2.7	114	2.4
62	3.0	115	3.1

Traverses 84-88 inclusive were discarded due to uncertainty in positioning.



SCHEMATIC CIRCUIT DIAGRAM OF AIRBORNE SCINTILLOMETER

Geophysical Section: Bureau of Mineral Resources, Geology and Geophysics

G 45- 41

PLATE I

PLATE 2

TRAVERSES 1-47 FLOWN ON 1·3·53 CONTOURS SHOWN —+100—

" 48-83 " " 2·3·53 " " --+100--

AREA GEOLOGICALLY MAPPED

SCALE

20 0 20 40 60 80 CHAINS

SCINTILLOMETER SURVEY AT CARCOAR N.S.W.

LOCALITY MAP

SHOWING

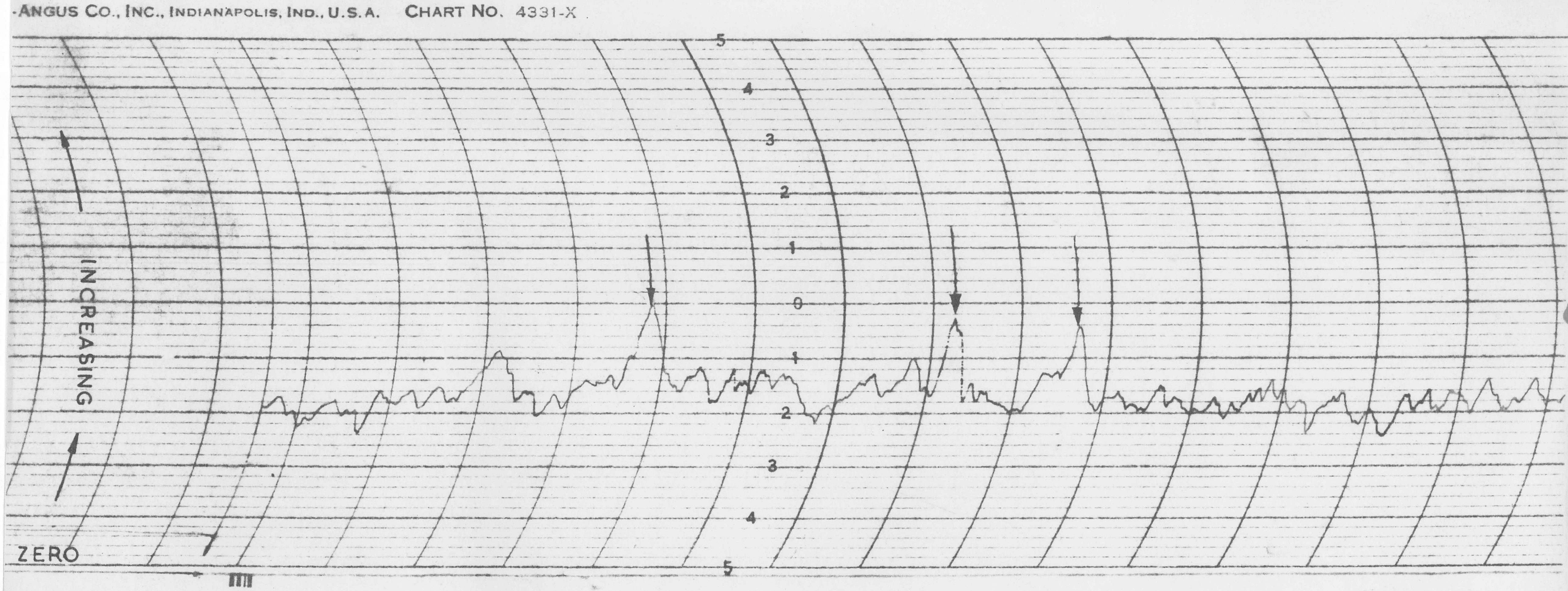
TRAVERSES FLOWN BY HELICOPTER AND CONTOURS OF GAMMA RAY INTENSITY

BASED ON RECORDER LEVELS IN MICRO AMPS ABOVE AN ARBITRARY ZERO

J. Va E. .... GEOPHYSICIST

Geophysical Section Bureau of Mineral Resources, Geology and Geophysics

G138-1



SCINTILLOMETER SURVEY AT CARCOAR N.S.W.

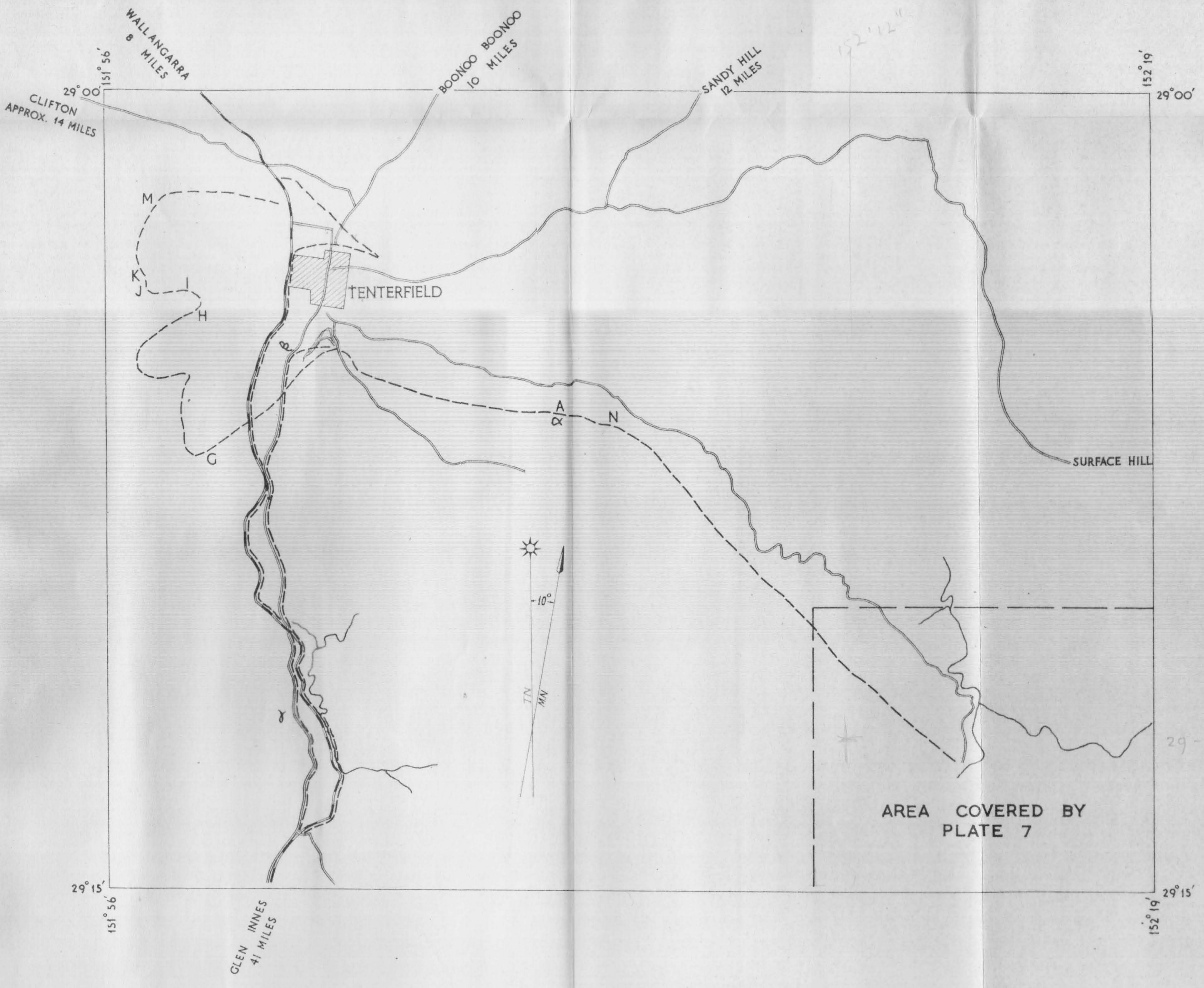
ANOMALY OVER COBALT WORKING G.

(REFER MATHESON 1952a)

PLATE 3
SHEET 1

G138-2

PLATE 4



SCINTILLOMETER SURVEY AT TENTERFIELD N.S.W.

LOCALITY MAP

SHOWING HELICOPTER FLIGHT LINES AND POSITIONS OF PRINCIPAL ANOMALIES

SCALE IN MILES

2 0 2 4 6

LEGEND

ROAD

RAILWAY

HELICOPTER FLIGHT LINE

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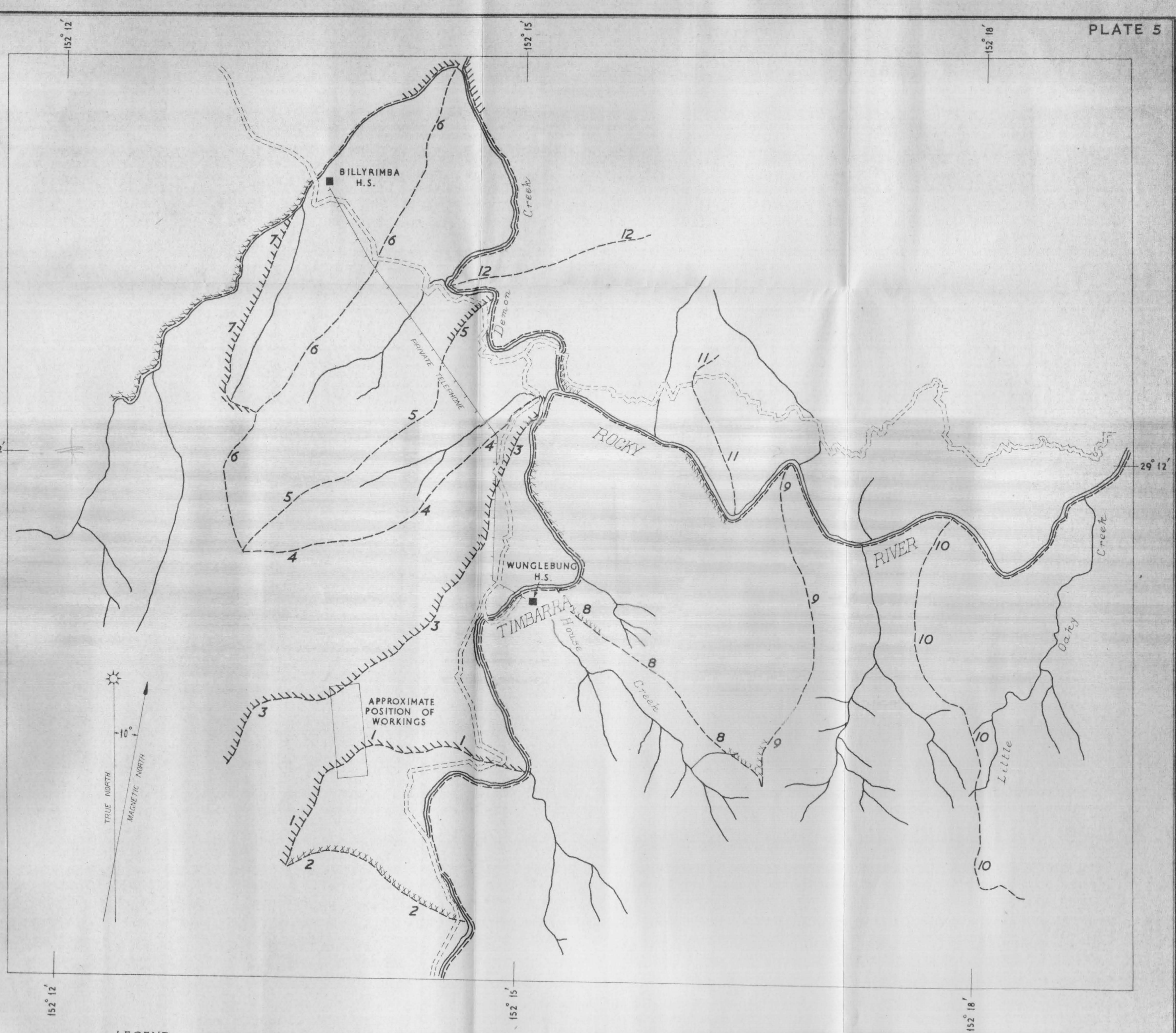
Geophysical Section: Bureau of Mineral Resources, Geology and Geophysics

G 136-2



LEGEND

ROAD
TELEPHONE
HELICOPTER FLIGHT LINE
RECORDS SHOWING HIGH ACTIVITY
RECORDS SHOWING MODERATE ACTIVITY

SCINTILLOMETER SURVEY AT TENTERFIELD N.S.W.

LOCALITY MAP OF WUNGLEBUNG AREA

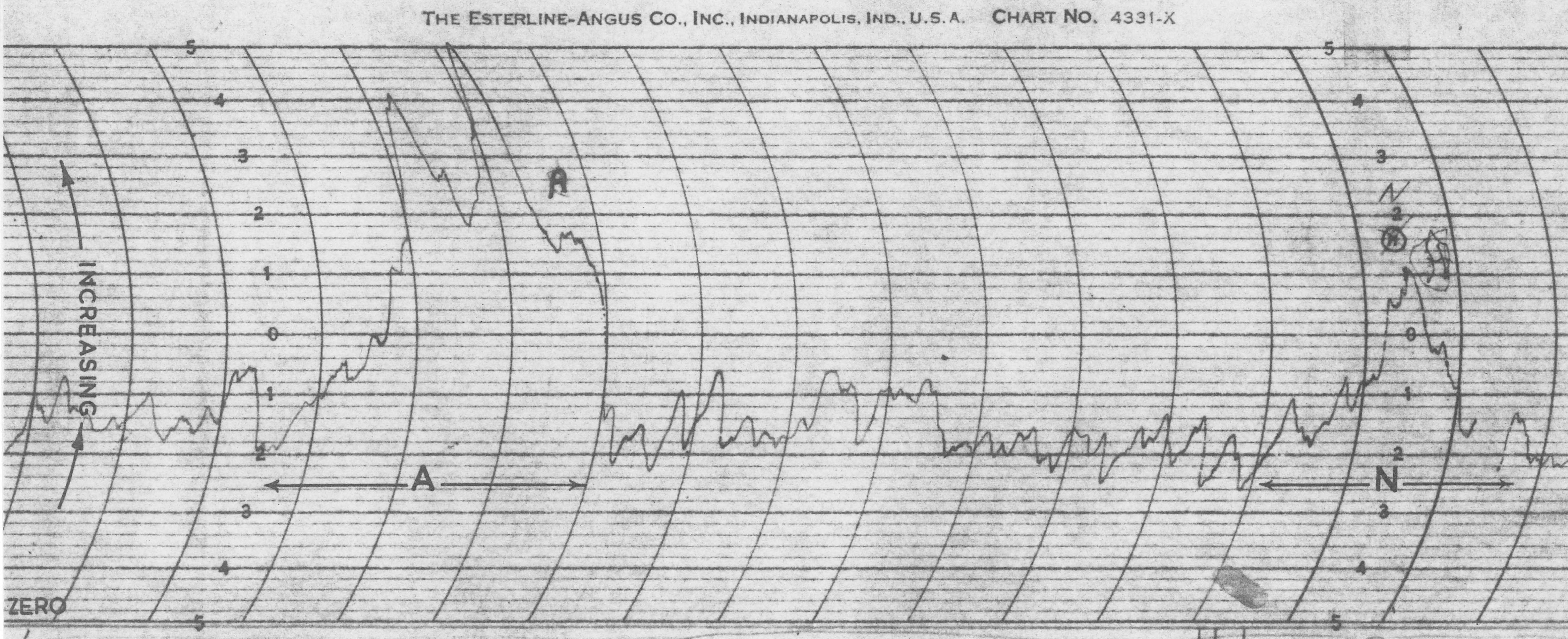
SHOWING POSITIONS OF HELICOPTER FLIGHT LINES

SCALE
1 0 1 MILES

GEOPHYSICIST J. Da E

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics.

G 136-1



SCINTILLOMETER SURVEY AT TENTERFIELD N.S.W.

ANOMALIES A & N

PLATE 6
SHEET 4

G136-6

PLATE 7

SCINTILLOMETER SURVEY AT BROKEN HILL N.S.W.

LOCALITY MAP

SHOWING POSITIONS OF HELICOPTER TEST FLIGHTS

J. Da E
Geophysicist

SCALE IN MILES
2 0 2 4 6

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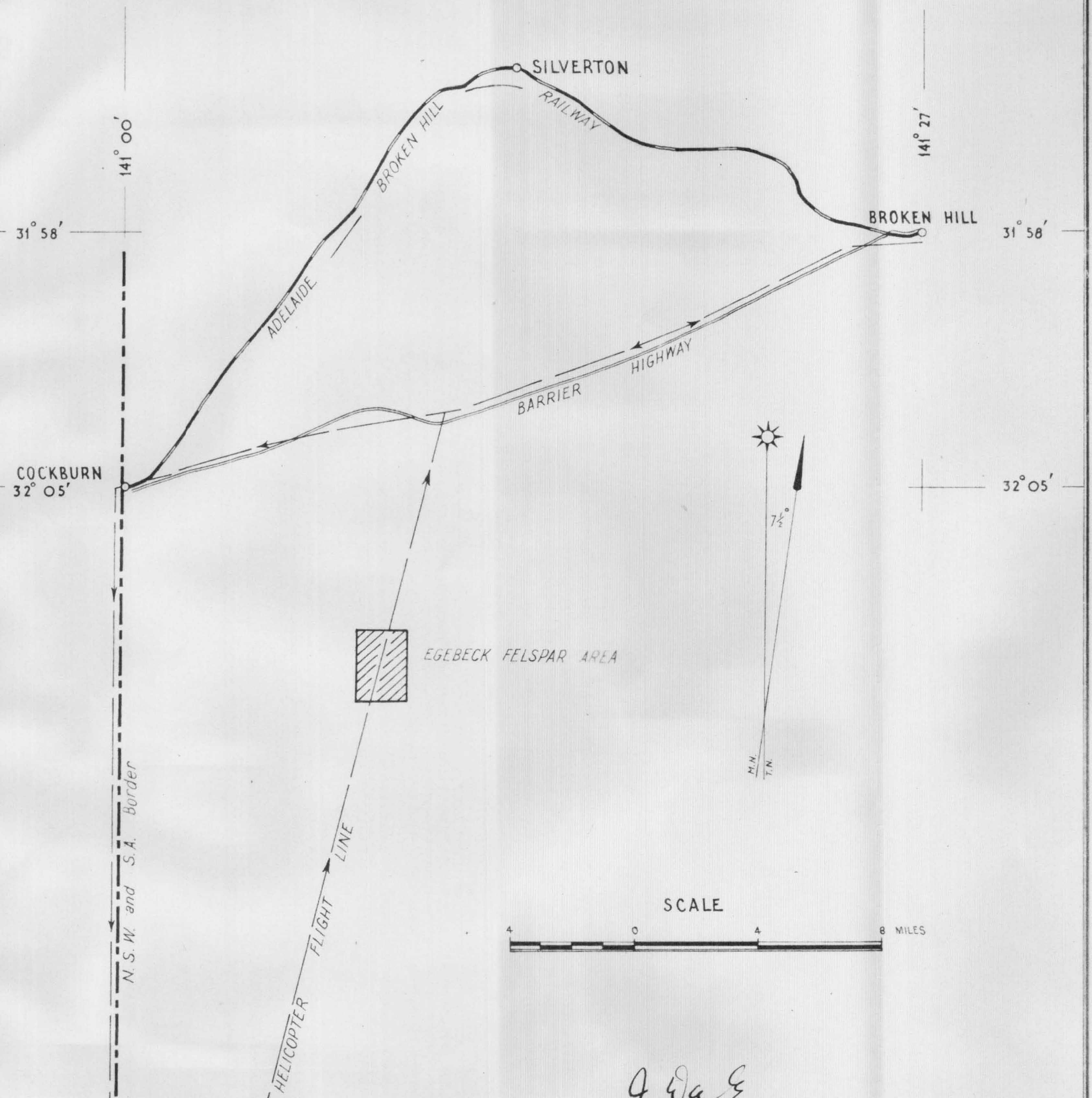
G 135-1

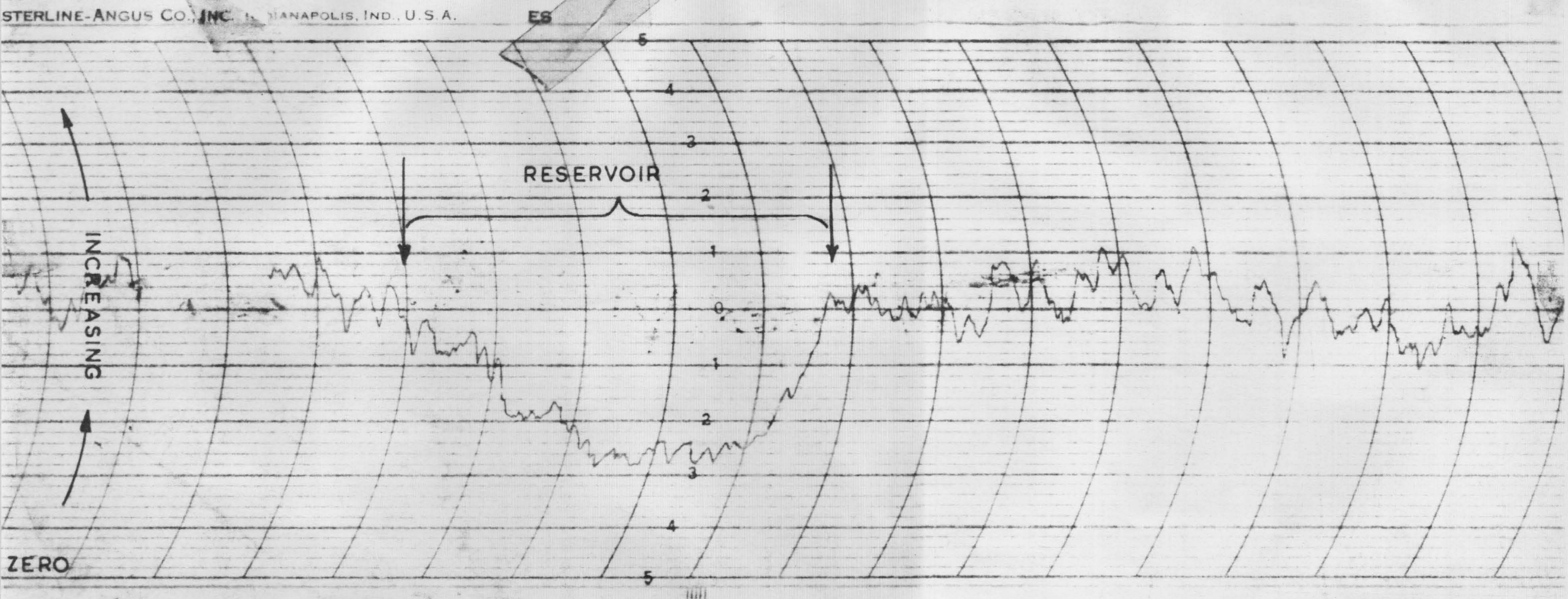


J. Da E
Geophysicist

SCINTILLOMETER SURVEY AT BROKEN HILL N.S.W.

LOCALITY MAP

SHOWING APPROXIMATE COURSE OF HELICOPTER PROSPECTING FLIGHT



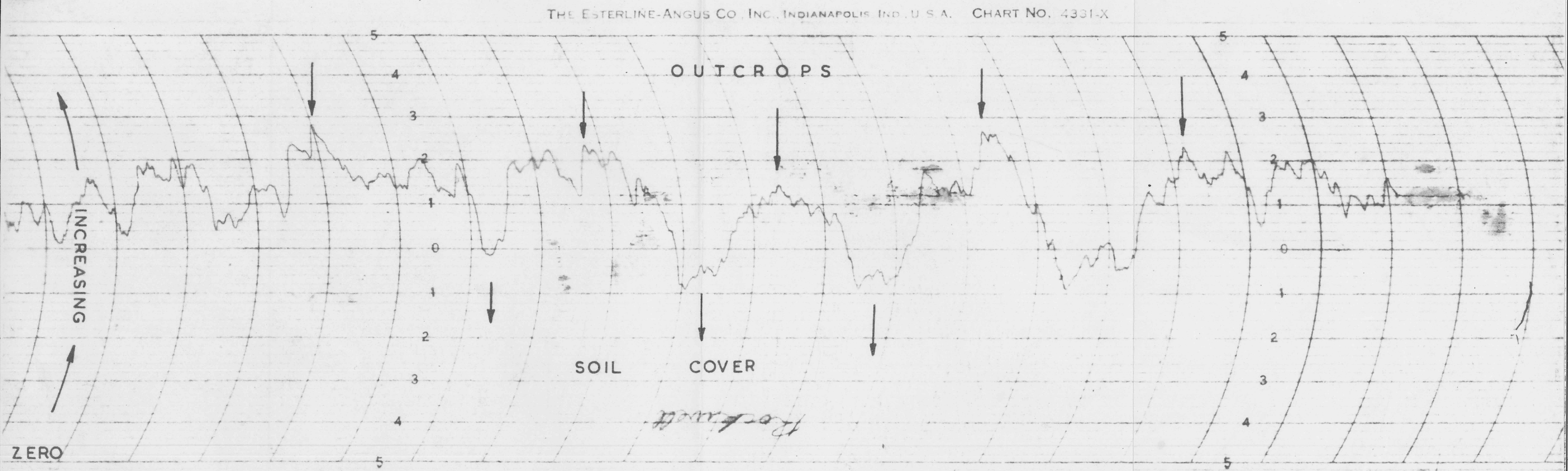
SCINTILLOMETER SURVEY AT BROKEN HILL N.S.W.

PROFILE OVER UMBERUMBERKA DAM

PLATE 9
SHEET 1

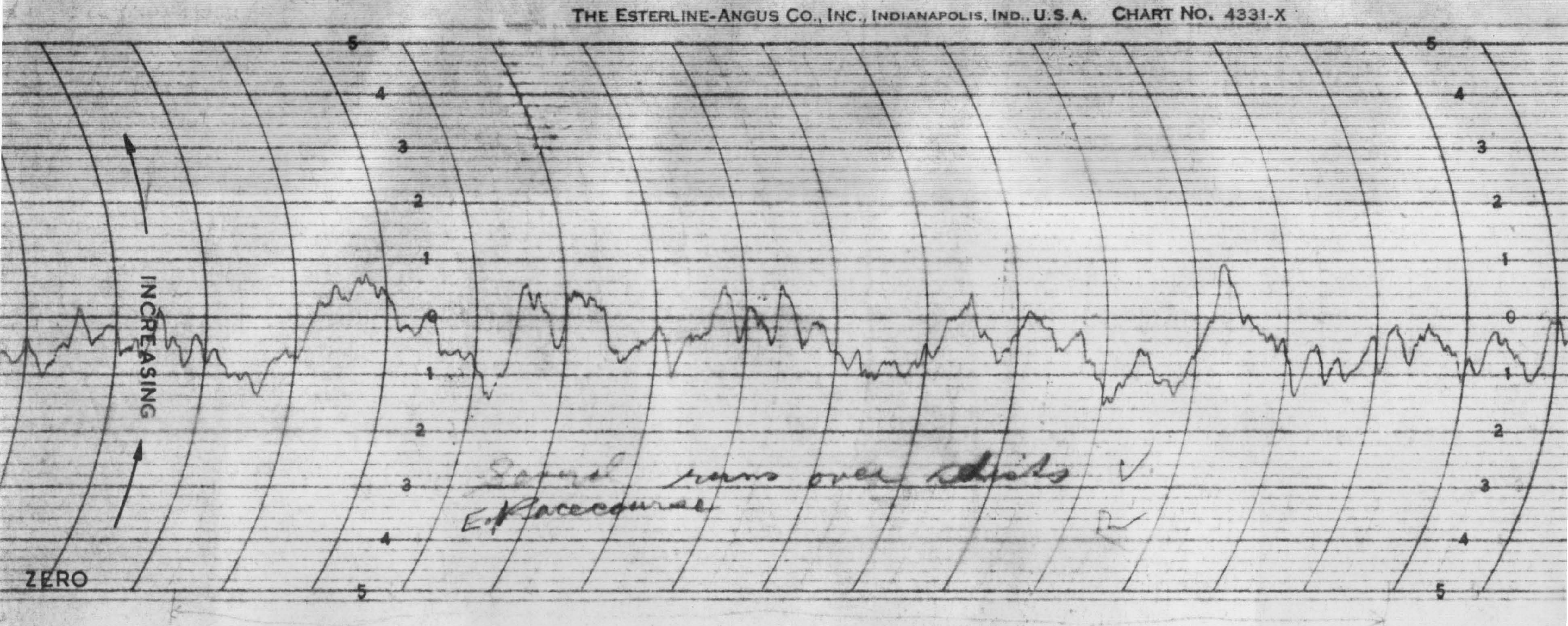
G135-7

PLATE 9
SHEET 2



SCINTILLOMETER SURVEY AT BROKEN HILL N.S.W.

PROFILE OVER ROCKWELL AREA



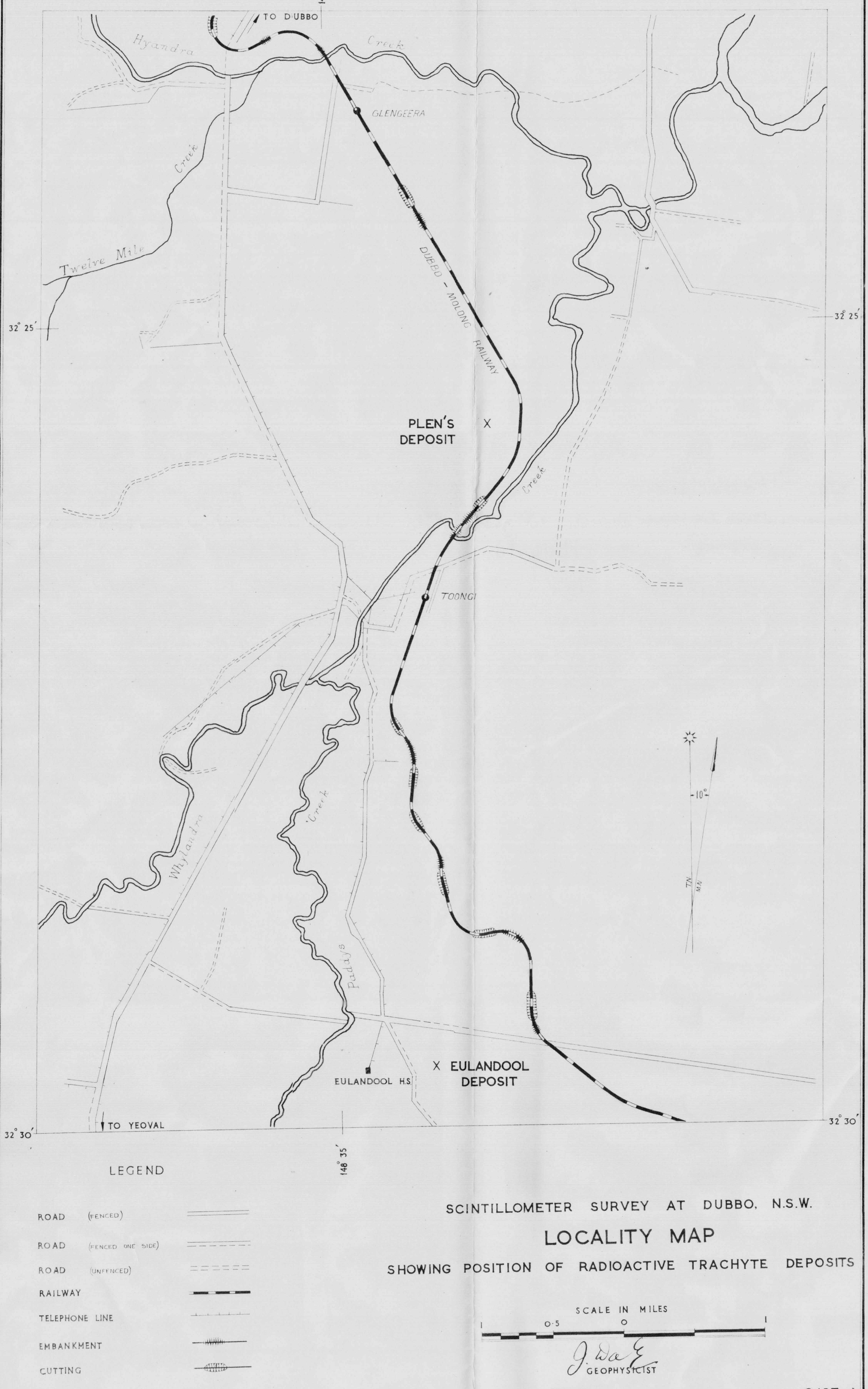
SCINTILLOMETER SURVEY AT BROKEN HILL N.S.W.

PROFILE OVER OUTCROPS EAST OF RACECOURSE

PLATE 9
SHEET 3

G135-9

PLATE 10



SCINTILLOMETER SURVEY AT DUBBO, N.S.W.

LOCALITY MAP

SHOWING POSITION OF RADIOACTIVE TRACHYTE DEPOSITS

J. Daly
GEOPHYSICIST

Geophysical Section: Bureau of Mineral Resources, Geology and Geophysics

G 137-1